ARMY RESEARCH LABORATORY

Alternatives to 1,1,1 Trichloroethane Prior to Adhesive Bonding and Non-Destructive Inspection (NDI)

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Weapons and Materials Research Directorate, ARL

Abstract

The utilization of chlorinated solvents, specifically Class I Ozone Depleting Compounds (ODCs), has been continually scrutinized by the U.S. Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA). This is a direct result of the United States entering into an agreement with several other nations throughout the world to limit the production of these materials (Montreal Protocol 1987). In fact, the EPA has placed very heavy restrictions on the production of 1,1,1 trichloroethane, one of the most commonly known and utilized chlorinated solvents, as of January 1996. This announcement prompted the Aviation and Troop Command (ATCOM) to fund a program designed to identify, test and evaluate commercially available cleaners to replace 1,1,1 trichloroethane during the processing of aviation components. ATCOM requested the Army Research Laboratory - Materials Directorate to develop and execute this test program. Two critical cleaning applications were identified based upon a thorough review of all cleaning processes utilized during part manufacture, and repair at Army depots: cleaning prior to non-destructive inspection (NDI) and cleaning prior to adhesive bonding. This report discusses the rational behind identifying alternative cleaners for these applications, the test and evaluation plan, and the results of the test program.

Preface

The work reported herein was performed by the U.S. Army Research Laboratory - Materials Directorate (ARL-MD), Aberdeen Proving Ground, MD, in conjunction with the Corpus Christi Army Depot, Corpus Christi, TX; RPI Design and Manufacturing Institute, Rensselaer, NY; the U.S. Army Research, Development, and Engineering Center (ARDEC), Picatinny Arsenal, NJ; the University of Connecticut Materials Department, Storrs, CT; and the Texas Research Institute (TRI) Austin, Austin, TX.

The final reports provided by these organizations and the supporting documentation included as appendices have been compiled and included in their original form, without editorial change.

Great appreciation is given for the technical support of and guidance for this program provided by Dr. Kirit Bhansali of the U.S. Army Aviation and Troop Command (ATCOM), St. Louis, MO.

Formatting Note: *Because of the length and number of sections in this document, the following colored dividing pages have been included to aid the reader:*

- *Red Pages - divide main report sections.*
- *Blue Pages - divide subsections.*
- *Yellow Pages - divide subsections of the externally generated reports.*

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Section 1:

Overview

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1.1 Objectives. The objectives of this work were as follows:

(1) To provide two alternative ozone depleting compound (ODC) compliant cleaners for use prior to adhesive bonding and prior to non-destructive inspection (NDI).

(2) To change the depot maintenance work requirements (DMWRs) and other maintenance manuals where 1,1,1 trichloroethane is called out, and substitute an appropriate alternative cleaner.

1.2 Introduction. Trichloroethane has been proven reliable as a cleaner prior to adhesive bonding and NDI. Any replacement must meet the same degree of reliability, while still maintaining material compatibility. Adhesive bonding and fluorescent penetrant inspection (FPI), which is one specific NDI test method, require a high degree of cleanliness; therefore, any replacement that meets the requirements of these applications should also meet the requirements of other NDI and joining disciplines that are not quite as sensitive to cleanliness. A single replacement for 1,1,1 trichloroethane will be difficult in that its utilization is so widespread. It has characteristics that are extremely advantageous from a procedural point of view. The low boiling point, low toxicity level, and proficient solubilizing potential make 1,1,1 ideal for manufacturing operations from degreasing to precision cleaning to nondestructive evaluation. Deviations from these effective characteristics will increase the procedural time, sometimes drastically, and may even increase cost due to hardware and/or machinery alterations that might be required. Regardless, the restriction on the use of 1,1,1 trichloroethane is imminent, and an environmentally acceptable replacement must be found. The focus of this program was to provide test data on prospective alternate cleaners prior to (1) adhesive bonding and (2) NDI in order that potential users can make more educated decisions on which products would best fit their needs.

1.3 Section 2: Identification of Commercially Available Products To Replace 1,1,1 Trichloroethane. The aircraft industry, chemical corporations, DOD agencies (Army, Navy, and Air Force), and the EPA were contacted in an attempt to develop a comprehensive listing of the most prospective candidate cleaners. The U.S. Army Research Laboratory Materials Directorate (ARL-MD) initially expanded upon the database of possible chemical cleaning replacements created and investigated by the Corpus Christi Army Depot (CCAD), Corpus Christi, TX. CCAD had performed total immersion corrosion and cleaning efficiency tests on a large number of alternative aqueous cleaners and their respective 10% dilutions. In addition, ARL-MD contracted the Texas Research Institute Austin, Inc. to perform a detailed search of related work on the subject of 1,1,1 replacement. This work has been included in section 2 of the report. The comprehensive listing formed was very dependent on the specific process being utilized. Therefore, two separate lists were generated, one for adhesive bonding and one for NDI. The industrial chemical companies are continually investing large amounts of money into developing replacements for 1,1,1 trichloroethane. Various private aviation corporations (i.e., McDonnell Douglas, Sikorsky, Boeing, Lockheed, and Northrop) have also contributed significantly to the replacement effort. However, it must be understood that these alternatives are continually changing, specifically the chemical compositions change as restrictions become tighter and cleaners that were acceptable gradually become obsolete. Many alternatives received from the aircraft industry were found to be out of date. The major chemical companies attempted to stay ahead of the new laws and regulations by developing improved formulations. In fact, some of the cleaners identified as viable replacements for 1,1,1 already have new formulations.

In addition, many of the private aviation corporations performed the bulk of their research as much as 5–10 years ago due to the restrictions and penalties placed on the use of these chlorinated solvents. Until recently, the government has traditionally been given exceptions to these restrictions and penalties.

1.4 Section 3: Downsizing of Alternatives Through Initial Testing. The comprehensive listing of candidate cleaners for adhesive bonding and NDI revealed more cleaners than could possibly be tested within the time constraints of this program. Therefore, both lists were shortened based upon a variety of performance and environmental factors. ARL-MD contracted Rensselaer Polytechnic Institute (RPI) to perform most of the initial qualification testing. The University of Connecticut was also contracted to perform auger and x-ray photoelectron spectroscopy (XPS) of the cleaners. The results of these works are found in section 3.

1.5 Section 4: Materials Compatibility Investigation. The top six candidates for cleaning prior to adhesive bonding were subjected to materials compatibility testing. The cleaners were Callosolve 120, Aerosolve 2000, Parts Prep, Shop Master, Solvall 5234, and ALK-660 acquired from the listing and analysis detailed in the previous section. The top 11 candidates for cleaning prior to NDI were also subjected to materials compatibility testing. They included isopropyl alcohol, P-D-680, Citrex, Spotcheck SKC-HF, Desoclean 45, Teksol EP, Bioact 113, Axarel 56, TPC Solvent, Dynasolv 108, and Electron NDE. Although it was not expected that these compliant solvent cleaners would be extremely corrosive or embrittling, the testing was carried out on the side of caution. The testing performed included total immersion corrosion, effects on unpainted surfaces, sandwich corrosion, stress corrosion cracking, and hydrogen embrittlement testing.

1.6 Section 5: Alternative Cleaners Effects on Adhesive Bonding. The actual number of alternate cleaners that could be utilized for adhesive bonding tests was decreased based upon the extensive amount of specimen preparation, testing, and the combination of materials that were to be tested. Therefore, the top cleaners from the downsized comprehensive list were chosen for testing. Since the top two cleaners were of the same general chemical make-up, it was thought that choosing two from the top five would provide a better guideline. In addition to the control, trichloroethane and isopropyl alcohol were utilized along with two prospective aqueous cleaners. The objective was to demonstrate that a replacement for 1,1,1 in the adhesive bonding process was feasible in both a manufacturing and a repair environment. The approach was to compare the effectiveness of the potential replacement on various metal substrates utilizing 1,1,1 trichloroethane as a baseline control group. ARL-MD contracted the U.S. Army Armament Research, Development, and Engineering Center (ARDEC), Picatinny Arsenal, NJ, to perform the adhesive bonding testing.

1.7 Section 6: Alternative Cleaner Effects on Non-Destructive Inspection. The main focus of this portion of the program was to find a cleaner that could be utilized as a replacement for 1,1,1 on the Depot Maintenance Work Requirements (DMWRs). It has been determined that, of all the NDI techniques, the FPI method—specifically, the solvent removable and post-emulsifiable methods—has utilized 1,1,1 trichloroethane to the greatest extent (according to MIL-STD-6866). Additionally, since those FPI methods require the highest level of cleanliness, if a replacement cleaner works well with these processes, it will work for all other NDI procedures as long as material compatibility is maintained.

1.8 Conclusion. The results obtained from this program indicate that Desoclean 45 and Dynasolv 108 (DS 108) would be viable alternatives to 1,1,1 with respect to cleaning prior to NDI and Parts Prep is recommended for use prior to adhesive bonding. The U.S. Army Aviation and Troop Command (ATCOM) is presently updating the DMWROs and maintenance manuals to reflect these findings. The results and conclusions drawn from this program are encouraging with respect to the ongoing effort of trichloroethane replacement. The results have shown that minimal material compatibility problems exist with the strongest of the alternative cleaners. It must be emphasized that even 1,1,1 trichloroethane has a dissociation problem when it becomes hydrolyzed. The diluted semi-aqueous replacements that contain a certain amount of blended solvents were not expected to have superior performance concerning hydrogen embrittlement. The program has identified two feasible candidates for adhesive bonding of the materials specified and several acceptable candidates for FPI processing.

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Section 2:

Identification of Commercially Available Products to Replace 1,1,1 Trichloroethane: TRI of Austin Report - "1,1,1 Trichloroethane Replacements State of the Art Report"

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The aircraft industry, chemical corporations, Department of Defense (DOD) agencies (Army, Navy, and Air Force), and the Environmental Protection Agency (EPA) were contacted in an attempt to develop a comprehensive listing of the most prospective candidate cleaners. ARL-MD initially expanded upon the database of possible chemical cleaning replacements created and investigated by the Corpus Christi Army Depot (CCAD), Corpus Christi, TX. CCAD had performed total immersion corrosion and cleaning efficiency tests on a large number of alternative aqueous cleaners and their respective 10% dilutions. In addition, ARL-MD contracted the Texas Research Institute Austin, Inc., to perform a detailed search of related work on the subject of 1,1,1 replacement. This report is included in this section. The comprehensive listing formed was very dependent on the specific process being utilized. Therefore, two separate lists were generated, one for adhesive bonding and one for NDI. The industrial chemical companies are continually investing large amounts of money into developing replacements for 1,1,1 trichloroethane. Various private aviation corporations (i.e., McDonnell Douglas, Sikorsky, Boeing, Lockheed, and Northrop) have also contributed significantly to the replacement effort. However, it must be understood that these alternatives are continually changing—specifically, the chemical compositions change as restrictions become tighter and cleaners that were acceptable gradually become obsolete. Many alternatives received from the aircraft industry were found to be out of date. The major chemical companies attempted to stay ahead of the new laws and regulations by developing improved formulations. In fact, some of the cleaners identified as viable replacements for 1,1,1 already have new formulations. In addition, many of the private aviation corporations performed the bulk of their research as much as 5–10 years ago due to the restrictions and penalties placed on the use of these chlorinated solvents. The Government has traditionally been given exceptions to these restrictions and penalties, until recently.

Identification of Alternatives

It was determined that due to the intricacy of the NDI process, alternatives would be limited to solvent-based-compliant (with present Federal regulations) cleaners, even though some chemical companies refer to their cleaners as “aqueous based” as they are not traditional solvents. The adhesive bonding segment of this work is relatively more forgiving and less stringent in regard to the chemical composition and characteristics of the alternative cleaners. Therefore, aqueous-based and citrus-based cleaners were investigated for replacing 1,1,1 trichloroethane prior to adhesive bonding. The classifications were clarified based upon ARL-MD discussions with the respective manufacturers.

Listing:

I. Alternatives for cleaning prior to adhesive bonding:

NAME	Manufacturer
1. Callosolve 120	Zip Chem Products
2. Aerosolve 2000	Aerocote
3. Parts Prep	Ecolink
4. Shop Master	Buckeye Int.
5. Solvall 5234	Working Solutions
6. Alk - 660	Eldorado Chem.
7. Quaker 624 GD	Quaker
8. Quaker 697 UT	Quaker
9. Power Cleaner 310 L	West Pentone
10. Cee-Bee Cleaner A 7x7	McGean-Rohco
11. Penair HD-1	West Pentone
12. Turco 4215-NCLT	Turco Products
13. Jettacin	Dubois Mfg.
14. Alu-Kleen	Heat Bath
15. Brulin 815 GD	Brulin
16. DOT 111/113	Delta Omega
17. Bioact 40	Petroferm
18. Metal Aid DR	PCT Tech.
19. Aeroclean DN 30	Aerocote
20. Blend 300	Ecolink
21. Natural Blue	Loctite
22. ReBound 7	XXCEL Tech.
23. ReBound 4	XXCEL Tech.
24. Soluclean 5131	Working Solutions
25. Turco Spray Ease	Turco Prod.
26. UniKleen # 129-3	Heat Bath
27. UniKleen # 14-B	Heat Bath
28. Bioact 50	Petroferm
29. Magnaflux 1-2-3	Magnaflux
30. Super Bee Cleaner 212	McGean-Rohco
31. Penair HD-4	West Pentone
32. Daraclean 282	W.R. Grace
33. Nectraclean	CRC Industrial

II. Alternatives for cleaning prior to Non-Destructive Inspection:

NAME	Manufacturer
1. Reagent Grade Isopropyl Alcohol	
2. P-D-680	
3. Citrex	Inland Tech.
4. Spotcheck SKC-HF	Magnaflux
5. Desoclean 45	Courtnald Aero.
6. Teksol EP	Inland Tech.
7. Axarel 56	Petroferm
8. Bioact 113	Petroferm
9. Dynasolv-108	Dynamold
10. Electron NDE	Ecolink
11. D-Greeze 500	Solvent Kleen Inc.
12. EP 921	Inland Tech.
13. Kustom	Certified Labs.
14. PF 01	P-T Tech.
15. PF 145 HP	P-T Tech.
16. Pre-Solv	LPS
17. Electro 140	LPS
18. Super 140	LPS
19. Super Chem Trust	Madison Bionics
20. Vortex	Ecolink
21. X-Caliber	Inland Tech.
22. Loctite 70/70	Loctite
23. Spotcheck-SKC-S	Magnaflux
24. Pensolv L805	West Pentone
25. Pensolv L945	West Pentone
26. Desoclean 110	Courtnauld Aero.
27. NMP	BASF
28. Kustom HFP	Certified Labs.
29. HF-165	Amax Industrial
30. TPC Solvent	West Pentone

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TEXAS RESEARCH INSTITUTE AUSTIN, INC.
A Texas Research International Company

1, 1, 1-Trichloroethane Replacements State of the Art Report

Submitted To: U.S. Army Research Laboratory

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John Bulluck TRI/Austin

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COTR: Victor Champagne

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1, 1, 1-TRICHLOROETHANE ALTERNATIVE CLEANERS FOR NDI AND ADHESIVE BONDING APPLICATIONS

1.0 Background

Many of the organic solvents that have historically found utility as cleaning solvents for metals and plastics are being replaced. Much of the impetus for this replacement is coming from government legislation and agencies. The chemical industry is undergoing dramatic changes due to the United States participation in cooperative international agreements such as the Montreal Protocol. This was a conference convened in 1987 as an international effort in response to the ozone depletion problem. The Protocol seeks to abolish the use of ozone depleting compounds such as chlorofluorocarbons (CFC's) and hydrogenated chlorofluorocarbons (HCFC's). The only commonly used solvent that was regulated by the Montreal Protocol is 1,1,1 - trichloroethane, which is to be phased out by 2002. In response to this meeting, the EPA has passed the Clean Air Act which mandates a 50 % reduction in the use of TCA by 1 January 94, and complete abolition of production by 1 January 96. In addition to the above incentives, a 1989 tax levied on CFC's has further limited their use. The phase out date for all HCFC's will be scheduled in 2030. When searching for an alternative solvent for TCA, one must be certain that the replacement compound is not a volatile organic compound, cancer causing agent or other environmentally regulated chemical.

TCA is an excellent solvent with a unique combination of characteristics that will make the development of an identical drop-in replacement difficult. However depending on the application, there are a number of chemicals that might function as an acceptable substitute. Among the advantageous characteristics of TCA is its high Hansen solubility, non-flammability, and evaporative properties. The Hansen solubility is a measure of solvating characteristics. TCA is excellent at solvating organics, greases, waxes, and polar contaminants, making it the compound of choice in the metal surface cleaning industry. TCA, like other chlorinated solvents, evaporates quickly and leaves behind very little residue. It is highly volatile, but is considered VOC exempt because of its inactivity as a smog precursor. This permits its widespread usage in adhesives and coatings.

Three companies control the vast majority of the world's TCA production: DOW, PPG, and Vulcan. Production of TCA last year was 600 million pounds with a value of \$280 M (C&E News, 1994). The financial impact of this ban has solvent manufacturers actively investigating and recommending alternative solvents. Dow has developed a computer program (Chemkop) which uses evaporation profiles and solubility parameters to select a combination of solvents (typically glycol ethers) that will provide performance similar to that of TCA. All of the alternatives have benefits and limitations, and customers are being forced to decide which replacement will best suit their needs.

TCA has been employed extensively in non-destructive analysis, primarily liquid penetrant testing. The Army Research Laboratory has been tasked to identify, test, and evaluate alternative cleaners to replace 1,1,1 - trichloroethane for use in non-destructive evaluation. The ideal substitute solvent should be environmentally safe, and should not be controlled as a volatile organic compound, ozone depleting, or a hazardous material. Because of TCA's excellent solvating properties, it is used in three steps of penetrant testing:

1. Precleaning. TCA was used to clean surfaces of grease, oil, films, dirt, and other contaminants before application of the penetrant. This ensures complete penetrant access to flaws, and surface wetting. For most simple cleaning, TCA precludes the use of a separate precleaning agent, and its drying time is very short.

2. Excess penetrant removal. After a suitable dwell, TCA can be used to remove penetrant from the surface, leaving only the penetrant that had infiltrated surface defects. Once again, the short drying time increases inspection efficiency by allowing near immediate application of developer.

3. Post Cleaning. After inspection for flaws, TCA can be used to remove developer and completely remove all penetrant from flaws.

TCA is commonly used as a solvent vehicle for the penetrant. TCA has been widely used in the cleaning of surfaces before adhesive bonding. TCA is the most widely used solvent in the vapor degreasing of large parts and the solvent wiping of small parts. Any alternative must be considered in light of toxicity, flammability, solubility characteristics, cost, and availability. Newly selected substitutes for TCA should not negatively affect NDI results, and should optimally provide the multiple cleaning capabilities exhibited by TCA so that multiple cleaners are not needed for each step of the penetrant testing process.

When class 2 solvent removers are used, proper procedures and strict adherence becomes paramount. Typically, these materials exhibit high boiling points (low evaporation rates) and high flammability (low flash points). When using these organic Class 2 materials it is imperative not to use too much cleaner in the solvent wiping process to prevent the penetrant from being displaced from the flaw. Surfaces must also be given adequate time to dry between cleaning and application of adhesive bonding material. Many of the Class 2 solvents have decreased solubility parameters reducing penetrant removal but some of the Class 2 aqueous emulsified detergent solvents have proven effective. Because it is an aqueous solvent, copious amounts can be applied to surfaces without risking penetrant removal from flaws. However, because of the solvent's slow evaporation rate, heat or long times must be employed before developer application. In lieu of evaporating solvents from the surface, isopropanol and methanol have been used as solvent removers, but they are flammable. A number of new Class 2 materials are available, as are a number of HCFC's with Class 1 status, including 141 B, which will be available for some time.

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2.0 Alternatives to 1,1,1 - Trichloroethane

2.1 Solvent Type Alternatives to 1,1,1 - TCA

Alternatives to TCA include the petroleum distillates of the following organic compounds: n-paraffins, alcohols, ketones, naphtha, and n - methyl - pyrrolidone. These solvents are acceptable in many instances where flammability is not an issue. Many chlorinated compounds can function as substitutes for TCA, however many have toxicity problems associated with their open use.

Ashland Chemical now markets seven alternative solvents for TCA. These solvents are composed of primarily hydrocarbon solvents with glycol ether additives. Ashland is also working with Shell to market its diacetone alcohol cleaner. The solvent is said to be safer than acetone (less volatile and a lower flash point) and exhibits excellent solvating properties.

Dupont's attempt to resolve the TCA issue include marketing HCFC's that are possible interim TCA replacements (until HCFC banning in 2020); selling perfluorocarbon solvents to a restricted clientele and researching a number of dibasic ester products (DBE). DBE is a refined mixture of dibasic esters typically including 17 % dimethyl adipate, 66 % dimethyl glurate and 17 % dimethyl succinate. DBE has exhibited no reproductive or developmental toxicity (Gallagher, 1990). DBE is suggested as an alternate to methylene chloride as well as TCA.

Dow Chemical, the largest manufacturer of TCA, is restructuring its chlorinated solvent business (C&E News 1994). It has been suggesting customers replace TCA with glycol ether combinations or trichloroethylene. Dow is also suggesting replacement of TCA with perchloroethylene in operations where toxicity problems are not a major concern.

Exxon produces a number of alternatives as TCA replacements and they include iso-paraffins, normal paraffins, and heavy aromatics. These solvents are not intended as drop in replacements because of differences in solubility and evaporation profiles. Hoechst Celanese produces a methylene dimethyl ether solvent, Methyal. The product possesses excellent potential for replacing many chlorinated solvents including TCA and methylene chloride.

Terpene type compounds are being touted as viable replacements for TCA and methylene chloride. A number of companies produce and market these terpenes that are isolated from natural sources such as orange peels or cantaloupes. The compounds are typically mixed with an organic solvent such as a hydrocarbon, a non-ionic type surfactant, and antioxidants.

Another alternative solvent for TCA is produced and marketed by GAF under the name Foamflush. These materials are believed to be an ester of organic acid and additives. Foamflush is a polar aprotic solvent with outstanding solvating characteristics. waste material is classified as non-hazardous, reducing disposal costs when compared with methylene chloride. Foamflush has a very slow evaporation rate that may present problems for some applications.

Below is a table that summarizes some of the information above regarding organic solvents , semi-aqueous, and aqueous alternatives to TCA:

ORGANIC SOLVENTS	**Producer**	**Advantages**	**Disadvantages**
Dibasic Ether	Dupont	Solubility	Flammability
HCFC's	Dupont	Solubility & Flammability	2020Controlled
Trichloroethylene	Dow Chemical	Solubility & Flammability	Toxicity
Paraffins / Aromatics	Exxon	Solubility	Flammability
Methylene Ether	Hoechst	Solubility	Flammability
Perchloroethylene	Dow Chemical	Solubility	Toxicity
Glycol Ethers	Dow Chemical	Solubility	Flammability
Ester Alcohols	Eastman	Solubility	Flammability
Hydrocarbon & Glycol Ethers	Ashland	Solubility	Flammability
Terpene & Hydrocarbon Based	Brinmont	Solubility	Toxicity
Diacetone Alcohol	Shell	Solubility	Flammability
Foam Flush	GAF	Solubility	Flammability
Aqueous & Semi-Aqueous & Solvent	Ecolink	Aqueous	Solubility
Terpene	Pride	Solubility	Toxicity
Terpene & Semi Aqueous	Macdermaid	Solubility	Toxicity
Aqueous	Kleer-Flo	Solubility	Toxicity

2.2 Solvent Based, Aqueous Emulsion Cleaners, & Semi Aqueous Cleaners

Solvent based and emulsion cleaners have been used for years to clean metal parts. Solvent based cleaning systems contain an organic solvent that is in combination with nonyl phenol ethoxylate surfactant and cosolvent. These cleaning systems are available from a variety of commercial sources.

Terpenes are a class of naturally occurring chemicals isolated from the essential oils of various fruits, spices, and vegetables. Brinmont Corporation markets a biodegradable cleaner based on D- limonene called Brinsolv DL. Brinsolv DL is a water dispersible and rinsable cleaning solvent. A number of other terpene cleaners can be formulated using Beta-pinene, Alpha-terpene, and Dipenetene (Robinson, 1991).

Water soaking for a specified time in a terpene solution is a good option to cleaning with TCA. A closed loop cleaning system should be used because of waste disposal considerations. D-limonene is a relatively safe and highly effective organic solvent that is replacing chlorinated solvents to find increasing usage in household and industrial cleaning. D-limonene has been described as a skin sensitizer although there has not been any scientific literature to confirm this assertion. The limonene based cleaners are high water type emulsion cleaners. The organic component of the emulsion solubilizes the organic contaminant and the water serves as a rinsing vehicle. The advantages of this type of cleaning system include a high flash point, low volatility, little residual material after cleaning, and they are not CFC's. The primary disadvantage of this type of cleaner is slightly different solubility parameters from TCA. This requires modification of degreasing equipment, making them more energy dependent. Another disadvantage is that the run off must be treated as waste chemical (Robinson, 1991).

Semi-aqueous cleaners, such as DuPont's Axarel, are another class of chemicals that could be effective replacements for TCA. Semi-aqueous cleaners are ideal for solvating heavy greases, oils and tars, but are typically flammable. Closed equipment is needed for any large scale processing using these solvents.

2.3 Aqueous Cleaners

Most aqueous cleaners consist primarily of an alkaline salt and they have been widely used in the adhesive area for years as metal pre-treatments. Detergents, soaps, and caustic soda are inexpensive, non-toxic, and the easiest cleaning agents to handle. They can be applied by spray, immersion or scrubbing, and can remove many types of dirt, oils, and grease. Aqueous cleaners typically contain organic surfactants that assist in emulsification of the organic contaminant. They also contain pH buffers, deflocculents, corrosion inhibitors, and other additives (Robinson, 1991).

The primary advantages of using aqueous cleaners are that they have no volatile organic compounds (VOC) or flash point problems. Switching to water based cleaners insures a long term solution and investment. Among the disadvantages are the time and energy associated with cleaning parts, lower solvating ability, modification of equipment, and in many instances, purchase of new equipment.

A great deal of variability has been noted in the cleaning of metal surfaces with aqueous cleaners. It is felt that much of this variability results from the cleaning technique. The most important factors in the aqueous alkaline cleaning of surfaces are: (1) the alkaline cleaning solution should be newly prepared and free of contaminants (2) the proper pH should be maintained for the cleaning solution (3) the temperature of the aqueous solution should be as high as convenient to achieve good cleaning in a minimum amount of time and (4) agitation of the cleaning solution will assist the dissolution of contaminants.

Steam cleaning with detergents is another well-developed water based method of cleaning surfaces. Steam can provide the mechanical agitation of the surface contaminant while the detergent emulsifies the contaminant. Filtration of the waste water can be accomplished and the water reused. Because of the cleanliness of the parts and the lack or residual contaminant, steam cleaning is an alternative to TCA cleaning of surfaces.

Surfactants can be combined with glycol coupling agents and water to form good water based cleaners. The surfactants typically used in these types of cleaners are primarily non-ionic, with a lesser amount being cationic, or anionic. Surfactants typically exhibit high surface tension as well as various degrees of detergency, foaming, solubility, and emulsification of contaminants.

2.4 Problems with Semi-Aqueous and Aqueous TCA Replacements

The two primary problems with aqueous or semi-aqueous replacements for TCA are waste disposal and solubility extent. The waste from the cleaning process will contain cleaners as well as a combination of greases, oils, and other contaminants. The regulations of the controlling municipality may consider these products to be hazardous waste. Consequently, specific water treatment methods may be required to make waste water acceptable for drain disposal.

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3.0 Industrial Contacts and Information Concerning Trichloroethane Substitutes

The chart below summarizes TRI/Austin's contacts with industrial producers of TCA substitutes. Section 5.0 contains technical information on the products. The alternatives to TCA include solvents, semi-aqueous, and aqueous materials.

Contact	Telephone	Product/Company	Comments
Sally McCoach	1-800-231-0988	DiBasic Ester/Dupont	Seven DBE Replacements
Alice Brown	1-800-234-5115	ArcoSolv Solvents	TCA Replacement, Flammable
Anthony Durante	1-201-628-3913	Foam Flush	MeCl2/TCA Replacements
Scott Lange	1-919-292-0566	Brinsolv DL	MeCl2 Replaces, Toxicity
Bill Green	1-404-621-8240	Ecolink Inc.	20 Alternatives, Excellent
Jeff Berlin	1-516-752-7848	Pride Inc.	Citrosolv Plus
Kevin Raberge	1-612-934-3909	Kleer Flo	Greasoff*2
Bob Griffiths	1-203-575-5700	MacDermaid	Multiple Products, Good

ATT is evaluating n-butyl butyrate isolated from cantaloupes for chip cleaning. Hewlett Packard is replacing CFC's with n-methyl pyrrolidone for cleaning processes. Ashai has been active in the development of TCA alternatives and has developed a series of semi-aqueous and aqueous alternatives. Oxychem has developed some chlorinated and fluorinated toluene derivatives.

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4.0 Contact With Other Government Agencies Concerning TCA Alternatives

At the suggestion of ARL-MD several other government sectors that are also looking for TCA alternative solvents were contacted in the execution of this study. The most useful information was obtained from the Wright Patterson Air Force Base, which has been actively involved in seeking TCA, ozone depleting compounds, and hazardous solvent replacements for several years. The investigations for the alternative solvents involve NDI as well as other specific applications. The literature obtained provides an excellent starting point in the identification of TCA alternatives, including many points of contact. Mr. Chuck Pallerin was extremely useful in identifying the key personnel involved with the identification of ozone depleting or hazardous materials options. The two individuals most intimately involved in this effort are Carroll Herring and Jim Folck. A booklet has been published entitled "ASC Alternative Materials Guide" identifying Air Force and private industry efforts in alternative solvents throughout the world. A new list of alternative materials and points of contact is under development for a new edition. The updated spreadsheet portion is included in this section. This includes the most updated information available from the Air Force on ozone depleting and hazardous materials alternatives. This should provide an excellent starting point for the Army effort. The information includes substance, specific process, alternative process / product being proposed or under investigation, status of implementation, information source, advantages, and points of contact. Two compounds that were mentioned in conversations of the penetrant process as TCA replacements were Electron (manufactured by Ecolink) and EPA 2000 (manufactured by Western Chemical International). There is a general agreement that there is no plug in alternative for TCA in all applications. The material or process chosen as TCA substitutes will depend on the complete service profile for the application. Steve Spatafora at the Naval Air Warfare Center was also contacted, and while NAWC is extremely concerned about the problem and investigating alternatives, their studies are not presently as developed as the Air Force at Wright Patterson.

INDIVIDUAL	**TELEPHONE #**
CHARLES PALLERIN	1-513-255-3929
JIM FOLCK	1-513-255-3059
CARROLL HERRING	1-513-257-5567
STEVE SPATAFORA	1-215-441-2704

Also included is Section 6.0, a copy of the "ASC Hazardous Material Alternatives Guide" that was compiled by the USAF. The document includes on hazardous materials and provides a listing of viable options for specific applications. The documents also includes general applications such as cleaning of surfaces as well as surface preparation before adhesive bonding. The appendix at the end of the ASC document concerning hazardous materials alternatives listing has been recently updated and is included.

Los Alamos National Laboratory (LANL) has also conducted a study to investigate identification of appropriate solvent substitutes (refer to the Pollution Advisor article). The study involved identifying, testing, and gathering information on alternative solvents and methods.

4.1 Government Information on TCA Substitutes

This section contains a number of tables and information concerning the studies and testing for TCA substitutes. It contains a great deal of relevant material concerning the products available, application, and points of contact. I would like to acknowledge the people previously mentioned at Wright Patterson for their assistance in obtaining this pertinent information.

Facsimile Cover Sheet

To: John Bulluck
Company: Texas Research Institute
Phone: 512 263-2101
Fax: 512 263-3530

From: Carroll Herring
Company: HQ AFMC, WPAFB, OH
Phone: DSN 787-5567
Fax: DSN 787-0841

Date: 08/23/94
Pages including this cover page:

Comments: Copy of potential ODC/HAZMAT alternatives.

DISCLAIMER

This listing is intended to be used as a starting point in your search for alternatives to Ozone Depleting Chemicals (ODCs) and Hazardous Materials (HAZMATs). The inclusion of a product on this list does not mean that we endorse its use or that adequate testing has been accomplished. The manager(s) of the end item(s) or weapon system(s) must consider critical part & process characteristics as well as performance, materials compatibility and toxicity in selecting the best substitute product or process for a specific application. Identification of an alternative on this list does not authorize deviation from the technical order.

PROCESSES AND POTENTIAL ALTERNATIVES

Regulated Constituent	Environmental Program	MAJOR PROCESS	SPECIFIC PROCESS	TYPE OF ALTERNATIVE	Potential Alternative	Alternative NSN	INFORMATION SOURCE	POC (NAME/SYMBOL/PHONE)	SUSPECTED ADVANTAGES
1,1,1 Trichloroethane	ODC Class I	CLEANING	ADHESIVE BONDING PRECLEANING	Chemicals	Parts Prep		1995 AF Worldwide P2 Conf	Scott Grandahl/Army/617 923-5334	
1,1,1 Trichloroethane	ODC Class I	CLEANING	ADHESIVE BONDING PRECLEANING	Chemicals	Terpene Based Cleaner		Elec & Prec Cleaning Crossfeed	Mike Wilson/APS Materials Inc/573 278-6547	
1,1,1 Trichloroethane	ODC Class I	CLEANING	AIRCRAFT TUBING CLEANING	Aqueous System	Aqueous Alkaline Degreaser		Vapor Degreasing Crossfeed	Tom Woodrow/Lockheed Fort Worth/817 777-4254	Used by Lockheed
1,1,1 Trichloroethane	ODC Class I	LUBRICATES	ANTI-SEIZE FITTINGS, NUTS & BOLTS		Dow Molykote 1000		9th Aerospace HAZMAT Conf	Merritte Ireland/Martin Marietta/303 977-3745	Equal or Better Performance
1,1,1 Trichloroethane	ODC Class I	CLEANING	AVIONICS CLEANING	Chemicals	OS-20 [Dow Corning]		SM-ALC Solvents Test Reprt	Cheryl Brandt SM-ALC/LIHM DSN 633-5026	Tested by SM-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	BEARINGS CLEANING	Chemicals	HSHID-5 & HSSF-5 [PCI of America]		Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	
1,1,1 Trichloroethane	ODC Class I	CLEANING	BENCHTOP CLEANING	Chemicals	LPS Presolv		SM-ALC Solvents Test Reprt	Cheryl Brandt SM-ALC/LIHM DSN 633-5026	Tested by SM-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	BONDING SHOP CLEANING	Chemicals	Brulin GD		Cold Clean& Wipe Crossfeed	Susie Barney OO-ALC/TIELM DSN 924-2994	Being tested by OO-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	BONDING SHOP CLEANING	Chemicals	GPC-R86		Cold Clean& Wipe Crossfeed	Susie Barney OO-ALC/TIELM DSN 924-2994	Being tested by OO-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	CLEAN & PRIME FASTENERS	Chemicals	SAF-T-LOK #19201		SM-ALC ODC Substitutes Database	David Heiser/SM-ALC/TIELA/DSN 633-5476	
1,1,1 Trichloroethane	ODC Class I	CLEANING	CLEAN & PRIME FASTENERS	Chemicals	SAF-T-LOK #19301		SM-ALC ODC Substitutes Database	David Heiser/SM-ALC/TIELA/DSN 633-5476	
1,1,1 Trichloroethane	ODC Class I	CLEANING	CLEAN & PRIME FOR ADHESIVES	Chemicals	Loctite's Locquic Primer N 7649		McD Douglas ODS Qtrly Report #5	Larry Sanders/McDonnell Douglas/ 314 233-9809	
1,1,1 Trichloroethane	ODC Class I	CLEANING	CLEAN & PRIME FOR ADHESIVES	Chemicals	Loctite's Locquic Primer T 7471		McD Douglas ODS Qtrly Report #5	Larry Sanders/McDonnell Douglas/ 314 233-9809	
1,1,1 Trichloroethane	ODC Class I	CLEANING	CLEAN EQUIP, PORTA TEST LEAK DETECTOR	Chemicals	Methyl Alcohol [O-M-232J, Grade A]		SM-ALC ODC Substitutes Database	David Heiser/SM-ALC/TIELA/DSN 633-5476	
1,1,1 Trichloroethane	ODC Class I	CLEANING	CLEAN GREASE FROM METAL PARTS	Ultrasonics	ODS H2002U		Navy Pol Prev Opportunity Handbook	Hazardous Technical Info Services 804 209-5168	
1,1,1 Trichloroethane	ODC Class I	CLEANING	CLEAN HONEYCOMB, UNBONDED AL	Chemicals	Brulin 815 GD		Aerospace Haz Mat'l Conf	Rimas Viktora/Northrop/Hawthorne,CA 90250-3277	
1,1,1 Trichloroethane	ODC Class I	CLEANING	CLEAN NDI DYES FROM AL PARTS	Chemicals	Desoclean 45		1995 AF Worldwide P2 Conf	Scott Grandahl/Army/617 923-5334	
1,1,1 Trichloroethane	ODC Class I	CLEANING	CLEAN NDI DYES FROM AL PARTS	Organics	PF Degreaser		Cold Clean& Wipe Crossfeed	Cathy Clayton/NASA UT/USBI Co/205 544-2836	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	CLEAN NDI DYES FROM AL PARTS	Organics	Prime		Cold Clean& Wipe Crossfeed	Cathy Clayton/NASA UT/USBI Co/205 544-2836	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	CLEAN NDI DYES FROM AL PARTS	Organics	Reveille		Cold Clean& Wipe Crossfeed	Cathy Clayton/NASA UT/USBI Co/205 544-2836	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	CLEANING HEAVY GREASES & OILS	Aliphatic Hydrocarbons	Actrel 3349L		Cold Clean& Wipe Crossfeed	Dale Casper/OO-ALC/TIELM/DSN 924-2483	Tested by OO-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	CLEANING HONEYCOMB	Chemicals	DS-108		Cold Clean& Wipe Crossfeed	Mary Beth Fennell/NADEP Cherry Pt/919 466-8142	Tested by NADEP Cherry Point
1,1,1 Trichloroethane	ODC Class I	CLEANING	CLEANING MATERIAL FOR HOSES		P-D-680 Type II or Type III		SM-ALC/TIEL LTR	John Meininger/SM-ALC/ DSN 633-2451	
1,1,1 Trichloroethane	ODC Class I	CLEANING	COLD METAL PARTS CLEANING	Chemicals	Hurri Safe (6850-01-369-2474 OESKI)	850-01-369-2475	Mail	Bobbie Pettit HURRI-SAFE 703 257-1331	Non-ODC & Biodegradable
1,1,1 Trichloroethane	ODC Class I	CLEANING	COLD TANK SOAK	Chemicals	Citrikleen		PRO-ACT	Penetone Corp 1-800-631-1652	
1,1,1 Trichloroethane	ODC Class I	COATING	CONFORMAL COATING CIRCUIT BOARDS	Chemicals	Humiseal 1B73 (ODC free)		SM-ALC ODC Substitutes Database	Ed Mines/Humiseal/ 718 932-0800	
1,1,1 Trichloroethane	ODC Class I	COATING	CONFORMAL COATING CIRCUIT BOARDS	Chemicals	Humiseal 1B73 (ODC free)		SM-ALC ODC Substitutes Database	Ed Mines/Humiseal/ 718 932-0800	
1,1,1 Trichloroethane	ODC Class I	CLEANING	CONFORMAL COATING REMOVAL	Abrasive Blasting	Microblasters		Elec & Prec Cleaning Crossfeed	Brent Baumgartner/WR-ALC/468-1422	
1,1,1 Trichloroethane	ODC Class I	CLEANING	CONFORMAL COATING REMOVAL	Chemicals	Conformax AU (Kizen) terpene		Elec & Prec Cleaning Crossfeed	Tim Eckert/Texas Instruments/214 462-2622	Fast Processing
1,1,1 Trichloroethane	ODC Class I	CLEANING	CONFORMAL COATING REMOVAL	Chemicals	Trans LC		Elec & Prec Cleaning Crossfeed	Brent Baumgartner/WR-ALC/912 926-1422	
1,1,1 Trichloroethane	ODC Class I	CLEANING	CONFORMAL COATING REMOVAL	Chemicals	OS-10 [Dow Corning]		SM-ALC Solvents Test Reprt	Cheryl Brandt SM-ALC/LIHM DSN 633-5026	Tested by SM-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	COSMOLENE REMOVAL	Chemicals	Electron Solvent	6850-01-375-555	DGSC HITS Bulletin	Cindy Cross/DGSC/DSN 695-6054	Non-ODC
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL CLEANING	Chemicals	Siege		HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Excellent Cleaner
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Aqueous	Enviro Klean, Formula 1000 [Allied Enterprises Inc]	850-01-061-5493	DGSC "Envir Preferred Products"	DGSC Market'g Off 1-800-352-2852 & DSN 695-6054	Low VOC
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Chemicals	Citragold [3D Inc]		HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Chemicals	DBE (Dupont)		HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Adequate Cleaner
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Chemicals	De-Solv-It [Orange-Sol Inc]	6520-01-341-276	HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Adequate Cleaner
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Chemicals	Isopar M [Exxon Co]	9150-00663-136	HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Adequate Cleaner
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Chemicals	PF 5060 [3M Chemical Product Div]		HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Adequate Cleaner
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Chemicals	PF Solvent [P-T Technologies]	7930-01-328-596	HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Works very Well
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Chemicals	Precision Clean [LPS Laboratory]		HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Adequate Cleaner
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Chemicals	Simple Green [Sunshine Makers Inc]	7930-01-306-836	HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Adequate Cleaner
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Chemicals	Tuff Job Degreaser [Cooke Industries Inc]	7930-01-336-719	HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Good in Spray Bottle
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Chemicals	Iso-Prep	6850-01-378-070	Navy CFC Halon News	Pete Mullenhard 703 769-1883	
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Chemicals	BMS 3-2 Type I		PRO-ACT		
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Heat & Vacuum	Furnace & Vacuum Equipment		CASC Henderson 932-5712	Mr McQuire/Nippondenso Auto Plant 616 965-3322	Used by Nippondenso
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Terpene	AI-22 Petroleum Degreaser		Vendor Brochure	Aurora International 1-800-722-0636	Biodegradable
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Ultrasonic & Immersion	HSHID [PCI of America]	850-01-373-5867	DGSC "Envir Preferred Products"	DGSC Market'g Off 1-800-352-2852 & DSN 695-6054	
1,1,1 Trichloroethane	ODC Class I	CLEANING	DEGREASING METAL PARTS	Ultrasonic & Immersion	HSSF [PCI of America]	850-01-369-2475	DGSC "Envir Preferred Products"	DGSC Market'g Off 1-800-352-2852 & DSN 695-6054	
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRICAL CABLES CLEANING	Chemicals	Citra-Safe		Elec & Prec Cleaning Crossfeed	Mr S. Hale/San Diego Gas & Elec/619 239-7511	
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONIC BOARDS CLEANING	Chemicals	Petroferm Bioact EC-7R		Elec & Prec Cleaning Crossfeed	Ed Farrell/Tobyhanna Army Depot/717 894-7131	
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONIC CONTACT CLEANING	Chemicals	Type KC Contact Cleaner		Vendor Brochure	Thomas Remboldt/Polywater Corp/1-800-328-9384	Non-ODC
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONIC SWITCHES CLEANING	Chemicals	Ecolink 2005	850-01-386-8419	SM-ALC Solvents Test Reprt	Cheryl Brandt SM-ALC/LIHM DSN 633-5026	Tested by SM-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS CLEAN & LUBRICATE	Chemicals	LPS Lubricant & Cleaner		Avionics Cleaning Crossfeed	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Proclean Alcohol		Avionics Cleaning Crossfeed	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Citra Safe	6850-01-378-056	Cold Clean& Wipe Crossfeed	Inland Technology Inc 1-800-552-3100	Non Chlorinated & low VOC
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Teksol EP	6850-01-378-058	Cold Clean& Wipe Crossfeed	Inland Technology Inc 1-800-552-3100	Non Chlorinated & low VOC
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Lectra Clean II [CRC Industries Inc]	850-01-382-5252	DGSC "Envir Safe Chem Alter"	DGSC Market'g Off 1-800-352-2852 & DSN 695-6054	
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Perchloroethylene		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Proclean		NAVAIR 4th Annual P2 Conf	Ken Clark/NAWC/215 441-1508	
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Citra Safe	6850-01-378-057	Navy CFC Halon News	Inland Technology Inc 1-800-552-3100	
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Citra Safe	6850-01-381-716	PRO-ACT	Inland Technology Inc 1-800-552-3100	Low VOC & Biodegradable ,
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Teksol EP	6850-01-378-065	PRO-ACT	Inland Technology Inc 1-800-552-3100	Low VOC & non-chlorinated
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Zep I.D. Red		SM-ALC Lessons Learned Database	Diane Spencer/SM-ALC/510 769-0100	
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS CLEANING	Radiate Energy	UV/Ozone		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS CLEANING	Super Critical Fluids	Super Critical Fluids		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed

List of potential ODC/HAZMAT alternatives. Identification of an alternative on this list does not endorse its use or authorize deviation from the Tech Order. The single manager must approve changes to Tech Orders.

PROCESSES AND POTENTIAL ALTERNATIVES

1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS CLEANING	Super Critical Fluids	Super Critical Fluids		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Type HP Cleaner/Degreaser [HP-P158ID]		Vendor Brochure	Thomas Ramboldt/Polywater Corp/1-800-328-9384	Non-ODC
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTRONICS FLUX REMOVAL	Semi-Aqueous System	Detrex Advance Vapor Degreasing		Elec & Prec Cleaning Crossfeed	Robin Zinsmaster/Hewlett-Packard/707 794-2701	
1,1,1 Trichloroethane	ODC Class I	CLEANING	ELECTROPLATING CLEANING	Ultrasonics	Blue-Gold [Carroll Company]		HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Works well for Ultrasonics
1,1,1 Trichloroethane	ODC Class I	CLEANING	ENGINE COMPLEX PARTS CLEANING	Aqueous System	Turco Sprayeze w/283, Blue Gold & Oakite 220-NP		NDCEE Crossfeed Report	Gary Lomasney/Pratt & Whitney/203 565-1333	Used by Pratt & Whitney
1,1,1 Trichloroethane	ODC Class I	CLEANING	ENGINE PARTS CLEANING	Vacuum System	Vacuum Deoiling		NDCEE Crossfeed Report	Jeff Conybear/Metal Labs/414 554-8720	Used by Metal Labs
1,1,1 Trichloroethane	ODC Class I	CLEANING	ENGINES & TRANSMISSIONS CLEANING	Aqueous System	Aqueous Immersion & Spray		NDCEE Crossfeed Report	Eaton Corp/John Burke/216 523-6775	Used by Eaton Corp
1,1,1 Trichloroethane	ODC Class I	CLEANING	FLUSH CLEANING	Aliphatic Hydrocarbons	Actrel 3349L		Cold Clean& Wipe Crossfeed	Dale Casper/OO-ALC/TIELM/DSN 924-2483	Tested by OO-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	FLUX & CONFORMAL COATING REMOVAL	Chemicals	749 N.O.D. Cleaner/Degreaser [Sprayon Products]		SM-ALC/TIEL Memo 30 Jan 95	Scott Dickinson/SA-ALC/TIEL-1/ 916 643-5476	
1,1,1 Trichloroethane	ODC Class I	CLEANING	FLUX & CONFORMAL COATING REMOVAL	Chemicals	LPS CFC-Free Electro Contact Cleaner [LPS Labs]	6830-P-03116	SM-ALC/TIEL Memo 30 Jan 95	Scott Dickinson/SA-ALC/TIEL-1/ 916 643-5476	
1,1,1 Trichloroethane	ODC Class I	CLEANING	FUEL LINES CLEANING	Aqueous System	Fremont 776		Elec & Prec Cleaning Crossfeed	Carlos Nazario/OC-ALC/405 736-7246	
1,1,1 Trichloroethane	ODC Class I	CLEANING	FUEL LINES CLEANING	Aqueous System	Hurri-Safe & Duraclean 282		Elec & Prec Cleaning Crossfeed	Jim Holliday/CCAD/512 939-2609	
1,1,1 Trichloroethane	ODC Class I	CLEANING	FUEL LINES CLEANING	Aqueous System	Spray w/Turco Ecosolve&Immersion w/Turco 6778		Elec & Prec Cleaning Crossfeed	Tim Woods/NADEP-North Island/619 545-9757	
1,1,1 Trichloroethane	ODC Class I	CLEANING	FUEL LINES CLEANING	Chemicals	Stoddard Solvent		Elec & Prec Cleaning Crossfeed	Lance Lankford/SM-ALC/916 643-0228	
1,1,1 Trichloroethane	ODC Class I	CLEANING	FUEL LINES CLEANING	Organics	Electron QED		Cold Clean& Wipe Crossfeed	Jim Holliday/Corpus Christi Army Depot/512 939-2603	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	GENERAL CLEANING	Chemicals	Brulin MP 1793		Cold Clean& Wipe Crossfeed	Jeffrey Jones/McDonnell Douglas/314 233-3708	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	GENERAL CLEANING	Chemicals	PF Degreaser		Cold Clean& Wipe Crossfeed	Jeffrey Jones/McDonnell Douglas/314 233-3708	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	GENERAL CLEANING	Chemicals	Brulin MP 1793		Int Wkshp on Solvent Substitutes	Jeffrey Jones/McDonnell Douglas/314 233-3708	Evaluated by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	GENERAL CLEANING	Chemicals	Octagon 855702		Int Wkshp on Solvent Substitutes	Jeffrey Jones/McDonnell Douglas/314 233-3708	Evaluated by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	GENERAL CLEANING	Chemicals	PF Degreaser		Int Wkshp on Solvent Substitutes	Jeffrey Jones/McDonnell Douglas/314 233-3708	Evaluated by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	GENERAL CLEANING	Chemicals	Isopropyl Alcohol		SM-ALC/TIEL LTR	John Meininger/SM-ALC/ DSN 633-2451	
1,1,1 Trichloroethane	ODC Class I	CLEANING	GENERAL DIP & BRUSH CLEANING	Semi-aqueous	Bio-T [Limonene-based]	6850-01-380-429	Cold Clean& Wipe Crossfeed	Bob Brady/Coors Brewing Co/303 277-0196	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	GENERAL DIP & BRUSH CLEANING		Exxol D-80 [Petroleum-based]		Cold Clean& Wipe Crossfeed	Bob Brady/Coors Brewing Co/303 277-0196	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	GENERAL DIP & BRUSH CLEANING		Superstip TM [glycol & ether mixture]		Cold Clean& Wipe Crossfeed	Bob Brady/Coors Brewing Co/303 277-0196	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	GUN SYSTEMS CLEANING	Aqueous System	Better Engr Washers w/Big Blue & Daraclean 282		Vapor Degreasing Crossfeed	Brad Christensen/OO-ALC/LICT/DSN 458-2341	Used by OO-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	HAND WIPE & FLUSHING	Chemicals	Actrel 3349L		Battelle App'd Alternatives Reprt	Susie Barney/OO-ALC/TIELM/801 775-2994	Improved Flushing Capability
1,1,1 Trichloroethane	ODC Class I	CLEANING	HAND WIPE METAL PARTS	Aqueous System	Aqueous with Sno-Sol 131R [Parker Amchem]		Vapor Degreasing Crossfeed	Tom Burke/FMC CTC/408 289-3820	Tested by FMC
1,1,1 Trichloroethane	ODC Class I	CLEANING	HAND WIPE PARTS CLEANING	Paraffinic Hydrocarbons	Skysol 200 [Inland Technology]	6850-01-381-441	Navy Pol Prev Opportunity Handbook	Hazardous Technical Info Services 804 209-5168	
1,1,1 Trichloroethane	ODC Class I	CLEANING	HANDGUN PARTS CLEANING	Aqueous System	Drum type w/agitation washer		Cold Clean& Wipe Crossfeed	Bill Serra/Smith & Wesson/413 781-3470	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	HANDWIPE CLEANING	Chemicals	Brulin 1793		McDonnell Douglas P2 Review	Larry Sanders/McDonnell Douglas/314 233-9309	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	HANDWIPE CLEANING	Chemicals	Electrolube Ultraclens		McDonnell Douglas P2 Review	Larry Sanders/McDonnell Douglas/314 233-9309	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	HANDWIPE CLEANING	Chemicals	MCC Proclean		McDonnell Douglas P2 Review	Larry Sanders/McDonnell Douglas/314 233-9309	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	HANDWIPE CLEANING	Chemicals	Techspray 1679		McDonnell Douglas P2 Review	Larry Sanders/McDonnell Douglas/314 233-9309	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	HANDWIPE CLEANING	Chemicals	Turco 4460BK		McDonnell Douglas P2 Review	Larry Sanders/McDonnell Douglas/314 233-9309	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	HANDWIPE METAL, PLASTIC & RUBBER	Organics	CRC 2000		Cold Clean& Wipe Crossfeed	Jim Holliday/Corpus Christi Army Depot/512 939-2603	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	HANDWIPE ROCKET COMPONENTS	Organics	Biogenic Regent [Rochester Midland]		Cold Clean& Wipe Crossfeed	Jack Snyder/Martin Marietta/303 977-3322	NDCEE Case Study & Cheaper
1,1,1 Trichloroethane	ODC Class I	CLEANING	HANDWIPE ROCKET MOTOR METAL PARTS	Chemicals	Reveille [DuBois Corp]		1996 Precision Cleaning Conference	Rick Golde/Thiokol Space Div, Brigham City,UT 84307	Tested by Thiokol for NASA
1,1,1 Trichloroethane	ODC Class I	CLEANING	HONEYCOMB CLEANING	Aqueous System	Aqueous Spray Washer [BDM Federal & Ikon Corp]		Int Wkshp on Solvent Substitutes	Jon Nimitz/Envir Tech & Ed Ctr/505 256-1463	AF Acquired Equip at NDCEE
1,1,1 Trichloroethane	ODC Class I	CLEANING	HONEYCOMB CLEANING	Aqueous System	Aqueous		NDCEE Crossfeed Report	Calvin Fong/Northrop/310 332-6661	Used by Northrop Corp
1,1,1 Trichloroethane	ODC Class I	CLEANING	HONEYCOMB CLEANING	Aqueous System	Aqueous Alkaline Degreaser		Vapor Degreasing Crossfeed	Tom Woodrow/Lockheed Fort Worth/817 777-4254	Used by Lockheed
1,1,1 Trichloroethane	ODC Class I	CLEANING	HONEYCOMB CLEANING	Aqueous System	Aqueous Immersion System		VTCN with BDM at SM-ALC	Sara Jane Blubaugh SM-ALC/TIME 916 643-2704	Qualified by Northrop & GE
1,1,1 Trichloroethane	ODC Class I	CLEANING	HONEYCOMB CLEANING		ART-96		Cold Clean& Wipe Crossfeed	Alan Rockwold SM-ALC/EMP DSN 633-3672 Ex165	Being tested by SM-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	HONEYCOMB CLEANING PARTS	Aqueous System	Aqueous Spray Washing		NDCEE Crossfeed Report	Sara Jane Blubaugh/SM-ALC/916 643-2704	Used by Aerojet & SM-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	HONEYCOMB CLEANING PARTS	Aqueous System	Spray Washer Designed for Honeycomb		Vapor Degreasing Crossfeed	John Toohey/BDM Federal/505 848-5591	Demo at NDCEE
1,1,1 Trichloroethane	ODC Class I	CLEANING	HYDRAULIC SYSTEMS CLEANING	Aqueous System	Aqueous Power Washing		NDCEE Crossfeed Report	Patrick Reust/SM-ALC/916 643-3787	Used by SM-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	HYDRAULIC SYSTEMS CLEANING	Aqueous System	MART Washers w/Big Blue & Daraclean 282		Vapor Degreasing Crossfeed	Brad Christensen/OO-ALC/LICT/DSN 458-2341	Used by OO-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	HYDRAULICS & INSTRUCTIONS CLEANING	Chemicals	Isopropyl Alcohol & Isohexane Mixture Aerosol		Elec & Prec Cleaning Crossfeed	Patrick Reust/SM-ALC/916 643-3787	
1,1,1 Trichloroethane	ODC Class I	CLEANING	INERTIAL SENSORS CLEANING	Chemicals	Isopropyl Alcohol & Isohexane Mixture Aerosol		Elec & Prec Cleaning Crossfeed	Patrick Reust/SM-ALC/916 643-3787	
1,1,1 Trichloroethane	ODC Class I	CLEANING	JET ENGINE PARTS CLEANING	Aqueous System	Aqueous		NDCEE Crossfeed Report	Ed Hanna/RRAD/903 334-3380	Used by Red River Army Depot
1,1,1 Trichloroethane	ODC Class I	CLEANING	JET ENGINE PARTS CLEANING	Aqueous System	Aqueous Alkaline & Neutral pH		NDCEE Crossfeed Report	Mark Linville/ Allison [General Motors]/317 230-3617	Used by Allison Gen Motors
1,1,1 Trichloroethane	ODC Class I	CLEANING	JET ENGINE PARTS CLEANING	Aqueous System	Turco Sprayeze w/283, Blue Gold & Oakite 220-NP		NDCEE Crossfeed Report	John Zavodjancik/Pratt & Whitney/203 565-5030	Used by Pratt & Whitney
1,1,1 Trichloroethane	ODC Class I	CLEANING	LANDING GEAR CLEANING	Aqueous System	MART Washer w/Big Blue & Turco Aviation		NDCEE Crossfeed Report	Mike Linr/NADEP Jacksonville/904 772-2469 x2457	Used by NADEP Jacksonville
1,1,1 Trichloroethane	ODC Class I	CLEANING	LANDING GEAR CLEANING	Chemicals	D-Limonene		Cold Clean& Wipe Crossfeed	Susie Barney OO-ALC/TIELM DSN 924-2994	Being tested by OO-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	LANDING GEAR CLEANING	Chemicals	Daraclean 282 [W.R. Grace Inc]	6850-01-364-832	Cold Clean& Wipe Crossfeed	Susie Barney OO-ALC/TIELM DSN 924-2994	Being tested by OO-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	LANDING GEAR CLEANING	No Clean	Eliminate Cleaning Process		Cold Clean& Wipe Crossfeed	Susie Barney OO-ALC/TIELM DSN 924-2994	Being tested by OO-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	LIFT TRUCK PARTS CLEANING	Aqueous System	Aqueous Dip Tanks		Cold Clean& Wipe Crossfeed	Brian Duffy/Crown Equip Corp/419 629-2311	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	LIGHTING SUPPORTS CLEANING	Aqueous System	Aqueous Alkaline		NDCEE Crossfeed Report	Faye Bentley/Philips Lighting/607 776-3311	Used by Philips Lighting Co
1,1,1 Trichloroethane	ODC Class I	LUBRICATES	LUBRICATE AS INSTALL ROTOR BLADE	Chemicals	321 Dry Film Lubricant	150-01-380-4235	C/KC-135 Pol Prev Status Rept	Capt Troy Lanier/OC-ALC/LACRA/405 736-3832	No ODC
1,1,1 Trichloroethane	ODC Class I	LUBRICATES	LUBRICATE AS INSTALL ROTOR BLADE	Chemicals	321 Dry Film Lubricant	150-01-380-4235	C/KC-135 Pol Prev Status Rept	Capt Troy Lanier/OC-ALC/LACRA/405 736-3832	No ODC
1,1,1 Trichloroethane	ODC Class I	LUBRICATES	LUBRICATE FASTENERS	Chemicals	Break-Free CLP-NC		SM-ALC ODC Substitutes Database	David Heiser/SM-ALC/TIELA/DSN 633-5476	
1,1,1 Trichloroethane	ODC Class I	CLEANING	MACHINE TOOLS CLEANING	Chemicals	EPA 2000 [Western Chemical Int Inc]		HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Removes Oil
1,1,1 Trichloroethane	ODC Class I	CLEANING	MACHINE TOOLS CLEANING	Chemicals	Planisol [Planisol Inc]		HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Excellent Cleaner
1,1,1 Trichloroethane	ODC Class I	CLEANING	MACHINE TOOLS CLEANING	Chemicals	Uniclean VII [Uniclean Products Inc]		HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Good Cleaner
1,1,1 Trichloroethane	ODC Class I	CLEANING	MANUFACTURING EQUIP CLEANING	Aqueous System	Aqueous		NDCEE Crossfeed Report	Coors Brewing Co/Bob Brady/303 277-7006	Used by Coors Brewing Co
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Aqueous System	Hermetic Vapor Degreasing w/TCE or PCE		NDCEE Crossfeed Report	Steve Mayer/SM-ALC/916 643-2704	Used by SM-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Aqueous System	Aerowash		Rockwell Solvents Study	Wyandotte Chemicals Corp	Removes dye, oil & grease
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Aqueous System	Ardrox 180-BH		Rockwell Solvents Study	Ardrox 714 739-2821	Removes ink & dye
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Aqueous System	Aqueous Immersion w/ Brulin 815GD & Agitation		Vapor Degreasing Crossfeed	Michael Grimm/McDonnell Douglas/314 233-5810	Used by McDonnell Douglas

List of potential ODC/HAZMAT alternatives. Identification of an alternative on this list does not endorse its use or authorize deviation from the Tech Order. The single manager must approve changes to Tech Orders.

1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Aqueous System	Brulin 815 GD	850-01-392-8430	VTCN with BDM at SM-ALC	Sara Jane Blubaugh SM-ALC/TIME 916 643-2704	
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Aqueous System	Turco 4215 NCLT		VTCN with BDM at SM-ALC	Turco 714 890-3600	
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Isopropyl Alcohol		Avionics Cleaning Crossfeed	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	N-methylpyrrolidone		Avionics Cleaning Crossfeed	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Oxsol 100		Avionics Cleaning Crossfeed	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Trans LC		Avionics Cleaning Crossfeed	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Arakawa Pine Alpha ST-100S		Elec & Prec Cleaning Crossfeed	Tim Crawford/EMPF/317 226-5634	
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Trichloroethylene		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Hurri-Safe Hot Immersion Degreaser	6850-01-373-586	Haz Tech Info Services	Hurri Kleen Corp	
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Brulin 1793		McDonnell Douglas P2 Review	Alice Garcia/McDonnell Douglas/314 232-9009	
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	PF Degreaser		McDonnell Douglas P2 Review	Alice Garcia/McDonnell Douglas/314 232-9009	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Shopmaster LPH		McDonnell Douglas P2 Review	Alice Garcia/McDonnell Douglas/314 232-9009	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Hurri-Safe Special Formula Degreaser	6850-01-369-930	Navy CFC Halon News	Hurri Kleen Corp	
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	HI-SOLV Degreaser		Navy Pol Prev Opportunity Handbook	Hazardous Technical Info Services 804 209-5168	
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Allied-Kelite 28		PRO-ACT	Allied-Kelite Products Division, Richardson Chem Co	
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	AXAREL 52 [Aliphatic Hydrocarbons]		PRO-ACT	Du Pont 800 237-2374	Contains Rust Inhibitors
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	AXAREL 56 [Aliphatic Hydrocarbons]		PRO-ACT	Du Pont 800 237-2374	Can Rinse Residue Free
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	AXAREL 6000 [Aliphatic Hydrocarbons]		PRO-ACT	Du Pont 800 237-2374	High Flash Point for Waxes
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	AXAREL 6100 [Aliphatic Hydrocarbons]		PRO-ACT	Du Pont 800 237-2374	Use in Spray Booths
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Cee Bee A-7X7, LF		PRO-ACT	Cee Bee Div, McGean-Robco, Inc.	
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Diversey 909		PRO-ACT		
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	EARTH3 Cleaners		PRO-ACT	Ashland Chemical 614 889-3333	Non-ODC
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	GMC 5288		PRO-ACT	Greater Mountain Chemical Company	
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Immersion with AXAREL 6100		SM-ALC Solvents Test Reprt	Cheryl Brandt SM-ALC/LIHM DSN 633-5026	Tested by SM-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Spray Booth with ReBOUND 4		SM-ALC Solvents Test Reprt	Cheryl Brandt SM-ALC/LIHM DSN 633-5026	Tested by SM-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Hi Pressure Spray Booth with Daraclean 282	6850-01-364-832	SM-ALC Solvents Test Rept	Cheryl Brandt SM-ALC/LIHM DSN 633-5026	Tested by SM-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	OXSOL 325 [contains 5% Perc]		Vendors Brochure	Occidental Chemical Corp. 1-800-752-5151	High Flash Point
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	OXSOL 550 [contains monochlorotoluene]		Vendors Brochure	John Neeb/HVC Inc/ 1-800-947-7373	
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	ReBOUND 4		XXCEL Tech Ltd	XXCEL Technology Ltd (714) 492-3559	Non-Emulsifying & Ambient
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	ReBOUND 7		XXCEL Tech Ltd	XXCEL Technology Ltd (714) 492-3559	Non-Emulsifying & Ambient
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Jet Clean C			Turco 714 890-3600	
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Detergent	The Metal Cleaner [for parts washers]		Vendors Brochure	Industrial Products Group, 1-800-537-8990	
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Hydrocarbon	ADL Enhanced		Rockwell Solvents Study	Orange-Sol Inc 800 877-7771	Removes oil & wax
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Inclosed System	Ecoclean 815		Lance Lankford/SM-ALC	Durr Industries Inc 313 459-6800	Low Solvent Consumption
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	NMP	Ambersolve 3000		Rockwell Solvents Study	Innovative Organics 714 771-9225	Removes dye,wax &mill marks
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Plasma	Plasma		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Radiate Energy	UV/Ozone		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Semi aqueous	Axarel 9100 (DuPont)		SM-ALC Solvents Test Reprt	Cheryl Brandt SM-ALC/LIHM DSN 633-5026	Tested by SM-ALC
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Solvent Blend	Desoto 112		Rockwell Solvents Study	Desoto 714 848-7051	Removes grease & wax
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS CLEANING	Super Critical Fluids	Super Critical Fluids		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL PARTS DEGREASING	Chemicals	3D Supreme [3D Inc]		HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	
1,1,1 Trichloroethane	ODC Class I	CLEANING	METAL WHEELS CLEANING		Fluidized Bed		NDCEE Crossfeed Report	Ed Hanna/RRAD/903 334-3380	Used by Red River Army Depot
1,1,1 Trichloroethane	ODC Class I	RELEASE AGENT	MOLD RELEASE	Chemicals	Chemlease 88MS3		McD Douglas ODS Qtrly Report #5	Larry Sanders/McDonnell Douglas/314 233-9809	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	RELEASE AGENT	MOLD RELEASE	Chemicals	Fluid Film		McDonnell Douglas P2 Review	Richard Sharp/McDonnell Douglas/314 233-5452	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	RELEASE AGENT	MOLD RELEASE	Chemicals	Frekote 815NC		McDonnell Douglas P2 Review	Richard Sharp/McDonnell Douglas/314 233-5452	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	INSPECTION	NDI PENETRANT DEVELOPER	Chemicals	Castrol PD4		McDonnell Douglas P2 Review	Robert Romine/McDonnell Douglas/314 233-5087	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	INSPECTION	NDI PENETRANT DEVELOPER	Chemicals	Cigiemme D.1		McDonnell Douglas P2 Review	Robert Romine/McDonnell Douglas/314 233-5087	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	INSPECTION	NDI PENETRANT DEVELOPER	Chemicals	Magnaflux ZP48		McDonnell Douglas P2 Review	Robert Romine/McDonnell Douglas/314 233-5087	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	INSPECTION	NDI PENETRANT DEVELOPER	Chemicals	Marktec D700		McDonnell Douglas P2 Review	Robert Romine/McDonnell Douglas/314 233-5087	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	INSPECTION	NDI PENETRANT DEVELOPER	Chemicals	Met-L-Chek D72A		McDonnell Douglas P2 Review	Robert Romine/McDonnell Douglas/314 233-5087	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	INSPECTION	NDI PENETRANT DEVELOPER	Chemicals	Sherwin D99A		McDonnell Douglas P2 Review	Robert Romine/McDonnell Douglas/314 233-5087	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	INSPECTION	NDI PENETRANT DEVELOPER	Chemicals	Turco DD28		McDonnell Douglas P2 Review	Robert Romine/McDonnell Douglas/314 233-5087	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	OIL PURIFIER PARTS CLEANING	Organics	ELECTRON [Sentry Chemical Co]		Cold Clean& Wipe Crossfeed	Gary Downer/Tennessee Valley Authority/615 751-4440	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	OIL REMOVAL	Chemicals	X-Caliber	850-01-378-0582	HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Excellent Cleaner
1,1,1 Trichloroethane	ODC Class I	CLEANING	OPTICS CLEANING	Chemicals	Calgon CPD-3060		Elec & Prec Cleaning Crossfeed	Todd Johnson/Letterkenny Army Dep/717 267-5506	
1,1,1 Trichloroethane	ODC Class I	CLEANING	OPTICS CLEANING	Chemicals	Genesolve HCFC Vapor Degreasing [Allied-Signal]		Elec & Prec Cleaning Crossfeed	Ms Sandy Reichenbach/ITT Corp/703 563-4430	
1,1,1 Trichloroethane	ODC Class I	CLEANING	OXYGEN TUBES CLEANING	Chemicals	Brulin 1990 w/ DI Water & Dry		9th Aerospace HAZMAT Conf	John Wiskoski/Rockwell/805 265-3348	
1,1,1 Trichloroethane	ODC Class I	CLEANING	OXYGEN TUBING CLEANING	Aqueous System	Aqueous w/ Brulin 815 GD Alkaline Cleaner		Cold Clean& Wipe Crossfeed	Tom Woodrow/Lockheed/817 777-4779	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	OXYGEN TUBING CLEANING	Aqueous System	Aqueous with Brulin 815GD		Vapor Degreasing Crossfeed	Tom Woodrow/Lockheed Fort Worth/817 777-4254	Used by Lockheed
1,1,1 Trichloroethane	ODC Class I	CLEANING	PRECISION & METAL CLEANING	Chemicals	Actrel Solvents [Aliphatic Hydrocarbons]		PRO-ACT	Exxon Chemical Co 800 526-0749 ext 6955	Non-ODC & non-hazardous
1,1,1 Trichloroethane	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	Volatile Methyl Siloxane		Aerospace Haz Mat'l Conf	Richard Burow/Dow Corning Corp/517 496-4035	
1,1,1 Trichloroethane	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	Alcohol/Iso-hexane		Avionics Cleaning Crossfeed	Patrick Reust/SM-ALC/LICF/DSN 633-3787	Non-ODC
1,1,1 Trichloroethane	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	Methylene Chloride		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
1,1,1 Trichloroethane	ODC Class I	CLEANING	PRECISION CLEANING	Plasma	Plasma		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
1,1,1 Trichloroethane	ODC Class I	CLEANING	PRECISION CLEANING	Plasma	Plasma		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
1,1,1 Trichloroethane	ODC Class I	CLEANING	PRECISION CLEANING	Radiate Energy	UV/Ozone		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
1,1,1 Trichloroethane	ODC Class I	CLEANING	PRECISION CLEANING	Super Critical Fluids	Supercritical CO2		9th Aerospace HAZMAT Conf	Kenneth Laintz/Los Alamos Nat'l Lab/505 665-3545	Non-ODC
1,1,1 Trichloroethane	ODC Class I	CLEANING	PRECISION CLEANING	Super Critical Fluids	Supercritical CO2		Avionics Cleaning Crossfeed	Patrick Reust/SM-ALC/LICF/DSN 633-3787	Non-ODC

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1,1,1 Trichloroethane	ODC Class I	CLEANING	PRECISION METAL PARTS CLEANING	Aqueous System	Crest (alkaline) Clean w/ultrasonic immersion		Elec & Prec Cleaning Crossfeed	Sandy Reichenbach/ITT Corp/703 563-4430	
1,1,1 Trichloroethane	ODC Class I	SEALING	PROMOTE ADHESION	Chemicals	PR-182		McD Douglas ODS Qtrly Report #5	Larry Sanders/McDonnell Douglas/314 233-9809	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	SEALING	PROMOTE SEALANT ADHESION	Chemicals	PR-182		McDonnell Douglas P2 Review	Richard Sharp/McDonnell Douglas/314 233-5452	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	REMOVE CONFORMAL COATINGS	Chemicals	749 N.O.D. Cleaner/Degreaser (Sprayon Products)		SM-ALC/TIEL LTR	David Heiser or Scott Dickinson/SM-ALC/ DSN 633-6151	
1,1,1 Trichloroethane	ODC Class I	CLEANING	REMOVE CUTTING FLUIDS	Organics	Isopropyl Alcohol		Cold Clean& Wipe Crossfeed	Jeff Mamix/OC-ALC/405 736-3819	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	REMOVE FLUORESCENT PENETRANT	Organics	Isopropyl Alcohol		Cold Clean& Wipe Crossfeed	Jeff Mamix/OC-ALC/405 736-3819	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	REMOVE TAR & COARSE GREASE	Aqueous	1D/4R (Finger Lakes Chemicals)	850-01-383-3053	DGSC "Envir Preferred Products"	DGSC Market'g Off 1-800-352-2852 & DSN 695-6054	
1,1,1 Trichloroethane	ODC Class I	CLEANING	REMOVE TAR & GREASE	Aqueous	3-D Degreaser (Finger Lakes Chemicals)	850-01-383-3052	DGSC "Envir Preferred Products"	DGSC Market'g Off 1-800-352-2852 & DSN 695-6054	
1,1,1 Trichloroethane	ODC Class I	CLEANING	RMA FLUX REMOVAL	Chemicals	Aqueous spray w/EZ 244 detergent		Elec & Prec Cleaning Crossfeed	Don Hunt/AGMC/614 522-7712	
1,1,1 Trichloroethane	ODC Class I	CLEANING	ROCKET PARTS CLEANING	Aqueous System	Aqueous Agitated Immersion w/ Daraclean 282		NDCEE Crossfeed Report	Martin Marietta/Jack Snyder/303 977-3322	Used by Martin Marietta
1,1,1 Trichloroethane	ODC Class I	CLEANING	ROCKET PROPELLANT MIX EQUIP CLEANING	Solvent	Ionox BC (Kyzen Corp)		1996 Precision Cleaning Conference	Kyzen Corp (Nashville, TN) / 603 622-2900	Tested by Thiokol for NASA
1,1,1 Trichloroethane	ODC Class I	CLEANING	SCREW MACHINES CLEANING	Aqueous System	Aqueous Immersion (Agitate)		NDCEE Crossfeed Report	Crown Equip Corp/ Brian Duffy/419 629-2311	Used by Crown Equip Corp
1,1,1 Trichloroethane	ODC Class I	CLEANING	SEALANT REMOVAL	Chemicals	DS-108F		Cold Clean& Wipe Crossfeed	Jeffrey Jones/McDonnell Douglas/314 233-3708	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	SEALANT REMOVAL	Chemicals	Shopmaster RC		Cold Clean& Wipe Crossfeed	Jeffrey Jones/McDonnell Douglas/314 233-3708	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	SEALANT REMOVAL	Chemicals	DS-108 F		Int Wkshp on Solvent Substitutes	Jeffrey Jones/McDonnell Douglas/314 233-3708	Evaluated by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	SEALANT REMOVAL	Chemicals	Shopmaster RC		Int Wkshp on Solvent Substitutes	Jeffrey Jones/McDonnell Douglas/314 233-3708	Evaluated by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	SEALANT REMOVAL	Chemicals	Skysolve 1000 (formerly Santasol DME)		McD Douglas ODS Qtrly Report #5	Larry Sanders/McDonnell Douglas/314 233-9809	Tested by McDonnell Douglas
1,1,1 Trichloroethane	ODC Class I	CLEANING	SOLDER FLUX REMOVAL	Chemicals	MCC Proclean		Elec & Prec Cleaning Crossfeed	Brent Baumgartner/WR-ALC/912 926-1422	
1,1,1 Trichloroethane	ODC Class I	CLEANING	SOLDER FLUX REMOVAL	Chemicals	MCC Proclean		McDonnell Douglas P2 Review	Robert Romine/McDonnell Douglas/314 233-5087	
1,1,1 Trichloroethane	ODC Class I	CLEANING	SOLID ROCKET MOTOR CLEANING	Aqueous System	Aqueous Spray Washer w/ Brulin 1990		9th Aerospace HAZMAT Conf	Kurt Evans/Thiokol Corp/801 863-6130	Low Foaming
1,1,1 Trichloroethane	ODC Class I	CLEANING	SOLID ROCKET MOTOR CLEANING	Aqueous System	Aqueous Spray Washer w/ Jettacin (Diversey Corp)		9th Aerospace HAZMAT Conf	Kurt Evans/Thiokol Corp/801 863-6130	Works at Low Temp
1,1,1 Trichloroethane	ODC Class I	CLEANING	SOLID ROCKET MOTOR SMALL PARTS CLEAN	Aqueous System	Proceco Spray Washer w/Brulin 1990 GD		1996 Precision Cleaning Conference	Rick Golde/Thiokol Space Div, Brigham City,UT 84307	Tested by Thiokol for NASA
1,1,1 Trichloroethane	ODC Class I	CLEANING	SOLVENT REMOVERS	Chemicals	Dynamold DS-104		SM-ALC/ TIELD LTR	Don Koscheski/SM-ALC/ DSN 633-2451	
1,1,1 Trichloroethane	ODC Class I	CLEANING	SOLVENT REMOVERS	Chemicals	Dynamold DS-108		SM-ALC/ TIELD LTR	Don Koscheski/SM-ALC/ DSN 633-2451	
1,1,1 Trichloroethane	ODC Class I	CLEANING	SOLVENT REMOVERS	Chemicals	Ecolink Electron		SM-ALC/ TIELD LTR	Don Koscheski/SM-ALC/ DSN 633-2451	
1,1,1 Trichloroethane	ODC Class I	CLEANING	SPECIALIZED WELDING PRECLEANING	Chemicals	Biogenic Regent (Rochester Midland)		Elec & Prec Cleaning Crossfeed	Jack Snyder/Martin Marietta/303 977-3322	
1,1,1 Trichloroethane	ODC Class I	CLEANING	SPOT CLEAN METAL, PLASTIC & RUBBER	Organics	PF Degreaser		Cold Clean& Wipe Crossfeed	Cathy Clayton/NASA UT/USBI Co/205 544-2836	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	SPOT CLEAN METAL, PLASTIC & RUBBER	Organics	Prime		Cold Clean& Wipe Crossfeed	Cathy Clayton/NASA UT/USBI Co/205 544-2836	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	SPOT CLEAN METAL, PLASTIC & RUBBER	Organics	Reveille		Cold Clean& Wipe Crossfeed	Cathy Clayton/NASA UT/USBI Co/205 544-2836	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	THIN FILM OPTICAL COATING CLEANING	Chemicals	Hot Isopropyl Alcohol (IPA)		Int Wkshp on Solvent Substitutes	Dr Gerry Garwood/Santa Barbara Res Ctr/805 562-2282	Evaluated by Hughes
1,1,1 Trichloroethane	ODC Class I	CLEANING	TOOLS & EQUIPMENT CLEANING	Chemicals	Impact Concentrated Industrial Degreaser	6850-01-380-405	Haz Tech Info Services	Allied Enterprises	
1,1,1 Trichloroethane	ODC Class I	CLEANING	TOOLS & EQUIPMENT CLEANING	Hydrocarbon	Hydrocarbon Cleaner		Cold Clean& Wipe Crossfeed	Tony Phillips Lockheed 817 777-3758	Used by Lockheed
1,1,1 Trichloroethane	ODC Class I	CLEANING	TOOLS & EQUIPMENT CLEANING		Axarel 9100		Cold Clean& Wipe Crossfeed	Tony Phillips Lockheed 817 777-3758	Used by Lockheed
1,1,1 Trichloroethane	ODC Class I	CLEANING	TOOLS & EQUIPMENT CLEANING		Petroferm Bioact DG-1		Cold Clean& Wipe Crossfeed	Tony Phillips Lockheed 817 777-3758	Used by Lockheed
1,1,1 Trichloroethane	ODC Class I	CLEANING	TUBING & METAL COMPONENTS CLEANING	Organics	Bioact 280		Cold Clean& Wipe Crossfeed	Merritte Ireland/Martin Marietta/303 977-5992	NDCEE Case Study
1,1,1 Trichloroethane	ODC Class I	CLEANING	TUBING CLEANING	Aqueous System	Aqueous Alkaline Degreaser		Halon Conf in Wash DC	Lockheed Fort Worth Texas	Used by Lockheed
1,1,1 Trichloroethane	ODC Class I	CLEANING	TUBING CLEANING		Brulin 815GD		Cold Clean& Wipe Crossfeed	Tony Phillips Lockheed 817 777-3758	Used by Lockheed
1,1,1 Trichloroethane	ODC Class I	CLEANING	VACUUM COMPONENTS CLEANING	Chemicals	PF Solvent (P-T Technologies)	7930-01-328-405	HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Efficient Cleaner
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Abrasive Blasting	Supersonic Abrasive Ice-Blasting		NSF PR 94-58 NEWS, 5 Oct 94	Beth Gaston/Nat'l Science Foundation/703 306-1070	Tested by Pen State Univ for NSF
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Abrasive Blasting	Bicarbonate of Soda		Vapor Degreaser Crossfeed	Charles Williams SA-ALC/EMP DSN 945-3100 ext331	Less Hazardous
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Aqueous System	Better Engineering Mfg Washer with Big Blue		Vapor Degreaser Crossfeed	Cheryl Francis NAVDEP Cherry Pt DSN 582-7396	
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Aqueous System	Dip Tank with Daraclean 282		Vapor Degreaser Crossfeed	Greg Fuqua NADEP Jacksonville DSN 942-5419	
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Aqueous System	Dip Tank with Turco 4215		Vapor Degreaser Crossfeed	Greg Fuqua NADEP Jacksonville DSN 942-5419	
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Aqueous System	Dip Tank with Turco Aviation		Vapor Degreaser Crossfeed	Greg Fuqua NADEP Jacksonville DSN 942-5419	
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Aqueous System	Mark Power Washer & Turco Aviation		Vapor Degreaser Crossfeed	Tommy Hunnicutt WR-ALC/TIMP DSN 468-4782	No Hazardous Chemicals
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Aqueous System	Mart Washer with Daraclean 282		Vapor Degreaser Crossfeed	Cheryl Francis NAVDEP Cherry Pt DSN 582-7396	
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Aqueous System	Parts Washers with Big Blue (B&B TriTech Inc)		Vapor Degreaser Crossfeed	Greg Fuqua NADEP Jacksonville DSN 942-5419	
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Aqueous System	Parts Washers with Blue Gold (Metalube Corp)		Vapor Degreaser Crossfeed	Greg Fuqua NADEP Jacksonville DSN 942-5419	
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Aqueous System	Parts Washers with Cee Bee A54LF		Vapor Degreaser Crossfeed	Carlos Nazario OC-ALC/LIPEB DSN 336-7246	No Hazardous Chemicals
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Aqueous System	Steam Cleaning		Vapor Degreaser Crossfeed	Greg Fuqua NADEP Jacksonville DSN 942-5419	
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Aqueous System	Ultrasonic Cleaning with Daraclean 282		Vapor Degreaser Crossfeed	Greg Fuqua NADEP Jacksonville DSN 942-5419	
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Chemicals	Vertrel MCA (HFC 43-10 & Trans-DCE & Stabilizer)		95 Int'l CFC & Halon Alternatives Conf	Kenneth Dishart/DuPont/800 237-2374	
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Chemicals	Vertrel SMT(43-10&Trans-DCE&Methanol&Stabilizer)		95 Int'l CFC & Halon Alternatives Conf	Kenneth Dishart/DuPont/800 237-2374	
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Chemicals	Vertrel XE (HFC 43-10 & Ethanol) (DuPont)		95 Int'l CFC & Halon Alternatives Conf	Kenneth Dishart/DuPont/800 237-2374	
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Chemicals	Vertrel XF (HFC 43-10mee) (DuPont)		95 Int'l CFC & Halon Alternatives Conf	Kenneth Dishart/DuPont/800 237-2374	
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Chemicals	Vertrel XM (HFC 43-10 & Methanol) (DuPont)		95 Int'l CFC & Halon Alternatives Conf	Kenneth Dishart/DuPont/800 237-2374	
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Chemicals	ART-222 (Advanced Research Technologies Inc)		SM-ALC/TIEL Ltr 21 Dec 94	Carlos Payne SM-ALC/TIEL-1 DSN 633-6151	
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Chemicals	ART-210 Terpene		Vapor Degreaser Crossfeed	Juliana MacPherson SM-ALC/TI-5 DSN 633-2920	Use Existing Equipment
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING	Liquid Blasting	Medium Pressure Water Aquamizer		Vapor Degreaser Crossfeed	Charles Williams SA-ALC/EMP DSN 945-3100 ext331	Low Cost & Less Hazardous
1,1,1 Trichloroethane	ODC Class I	CLEANING	VAPOR DEGREASING (7075 AL)	Chemicals	Spray-in-air Cleaning		Aerospace Haz Mat'l Conf	K.B. Evans/Thiokol Corp/801 863-6130	
1,1,1 Trichloroethane	ODC Class I	CLEANING	WIPE CLEANING OPERATIONS	Chemicals	PF 16		PT Technologies	PT Tecnologies 800 441-7874	
1,1,1 Trichloroethane	ODC Class I	CLEANING	WIPE CLEANING ROCKET BOOSTER PARTS	Chemicals	Isopropanol 3-Carbon Alcohol		Int Wkshp on Solvent Substitutes	Catherine Clayton/United Technologies/205 544-2836	Evaluated by United Technologies
1,1,1 Trichloroethane	ODC Class I	CLEANING	WIPE CLEANING ROCKET BOOSTER PARTS	Chemicals	Jettacin Aqueous w/D-Limonene (DuBios)		Int Wkshp on Solvent Substitutes	Catherine Clayton/United Technologies/205 544-2836	Evaluated by United Technologies
1,1,1 Trichloroethane	ODC Class I	CLEANING	WIPE CLEANING ROCKET BOOSTER PARTS	Chemicals	PF Degreaser Organic Cleaner (PT Technologies)		Int Wkshp on Solvent Substitutes	Catherine Clayton/United Technologies/205 544-2836	Evaluated by United Technologies
1,1,1 Trichloroethane	ODC Class I	CLEANING	WIPE CLEANING ROCKET BOOSTER PARTS	Chemicals	Prime Alkaline Cleaner (DuBios)		Int Wkshp on Solvent Substitutes	Catherine Clayton/United Technologies/205 544-2836	Evaluated by United Technologies
1,1,1 Trichloroethane	ODC Class I	CLEANING	WIPE CLEANING ROCKET BOOSTER PARTS	Chemicals	Reveille Petroluem Distillate (DuBois)		Int Wkshp on Solvent Substitutes	Catherine Clayton/United Technologies/205 544-2836	Evaluated by United Technologies
1,1,1 Trichloroethane	ODC Class I	CLEANING	WIPE PRIOR TO BOND	Chemicals	DS-108		Cold Clean& Wipe Crossfeed	Mary Beth Fennell/NADEP Cherry Pt/919 466-8142	Tested by NADEP Cherry Point
1,1,1 Trichloroethane	ODC Class I	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	Denatured Alcohol		Cold Clean& Wipe Crossfeed	Paul Hughes SA-ALC/EMP DSN 945-3100	Used by SA-ALC

List of potential ODC/HAZMAT alternatives. Identification of an alternative on this list does not endorse its use or authorize deviation from the Tech Order. The single manager must approve changes to Tech Orders.

1,1,1 Trichloroethane	ODC Class I	COATINGS						Capt Carolyn Westmark WL/MLSA DSN 785-3637	
1,1,1 Trichloroethane	ODC Class I	LUBRICATES							
CFC-113	ODC Class I	LUBRICATES	LUBRICATION	Chemicals	Break-free CLP NC (Non-Chlorinated Formula)		SM-ALC/TIEL LTR	Jack Weddell/SM-ALC/ DSN 633-6151	
Acetone	TRI Section 313	CLEANING	HYDRAULICS & INSTRUCTIONS CLEANING	Chemicals	Citra-Safe Terpene	6850-01-378-079	Elec & Prec Cleaning Crossfeed	Envir Affairs/Hewlett Packard/503 757-2000	
Acetone	TRI Section 313	CLEANING	OPTICS CLEANING	Aqueous System	Automated Aqueous Cleaning		Elec & Prec Cleaning Crossfeed	Rick Harmon/Texas Instruments/212 480-4562	
Cadmium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	Tin-Zinc Plating		F-22 Specs & Alternatives		Less Hazardous
Cadmium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	Ion Vapor Deposition (IVD)		Tech Advisory Team	Marty Sedgwick WR-ALC/TIBO DSN 468-4800	Less Hazardous
Cadmium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	Zinc Nickel Plating		Tech Advisory Team	Nancy Strapper SA-ALC/TIESM DSN 945-5338	Less Hazardous
Cadmium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	Chemical Vapor Deposition (CVD)		Tech Fact Sheet 21795-40	John Adams/NDCEE/814 268-2855	Not Line-of-Sight Process
Cadmium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	Elecroless Plating (nickel, platinum, etc)		Tech Fact Sheet 21795-40	John Adams/NDCEE/814 268-2855	
Cadmium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	Corroban (Zinc & Nickel)		Waste Reduction Resource Ctr Rpt	Waste Reduction Resource Center 800 476-8686	Compatible with Aluminium
Cadmium	EPA-17	PLATING	PLATING STEEL & TITANIUM FASTENERS	Metal Depositing	Ion Plating (deposit metal via reactive gas)		Tech Fact Sheet 21795-40	John Adams/NDCEE/814 268-2855	
Cadmium	EPA-17	PLATING	PLATING TURBINE BLADES	Metal Depositing	Sputtering (chromium coating via pos ions)		Tech Fact Sheet 21795-40	John Adams/NDCEE/814 268-2855	
CFC-11	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Absorption	Ammonia-Water		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-11	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Absorption	Lithium Bromide-Water		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-11	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	Ammonia		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-11	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HCFC-123		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-11	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HCFC-22		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-11	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HFC-134a		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-11	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HCFC-123 [SUVA Centri-LP]		Vendor Brochure	DuPont 1-800-441-9450	
CFC-11	ODC Class I	INSECTICIDE	KILL INSECTS	Chemicals	PT 565 plus XLO		SM-ALC ODC Substitutes Database	David Heiser/SM-ALC/TIELA/DSN 633-5476	
CFC-11	ODC Class I	REFRIGERANT	SHORE FACILITIES AIR CONDITIONING	Chemicals	HCFC-123		Used by Navy		
CFC-113	ODC Class I	CLEANING	AIR ACCESSORIES CLEANING	Chemicals	Turco 6780		Cold Clean& Wipe Crossfeed	Carlos Nazario OC-ALC/LIPEB DSN 336-7246	Used at OC-ALC
CFC-113	ODC Class I	CLEANING	AVIONICS CLEANING	Chemicals	Isopropyl Alcohol		Cold Clean& Wipe Crossfeed	Carlos Nazario OC-ALC/LIPEB DSN 336-7246	Used at OC-ALC
CFC-113	ODC Class I	CLEANING	AVIONICS CLEANING	Chemicals	Crest ABS 901		Elec & Prec Cleaning Crossfeed	Ken Clark/NAWC/215 441-1508	
CFC-113	ODC Class I	CLEANING	CIRCUIT BOARD CLEANING	Aqueous System	JetClean Equipment for batch Processing		9th Aerospace HAZMAT Conf	Joseph Kane/Martin Marietta [NY]/303 977-3441	
CFC-113	ODC Class I	CLEANING	CIRCUIT BOARD CLEANING	Aqueous System	Aqueous Ultrasonics		Elec & Prec Cleaning Crossfeed	Todd Johnson/Letterkenny Army Dep/717 267-9506	
CFC-113	ODC Class I	CLEANING	CIRCUIT BOARD CLEANING	Aqueous System	Water Soluble Flux w/Aqueous Cleaning		Elec & Prec Cleaning Crossfeed	Dhiren Mehta/Hughes Aircraft/310 568-6791	Reduced Failures
CFC-113	ODC Class I	CLEANING	CIRCUIT BOARD CLEANING	No Clean	Delco-patented low flux in nitrogen atmosphere		Elec & Prec Cleaning Crossfeed	Eugene Hanaway/Delco Elec Corp/914 789-2000	Minimal Non-corrosive Residue
CFC-113	ODC Class I	CLEANING	CIRCUIT BOARD CLEANING	Semi-Aqueous System	Alcohol-based solvent		Elec & Prec Cleaning Crossfeed	Peter Cote/United Technologies/203 654-3291	
CFC-113	ODC Class I	CLEANING	CLEAN BEARINGS		P-D-680 Type II		SM-ALC/TIEL LTR	John Meininger/SM-ALC/ DSN 633-2451	
CFC-113	ODC Class I	CLEANING	CLEAN INTERIOR OF PIPES	Ultraviolet Photons	Laser Assisted Inert Gas Flow		Precision Cleaning May 1995	Audrey Engelsberg/Radiance Services Berthesda, MD	
CFC-113	ODC Class I	CLEANING	CLEAN NDI DYES FROM AL PARTS	Organics	Isopropyl Alcohol		Cold Clean& Wipe Crossfeed	John Zavodjancik/Pratt & Whitney/203 565-5030	NDCEE Case Study
CFC-113	ODC Class I	CLEANING	CLEAN OXYGEN EXTERNAL SURFACES		LPS NoFlash Electro Contact Cleaner	7930-01-398-098	OC-ALC/LCR Msg 28 Mar 95	Jan Goldenberg/OC-ALC/LIRC/ DSN 336-5080	
CFC-113	ODC Class I	CLEANING	CLEAN PORTA-TEST LEAK DETECTOR	Chemicals	Grade A or AA Methanol		SM-ALC/TIEL LTR	Scott Dickinson/SM-ALC/ DSN 633-6151	
CFC-113	ODC Class I	CLEANING	CLEANING & LUBRICATING		CRC 3-36		SM-ALC/TIEL LTR	Scott Dickinson/SM-ALC/ DSN 633-5476	
CFC-113	ODC Class I	CLEANING	CLEANING, AIR CONDITIONING REPAIR		P-C-437		SM-ALC/TIEL LTR	John Meininger/SM-ALC/ DSN 633-2451	
CFC-113	ODC Class I	CLEANING	CLEANROOM PRECISION CLEANING	Chemicals	Acetone [5%] & D.I. Water [95%]		1996 Precision Cleaning Conference	Katy Wolf/Institute for Res & Tech Asst/310 453-6919	Removes Organic Particles
CFC-113	ODC Class I	CLEANING	CLEANROOM PRECISION CLEANING	Chemicals	IPA [10%] & D.I. Water [90%]		1996 Precision Cleaning Conference	Katy Wolf/Institute for Res & Tech Asst/310 453-6919	Removes Ionic Particles
CFC-113	ODC Class I	CLEANING	DEGREASING METAL CLEANING	Chemicals	Ethyl Acetate		9th Aerospace HAZMAT Conf	Elizabeth King/Martin Marietta/303 977-8294	Tested by Martin Marietta
CFC-113	ODC Class I	CLEANING	DEGREASING METAL CLEANING	Chemicals	Simple Green		PRO-ACT		Tested by Martin Marietta
CFC-113	ODC Class I	CLEANING	DEGREASING METAL PARTS	Aqueous System	Quaker 624 GD		PRO-ACT		Tested by Martin Marietta
CFC-113	ODC Class I	CLEANING	DEGREASING METAL PARTS	Chemicals	BIO ACT EC7		PRO-ACT	Petroferm Inc 904 261-8286	Tested by Martin Marietta
CFC-113	ODC Class I	CLEANING	DEGREASING METAL PARTS	Chemicals	Coors Bio T		PRO-ACT		Tested by Martin Marietta
CFC-113	ODC Class I	CLEANING	ELEC & ELECTROMECH CLEANING	Chemicals	Isoparaffin Hydrocarbons		Cold Clean& Wipe Crossfeed	Carlos Nazario OC-ALC/LIPEB DSN 336-7246	To be tested bt OC-ALC
CFC-113	ODC Class I	CLEANING	ELECTRICAL CONTACT CLEANING	Chemicals	MCC-PC2		Elec & Prec Cleaning Crossfeed	Brent Baumgartner/WR-ALC/912 926-1422	Doesn't Degrade Plastics
CFC-113	ODC Class I	CLEANING	ELECTRICAL CONTACT CLEANING	Chemicals	Vatran Cold Gun		Elec & Prec Cleaning Crossfeed	Brent Baumgartner/WR-ALC/912 926-1422	
CFC-113	ODC Class I	CLEANING	ELECTRONIC CIRCUIT BOARD CLEANING	Aqueous System	Reactive Aqueous Defluxing System (RADS)		Int Wkshp on Solvent Substitutes	Dr Gerry Garwood/Santa Barbara Res Ctr/805 562-2282	Developed by Hughes
CFC-113	ODC Class I	CLEANING	ELECTRONIC CONNECTOR CLEANING	Chemicals	IPA Aerosol Spray Brush		EMPF Workshop	Ken Clark/NAWC/215 441-1508	
CFC-113	ODC Class I	CLEANING	ELECTRONIC CONTACT CLEANING	Chemicals	ART-201 Electronic & Prec Comp Cleaner		Avionics Cleaning Crossfeed	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
CFC-113	ODC Class I	CLEANING	ELECTRONIC CONTACT CLEANING	Chemicals	LPS Electro Contact Cleaner		Avionics Cleaning Crossfeed	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
CFC-113	ODC Class I	CLEANING	ELECTRONIC CONTACT CLEANING	Chemicals	Pensolv L805		Avionics Cleaning Crossfeed	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
CFC-113	ODC Class I	CLEANING	ELECTRONIC CONTACT CLEANING	Chemicals	Contact Cleaner 2000 (03150)	850-01-375-5690	DGSC "Envir Safe Chem Alter"	DGSC Market'g Off 1-800-352-2852 & DSN 695-6054	Fast Evaporation Rate
CFC-113	ODC Class I	CLEANING	ELECTRONIC CONTACT CLEANING	Chemicals	FLUX-OFF		Elec & Prec Cleaning Crossfeed	Ken Clark/NAWC/215 441-1508	
CFC-113	ODC Class I	CLEANING	ELECTRONIC CONTACT CLEANING	Chemicals	LPS CFC-FREE		Elec & Prec Cleaning Crossfeed	Ken Clark/NAWC/215 441-1508	
CFC-113	ODC Class I	CLEANING	ELECTRONIC CONTACT CLEANING	Chemicals	LPS Electro Contact Cleaner		SM-ALC Solvents Test Reprt	Cheryl Brandt SM-ALC/LIHM DSN 633-5026	Tested by SM-ALC
CFC-113	ODC Class I	CLEANING	ELECTRONIC CURCUIT BOARDS CLEAN	Chemicals	Micropure CDF	6850-01-383-304	DGSC "Envir Safe Chem Alter"	DGSC Market'g Off 1-800-352-2852 & DSN 695-6054	
CFC-113	ODC Class I	CLEANING	ELECTRONIC FLUX REMOVAL	Aqueous System	Cyclohexane in single sump vapor degreaser		1996 Precision Cleaning Conference	Robert Polhamus/S&K Products Internat'l, 914 425-6200	
CFC-113	ODC Class I	CLEANING	ELECTRONIC FLUX REMOVAL	Chemicals	HF-1189 (Water Soluble Solder Flux)		Int Wkshp on Solvent Substitutes	Dr Gerry Garwood/Santa Barbara Res Ctr/805 562-2282	Developed by Hughes
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	2110 [Alpha]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Actrel ED11 [Exxon]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Actrel ES [Exxon]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Armakleen 2001(Church & Dwight)		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	AVD [Petroferm/3M]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Being Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Axarel 32 [DuPont]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Axarel 36 [DuPont]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Axarel 38 [DuPont]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Biopact EC-7 [Petroferm]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF

List of potential ODC/HAZMAT alternatives. Identification of an alternative on this list does not endorse its use or authorize deviation from the Tech Order. The single manager must approve changes to Tech Orders.

CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Biopact EC-7R [Petroferm]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Biopact EC-Ultra [Petroferm]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	E-212 [Union Camp]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Being Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Genesolv 2004 [Allied]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Genesolv 2010 [Allied]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Ionox MC [Kyzen]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	KNI-2000 [Envirosolv]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Marclean R [Martin Marietta]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Micropure CDF [ISP]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Pine Alpha ST-100S [Arakawa]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Being Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Prozone [British Petroleom]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	RADS [Hughes]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Vertrel 434 [DuPont]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC PWA CLEANING	Chemicals	Zestron FA [Dr. OK Wack]		ESC [Ad hoc Solvents Wkg Grp]	Tim Crawford/EMPF/317 226-5634	Tested by NAWC & EMPF
CFC-113	ODC Class I	CLEANING	ELECTRONIC SILICON WAFER CLEANING	Acoustic Streaming	Megasonics		1998 Precision Cleaning Conference	Ahmed Busnaina/Clarkson Univ, Potsdam, NY 13699	
CFC-113	ODC Class I	CLEANING	ELECTRONIC SOLDERED BOARD CLEAN	Chemicals	Crest ABS 901		NAVAIR 4th Annual P2 Conf	Ken Clark/NAWC/215 441-1508	
CFC-113	ODC Class I	CLEANING	ELECTRONIC WAFER CLEANING	Chemicals	New Critical Cleaning Solvent (CCS)		Int Wkshp on Solvent Substitutes	Mike Powers/Hewlett Packard/707 577-4022	Tested by Hewlett Packard
CFC-113	ODC Class I	CLEANING	ELECTRONICS & PRECISION CLEANING	Chemicals	AK-225 (HCFC-225ca & HCFC-225cb)		95 Int'l CFC & Halon Alternatives Conf	Asahi Glass America Inc, New York,N.Y. 212 687-4600	Potential "Drop-in" replacement
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Aqueous System	Aqueous Cleaner w/Mechanical Agitation		Avionics Cleaning Crossfeed	Glenn Anderson/Corpus Christi Army Depot/861-2660	Non-ODC
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Aqueous System	High Pressure Water		Avionics Cleaning Crossfeed	Glenn Anderson/Corpus Christi Army Depot/861-2660	
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Aqueous System	Aqueous		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Alcohol		Avionics Cleaning Crossfeed	Glenn Anderson/Corpus Christi Army Depot/861-2660	Non-ODC
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Allied Genesolv 2004		Avionics Cleaning Crossfeed	Tim Crawford/Elec Mfg Productivity Fac/317 226-5634	
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Allied Genesolv 2010		Avionics Cleaning Crossfeed	Tim Crawford/Elec Mfg Productivity Fac/317 226-5634	
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Alpha 2110		Avionics Cleaning Crossfeed	Tim Crawford/Elec Mfg Productivity Fac/317 226-5634	
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Axarel 32 [Dupont]		Avionics Cleaning Crossfeed	Tim Crawford/Elec Mfg Productivity Fac/317 226-5634	
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Axarel 38 [Dupont]		Avionics Cleaning Crossfeed	Tim Crawford/Elec Mfg Productivity Fac/317 226-5634	Mat'l Comp Tested by NCMS
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Church & Dwight Armakleen 2001		Avionics Cleaning Crossfeed	Tim Crawford/Elec Mfg Productivity Fac/317 226-5634	
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Environsolv KNI-2000		Avionics Cleaning Crossfeed	Tim Crawford/Elec Mfg Productivity Fac/317 226-5634	
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Envirosolv 655		Avionics Cleaning Crossfeed	Patrick Reust/SM-ALC/LICF/DSN 633-3787	Non-ODC
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Exxon Actrel ED11 & Actrel ES		Avionics Cleaning Crossfeed	Tim Crawford/Elec Mfg Productivity Fac/317 226-5634	
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Freon SMT [Dupont]		Avionics Cleaning Crossfeed	Tim Crawford/Elec Mfg Productivity Fac/317 226-5634	
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Hughes RADS		Avionics Cleaning Crossfeed	Tim Crawford/Elec Mfg Productivity Fac/317 226-5634	Mat'l Comp Tested by NCMS
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Isopropyl Alcohol Clean w/Batch Soldering		Avionics Cleaning Crossfeed	Michael J. Leake/Texas Instruments/214 480-7030	Mat'l Comp Tested by NCMS
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	ISP Micropure CDF		Avionics Cleaning Crossfeed	Tim Crawford/Elec Mfg Productivity Fac/317 226-5634	
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Kyzen Ionox MC		Avionics Cleaning Crossfeed	Tim Crawford/Elec Mfg Productivity Fac/317 226-5634	Mat'l Comp Tested by NCMS
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Martin Marieta Marclean R		Avionics Cleaning Crossfeed	Tim Crawford/EMPF/317 226-5634	
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Petroferm EC-5		Avionics Cleaning Crossfeed	Clare Vinton/Nat'l Ctr for Mfg Sciences/313 995-0300	Mat'l Comp Tested by NCMS
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Petroferm Bioact EC-7		Avionics Cleaning Crossfeed	Tim Crawford/Elec Mfg Productivity Fac/317 226-5634	
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Petroferm Bioact EC-7R		Avionics Cleaning Crossfeed	Tim Crawford/Elec Mfg Productivity Fac/317 226-5634	Mat'l Comp Tested by NCMS
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Vertrel 245 [Dupont]		Avionics Cleaning Crossfeed	Clare Vinton/Nat'l Ctr for Mfg Sciences/313 995-0300	Mat'l Comp Tested by NCMS
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Vertrel 434 [Dupont]		Avionics Cleaning Crossfeed	Tim Crawford/Elec Mfg Productivity Fac/317 226-5634	
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Brominated Hydrocarbons		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Perfluorocarbons		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Ultrasonic Cleaning in Exxsol D40		ICOLP (Sweden Report)	NAIC/STINFO DSN 787-2435 [Doc # T-0433-93]	
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Chemicals	Spectrum 1A		XXCEL Tech Ltd	XXCEL Technology Ltd (714) 492-3559	Biodegradable
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	No Clean	Low Residue (No-clean) Fluxes		Avionics Cleaning Crossfeed	John Fisher/Naval Air Warefare Ctr/DSN 437-1798	No Cleaning Required
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	No Clean	Low Residue (No-clean) Fluxes		Avionics Cleaning Crossfeed	Michael J. Leake/Texas Instruments/214 480-7030	No Cleaning Required
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	No Clean	Low Residue (No-clean) Fluxes		Electronics PAC	Mark Siewers/ESC/EN-2/617 377-8269	No Cleaning Required
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	No Clean	Low Residue (No-clean) Fluxes		EMPF Workshop	Tim Crawford/EMPF/317 226-5634	No Cleaning Required
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	No Clean	No Clean		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Organic Substances	Organic (esters, ketones,ethers, etc.)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Semi-Aqueous System	Axarel 32 [Dupont]		Avionics Cleaning Crossfeed	Patrick Reust/SM-ALC/LICF/DSN 633-3787	Non-ODC
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Semi-aqueous System	Semi-aqueous Cleaner		Avionics Cleaning Crossfeed	Glenn Anderson/Corpus Christi Army Depot/861-2660	Non-ODC
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Semi-Aqueous System	Semi-aqueous Cleaning w/rosin flux		Avionics Cleaning Crossfeed	Michael J. Leake/Texas Instruments/214 480-7030	Non-ODC
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Semi-Aqueous System	Water Based Solder Fluxes		Avionics Cleaning Crossfeed	Patrick Reust/SM-ALC/LICF/DSN 633-3787	Non-ODC
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Semi-Aqueous System	Water Soluble Flux, HF 1189		Avionics Cleaning Crossfeed	John Fisher/Naval Air Warefare Ctr/DSN 437-1798	Non-ODC
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Semi-Aqueous System	Water Soluble Fluxes		Avionics Cleaning Crossfeed	Michael J. Leake/Texas Instruments/214 480-7030	Non-ODC
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Semi-Aqueous System	Semi-Aqueous (alcohols)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Semi-Aqueous System	Semi-Aqueous (petroleum hydrocarbon)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Semi-Aqueous System	Semi-Aqueous (terpene/surfactant)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	ELECTRONICS CLEANING	Ultrasonics	Blue Wave Ultrasonic Cleaner		Avionics Cleaning Crossfeed	Glenn Anderson/Corpus Christi Army Depot/861-2660	Non-ODC
CFC-113	ODC Class I	CLEANING	ELECTRONICS FLUX REMOVAL	Aqueous	Reactive Aqueous Defluxing System		AdHoc Solvents Wkg Grp	Elec Mfg Productivity Facility, 317 226-5607	
CFC-113	ODC Class I	CLEANING	ELECTRONICS FLUX REMOVAL	Aqueous System	ECOSOLVE (Lonco 1-800-323-9625)		Elec & Prec Cleaning Crossfeed	Dhiren Mehta/Hughes Aircraft/310 568-6791	
CFC-113	ODC Class I	CLEANING	ELECTRONICS FLUX REMOVAL	Aqueous System	Hollis Hydrostation 332		Elec & Prec Cleaning Crossfeed	Joe Murphy/Cherry Electric Products/708 662-9200	
CFC-113	ODC Class I	CLEANING	ELECTRONICS FLUX REMOVAL	Chemicals	BIOACT EC7R (Terpene Hydrocarbons)		AdHoc Solvents Wkg Grp	Chemtrec 1-800-424-9300	
CFC-113	ODC Class I	CLEANING	ELECTRONICS FLUX REMOVAL	Chemicals	IONOX MC (Kyzen Corp)		AdHoc Solvents Wkg Grp	Entra Corp, Indianapolis, Indiana	
CFC-113	ODC Class I	CLEANING	ELECTRONICS FLUX REMOVAL	Chemicals	KCD 9434 [E.I. DuPont De Nemours]		AdHoc Solvents Wkg Grp	E.I. DuPONT Wilmington, Delaware	

CFC-113	ODC Class I	CLEANING	ELECTRONICS FLUX REMOVAL	Chemicals	MARCLEAN-R (Martin Marietta Corp)		AdHoc Solvents Wkg Grp	Elec Mfg Productivity Facility, 317 226-5607	
CFC-113	ODC Class I	CLEANING	ELECTRONICS FLUX REMOVAL	Chemicals	MICROPURE CDF		AdHoc Solvents Wkg Grp	Elec Mfg Productivity Facility, 317 226-5607	
CFC-113	ODC Class I	CLEANING	ELECTRONICS FLUX REMOVAL	Chemicals	Zero Trl		SM-ALC Solvents Test Reprt	Cheryl Brandt SM-ALC/LIHM DSN 633-5026	Tested by SM-ALC
CFC-113	ODC Class I	CLEANING	ELECTRONICS FLUX REMOVAL	Semi-Aqueous System	Axarel 32, DI Water & Air Dry		Elec & Prec Cleaning Crossfeed	Oscar Estella/SM-ALC/916 643-6926	
CFC-113	ODC Class I	CLEANING	ENGINE PARTS CLEANING	Chemicals	Alcohol Cleaner Type KLN AIV/65-40-40		ICOLP (Sweden Report)	NAIC/STINFO DSN 787-2435 [Doc # T-0433-93]	
CFC-113	ODC Class I	REFRIGERANT	EQUIPMENT COOLANT	Chemicals	R-134A		ICOLP	Mike Zatz ICF Inc (202) 862-1105	Less ODP
CFC-113	ODC Class I	CLEANING	FLUX REMOVER	Chemicals	HCHCs		OC-ALC Chemical Study	Mark Ryan 205 592-0011 ex 4208	
CFC-113	ODC Class I	CLEANING	GYROSCOPE CLEANING	Semi-Aqueous System	Teksol EP		Elec & Prec Cleaning Crossfeed	Steve Hartle/NADEP JAX/904 772-2469	
CFC-113	ODC Class I	CLEANING	HEAVY OILS PRECISION CLEANING	Chemicals	HFE-71DE Azeotrope		1996 Precision Cleaning Conference	Karl Warren/3M/612 733-3735	Being tested by Dunlee Corp
CFC-113	ODC Class I	TESTING	HYDRAULIC FLUID CONTAMINATION TEST	Chemicals	Particle Counter		Int Wkshp on Solvent Substitutes	Cary Roque/NADEP Jacksonville/904 772-4519	Non-ODC
CFC-113	ODC Class I	CLEANING	HYDRAULIC FLUIDS CONTAM TESTING	Chemicals	Particle Counter (HIAC 8000)		EMPF Workshop	Betty Ann Lurton/NADEP/904 452-3175	
CFC-113	ODC Class I	CLEANING	LOX SYSTEMS CLEANING	Chemicals	Trichloroethylene		Elec & Prec Cleaning Crossfeed	Arthur Henderson/NASA-Marshall/205 544-2577	
CFC-113	ODC Class I	LUBRICATES	LUBRICATING RELEASE AGENT		Dry Film Lubricant #6075N		SM-ALC/TIEL LTR	Jack Weddell/SM-ALC/ DSN 633-6151	
CFC-113	ODC Class I	CLEANING	MECHANICAL PARTS CLEANING	Chemicals	Actrel 3338L		ICOLP (Sweden Report)	NAIC/STINFO DSN 787-2435 [Doc # T-0433-93]	
CFC-113	ODC Class I	CLEANING	MECHANICAL PARTS CLEANING	Chemicals	Cleaning Cabinet with Exxol D60		ICOLP (Sweden Report)	NAIC/STINFO DSN 787-2435 [Doc # T-0433-93]	
CFC-113	ODC Class I	CLEANING	MEDICAL DEVICE CLEANING	Chemicals	HFC Solvents Genesolv 3000		Aerospace Haz Mat'l Conf	Ellen Swan/Allied Signal/716 827-6200	0 ODP/non-toxic/low Global
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Aqueous System	Aqueous		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Daraclean 282 (W.R. Grace Inc)	6850-01-364-832	Avionics Cleaning Crossfeed	Glenn Anderson/Corpus Christi Army Depot/861-2660	Tested by Martin Marietta
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	EC-7 Terpene		Avionics Cleaning Crossfeed	Glenn Anderson/Corpus Christi Army Depot/861-2660	Non-ODC
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Electron Solvent	6850-01-371-804	Avionics Cleaning Crossfeed	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Hurrisafe HK 288-A		Avionics Cleaning Crossfeed	Glenn Anderson/Corpus Christi Army Depot/861-2660	Non-ODC
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Pensolv 805		Avionics Cleaning Crossfeed	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Solvall 5234		Avionics Cleaning Crossfeed	Glenn Anderson/Corpus Christi Army Depot/861-2660	Non-ODC
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	TPC Solvent		Avionics Cleaning Crossfeed	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Brominated Hydrocarbons		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	MonochloroToluene/Benzotrifluorides		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Volatile Methyl Siloxanes		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Electron 0296-06	6850-01-375-555	Navy CFC Halon News	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Chemicals	Electron 22	6850-01-371-804	Navy CFC Halon News	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Organic Substances	Organic (esters, ketones,ethers, etc.)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Semi-Aqueous System	Semi-Aqueous (alcohols)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Semi-Aqueous System	Semi-Aqueous (petroleum hydrocarbon)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Semi-Aqueous System	Semi-Aqueous (terpene/surfactant)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	METAL PARTS CLEANING	Semi-Aqueous System	Semi-Aqueous (terpene/surfactant)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	MICRO-CIRCUITS CLEANING	Plasma System	Oxygen-plasma cleaning		Elec & Prec Cleaning Crossfeed	Robert Brunner/AT&T/508 960-2000	
CFC-113	ODC Class I	CLEANING	OPTICS CLEANING	Super Critical Fluids	Supercritical CO2 & Eco-Snow		Elec & Prec Cleaning Crossfeed	John McHardy/Hughes Aircraft/310 615-8674	Faster
CFC-113	ODC Class I	CLEANING	OXYGEN CONVERTER CLEANING	Abrasive Blasting	Baking Soda Blast & Rotojet		Elec & Prec Cleaning Crossfeed	Gordon Heiniger OC-ALC/EMV DSN 884-7071	Used at OC-ALC
CFC-113	ODC Class I	CLEANING	OXYGEN EQUIP & INST CLEANING	Chemicals	Alcohol & Ultrasound		ICOLP (Sweden Report)	NAIC/STINFO DSN 787-2435 [Doc # T-0434-93]	
CFC-113	ODC Class I	CLEANING	OXYGEN EQUIPMENT CLEANING	Chemicals	Trisodium Phosphate- Hot Alkaline Cleaner		ASC/ENEC	Neil Antin Naval Sea Sys Command 703 602-5553	No organic mat'l or oxygen flash pt
CFC-113	ODC Class I	CLEANING	OXYGEN REGULATORS CLEANING	Aqueous System	Aqueous Ultrasonics		Cold Clean& Wipe Crossfeed	Carlos Nazario OC-ALC/LIPEB DSN 336-7246	Used at OC-ALC
CFC-113	ODC Class I	CLEANING	OXYGEN SYSTEM GAGE CLEANING	Chemicals	HFE		JDEP Mtg 27-29 Aug 96	Navy Cherry Point/Stacey Luker/919 466-8142	
CFC-113	ODC Class I	CLEANING	OXYGEN SYSTEMS CLEANING	Chemicals	HFE-A		27-28 Feb 96 LOX Sys Cleaning Mtg	Harold Beeson/NASA/505 524-5592	Being tested by NASA
CFC-113	ODC Class I	CLEANING	OXYGEN SYSTEMS CLEANING	Chemicals	Vertrel MCA w/Nitromethane		27-28 Feb 96 LOX Sys Cleaning Mtg	Harold Beeson/NASA/505 524-5592	Being tested by NASA
CFC-113	ODC Class I	CLEANING	OXYGEN SYSTEMS CLEANING	Chemicals	Brulin 815 GD		NAVAIR 4th Annual P2 Conf	Paul Klien/NAWC/	
CFC-113	ODC Class I	CLEANING	OXYGEN SYSTEMS CLEANING	Chemicals	LPS Noflash Electro Contact Cleaner	7930-01-398-098	OC-ALC/LCR Msg 281427ZMAR95	Jan Goldberg OC-ALC/LIIRC DSN 336-5030	
CFC-113	ODC Class I	CLEANING	OXYGEN SYSTEMS CLEANING	Chemicals	Ethanol w/keytone additive		Oxy Systems Cleaning Crossfeed	Don Hunt/AGMC/CN/DSN 346-7712	Used by Lufthansa Airlines (Germany
CFC-113	ODC Class I	CLEANING	OXYGEN SYSTEMS CLEANING	Chemicals	HCFC-141b		Oxy Systems Cleaning Crossfeed	Harold Beeson/NASA/505 524-5542	
CFC-113	ODC Class I	CLEANING	OXYGEN SYSTEMS CLEANING	Chemicals	HCFC-225		Oxy Systems Cleaning Crossfeed	Harold Beeson/NASA/505 524-5542	
CFC-113	ODC Class I	CLEANING	OXYGEN SYSTEMS CLEANING	Chemicals	Supercritical & Liquid CO2		Oxy Systems Cleaning Crossfeed	Max Phelps/Pacific Northwest Lab/ 509 375-6678	Liquid CO2 provides Shear Forces
CFC-113	ODC Class I	CLEANING	OXYGEN TUBING CLEANING	Aqueous System	Aqueous (emulsion) Cleaning		Elec & Prec Cleaning Crossfeed	Ron Stephenson/Boeing Aerospace/206 773-2635	
CFC-113	ODC Class I	CLEANING	OXYGEN TUBING CLEANING	Aqueous System	Bendix 25-I in ultrasonic bath		Elec & Prec Cleaning Crossfeed	Carlos Nazario/OC-ALC/405 736-7246	
CFC-113	ODC Class I	CLEANING	OXYGEN TUBING CLEANING	Aqueous System	Navy Oxygen Cleaner (NOC) (OCTAGON Process)	6850-01-389-385	Elec & Prec Cleaning Crossfeed	Neil Antin/NAVSEA/703 602-5552 ext 205	
CFC-113	ODC Class I	CLEANING	OXYGEN TUBING CLEANING	Aqueous System	Navy Oxygen Cleaner (NOC) (LABTECH Corp)		NAVSEA Ltr dated 12 Jul 96	Neil Antin/NAVSEA/703 602-5552 ext 205	
CFC-113	ODC Class I	CLEANING	OXYGEN TUBING CLEANING	Chemicals	OCC-RTU (OCTAGON)	6850-01-389-388	Navy CFC Halon News	Neil Antin Naval Sea Sys Cmd 703 602-5552 x205	Tested by NAVSEA
CFC-113	ODC Class I	TESTING	PARTS COOLING	Mechanical Device	Vortex Air Guns		Avionics Cleaning Crossfeed	Patrick Reust/SM-ALC/LICF/DSN 633-3787	Non-ODC
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Aqueous System	Aqueous		Avionics Cleaning Crossfeed	Don Hunt/AGMC/CN/DSN 346-7712	Non-ODC
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Aqueous System	Aqueous		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	C4F9OCH HFE-7100 (1-methoxy-nonafluorobutane)		1996 Precision Cleaning Conference	Karl Warren/3M/612 733-3735	Being tested by NAVSEA & WR-ALC
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	Synergy 3000 CCS		95 Int'l CFC & Halon Alternatives Conf	Mike Powers/Hewlett Packard/707 577-4022	
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	Volatile Methyl Siloxanes (Dow Corning OS-10)		95 Int'l CFC & Halon Alternatives Conf	John Moore/Dow Corning Corp/517 496-5205	
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	Volatile Methyl Siloxanes (Dow Corning OS-20)		95 Int'l CFC & Halon Alternatives Conf	Robert Campbell/AGMC/614 522-8072	
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	Volatile Methyl Siloxanes (Dow Corning OS-20)		95 Int'l CFC & Halon Alternatives Conf	John Moore/Dow Corning Corp/517 496-5205	
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	Volatile Methyl Siloxanes (Dow Corning OS-30)		95 Int'l CFC & Halon Alternatives Conf	John Moore/Dow Corning Corp/517 496-5205	
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	Brominated Hydrocarbons		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	HCFC-123		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	HCFC-225		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	Perfluorocarbons		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	Co-Solvent w/HFE (e.g., AVD)		JANNAF Env Sound Proc Tech Mtg	F. Klink/ 3M (800 235-2376 ext 3119)	Cleans very heavy soils

PROCESSES AND POTENTIAL ALTERNATIVES

CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	HFC-4310 mee		JANNAF Env Sound Proc Tech Mtg	Garry Kennedy/DuPont-Haskell [410 992-7305]	
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	HFE A (C4F9OCH3)		JANNAF Env Sound Proc Tech Mtg	F. Klink/ 3M [800 235-2376 ext 3119]	Well Suited for Vapor Degreasers
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	HFE Azeotrope		JANNAF Env Sound Proc Tech Mtg	F. Klink/ 3M [800 235-2376 ext 3119]	Cleans heavy soils
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Chemicals	HFE B (C4F9OC2H5)		JANNAF Env Sound Proc Tech Mtg	F. Klink/ 3M [800 235-2376 ext 3119]	Removes Flux Residue & Mineral Oil
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Modified Degreaser	RE-ENTRY KNI Solvent - 2000		Halon Conf in Wash DC	Jonathan Harman/Envir Solv Corp/Jacksonville, FL	Low Costs
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Organic Substances	Organic [esters, ketones,ethers, etc.]		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Semi-Aqueous System	Semi-Aqueous [alcohols]		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Semi-Aqueous System	Semi-Aqueous [petroleum hydrocarbon]		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Super Critical Fluids	SuperScrub [Supercritical Fluid]		Int Wkshp on Solvent Substitutes	Dr Garry Garwood/Santa Barbara Res Ctr/805 562-2282	Developed by Hughes
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING	Super Critical Fluids	Super Critical CO2		JDEP Meeting	Don Hunt/AGMC/CN/DSN 346-7712	Machine developed & used by AGMC
CFC-113	ODC Class I	CLEANING	PRECISION CLEANING		CO2 "snow" Cleaning System		Int Wkshp on Solvent Substitutes	Dr Garry Garwood/Santa Barbara Res Ctr/805 562-2282	Developed by Hughes
CFC-113	ODC Class I	CLEANING	PRECISION CLEANNING VALVES	Chemicals	Ethyl Acetate		Martin Marietta PJKS Report	Beth King/Martin Marietta/303 977-8294	Tested by PJKS
CFC-113	ODC Class I	CLEANING	SPOT CLEAN PLASTIC PARTS	Chemicals	Precision Cleaner II		NAVAIR 4th Annual P2 Conf	Ken Clark/NAWC/215 441-1508	
CFC-113	ODC Class I	CLEANING	SPOT CLEANING LANDING GEAR	Organics	Teksol EP [Inland Technology]	6850-01-378-065	Cold Clean& Wipe Crossfeed	Steve Hartle/NADEP Jacksonville/904 772-2469	NDCEE Case Study
CFC-113	ODC Class I	TESTING	TEST HYDRAULIC FLUID [Patch Test]	Electronic Counting	Electronic Particle Counter		Navy Pol Prev Opportunity Handbook	Mary Beth Fennell / NADEP Cherry Pt / 919 466-7396	
CFC-113	ODC Class I	CLEANING	VAPOR DEGREASE ENGINE PARTS	Aqueous System	Daraclean 282		JANNAF Env Sound Proc Tech Mtg	Kelvin Tse/Naval Weapons Station [410 992-7305]	
CFC-113	ODC Class I	CLEANING	VAPOR DEGREASE ENGINE PARTS	Aqueous System	Sprayeze		JANNAF Env Sound Proc Tech Mtg	Kelvin Tse/Naval Weapons Station [410 992-7305]	
CFC-113	ODC Class I	CLEANING	VAPOR DEGREASE ENGINE PARTS	Aqueous System	Turco 6778		JANNAF Env Sound Proc Tech Mtg	Kelvin Tse/Naval Weapons Station [410 992-7305]	
CFC-113	ODC Class I	CLEANING	VAPOR DEGREASE ENGINE PARTS	Chemicals	Biogenic		JANNAF Env Sound Proc Tech Mtg	Kelvin Tse/Naval Weapons Station [410 992-7305]	
CFC-113	ODC Class I	CLEANING	VAPOR DEGREASE ENGINE PARTS	Chemicals	Envirosolv 655		JANNAF Env Sound Proc Tech Mtg	Kelvin Tse/Naval Weapons Station [410 992-7305]	
CFC-113	ODC Class I	CLEANING	WIRE BONDING CLEANING	Aqueous System	DI Spray, Isopropyl Rinse & Nitrogen Blow Dry		Elec & Prec Cleaning Crossfeed	Bruce Adams/Allied-Signal Aerospace/816 997-2000	
CFC-113	ODC Class I	CLEANING	CANOPIES CLEANING	Chemicals	Isopropanol 50% in Water		Cold Clean& Wipe Crossfeed	Tony Phillips Lockheed 817 777-3758	Used by Lockheed
CFC-113	ODC Class I	CLEANING	De-FOD		Boraxo Hand Soap 10% in Water		Cold Clean& Wipe Crossfeed	Tony Phillips Lockheed 817 777-3758	Used by Lockheed
CFC-113	ODC Class I	CLEANING	De-FOD RINSE		Isopropanol 10% in Water		Cold Clean& Wipe Crossfeed	Tony Phillips Lockheed 817 777-3758	Used by Lockheed
CFC-113	ODC Class I	CLEANING	VALUES & TUBING CLEANING		Ultrasonic Immersion Cleaning w/Bioact 280		9th Aerospace HAZMAT Conf	Merritte Ireland/Martin Marietta/303 977-3745	Equal or Better Performance
CFC-113	ODC Class I	CLEANING	WIPING PRODUCTION PARTS	Solvent Blend	DS-104		Cold Clean& Wipe Crossfeed	Tony Phillips Lockheed 817 777-3758	Used on F-16
CFC-114	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HFC-236fa		CFC Halon News, Jun 95 Issue	Mr Greg Toms/NSWC/410 293-3308	NREC developing compresors
CFC-114	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HCFC-124		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-114	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HCFC-142b		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-114	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HFC-227 ea		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-114	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	R200b,c,d,e,f,g,i,j		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-114	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HCFC-124 [SUVA Chill-LP]		Vendor Brochure	DuPont 1-800-441-9450	
CFC-114	ODC Class I	REFRIGERANT	FACILITY AIR CONDITIONING	Chemicals	E-134		PRO-ACT		Used by Navy
CFC-114	ODC Class I	REFRIGERANT	POD REFRIGERATION	Chemicals	HCFC-124		PAVE Tack Fairchild Study	Chuck Anthens, WR-ALC/LYLFE, DSN 468-3452	
CFC-115	ODC Class I	REFRIGERANT	COLD STORAGE WAREHOUSE	Chemicals	Ammonia		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-115	ODC Class I	REFRIGERANT	COLD STORAGE WAREHOUSE	Chemicals	HCFC-22		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-115	ODC Class I	REFRIGERANT	COLD STORAGE WAREHOUSE	Chemicals	HCFC-22/Propane/HFC-125		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-115	ODC Class I	REFRIGERANT	COLD STORAGE WAREHOUSE	Chemicals	HFC-125		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-115	ODC Class I	REFRIGERANT	COLD STORAGE WAREHOUSE	Chemicals	HFC-125/HFC-143a/HFC-134a		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-115	ODC Class I	REFRIGERANT	COLD STORAGE WAREHOUSE	Chemicals	R-200a		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-115	ODC Class I	REFRIGERANT	INDUST PROCESS REFRIGERATION	Chemicals	Ammonia		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-115	ODC Class I	REFRIGERANT	INDUST PROCESS REFRIGERATION	Chemicals	Chlorine		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-115	ODC Class I	REFRIGERANT	INDUST PROCESS REFRIGERATION	Chemicals	HCFC-22		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-115	ODC Class I	REFRIGERANT	INDUST PROCESS REFRIGERATION	Chemicals	HCFC-22/Propane/HFC-125		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-115	ODC Class I	REFRIGERANT	INDUST PROCESS REFRIGERATION	Chemicals	HFC-125/HFC-143a/HFC-134a		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-115	ODC Class I	REFRIGERANT	INDUST PROCESS REFRIGERATION	Chemicals	HFC-134a		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-115	ODC Class I	REFRIGERANT	INDUST PROCESS REFRIGERATION	Chemicals	HFC-143a		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-115	ODC Class I	REFRIGERANT	REFRIGERATION		HCFC-22		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	ODP 0.05
CFC-115	ODC Class I	REFRIGERANT	REFRIGERATION		HP-62		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	Not Regulated
CFC-115	ODC Class I	REFRIGERANT	REFRIGERATION [LM]	Chemicals	AZ50 [Allied]		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	Not Regulated [Zero ODP]
CFC-115	ODC Class I	REFRIGERANT	REFRIGERATION [LM]	Chemicals	Forane FX-70 [Elf-Atochem]		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	Not Regulated [Zero ODP]
CFC-115	ODC Class I	REFRIGERANT	REFRIGERATION [LM]	Chemicals	Forane FX-10 [Elf- Atoclem]		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	ODP 0.023
CFC-115	ODC Class I	REFRIGERANT	REFRIGERATION [LM]	Chemicals	HFC-125		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	Zero ODP
CFC-115	ODC Class I	REFRIGERANT	REFRIGERATION [LM]	Chemicals	KLEA-60 [ICI]		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	Not Regulated [Zero ODP]
CFC-115	ODC Class I	REFRIGERANT	REFRIGERATION [LM]	Chemicals	R-691 [Rhone-Poulenc]		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	ODP 0.028
CFC-115	ODC Class I	REFRIGERANT	REFRIGERATION [LM]	Chemicals	R-69s [Rhone-Poulenc]		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	ODP 0.043
CFC-115	ODC Class I	REFRIGERANT	REFRIGERATION [LM]	Chemicals	SUVA HP-80 [DuPont]		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	ODP 0.030
CFC-115	ODC Class I	REFRIGERANT	REFRIGERATION [LM]	Chemicals	SUVA HP-81 [DuPont]		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	ODP 0.020
CFC-115	ODC Class I	REFRIGERANT	REFRIGERATION [LM]	Chemicals	SUVA HP62 [DuPont]		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	Not Regulated [Zero ODP]
CFC-115	ODC Class I	REFRIGERANT	RETAIL FOOD REFRIGERATION	Chemicals	Ammonia		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-115	ODC Class I	REFRIGERANT	RETAIL FOOD REFRIGERATION	Chemicals	HCFC-22		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-115	ODC Class I	REFRIGERANT	RETAIL FOOD REFRIGERATION	Chemicals	HCFC-22/Propane/HFC-125		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-115	ODC Class I	REFRIGERANT	RETAIL FOOD REFRIGERATION	Chemicals	HFC-125		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-115	ODC Class I	REFRIGERANT	RETAIL FOOD REFRIGERATION	Chemicals	HFC-125/HFC-143a/HFC-134a		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-115	ODC Class I	REFRIGERANT	RETAIL FOOD REFRIGERATION	Chemicals	HFC-143a		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-12	ODC Class I	REFRIGERANT	AUTOMOTIVE AIRCONDITIONING	Chemicals	HFC-134a [Cold-MP w/polyalkylene glycol]		Vendor Brochure	DuPont 1-800-441-9450	
CFC-12	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Absorption	Ammonia-Water		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Absorption	Lithium Bromide-Water		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed

List of potential ODC/HAZMAT alternatives. Identification of an alternative on this list does not endorse its use or authorize deviation from the Tech Order. The single manager must approve changes to Tech Orders.

CFC-12	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Absorption	Lithium Bromide-Water		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	Ammonia		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	Ammonia		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HCFC-123		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HCFC-123		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HCFC-22		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HCFC-22		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HCFC-22/HFC-152a/HCFC-124		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HFC-134a		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HFC-134a		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	CENTRIFUGAL CHILLERS	Chemicals	HFC-227 ea		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-12	ODC Class I	REFRIGERANT	COLD STORAGE WAREHOUSE	Chemicals	Ammonia		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	COLD STORAGE WAREHOUSE	Chemicals	HCFC-22		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	COLD STORAGE WAREHOUSE	Chemicals	HCFC-22/HFC-152a/HCFC-124		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	COLD STORAGE WAREHOUSE	Chemicals	HFC-134a		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	COLD STORAGE WAREHOUSE	Chemicals	HFC-227 ea		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-12	ODC Class I	FAULT ISOLATION	FREEZE SPRAY FOR TROUBLESHOOTING	Pressure Change	High to Low Pressure Stepdown Process		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	FAULT ISOLATION	FREEZE SPRAY FOR TROUBLESHOOTING	Chemicals	HFC-134		Elec & Prec Cleaning Crossfeed	Brent Baumgartner/WR-ALC/912 926-1422	
CFC-12	ODC Class I	REFRIGERANT	GRD FLIGHT LINE AIR CONDITIONING	Chemicals	Vatran CO2 Cold Gun		Elec & Prec Cleaning Crossfeed	Brent Baumgartner/WR-ALC/912 926-1422	
CFC-12	ODC Class I	CLEANING	HAND WIPE PARTS CLEANING	Chemicals	Suva MP39 (Dupont)		Phone Call	Lance Lankford SM-ALC/EMPW DSN 633-0228	Used at SM-ALC
CFC-12	ODC Class I	CLEANING	HAND WIPE PARTS CLEANING	Abrasive Blasting	Sno Gun		TechTIP	Jim Sloan Va-Tran Systems Inc 619 423-4555	Non-ODC
CFC-12	ODC Class I	REFRIGERANT	INDUST PROCESS REFRIGERATION	Chemicals	LIXTON (Soak Rinse & Dry) System		Tech Advisory Team	Chem Tech International Inc 703 549-1001	Little Disassembly
CFC-12	ODC Class I	REFRIGERANT	INDUST PROCESS REFRIGERATION	Chemicals	Ammonia		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	INDUST PROCESS REFRIGERATION	Chemicals	Butane		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	INDUST PROCESS REFRIGERATION	Chemicals	Chlorine		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	INDUST PROCESS REFRIGERATION	Chemicals	HCFC-22		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	INDUST PROCESS REFRIGERATION	Chemicals	HCFC-22/HFC-152a/HCFC-124		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	INDUST PROCESS REFRIGERATION	Chemicals	HFC-134a		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	INSECTICIDE	KILL INSECTS	Chemicals	Propane		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	MOBILE AIR CONDITIONING		PT565 + XLO		SM-ALC/TIEL LTR	Carlos Payne/SM-ALC/ DSN 633-6151	
CFC-12	ODC Class I	REFRIGERANT	MOBILE AIR CONDITIONING	Chemicals	CO2		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-12	ODC Class I	REFRIGERANT	MOBILE AIR CONDITIONING	Chemicals	HCFC-22/HFC-152a/CFC-124		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	MOBILE AIR CONDITIONING	Chemicals	HCFC/HFC/FC Blend		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-12	ODC Class I	TESTING	PARTS COOLING	Evaporative	Evaporative		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-12	ODC Class I	TESTING	PARTS COOLING	Chemicals	HF-134 Microfreeze		Avionics Cleaning Crossfeed	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
CFC-12	ODC Class I	REFRIGERANT	RECIPROCATING CHILLERS	Mechanical Device	Exair Cold Gun		Avionics Cleaning Crossfeed	Brent Baumgartner/WR-ALC/468-1422	Non-ODC
CFC-12	ODC Class I	REFRIGERANT	RECIPROCATING CHILLERS	Chemicals	HCFC-142b		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-12	ODC Class I	REFRIGERANT	RECIPROCATING CHILLERS	Chemicals	HCFC-22		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	RECIPROCATING CHILLERS	Chemicals	HFC-134a		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	RECIPROCATING CHILLERS	Chemicals	HFC-227 ea		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
CFC-12	ODC Class I	REFRIGERANT	RECIPROCATING CHILLERS	Chemicals	HCFC-22		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	REFRIGERANT AUTOMOTIVE	Chemicals	HFC-134a		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	REFRIGERANT AUTOMOTIVE	Azeotropic Mixture	FRIGC		C/KC-135 Pol Prev Status Rept	Capt Troy Lanier/OC-ALC/LAC/405 736-3832	May be drop-in replacement
CFC-12	ODC Class I	REFRIGERANT	REFRIGERANT AUTOMOTIVE	Chemicals	R-276		E-Mail from AFLMA/LGME	Capt Ed Stalker/AFLMA/LGME/205 416-4581	May be drop-in replacement
CFC-12	ODC Class I	REFRIGERANT	REFRIGERANT AUTOMOTIVE	Chemicals	FRIGC-12 (IGC)		E-Mail from Army CECOM	Chris Bolton/Army CECOM RD&E Ctr/703 704-1995	Drop-in being tested at OC-ALC
CFC-12	ODC Class I	REFRIGERANT	REFRIGERANT AUTOMOTIVE	Chemicals	R-405A (G2015 by Greencool)		E-Mail from Army CECOM	Chris Bolton/Army CECOM RD&E Ctr/703 704-1995	May be drop-in replacement
CFC-12	ODC Class I	REFRIGERANT	REFRIGERANT AUTOMOTIVE	Chemicals	R-406A (GHG by Monroe Air Technologies)		E-Mail from Army CECOM	Chris Bolton/Army CECOM RD&E Ctr/703 704-1995	May be drop-in replacement
CFC-12	ODC Class I	REFRIGERANT	REFRIGERATION (LM)	Chemicals	R-409A (FX-56 by Elf Atochem)		E-Mail from Army CECOM	Chris Bolton/Army CECOM RD&E Ctr/703 704-1995	May be drop-in replacement
CFC-12	ODC Class I	REFRIGERANT	REFRIGERATION (MH)	Chemicals	MP-66 (DuPont/Allied)		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	ODP 0.035
CFC-12	ODC Class I	REFRIGERANT	REFRIGERATION (MH)	Chemicals	MP-39 (DuPont/Allied)		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	ODP 0.030
CFC-12	ODC Class I	REFRIGERANT	REFRIGERATION EQUIPMENT	Chemicals	R-134A		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	Not Regulated (Zero ODP)
CFC-12	ODC Class I	REFRIGERANT	REFRIGERATION EQUIPMENT	Chemicals	HFC-134a (SUVA Cold-MP w/PAG)		Vendor Brochure	DuPont 1-800-441-9450	
CFC-12	ODC Class I	REFRIGERANT	REFRIGERATION EQUIPMENT	Chemicals	SUVA MP39 (R-22/HFC-152a/R-124)		Vendor Brochure	DuPont 1-800-441-9450	
CFC-12	ODC Class I	REFRIGERANT	REFRIGERATION EQUIPMENT	Chemicals	SUVA MP52 (R-22/HFC-152a/R-124)		Vendor Brochure	DuPont 1-800-441-9450	
CFC-12	ODC Class I	REFRIGERANT	RETAIL FOOD REFRIGERATION	Chemicals	SUVA MP66 (R-22/HFC-152a/R-124)		Vendor Brochure	DuPont 1-800-441-9450	
CFC-12	ODC Class I	REFRIGERANT	RETAIL FOOD REFRIGERATION	Chemicals	Ammonia		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	RETAIL FOOD REFRIGERATION	Chemicals	HCFC-22/HFC-152a/HCFC-124		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-12	ODC Class I	REFRIGERANT	RETAIL FOOD REFRIGERATION	Chemicals	HFC-134a		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
CFC-13	ODC Class I	REFRIGERANT	REFRIGERATION	Chemicals	HFC-227 ea		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
Chrome	EPA-17	PAINTING	PRIME SURFACE FOR PAINT	Chemicals	R-23		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	Not Regulated
Chromium	EPA-17	SURFACE PREP	ANODIZING ALUMINUM SURFACES	Chemicals	Non-Chromated Aerospace Primer		JDEP Mtg 27-29 Aug 96	NAWC PAX/Tony Eng/301 342-8067	
Chromium	EPA-17	SURFACE PREP	ANODIZING ALUMINUM SURFACES	Chemicals	Alodine 2000 (Parker Amchem)		JG-APP Hughes Report 18 Jan 96	John Tanzola/NDCEE/814 269-6856	Chromate-free
Chromium	EPA-17	SURFACE PREP	ANODIZING ALUMINUM SURFACES	Chemicals	Alumicoat 6788 (Elf Atochem)		JG-APP Hughes Report 18 Jan 96	John Tanzola/NDCEE/814 269-6856	Chromate-free
Chromium	EPA-17	SURFACE PREP	ANODIZING ALUMINUM SURFACES	Chemicals	Boric-sulfuric Acid Anodizing		Navy Pol Prev Opportunity Handbook	Michael Viggiano NFESC Port Hueneme 805 982-4895	Chromate-free
Chromium	EPA-17	SURFACE PREP	ANODIZING ALUMINUM SURFACES	Chemicals	Boric-sulfuric Acid Anodizing		Tech Fact Sheet 112994-20	Jack Adams/NDCEE/814 269-2801	Chromate-free
Chromium	EPA-17	SURFACE PREP	ANODIZING ALUMINUM SURFACES	Chemicals	Phosphoric Acid Anodizing		Tech Fact Sheet 112994-20	Jack Adams/NDCEE/814 269-2801	Chromate-free
Chromium	EPA-17	PAINTING	PAINTING AIRCRAFT	Chemicals	Sulfuric Acid Anodizing		Tech Fact Sheet 112994-20	Jack Adams/NDCEE/814 269-2801	Chromate-free
				Chemicals	Self-Priming Topcoat		9th Aerospace HAZMAT Conf	Thomas Rose/Sikorsky Aircraft/203 386-3619	No Strontium Chromate & less VOC

List of potential ODC/HAZMAT alternatives. Identification of an alternative on this list does not endorse its use or authorize deviation from the Tech Order. The single manager must approve changes to Tech Orders.

PROCESSES AND POTENTIAL ALTERNATIVES

Chromium	EPA-17	PAINTING	PAINTING AIRCRAFT	Chemicals	Plural Component Epoxy Paint Mixing System		Navy Pol Prev Opportunity Handbook	Tony Gomes / NFESC Port Hueneme 805 982-3425	Eliminates premixing of paint
Chromium	EPA-17	PAINTING	PAINTING AIRCRAFT	Chemicals	Unicoat Paint		Navy Pol Prev Opportunity Handbook	Anthony Eng / NAWC Warminster / 215 441-3269	
Chromium	EPA-17	PAINTING	PRIME SURFACE FOR PAINT	Chemicals	Low Density Primer		9th Aerospace HAZMAT Conf	Thomas Rose/Sikorsky Aircraft/203 386-3619	Less Strontium Chromate
Chromium	EPA-17	PAINTING	PRIME SURFACE FOR PAINT	Supercritical CO2	SCCO2 (UNICARB BY Union Carbide Corp)		JDMAG Ltr 23 Mar 95	John Adams/NDCEE/814 269-2855	Reduces VOC emissions
Chromium	EPA-17	SEALING	SEALING ANODIZED ALUMINUM	Chemicals	Alumitec D		9th Aerospace HAZMAT Conf	Garson Shulman/Alumitec Products Corp/310 793-9861	Eliminates Hexavalent Chrome
Chromium	EPA-17	SURFACE PREP	ALODINING OF METAL PARTS	Chemicals	Foaming Alcoholic Phosphoric Acid		9th Aerospace HAZMAT Conf	Luis Trupia/Grumman A/C Systems/516 575-7923	
Chromium	EPA-17	SURFACE PREP	ALODINING OF METAL PARTS				OC-ALC Chemical Study	Mark Ryan 205 592-0011 ex 4208	
Chromium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	Heavy Metals Ion Vapor Deposition		25Mar96 WL Chrom Plat White Paper	Lt Ray Smith AL/EQ 904 283-6462	
Chromium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	Super D-Gun Coating		25Mar96 WL Chrom Plat White Paper	John Falkowski 206 965-3828	Improves Fatigue; Boeing Evaluated
Chromium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	Plasma Source Ion Implantation (PSII)		25Mar96 WL Chrom Plat White Paper	Jay Scheuer 505 665-6525	Non-line of Sight; Fac in Los Alamos
Chromium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	Ni-W-B (AMPLATE)		25Mar96 WL Chrom Plat White Paper	Ahmet Palazoglu 916 752-8774	
Chromium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	Very Hard Electroless Nickel Deposits		25Mar96 WL Chrom Plat White Paper	Kent Dickie, PhD 216 441-4900 ex 5529	
Chromium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	High Velocity Oxy-Fuel (HVOF)		25Mar96 WL Chrom Plat White Paper	Neil Sylvestre 703 883-5708	
Chromium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	Ion-beam Assisted Deposition (IBAD)		25Mar96 WL Chrom Plat White Paper	John Beatty, PhD 410 516-4748	Evaluation by Army Research Lab
Chromium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	Rail Gun Electromagnetic Powder Spray Technology		25Mar96 WL Chrom Plat White Paper	Grizelda Kraft 405 736-2325	
Chromium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	Laser Surface Treatment w/Cr/Ni Organo-Metallic		25Mar96 WL Chrom Plat White Paper	Rob Hull 513 255-2334	
Chromium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	PCAP Thermal Spray w/VERSAlloy 50		25Mar96 WL Chrom Plat White Paper	Lt Ray Smith 904 283-6462	Demo at NDCEE in Johnstown, PA
Chromium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	High Velocity Oxy-Fuel (HVOF) Thermal Spray		Navy Pol Prev Opportunity Handbook	Michael Viggiano NFESC Port Hueneme 805 982-4895	
Chromium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	High Velocity Oxy-Fuel (HVOF)		OO-ALC/LN 12 Jun 95 Memo	Mark Child OO-ALC/LILEP DSN 777-2558	Being tested at OO-ALC
Chromium	EPA-17	PLATING	PLATING OF METAL PARTS	Metal Depositing	Cobalt Alloy Electroplating		Waste Reduction Resource Ctr Rpt	Waste Reduction Resource Center 800 476-8686	Complex parts & Wear Resistance
Chromium	EPA-17	PAINTING	PRIME SURFACE FOR PAINT	Chemicals	Molybdate Compounds		1995 AF Worldwide P2 Conf	Stiles Thompson/Eglin AFB/904 678-2001	Best on stainless steel & titanium
Chromium	EPA-17	PAINTING	PRIME SURFACE FOR PAINT	Chemicals	Molybdate Compounds		Tech Abstract 71495-82	Jack Adams/NDCEE/814 269-2801	Organic emulsion sealing improves it
Cyanide	EPA-17	BONDING	BONDING SOFT RUBBER		Non Cyanoacrylate Adhesives		OC-ALC Chemical Study	Mark Ryan 205 592-0011 ex 4208	
Cyanide	EPA-17	PLATING	PLATING SOLUTIONS	Metal Depositing	Electroless Nickel		Tech Advisory Team	Mike Patry OC-ALC/LPPNP DSN 336-5185	Less Hazardous
Cyanide	EPA-17	PLATING	PLATING SOLUTIONS	Metal Depositing	Electromagnetic Powder Deposition		Tech Advisory Team	Glen Graham OC-ALC/LPPNP DSN 336-2635	Less Hazardous & Low Temp
Cyanide	EPA-17	PLATING	PLATING SOLUTIONS	Metal Depositing	Ion Vapor Deposition (IVD)		Tech Advisory Team	Marty Sedgwick WR-ALC/TIBO DSN 468-4800	Less Hazardous
Cyanide	EPA-17	PLATING	PLATING SOLUTIONS	Metal Depositing	Non-Cyanide Solutions		Tech Advisory Team	Debra Mital SM-ALC/SGB DSN 633-0311 ext 312	Less Hazardous
Cyanide	EPA-17	PLATING	PLATING SOLUTIONS	Metal Depositing	Plasma Spray		Tech Advisory Team	Nancy Strapper SA-ALC/TIESM DSN 945-5338	Less Hazardous
Cyanide	EPA-17	PLATING	STRIPPING NICKEL	Metal Depositing	Non-Cyanide Solutions		Navy Pol Prev Opportunity Handbook	Michael Viggiano NFESC Port Hueneme 805 982-4895	
Cyanide	EPA-17	WATERPROOFING	WATERPROOF CANVAS	Chemicals	Fastbond 2000-NF		3M Vendor Data	Bob Norris/3M Fed Sys Dept/612 736-8236	non-ODC, low haps & sets fast
Ethylene Glycol	TRI Section 313	DEICING	DEICE AIRCRAFT	Chemicals	Propylene glycol		Deicing & Anti-icing Crossfeed	Octagon/Jane Hinkle/201 945-9400	
Ethylene Glycol	TRI Section 313	DEICING	DEICE AIRCRAFT	Chemicals	Propylene glycol		Proposed Project LM9416500	Joyce Ross/HQ USAF/LGMM/DSN 225-0844	
Ethylene Glycol	TRI Section 313	DEICING	DEICE AIRCRAFT	Mechanical	Deicing Truck w/Air Blast		Deicing & Anti-icing Crossfeed	Navy Lakehurst/Lt Felipe Lopez/908 323-4702	Reduces use of glycol
Ethylene Glycol	TRI Section 313	DEICING	DEICE AIRCRAFT	Radiate Energy	Radiant Heat		Deicing & Anti-icing Crossfeed	Process Technologies/John Chew/716 662-0022	Reduces use of glycol
Ethylene Glycol	TRI Section 313	DEICING	DEICE AIRPLANE RUNWAY	Chemicals	E36 Runway Deicer	850-01-341-9855	DGSC "Envir Safe Chem Alter"	DGSC Market'g Off 1-800-352-2852 & DSN 695-6054	
Glycol	TRI Section 313	CLEANING	CLEANING ENGINE AIR PASSAGES	Chemicals	TC-100	850-01-370-5244	C/KC-135 Pol Prev Status Rept	Capt Troy Lanier/OC-ALC/LACRA/405 736-3832	
Halon 1211	ODC Class I	FIRE SUPPRESSION	AIRCRAFT CRASH & RESCUE TRUCKS	Chemicals	Halotron I (blend of HCFC 123 & two other gases)		JDMAG & HQ AMC E-Mail Msg	Carl Adams JDMAG/MAT/513 296-8295	Tested by FAA & Military
Halon 1211	ODC Class I	FIRE SUPPRESSION	JET ENGINE FIRE EXTINGUISHING	Chemicals	Dry Chemical Spray		HQ ATC Message	J. Johnston HQ ATC/LGMAJ DSN 487-4981	Non-ODC
Halon 1211	ODC Class I	FIRE SUPPRESSION	JET ENGINE FIRE EXTINGUISHING	Foaming Agent	Detergent Foam		HQ ATC Message	J. Johnston HQ ATC/LGMAJ DSN 487-4981	Non-ODC
Halon 1211	ODC Class I	FIRE SUPPRESSION	JET ENGINE FIRE EXTINGUISHING	Organic Substances	Animal Protein		HQ ATC Message	J. Johnston HQ ATC/LGMAJ DSN 487-4981	Non-ODC
Halon 1211	ODC Class I	FIRE SUPPRESSION	MILITARY APPLICATION	Chemicals	Carbon Dioxide		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1211	ODC Class I	FIRE SUPPRESSION	MILITARY APPLICATION	Chemicals	CFC-Blend (NAF P)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1211	ODC Class I	FIRE SUPPRESSION	MILITARY APPLICATION	Chemicals	Dry Chemical		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1211	ODC Class I	FIRE SUPPRESSION	MILITARY APPLICATION	Chemicals	FC-5-1-14		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1211	ODC Class I	FIRE SUPPRESSION	MILITARY APPLICATION	Chemicals	Foam		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1211	ODC Class I	FIRE SUPPRESSION	MILITARY APPLICATION	Chemicals	HBFC-2281 (FM-100)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1211	ODC Class I	FIRE SUPPRESSION	MILITARY APPLICATION	Chemicals	HBFC-2281/HFC-227ea		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
Halon 1211	ODC Class I	FIRE SUPPRESSION	MILITARY APPLICATION	Chemicals	HCFC Blend B (Halotron I)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1211	ODC Class I	FIRE SUPPRESSION	MILITARY APPLICATION	Chemicals	HCFC-123		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1211	ODC Class I	FIRE SUPPRESSION	MILITARY APPLICATION	Chemicals	HFC-227ea (FM-200)		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
Halon 1211	ODC Class I	FIRE SUPPRESSION	MILITARY APPLICATION	Chemicals	Water		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1211	ODC Class I	FIRE SUPPRESSION	MILITARY APPLICATION	Chemicals	FE-232 (CHCL2-CF3)		PRO-ACT		Used by Navy
Halon 1211	ODC Class I	FIRE SUPPRESSION	MILITARY APPLICATION	Chemicals	FM-100 (CF2BrH)		PRO-ACT		Used by Navy
Halon 1211	ODC Class I	FIRE SUPPRESSION	MILITARY APPLICATION	Chemicals	Perfluorohexane (C6F14)		PRO-ACT		Used by Navy
Halon 1211	ODC Class I	FIRE SUPPRESSION	PORTABLE AIRCRAFT EXTINGUISHERS	Chemicals	CO2 potable extinguisher		Navy CID review package	Don MacElwee/POWSUS/215 296-2237	Non--ODC
Halon 1211	ODC Class I	FIRE SUPPRESSION	PORTABLE EXTINGUISHERS	Chemicals	CEA-614		95 Int'l CFC & Halon Alternatives Conf	John Chorba/3M/612 736-7569	
Halon 1211	ODC Class I	FIRE SUPPRESSION	PORTABLE EXTINGUISHERS	Chemicals	FE-241 (DuPont)		95 Int'l CFC & Halon Alternatives Conf	Daniel Moore/DuPont/302 992-2177	
Halon 1211	ODC Class I	FIRE SUPPRESSION	PORTABLE EXTINGUISHERS	Chemicals	FE-36 (DuPont)		95 Int'l CFC & Halon Alternatives Conf	Daniel Moore/DuPont/302 992-2177	
Halon 1211	ODC Class I	FIRE SUPPRESSION	PORTABLE EXTINGUISHERS	Chemicals	FM-200 (Great Lakes Chemical Corp)		95 Int'l CFC & Halon Alternatives Conf	Gerald Walter/Fluorine Chemicals/ 317 497-6291	
Halon 1211	ODC Class I	FIRE SUPPRESSION	PORTABLE EXTINGUISHERS	Chemicals	Halotron I (Halotron Inc)		95 Int'l CFC & Halon Alternatives Conf	Jeff Gibson/Halotron Inc/ 702 735-2200	
Halon 1211	ODC Class I	FIRE SUPPRESSION	PORTABLE EXTINGUISHERS	Chemicals	NAF P-III		95 Int'l CFC & Halon Alternatives Conf	Elio Guglielmi/No Amer Fire Guardian Tech/604 684-7374	
Halon 1211	ODC Class I	FIRE SUPPRESSION	PORTABLE EXTINGUISHERS	Chemicals	Triodide (CF3I)		95 Int'l CFC & Halon Alternatives Conf	James Davis/HTL Kin-Tec Div/ 302 633-1045	
Halon 1211	ODC Class I	FIRE SUPPRESSION	PORTABLE EXTINGUISHERS	Chemicals	PGATM (EnvirogelTM) (POWSUS)		NAVSEA E-Mail Message	Don MacElwee/POWSUS/215 296-2237	
Halon 1301	ODC Class I	FIRE SUPPRESSION	AIRCRAFT FIRE EXTINGUISHING	Chemicals	Fluoroiodocarbon & Other Chem Blends		OC-ALC/LAKR Facsimile	Lance Lankford SM-ALC/EMPW DSN 633-3672	Stable & Non-ODC
Halon 1301	ODC Class I	FIRE SUPPRESSION	AIRCRAFT FIRE EXTINGUISHING		FC-116 (C2F6)		Lockheed at Halon Meeting	Maj Samuel Carbaugh WL/FIVS DSN 785-6823	Evaluated for C-5 Aircraft
Halon 1301	ODC Class I	FIRE SUPPRESSION	AIRCRAFT FIRE EXTINGUISHING		FC-218 (C3F8)		Lockheed at Halon Meeting	Maj Samuel Carbaugh WL/FIVS DSN 785-6823	Evaluated for C-5 Aircraft
Halon 1301	ODC Class I	FIRE SUPPRESSION	AIRCRAFT FIRE EXTINGUISHING		FC-3-1-10 (C4F10)		Lockheed at Halon Meeting	Maj Samuel Carbaugh WL/FIVS DSN 785-6823	Evaluated for C-5 Aircraft
Halon 1301	ODC Class I	FIRE SUPPRESSION	AIRCRAFT FIRE EXTINGUISHING		FC-318 (CYCLO-C4F8)		Lockheed at Halon Meeting	Maj Samuel Carbaugh WL/FIVS DSN 785-6823	Evaluated for C-5 Aircraft

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Halon 1301	ODC Class I	FIRE SUPPRESSION	AIRCRAFT FIRE EXTINGUISHING		HCFC-124 (C2HF4CL)		Lockheed at Halon Meeting	Maj Samuel Carbaugh WL/FIVS DSN 785-6823	Evaluated for C-5 Aircraft
Halon 1301	ODC Class I	FIRE SUPPRESSION	AIRCRAFT FIRE EXTINGUISHING		HFC-125 (FE-25) (C2HF5)		Lockheed at Halon Meeting	Maj Samuel Carbaugh WL/FIVS DSN 785-6823	Evaluated for C-5 Aircraft
Halon 1301	ODC Class I	FIRE SUPPRESSION	AIRCRAFT FIRE EXTINGUISHING		HFC-134a (C2H2F4)		Lockheed at Halon Meeting	Maj Samuel Carbaugh WL/FIVS DSN 785-6823	Evaluated for C-5 Aircraft
Halon 1301	ODC Class I	FIRE SUPPRESSION	AIRCRAFT FIRE EXTINGUISHING		HFC-22 (CHF2CL)		Lockheed at Halon Meeting	Maj Samuel Carbaugh WL/FIVS DSN 785-6823	Evaluated for C-5 Aircraft
Halon 1301	ODC Class I	FIRE SUPPRESSION	AIRCRAFT FIRE EXTINGUISHING		HFC-227 (FM-200) (C3HF7)		Lockheed at Halon Meeting	Maj Samuel Carbaugh WL/FIVS DSN 785-6823	Proposed for C-5 Aircraft
Halon 1301	ODC Class I	FIRE SUPPRESSION	AIRCRAFT FIRE EXTINGUISHING		HFC-32 (CH2F2)		Lockheed at Halon Meeting	Maj Samuel Carbaugh WL/FIVS DSN 785-6823	Evaluated for C-5 Aircraft
Halon 1301	ODC Class I	FIRE SUPPRESSION	AIRCRAFT FIRE EXTINGUISHING		HFC-32/HFC-125 (CH2F2/CHF2CF3)		Lockheed at Halon Meeting	Maj Samuel Carbaugh WL/FIVS DSN 785-6823	Evaluated for C-5 Aircraft
Halon 1301	ODC Class I	FIRE SUPPRESSION	COMPUTER ROOM FIRE SUPPRESSION	Chemicals	Inert Gas Blend (Inergen) (R-595)		Vendor Information	Mark Pillow/Ansul/812 474-1511	Safe to People & Electronics
Halon 1301	ODC Class I	FIRE SUPPRESSION	EXPLOSION INERTING	Chemicals	HCFC Blend (NAF SIII)		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
Halon 1301	ODC Class I	FIRE SUPPRESSION	TOTAL FLOOD & EXPLOSION INERTING	Chemicals	HBFC-2281 (FM-100)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1301	ODC Class I	FIRE SUPPRESSION	TOTAL FLOOD & EXPLOSION INERTING	Chemicals	HFC-23 (FE-13)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1301	ODC Class I	FIRE SUPPRESSION	TOTAL FLOOD & EXPLOSION INERTING	Chemicals	Inert Gas Blend (Inergen)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1301	ODC Class I	FIRE SUPPRESSION	TOTAL FLOOD OCC & UNOCCUPIED	Chemicals	Carbon Dioxide		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1301	ODC Class I	FIRE SUPPRESSION	TOTAL FLOOD OCC & UNOCCUPIED	Chemicals	HCFC Blend (NAF SIII)		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1301	ODC Class I	FIRE SUPPRESSION	TOTAL FLOOD OCC & UNOCCUPIED	Chemicals	HCFC-124		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1301	ODC Class I	FIRE SUPPRESSION	TOTAL FLOOD OCC & UNOCCUPIED	Chemicals	HCFC-22		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1301	ODC Class I	FIRE SUPPRESSION	TOTAL FLOOD OCC & UNOCCUPIED	Chemicals	HFC-134a		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1301	ODC Class I	FIRE SUPPRESSION	TOTAL FLOOD OCC & UNOCCUPIED	Chemicals	Water		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
Halon 1301	ODC Class I	FIRE SUPPRESSION	TOTAL FLOOD OCC & UNOCCUPIED	Chemicals	Water Mist/Fog		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
Halon 1301	ODC Class I	FIRE SUPPRESSION	TOTAL FLOOD OCCUPIED	Chemicals	HFC-125		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
Halon 1301	ODC Class I	FIRE SUPPRESSION	TOTAL FLOOD OCCUPIED	Chemicals	HBFC-2281(FM-100)/HFC-227ea(FM-200)		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
Halon 1301	ODC Class I	FIRE SUPPRESSION	TOTAL FLOOD OCCUPIED	Chemicals	HFC-32		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
Halon 1301	ODC Class I	FIRE SUPPRESSION	TOTAL FLOOD OCCUPIED & EXP INERT	Chemicals	SF6 (Discharge Test)		EPA SNAP Program	EPA Hotline 800 296-1996	Pending EPA SNAP Listing
Halon 1301	ODC Class I	FIRE SUPPRESSION	TOTAL FLOOD UNOCC & EXP INERTING	Chemicals	HFC-125		EPA SNAP Program	EPA Hotline 800 296-1996	EPA SNAP Listed
HCFC-22	ODC Class II	REFRIGERANT	AIRCONDITIONING	Chemicals	SUVA AC9000 (HFC-32/HFC-125a/HFC-134a)		Vendor Brochure	DuPont 1-800-441-9450	
HCFC-22	ODC Class II	REFRIGERANT	REFRIGERATION (MH)	Chemicals	AZ20 (Allied)		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	Not Regulated (Zero ODP)
HCFC-22	ODC Class II	REFRIGERANT	REFRIGERATION (MH)	Chemicals	KLEA-66		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	Not Regulated (Zero ODP)
HCFC-22	ODC Class II	REFRIGERANT	REFRIGERATION (MH)	Chemicals	SUVA AC9000 (DuPont)		SA-ALC/TI Waiver	Vincent Zapata/SA-ALC/TI DSN 945-7841	Not Regulated (Zero ODP)
Isocyanate	AFMC HIT LIST	COATINGS	AIRCRAFT PAINTING		Pre-polymerized Polyurethane		Tech Advisory Team	Capt Carolyn Westmark WL/MLSA DSN 785-3637	
Lead	EPA-17	SEALING	COMPONENT OF SEALANT	Chemicals	Lead Free Sealants		Tech Advisory Team	John Vidic OO-ALC/LAOPE DSN 458-2050	Less Hazardous
Methyl Ethyl Ketone	EPA-17	CLEANING	CLEAN AIRCRAFT SURFACES	Chemicals	MA-102MF Aircraft Cleaning Compound (JAD)	6850-01-378-042	Navy Pol Prev Opportunity Handbook	Hazardous Technical Info Services 804 209-5168	Leaves No Residue
Methyl Ethyl Ketone	EPA-17	CLEANING	CLEANING BOOM SIGNAL COILS	Chemicals	Isopropyl Alcohol		C/KC-135 Pol Prev Status Rept	Capt Troy Lanier/OC-ALC/LACRA/405 736-3832	
Methyl Ethyl Ketone	EPA-17	CLEANING	ENGINES DEGREASING	Chemicals	Gunk EB-8		Vendor Brochure	Radiator Specialty Co 704 377-6555	ODC free
Methyl Ethyl Ketone	EPA-17	CLEANING	EXPOXY ADHESIVE REMOVAL	Chemicals	M-PYROL		Cold Clean& Wipe Crossfeed	Dave Leeson/SA-ALC/EMP/945 3100 EX 206	Tested by SA-ALC
Methyl Ethyl Ketone	EPA-17	CLEANING	GASKET & SEALANT REMOVAL	Chemicals	Benzyl Alcohol		Cold Clean& Wipe Crossfeed	Paul Hughes SA-ALC/EMP DSN 945-3100	Being tested by SA-ALC
Methyl Ethyl Ketone	EPA-17	CLEANING	GASKET & SEALANT REMOVAL	Chemicals	Ethanolamine		Cold Clean& Wipe Crossfeed	Paul Hughes SA-ALC/EMP DSN 945-3100	Being tested by SA-ALC
Methyl Ethyl Ketone	EPA-17	CLEANING	GASKET & SEALANT REMOVAL	Chemicals	N-methylpyrrolidone		Cold Clean& Wipe Crossfeed	Paul Hughes SA-ALC/EMP DSN 945-3100	Being tested by SA-ALC
Methyl Ethyl Ketone	EPA-17	CLEANING	HAND WIPE PARTS CLEANING	Solvent Blend	DS-104 Wipe Solvent		PRO-ACT	Dynamold Solvents Inc 817 335-0862	
Methyl Ethyl Ketone	EPA-17	CLEANING	METAL PARTS CLEANING	Aqueous System	Parts Washers		Tech Advisory Team	Martin Chatanett OC-ALC/LPPNP DSN 336-2635	No Hazardous Chemicals
Methyl Ethyl Ketone	EPA-17	CLEANING	METAL PARTS CLEANING	Chemicals	UBIX 0092		Cold Clean& Wipe Crossfeed	Susie Barney OO-ALC/TIELM DSN 924-2994	Being tested by OO-ALC
Methyl Ethyl Ketone	EPA-17	CLEANING	METAL PARTS CLEANING	Chemicals	Exxate Solvents (Aliphatic Esters)		PRO-ACT	Exxon Chemical Co 800 526-0749 ext 6955	Low Corrosivity
Methyl Ethyl Ketone	EPA-17	CLEANING	METAL PARTS CLEANING	Chemicals	Acetone		Tech Advisory Team	Glenn McCall WR-ALC/TIELC DSN 468-4930	Less Hazardous
Methyl Ethyl Ketone	EPA-17	CLEANING	METAL PARTS CLEANING	Chemicals	Acidic Cleaner		Tech Advisory Team	Glenn McCall WR-ALC/TIELC DSN 468-4930	No Environmental Hazard
Methyl Ethyl Ketone	EPA-17	CLEANING	METAL PARTS CLEANING	Chemicals	Calla 800 (alkaline water based cleaner)		Tech Advisory Team	Calla Chemical Operations 713 599-7473	Non-corrosive
Methyl Ethyl Ketone	EPA-17	CLEANING	METAL PARTS CLEANING	Chemicals	DOT-111/113		Tech Advisory Team	Lt Jay Gendron SA-ALC/TIESM DSN 945-8745	Light Cleaning
Methyl Ethyl Ketone	EPA-17	CLEANING	METAL PARTS CLEANING	Chemicals	Isopropyl Alcohol		Tech Advisory Team	Lt Jay Gendron SA-ALC/TIESM DSN 945-8745	
Methyl Ethyl Ketone	EPA-17	CLEANING	METAL PARTS CLEANING	Chemicals	UBIX 0092		Tech Advisory Team	Gus Zacharjades SA-ALC DSN 945-7613	Non-corrosive & no residue
Methyl Ethyl Ketone	EPA-17	CLEANING	METAL PARTS CLEANING	Chemicals	World Enzyme Cleaner 109		Tech Advisory Team	Glenn McCall WR-ALC/TIELC DSN 468-4930	No Environmental Hazard
Methyl Ethyl Ketone	EPA-17	CLEANING	PAINT GUNS & EQUIPMENT CLEANING	Chemicals	EP-921	6850-01-381-330	Boeing Case Study	Inland Technology Inc 206 922-8932	Effective & Mimics MEK
Methyl Ethyl Ketone	EPA-17	CLEANING	PAINT GUNS & EQUIPMENT CLEANING	Chemicals	Foamflush	6850-01-383-303	DGSC "Envir Safe Chem Alter"	DGSC Market'g Off 1-800-352-2852 & DSN 695-6054	
Methyl Ethyl Ketone	EPA-17	CLEANING	PAINT GUNS & EQUIPMENT CLEANING	Chemicals	FORMULA RX 700PLC		XXCEL Tech Ltd	XXCEL Technology Ltd (714) 492-3559	Low VOC & Recycleable
Methyl Ethyl Ketone	EPA-17	PAINTING	PAINTING AIRCRAFT	Chemicals	Airborne Topcoat		JG-APP Texas Instru Report 20 Mar 9	John Tanzola/NDCEE/814 269-6856	Low VOC
Methyl Ethyl Ketone	EPA-17	PAINTING	PAINTING AIRCRAFT	Chemicals	High Solids Polyurethane w/Methyl amyl ketone		MDA Envir Tech Notes, Aug 95	John DeAntoni/MDA/314 232-2198	Low VOC
Methyl Ethyl Ketone	EPA-17	PAINTING	PAINTING GROUND SUPPORT EQUIPMENT	Chemicals	Ground Support Topcoat		JG-APP Texas Instru Report 20 Mar 9	John Tanzola/NDCEE/814 269-6856	Lead & chromate free; low VOC
Methyl Ethyl Ketone	EPA-17	PAINTING	PRIME SURFACE FOR PAINT	Chemicals	Waterborne Primer		JG-APP Texas Instru Report 20 Mar 9	John Tanzola/NDCEE/814 269-6856	Low VOC
Methyl Ethyl Ketone	EPA-17	STRIPPING	RADOME STRIPPING	Chemicals	PC Blend		1995 AF Worldwide P2 Conf	Johnny Springer, Jr/EPA Cincinnati/513 569-7542	
Methyl Ethyl Ketone	EPA-17	STRIPPING	RADOME STRIPPING	Chemicals	PC Blend 2		Int Wkshp on Solvent Substitutes	Johnny Springer, Jr/EPA Cincinnati/513 569-7542	Evaluated by EPA for OC-ALC
Methyl Ethyl Ketone	EPA-17	STRIPPING	RADOME STRIPPING/REPAIR	Abrasive Blasting	Wheat Starch		Tech Advisory Team	John Vidic OO-ALC/LAOPE DSN 458-2050	Minimal Surface Damage
Methyl Ethyl Ketone	EPA-17	STRIPPING	RADOME STRIPPING/REPAIR	Radiate Energy	Laser Stripping		Tech Advisory Team	John Vidic OO-ALC/LAOPE DSN 458-2050	Less Waste & Controllability
Methyl Ethyl Ketone	EPA-17	CLEANING	REMOVE BEAD BLAST RESIDUE	Solvent Blend	DS-108		Cold Clean& Wipe Crossfeed	Dale Casper/OO-ALC/TIELM/DSN 924-2483	Tested by OO-ALC
Methyl Ethyl Ketone	EPA-17	CLEANING	SEALANT REMOVAL	Chemicals	DS-108		McDonnell Douglas P2 Review	Alice Garcia/McDonnell Douglas/314 232-9009	Tested by McDonnell Douglas
Methyl Ethyl Ketone	EPA-17	CLEANING	SEALANT REMOVAL	Chemicals	Shopmaster RC		McDonnell Douglas P2 Review	Alice Garcia/McDonnell Douglas/314 232-9009	
Methyl Ethyl Ketone	EPA-17	CLEANING	SEALANT REMOVAL (Uncured Polysulfide)	Chemicals	M-PYROL		Cold Clean& Wipe Crossfeed	Dave Leeson/SA-ALC/EMP/945 3100 EX 206	Tested by SA-ALC
Methyl Ethyl Ketone	EPA-17	CLEANING	SEALANT REMOVAL, UNCURED	Solvent Blend	DS-108		Cold Clean& Wipe Crossfeed	Dale Casper/OO-ALC/TIELM/DSN 924-2483	Tested by OO-ALC
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING	Solvent Blend	FMS-2004 (DS-104)		Cold Clean& Wipe Crossfeed	Steve Evanoff/Lockheed/702 897-3228	Tested by Lockheed
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING AIRCRAFT PARTS	Chemicals	Actrel 3349L (Exxon)		Int Wkshp on Solvent Substitutes	D. D. Currie/Vought Aircraft Co/214 266-5280	Evaluated by Vought
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING AIRCRAFT PARTS	Chemicals	DS-108 (Dynamold)		Int Wkshp on Solvent Substitutes	D. D. Currie/Vought Aircraft Co/214 266-5280	Evaluated by Vought
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING FOR BONDING	Solvent Blend	Desoclean 45		McD Douglas ODS Qtrly Report #5	Larry Sanders/McDonnell Douglas/ 314 233-9809	Tested by McDonnell Douglas

List of potential ODC/HAZMAT alternatives. Identification of an alternative on this list does not endorse its use or authorize deviation from the Tech Order. The single manager must approve changes to Tech Orders.

Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Aqueous System	3D Supreme		Rockwell Solvents Study	3D Inc	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Aqueous System	Amberclean L12		Rockwell Solvents Study	Innovative Organics 714 771-9225	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Aqueous System	Ardrox 405-V		Rockwell Solvents Study	Ardrox 714 739-2821	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Aqueous System	Diana HS1000		Rockwell Solvents Study	Diana 800 343-5325	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Aqueous System	Hurrisafe		Rockwell Solvents Study	O.C.S. MFG Co 818 458-2471	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Aqueous System	Metalube 4U		Rockwell Solvents Study	Metalube 310 869-7273	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Aqueous System	RB Degreaser		Rockwell Solvents Study	Environmental Tech 407 321-7910	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Aqueous System	Shopmaster		Rockwell Solvents Study	Buckeye 314 291-1900	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Aqueous System	Turco 3878		Rockwell Solvents Study	Turco 714 890-3600	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Chemicals	MA 102	6850-01-378-040	Haz Tech Info Services	JAD Chemical Inc	No residue on aircraft surface
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Chemicals	Strip 2000 (Brulin)		SM-ALC Solvents Test Reprt	Cheryl Brandt SM-ALC/LIHM DSN 633-5026	Tested by SM-ALC
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	d-Limonene	BIO T MAX	6850-01-381-378	Rockwell Solvents Study	Petroferm Inc 904 261-8286	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	d-Limonene	Citra Safe	6850-01-378-088	Rockwell Solvents Study	Inland Technology 800 552-3100	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Glycol Ether	Brulin 1291		Rockwell Solvents Study	Brulin Co 714 751-4853	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Hydrocarbon	BIO ACT 240		Rockwell Solvents Study	Petroferm Inc 904 261-8286	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Hydrocarbon	De-Solve-it 241		Rockwell Solvents Study	Orange-Sol Inc 800 877-7771	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Hydrocarbon	Dynasolve 108		Rockwell Solvents Study	Dynamold 314 872-3191	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Hydrocarbon	EPA 2000	6850-01-359-921	Rockwell Solvents Study	Western Chemical Intl 602 990-9487	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Hydrocarbon	PF 145 HP	6850-01-377-936	Rockwell Solvents Study	PT Tecnologies 800 441-7874	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Solvent Blend	Desoclean 45		Rockwell Solvents Study	Desoto 714 848-7051	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPE CLEANING OPERATIONS		Desoclean 20		Rockwell Solvents Study	Desoto 714 848-7051	Tested by Rockwell
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	Aqueous System	Ardrox 1900-BD		Rockwell Solvents Study	Ardrox 714 739-2821	Removes dye, ink & rosin flux
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	Chemicals	Safety Prep	6850-01-381-513	PRO-ACT	Inland Technology Inc 1-800-552-3100	Low VOC & Biodegradable
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	Chemicals	Acidic Cleaner		Tech Advisory Team	John Lindsey WR-ALC/TIELN DSN 468-1287	No Environmental Hazard
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	Chemicals	Deso Clean 50 Organic Cleaner		Tech Advisory Team	Eric Gardner SM-ALC/SGB DSN 633-0311	Less hazardous & low VOC
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	Chemicals	DS-108 Wipe Solvent		Tech Advisory Team	Steven Evenoff Lockheed 817 777-3772	Less Hazardous
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	Chemicals	Enzyme Cleaner		Tech Advisory Team	Lt Jay Gendron SA-ALC/TIESM DSN 945-8745	Used on C-5 & B-52
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	Chemicals	PENAIR PSA-2		Telephone Discussion	John Vidic OO-ALC/LAOPE DSN 458-2050	
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	Hydrocarbon	ADL Enhanced		Rockwell Solvents Study	Orange-Sol Inc 800 877-7771	Good Adhesion Results
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	NMP	X-Caliber		Rockwell Solvents Study	Inland Technology Inc 1-800-552-3100	Removes dye & ink
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	77X004		Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	Axarel 2200		Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	Axarel 6100		Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	Citra Safe	6850-01-378-061	Cold Clean& Wipe Crossfeed	Inland Technology Inc 1-800-552-3100	Non Chlorinated & low VOC
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	Citra Safe	6850-01-378-057	Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	Citrikleen HD & Isopropyl Alcohol		Cold Clean& Wipe Crossfeed	Carlos Nazario OC-ALC/LIPEB DSN 336-7246	Used by Oc-ALC
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	DOT-111/113		Cold Clean& Wipe Crossfeed	Susie Barney OO-ALC/TIELM DSN 924-2994	Being Tested by OO-ALC
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	DOT-111/113		Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	DS-108		Cold Clean& Wipe Crossfeed	Susie Barney OO-ALC/TIELM DSN 924-2994	Being Tested by OO-ALC
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	DS-108		Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	Envirosolv 655		Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	FO 425Q		Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	Isopar L		Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	Isopar M		Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	PF Degreaser	7930-01-328-595	Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	Primaclean 3600		Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	Safety Prep	6850-01-381-508	Cold Clean& Wipe Crossfeed	Inland Technology Inc 1-800-552-3100	Low VOC
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	Shopmaster		Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	Teksol EP	6850-01-378-058	Cold Clean& Wipe Crossfeed	Inland Technology Inc 1-800-552-3100	Non Chlorinated & low VOC
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	TPC		Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	Turco 6226		Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Chemicals	Hurri-Safe HK-188	6850-01-373-586	Haz Tech Info Services	Hurri Kleen Corp	
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Distilled Mono Terpene	Citra Safe	6850-01-378-079	Boeing Case Study	Inland Technology Inc 206 922-8932	Boeing uses on B-2
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Solvent Blend	DS-104		Cold Clean& Wipe Crossfeed	Susie Barney OO-ALC/TIELM DSN 924-2994	Being Tested by OO-ALC
Methyl Ethyl Ketone	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Solvent Blend	DS-104		Cold Clean& Wipe Crossfeed	Cary Roque/NADEP Jacksonville/DSN 942-3444	Being Tested by Navy
Methylene Chloride	EPA-17	CLEANING	CARBON REMOVAL	Abrasive Blasting	Abrasive Flow Cleaning		Tech Advisory Team	Nick Neeley OC-ALC/LIPEB DSN 336-7246	Minimal Metal Removal
Methylene Chloride	EPA-17	CLEANING	CARBON REMOVAL	Aqueous System	Parts Washers		Tech Advisory Team	Brad Christensen OO-ALC/LICT DSN 458-2341	No Hazardous Chemicals
Methylene Chloride	EPA-17	CLEANING	CARBON REMOVAL	Chemicals	N-methyl Pyrrolidone (NMP)		Tech Advisory Team	Jeff Marnix OC-ALC/LPPNP DSN 336-3819	Less Hazardous
Methylene Chloride	EPA-17	CLEANING	CARBON REMOVAL	Chemicals	Potassium Permanganate		Tech Advisory Team	Jeff Marnix OC-ALC/LPPNP DSN 336-3819	Can be Rejuvenated
Methylene Chloride	EPA-17	CLEANING	CARBON REMOVAL	Chemicals	Terpenes		Tech Advisory Team	Jeff Marnix OC-ALC/LPPNP DSN 336-3819	Non-Hazardous Chemical
Methylene Chloride	EPA-17	CLEANING	CARBURETOR CLEANING	Chemicals	Citrix Solvent		Navy Pol Prev Opportunity Handbook	Hazardous Technical Info Services 804 209-5168	
Methylene Chloride	EPA-17	CLEANING	COLD TANK SOAK	Chemicals	Citrex	850-01-378-0839	PRO-ACT	Inland Technology Inc 1-800-552-3100	Biodegradable & Low VOC
Methylene Chloride	EPA-17	CLEANING	COLD TANK SOAK	Chemicals	X-Caliber	850-01-378-0582	PRO-ACT	Inland Technology Inc 1-800-552-3100	Biodegradable & Low VOC
Methylene Chloride	EPA-17	STRIPPING	PAINT (Zinc) STRIPPING	Chemicals	Safety Strip 4000 (Brulin)		SM-ALC Solvents Test Reprt	Cheryl Brandt SM-ALC/LIHM DSN 633-5026	Tested by SM-ALC
Methylene Chloride	EPA-17	STRIPPING	PAINT (CARC) PAINT REMOVAL	NMP	NMP		JDEP Mtg 27-29 Aug 96	MCLB Albany/Ron Vargo/912 439-6805	Not a HAP & has low vapor pressure
Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING	Abrasive Blasting	Wheat Starch		Navy Pol Prev Opportunity Handbook	Tony Gomes / NFESC Port Hueneme / 805 982-3425	Minimal Surface Damage
Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING	Abrasive Blasting	Carbon Dioxide Pellets		Tech Advisory Team	John Lindsey WR-ALC/TIELN DSN 468-1287	Minimal Hazardous Waste
Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING	Abrasive Blasting	Plastic Media Blast		Tech Advisory Team	John Vidic OO-ALC/LAOPE DSN 458-2050	Eliminates Chemicals

List of potential ODC/HAZMAT alternatives. Identification of an alternative on this list does not endorse its use or authorize deviation from the Tech Order. The single manager must approve changes to Tech Orders.

Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING	Abrasive Blasting	Wheat Starch		Tech Advisory Team	Richard Slife WR-ALC/CNC 912 926-3284	Minimal Surface Damage
Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING	Chemicals	Citrex	850-01-378-0599	Cold Clean& Wipe Crossfeed	Inland Technology Inc 1-800-552-3100	Not Reg by RCRA or SARA
Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING	Chemicals	X-Caliber	850-01-378-0809	Cold Clean& Wipe Crossfeed	Inland Technology Inc 1-800-552-3100	Not Reg by RCRA or SARA
Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING	Chemicals	Preprite [ISP]	850-01-383-0445	DGSC "Envir Safe Chem Alter"	DGSC Market'g Off 1-800-352-2852 & DSN 695-6054	
Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING	Chemicals	X-Caliber	850-01-378-0662	HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Compatible w/hmx,tatb & petn
Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING	Chemicals	Citrex	850-01-378-0649	PRO-ACT	Inland Technology Inc 1-800-552-3100	Biodegradable & Low VOC
Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING	Chemicals	X-Caliber	850-01-378-0662	PRO-ACT	Inland Technology Inc 1-800-552-3100	Biodegradable & Low VOC
Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING	Chemicals	Benzyl Alcohol		Tech Advisory Team	Robin Stearns OC-ALC/LAPEP DSN 336-5986	
Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING	Liquid Blasting	High Pressure Water		Tech Advisory Team	Robin Stearns OC-ALC/LAPEP DSN 336-5986	Less Labor to Operate
Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING	Liquid Blasting	Medium Pressure Water		Tech Advisory Team	John Lindsey WR-ALC/TIELN DSN 468-1287	Low Cost & Less Hazardous
Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING AIRCRAFT	Abrasive Blasting	Supersonic Abrasive Ice-Blasting		NSF PR 94-58 NEWS, 5 Oct 94	Beth Gaston/Nat'l Science Foundation/703 306-1070	May not damage underlying surface
Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING AIRCRAFT	Chemicals	Turco 6813		NAVAIR 4th Annual P2 Conf	Ken Clark/NAWC/215 441-1508	
Methylene Chloride	EPA-17	STRIPPING	PAINT STRIPPING POLYURETHANE	Chemicals	B&B 5151M		NAVAIR 4th Annual P2 Conf	Ken Clark/NAWC/215 441-1508	
Methylene Chloride	EPA-17	BONDING	PLASTICS-WELDING	Chemicals	X-Caliber	850-01-378-0662	HTIS Vol 3 No 3 Fall 1993	Mat'ls Substitution Committee 505 665-8294	Compatible w/hmx,tatb & petn
Methylene Chloride	EPA-17	STRIPPING	PLASTISOL REMOVAL	Chemicals	Brulin 1291	6850-01-394-016	JDEP Mtg 27-29 Aug 96	Army Letterkenny Depot/Dennis Reed/717 267-9506	
Methylene Chloride	EPA-17	STRIPPING	PLASTISOL REMOVAL	NMP	Ecolink Safe Strip	6850-01-386-842	JDEP Mtg 27-29 Aug 96	Army Letterkenny Depot/Dennis Reed/717 267-9506	
Methylene Chloride	EPA-17	CLEANING	RESIN REMOVAL	Chemicals	Citrex	850-01-378-0887	PRO-ACT	Inland Technology Inc 1-800-552-3100	Biodegradable & Low VOC
Methylene Chloride	EPA-17	CLEANING	RESIN REMOVAL	Chemicals	X-Caliber		PRO-ACT	Inland Technology Inc 1-800-552-3100	Biodegradable & Low VOC
Methylene Chloride	EPA-17	CLEANING	RESIN REMOVAL, EPOXY	Chemicals	Z-Strip		PRO-ACT	Inland Technology Inc 1-800-552-3100	Low VOC & High Flash Point
Methylene Chloride	EPA-17	CLEANING	SEALANT & ADHESIVE REMOVAL	Water Blasting	High pressure [20,000 psi] Water Blasting		Cold Clean& Wipe Crossfeed	Mike Patry/OC-ALC/405 736-5185	NDCEE Case Study
Methylene Chloride	EPA-17	CLEANING	SEALANT REMOVAL	Abrasive Blasting	Carbon Dioxide Pellets		Tech Advisory Team	Robin Stearns OC-ALC/LAPEP DSN 336-5986	Minimal Hazardous Waste
Methylene Chloride	EPA-17	CLEANING	SEALANT REMOVAL	Abrasive Blasting	CO2 Blasting with Waterpick		Tech Advisory Team	John Lindsey WR-ALC/TIELN DSN 468-1287	Minimal Hazardous Waste
Methylene Chloride	EPA-17	CLEANING	SEALANT REMOVAL	Liquid Blasting	High Pressure Water Jet		Tech Advisory Team	Robin Stearns OC-ALC/LAPEP DSN 336-5986	No Hazardous Chemicals
Nickel	EPA-17	PLATING	NICKEL PLATING OF METAL PARTS		Flame Spray		OC-ALC Plating Study	Glen Graham OC-ALC/LPPNP DSN 336-4414	
PD 680 Type I & II	AFMC HIT LIST	CLEANING	DEGREASING INDUSTRIAL SURFACES	Aqueous	Formula P-98 [Allied Enterprises Inc]	850-01-278-4420	DGSC "Envir Preferred Products"	DGSC Market'g Off 1-800-352-2852 & DSN 695-6054	
PD 680 Type I & II	AFMC HIT LIST	CLEANING	DEGREASING METAL DECKS	Aqueous	Task Force [Allied Enterprises Inc]	850-01-376-1202	DGSC "Envir Preferred Products"	DGSC Market'g Off 1-800-352-2852 & DSN 695-6054	
PD 680 Type I & II	AFMC HIT LIST	CLEANING	METAL PARTS CLEAN & DEGREASE	Chemicals	TPC SOLVENT		E-Mail from ASC/YPVF	Perry Beaver/WR-ALC/EMP/DSN 468-1124	145 deg F [C.O.C] flash point
PD 680 Type I & II	AFMC HIT LIST	CLEANING	METAL PARTS CLEAN & DEGREASE	Chemicals	BREAKTHROUGH [Inland Technology]	850-01-378-0679	PRO-ACT	Inland Technology Inc 1-800-552-3100	Used by Weyerhaeuser Corp
PD 680 Type I & II	AFMC HIT LIST	CLEANING	METAL PARTS CLEAN & DEGREASE	Chemicals	Isopropyl Alcohol		Tech Advisory Team	Lt Jay Gendron SA-ALC/TIESM DSN 945-8745	
PD 680 Type I & II	AFMC HIT LIST	CLEANING	METAL PARTS CLEAN & DEGREASE	Chemicals	P-D-680 Type III	850-01-377-1812	Tech Advisory Team	Brian Ballew SA-ALC/TIESM DSN 945-8745	Non-Hazardous Chemical
PD 680 Type I & II	AFMC HIT LIST	RUST PROTECTION	RUST PROTECTION COATING	Chemicals	P-D-680 Type III	850-01-377-1812	Tech Advisory Team	Mathew Chathanatt OC-ALC/LPPNP DSN 336-2635	Non-Hazardous Chemical
PD 680 Type I & II	AFMC HIT LIST	CLEANING	WHEEL BEARINGS CLEANING	Chemicals	FORMULA 724 [Aliphatic Pet'm Hydroc'n]		E-Mail from ASC/YPVF	Alan Meyers/WR-ALC/LKJTC/DSN 468-6747	175 deg F [C.O.C] flash point
Perchloroethylene	EPA-17	CLEANING	COLD CLEANING	Chemicals	Alkaline		Cold Clean& Wipe Crossfeed	Paul Hughes SA-ALC/EMP DSN 945-3100	Used at SA-ALC
Perchloroethylene	EPA-17	CLEANING	COLD CLEANING	Chemicals	Citrikleen		Cold Clean& Wipe Crossfeed	Paul Hughes SA-ALC/EMP DSN 945-3100	Used at SA-ALC
Perchloroethylene	EPA-17	CLEANING	COSMOLINE REMOVAL	Aqueous System	Aqueous Spray Washing		NDCEE Crossfeed Report	Mike Patry/OC-ALC/405 736-5185	Used by OC-ALC
Perchloroethylene	EPA-17	CLEANING	DEGREASING METAL PARTS	Abrasive Blasting	Bicarbonate of Soda		Tech Advisory Team	Ed Wesson SA-ALC/TIESM DSN 945-4984	Less Hazardous
Perchloroethylene	EPA-17	CLEANING	DEGREASING METAL PARTS	Aqueous System	Parts Washers		Tech Advisory Team	Jeff Mamix OC-ALC/LPPNP DSN 336-3819	No Hazardous Chemicals
Perchloroethylene	EPA-17	CLEANING	DEGREASING METAL PARTS	Chemicals	ART-141 Terpene		Tech Advisory Team	Russ Denny SM-ALC/SGB DSN 633-0311	Non-Hazardous Chemical
Perchloroethylene	EPA-17	CLEANING	DEGREASING METAL PARTS	Closed Loop System	Advanced Vapor Degreaser		Tech Advisory Team	Brian Ballew SA-ALC/TIESM DSN 945-8745	Can Use Existing Chemicals
Perchloroethylene	EPA-17	CLEANING	PLATING MASKING WAX REMOVAL	Chemicals	Hot Mineral Oil & Alkaline Cleaner		OC-ALC Plating Study	Pratt & Whitney	Less Hazardous
Perchloroethylene	EPA-17	CLEANING	WAX REMOVAL	Aqueous System	Aqueous Immersion		NDCEE Crossfeed Report	Mike Patry/OC-ALC/405 736-5185	Used by OC-ALC
Polychlorinated biphenyls	TRI Section 313	INSULATION	INSULATE & COOL TRANSFORMERS						
Potassium Permanganate		CLEANING	CARBON REMOVAL	Abrasive Blasting	Extrude Hone Abrasive Flow Cleaning		Cold Clean& Wipe Crossfeed	Nick Neeley/OC-ALC/405 736-7246	NDCEE Case Study
Toluene	EPA-17	CLEANING	CLEANING BOOM SIGNAL COILS	Chemicals	Isopropyl Alcohol		C/KC-135 Pol Prev Status Rept	Capt Troy Lanier/OC-ALC/LACRA/405 736-3832	
Toluene	EPA-17	COATING	CONFORMAL COATING CIRCUIT BOARDS	Chemicals	Conathane 1175		JPPAB 6 Apr 95 Joint Initiatives Rpt	Robert Hill, HQ AFMC/DR, 513 257-5591	
Toluene	EPA-17	COATINGS	PAINT STEEL PARTS	Chemical Bath	Autodeposition		Tech Fact Sheet 40004	Jack Adams/NDCEE/814 269-2801	Low VOC
Toluene	EPA-17	PAINTING	PAINTING METAL PARTS	Chemicals	High Volume Low Pressure (HVLP) Spray System		Navy Pol Prev Opportunity Handbook	Michael Viggiano NFESC Port Hueneme 805 982-4895	
Toluene	EPA-17	PAINTING	PRIMING AIRCRAFT FOR PAINTING	Chemicals	Deft 44-GN-36 Primer		McDonnell Douglas P2 Review	Sheldon Toepke/McDonnell Douglas/314 233-2610	Low VOC
Toluene	EPA-17	CLEANING	SPOT CLEANING AIRCRAFT	Chemicals	Acetone		Tech Advisory Team	Glenn McCall WR-ALC/TIELC DSN 468-4930	Less Hazardous
Toluene	EPA-17	CLEANING	SPOT CLEANING AIRCRAFT	Chemicals	Acidic Cleaner		Tech Advisory Team	John Lindsey WR-ALC/TIELN DSN 468-1287	No Environmental Hazard
Toluene	EPA-17	CLEANING	TOOLS & PARTS CLEANING	Chemicals	Acetone		Tech Advisory Team	Glenn McCall WR-ALC/TIELC DSN 468-4930	Less Hazardous
Toluene	EPA-17	CLEANING	TOOLS & PARTS CLEANING	Chemicals	Acidic Cleaner		Tech Advisory Team	John Lindsey WR-ALC/TIELN DSN 468-1287	No Environmental Hazard
Trichloroethylene	EPA-17	CLEANING	COSMOLENE REMOVAL	Chemicals	Petroferm Bioact DG-1		Cold Clean& Wipe Crossfeed	Tony Phillips Lockheed 817 777-3758	Used by Lockheed
Trichloroethylene	EPA-17	CLEANING	HONEYCOMB CLEANING	Aqueous System	Aqueous		NDCEE Crossfeed Report	Stephen Gaydos/McDonnell Douglas/314 233-3451	Used by Mc Donnell Douglas
Trichloroethylene	EPA-17	CLEANING	METAL PARTS CLEANING	Aqueous System	Aqueous with Mechanical Agitation		NDCEE Crossfeed Report	Stephen Gaydos/McDonnell Douglas/314 233-3451	Used by Mc Donnell Douglas
Urea	CWA	DEICING	DEICE AIRPLANE RUNWAY	Chemicals	Sodium Acetate		Deicing & Anti-icing Crossfeed	3CE/CEORH Elmendorf/Joseph Cross/907 552-2994	
Urea	CWA	DEICING	DEICE AIRPLANE RUNWAY	Chemicals	Sodium Formate		Deicing & Anti-icing Crossfeed	AFCESA/SMsgt Earl Labonte/904 283-6386	
Urea	CWA	DEICING	DEICE AIRPLANE RUNWAY	Chemicals	Potassium Acetate		Deicing & Anti-icing Crossfeed	AFCESA/SMsgt Earl Labonte/904 283-6386	
Xylene	EPA-17	COATING	CONFORMAL COATING CIRCUIT BOARDS	Chemicals	Humiseal 1B31EPA		AFMC/ENSE Pt Paper 18 Apr 95	Ed Mines/Humiseal/ 718 932-0800	
Xylene	EPA-17	COATING	CONFORMAL COATING CIRCUIT BOARDS	Chemicals	Humiseal 1B31LOC		AFMC/ENSE Pt Paper 18 Apr 95	Ed Mines/Humiseal/ 718 932-0800	

List of potential ODC/HAZMAT alternatives. Identification of an alternative on this list does not endorse its use or authorize deviation from the Tech Order. The single manager must approve changes to Tech Orders.

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5.0 Supplier Information on Products

This section contains some technical product literature of identified products. This section is not intended to provide information on all the TCA substitutes but provides information on some of the viable materials unearthed in this study.

MacDermid
INCORPORATED

245 FREIGHT STREET - WATERBURY, CT 06702 - TELEPHONE (203) 575-5700 - INTL. FAX 203-575-7900 - DOM. FAX 203-575-5630

August 24,1994

Mr. John Bulluck
Texas Research Institute
91063 Bee Caves Rd.
Austin, Tx 78733

Dear Mr. Bulluck,

Thank you for your interest in MacDermid's new line of aqueous cleaners - New Dimensions. MacDermid has been a leader in cleaning technology for over 75 years. This breadth of technology has enabled us to develop a series of cleaners specifically designed to replace harmful chlorinated solvents.

New Dimensions are environmentally safe and in most cases clean better than the harmful products they replace. Here is what one large automotive supplier had to say.

> "New Dimensions provided capable degreasing performance with a 67% reduction in cycle times. Mechanical evaluation of bond integrity indicated a 14% increase in bond strength and a 37% increase in bond ductility when compared to current vapor degreasing methods."

Our best selling product, Supreme (#10007) has proven to be an effective solvent replacement. Supreme will safely and effectively remove most soils from steel as well as other substrates. Enclosed you will find a technical data sheet and MSDS for Supreme.

We would be happy to test your parts at MacDermid's pilot test facility. Here we utilize agitation, ultrasonics or spray agitation to duplicate your process. If you have any further questions or would like to arrange for testing please call me at 203-575-5726.

Sincerely,

Robert Griffiths

Robert Griffiths
Program Manager

MacDermid
INCORPORATED

NEW DIMENSIONS SUPREME

Alkaline Liquid Cleaner Degreaser

Product Code No. 10007

A HIGHLY CONCENTRATED MILD ALKALINE LIQUID CLEANER/DEGREASER

DESCRIPTION:

NEW DIMENSIONS Supreme is a concentrated all purpose mildly alkaline cleaner and degreaser.

Supreme helps to eliminate high disposal costs and problems.

Supreme can be used over and over in the same solution effectively.

Supreme eliminates highly dangerous vapor systems.

Supreme makes water "wetter", penetrate deeper, emulsifies and suspends dirts and soil quicker, safer and easier.

Supreme is free rinsing and therefore, leaves no film or residue.

After cleaning with Supreme, the surface is often ready for plating, painting or welding with no additional preparation necessary.

Supreme has a built-in passive inhibitor for short term elimination of oxidation.

FEATURES & BENEFITS:

• Environmentally Safe Liquid	• Contains no chlorinated solvents
	• Contains no petroleum distillates
	• Non-flammable
	• Biodegradable
	• USDA approved
• Safe on all surfaces (when used as directed)	• General purpose cleaner
•	• Free rinsing
	• Built-in corrosion inhibitor
• Super Concentrate	• Economical
	• Can be used in any type of immersion cleaning equipment or one-shot off-line spray cleaning
	• Effective in hot or cold solutions
	• Degreaser replacement

CONTROL:

A hand-held refractometer is the recommended method for analysis of Supreme. A refractometer calibrated in °BRIX with a range of 0 to 10° is suitable. The refractometer reading times 5.5 will give an approximate of the concentration.

% Supreme = (Refractometer Reading) x 5.5

Wet analysis of Supreme is as follows:

Indicator - methyl orange
dissolve 1 gram methyl orange into 1,000 mL deionized water

Titrant - 0.5N sulfuric acid

1. 25 mL sample of working solution (be careful not to collect any oils, greases from surface)
2. Add 50 mL deionized water
3. Add 10 drops of methyl orange indicator
4. Titrate sample with 0.5N acid to pink end point
5. % Supreme b/v = mL of 0.5N acid x 3.1

An automatic control system is also available for continuous analysis and replenishment. Contact your MacDermid representative for additional details.

SAFETY & WARNING :

MacDermid Inc. recommends that the company/operater read and review the MacDermid Materials Safety Data Sheets for the appropriate health and safety warnings before use.

Material Safety Data Sheets are available from MacDermid Incorporated.

WASTE DISPOSAL :

Prior to using any recommendations or suggestions by MacDermid Inc. for waste treatment, the user is required to know the appropriate local/state/federal regulations for on-site or off- site treatment which may require permits. If there is any conflict regarding our recommendations, local/state/federal regulations take precedent.

In order to separate greasy, oily contaminants from a used Supreme emulsion, the pH of the spent solution should be dropped to between 6.5-7.5 with muriatic acid (consult your supplier for proper handling and treatment procedures) and allowed to sit in a still tank for up to 36 hours.

After the material has been released and has risen to the surface, it can be skimmed from the top. The oily waste material can then be drained off and disposed of as hazardous waste. The spent cleaning solution can then be disposed of through an effluent waste water disposal system.

ORDER INFORMATION:

Product	Product Code	Container
NEW DIMENSIONS Supreme	10007	330 gal tote 55 gal drum 5 gal pail

MATERIAL SAFETY DATA SHEET

MacDermid
INCORPORATED
245 FREIGHT ST. • WATERBURY, CT 06702 • (203) 575-5700

Health	Flammability	Reactivity	Other
1	0	0	

PRODUCT NEW DIMENSIONS SUPREME

PRODUCT CODE 10007

PRODUCT CODE MUST ACCOMPANY ALL INQUIRIES REGARDING THIS PRODUCT

Issue Date: 09/30/91 Page 1 of 7

~~Revised Date: 12/17/93 4 7~~

24 HR. EMERGENCY NUMBER: CHEMTREC (800) 424-9300

SECTION 1 PRODUCT IDENTIFICATION

TRADE NAME: NEW DIMENSIONS SUPREME

CHEMICAL FAMILY: INORGANIC /ORGANIC MIXTURE

FORMULA: Proprietary Mixture

HMIS RATING: 1 HEALTH 0 FLAMABILITY 0 REACTIVITY OTHER
0=Insignificant 1=Slight 2=Moderate 3=High 4=Extreme

SECTION 2 HAZARDOUS INGREDIENTS

MacDermid Incorporated has identified the following chemical ingredient(s) as hazardous.

INGREDIENT(S)	CAS #	BY WEIGHT %
Dipropylene Glycol Methyl Ether	34590-94-8	4 - 8

SECTION 3 PHYSICAL DATA

DENSITY: 9.01 LB/GL

SPECIFIC GRAVITY: 1.080

FREEZING POINT: 32 F 0C

SOLUBILITY IN WATER: Complete

COLOR: Blue

ODOR: Mild

FORM: Liquid

pH: 12.8

FLASH POINT: n/a

VAPOR PRESSURE: n/a

NOTE: These physical properties are typical values for this product

SECTION 4 FIRE AND EXPLOSION DATA

FLASH POINT: n/a

EXTINGUISHING MEDIA:
NEVER allow run-off to enter sewers or waterways.
Waterspray; carbon dioxide; dry chemical; foam; halon
As appropriate for surrounding material

UNUSUAL FIRE AND EXPLOSION HAZARDS:
Wear self-contained breathing apparatus/protective clothing
Fight fire from remote locations

SECTION 7 PERSONAL PROTECTIVE DATA

RESPIRATORY PROTECTION: If the OSHA-PEL/ACGIH-TLV are exceeded, it is recommended that a NIOSH approved respirator be used. Consult with your industrial hygienist for appropriate cartridge selection & use.

For large spills, entry into large tanks, vessels or enclosed small spaces with inadequate ventilation, a pressure-demand, self-contained breathing apparatus is recommended.

VENTILATION: General ventilation is recommended. Additionally, local exhaust ventilation is recommended where vapors, dusts, mists, or aerosols may be released.

PROTECTIVE EQUIPMENT:

Splash proof goggles; Face shields; Chemical aprons; Boots and gloves.

The availability of an eye wash fountain and safety shower is recommended.

If clothing is contaminated, remove clothing and thoroughly wash the affected body area. Launder contaminated clothing before reuse.

Consult with your Safety Professional/Industrial Hygienists for specific information regarding applications at your facility.

SECTION 8 TOXICOLOGY DATA

TOXICITY STUDIES: Toxicity Studies have not been conducted on this product. However, toxicity literature surveys have been conducted on the ingredient(s) in Section 2. The results are as follows:

ACUTE ORAL TOXICITY: Dipropylene Glycol Methyl Ether: LD50 = 5660 mg/kg (Rat)

ACUTE DERMAL TOXICITY: Dipropylene Glycol Methyl Ether: LD50 = 9500 mg/kg (Rat)

ACUTE RESPIRATORY TOXICITY: Unknown

TOXICITY HAZARD REVIEW (THR):
Dipropylene Glycol Methyl Ether is mildly toxic by ingestion and skin contact. A mild allergen. Flammable when exposed to heat or flame. Can react with oxidizing material. Excessive exposure to heat may cause polymerization.

Listed as suspected carcinogen by: IARC: no NTP: no OSHA: no

SECTION 9 REACTIVITY DATA

INCOMPATIBILITY: Acids

HAZARD DECOMPOSITION PRODUCTS: Unknown

STABILITY: Stable

CONDITIONS TO AVOID: Unknown

HAZARDOUS POLYMERIZATION: No

MATERIAL SAFETY DATA SHEET

Product: NEW DIMENSIONS SUPREME **Issue Date:** 09/30/91
Product Code: 10007 **Revised Date:** 12/17/93

24 Hour Emergency Number: CHEMTREC (1-800-424-9300)

4 7

SECTION 13 REGULATORY DATA

The Following Regulations apply to this product.

FEDERAL REGULATIONS:

OSHA HAZARD COMMUNICATION RULE, 29 CFR 1910.1200: Based on our evaluation, the following ingredients in this product are subject to this rule:

CHEMICAL NAME	CAS #	BY WEIGHT %	OSHA-PEL	ACGIH-TLV
Dipropylene Glycol Methyl Ether	34590-94-8	4 - 8	100 ppm	100 ppm

CERCLA/SUPERFUND, 40 CFR 117, 302/304: Notification of spills of this product is NOT required.

SARA/SUPERFUND AMENDENTS & REAUTHORIZATION ACT of 1986 (TITLE III)-Sections 302,311,312,& 313:

SECTION 302: Extremely Hazardous Substances (40 CFR 355)
This product does not contain ingredients listed in APPENDIX A of 40 CFR 355 as an extremely hazardous substance (EHS):

SECTIONS 311 & 312 - M.S.D.S. REQUIREMENTS (40 CFR 370):

This product contains ingredients listed in APPENDIX A of 40 CFR 355 and hazardous chemicals under 29 CFR 1910.1200 (c). The product should be reported under the following E.P.A. hazard categories:

x Immediate (Acute) health hazard ___ Delayed (Chronic) health hazard

___ Fire Hazard ___ Sudden release of pressure hazard

___ Reactive hazard

Under Section 311, submittal of MSDS's or a list of product names to the local emergency planning commision, state emergency response commission, the local fire department is required after October 17,1987. Consult the regulation for pertinent changes and updates.

SECTION 13 REGULATORY DATA (Continued)

INTERNATIONAL REGULATIONS:

Canadian Domestic Substance List (CDSL):

The chemical ingredients in this product are listed with the C.D.S.L.

The information listed above does not include all Federal, State, and International regulations. The regulations listed above may change from time to time; it is the user's responsibility to keep advised of current regulatory requirements.

Prepared by MacDermid Inc. Safety & Regulatory Compliance Department, based upon publicly available reference information.

SECTION 14 USER NOTIFICATION

To the best of our knowledge the information contained herein is correct. All chemicals may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist. Final determination of suitibility of the chemical is the sole reponsibility of the user. Users of any chemical should satisfy themselves that the conditions and methods of use assure that the chemical is used safely. NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESSED OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER NATURE ARE MADE HERE UNDER WITH RESPECT TO THE INFORMATION CONTAINED HEREIN OR THE CHEMICAL TO WHICH THE INFORMATION REFERS.

Ecolink
Environmentally Preferred
Solutions For Industry

FAX MESSAGE

From: BILL GREEN
ECOLINK INC.
PH: 404/621-8240 FAX: 404/621-8245
DATE: August 23, 1994

# of Pages in Transmission, Including This One: 7

TO: John Bullock
Texas Research Institute

FAX: 512-263-3530

Thanks for your interest in ECOLINK's Environmentally preferred products. Attached you will find some information about Ecolink, our philosophy and our methods. I have also enclosed a catalog sheet detailing several of our most popular items.

ECOLINK products are used by a wide range of local and regional companies as well as Fortune 500 companies, including Southern California Edison, General Dynamics, Litton Industries, General Electric and Westinghouse. We pride ourselves on being able to offer large and small customers alike, equivalent levels of unsurpassed service.

Please review the attached information at your earliest convenience. If you have any questions or need more information, please call me.

1481 Rock Mountain Blvd. / Stone Mountain, Georgia 30083 / (404) 621-8240 / 1-800-886-8240 / Fax (404) 621-8245

Ecolink
Environmentally Preferred
Solutions For Industry

Product Data

ELECTRON

Environmentally Preferred Dielectric Solvent

In response to the demand for a non-hazardous electrical solvent, we have created ELECTRON Environmentally Preferred Dielectric Solvent. In today's world of complex chemicals and strict chemical controls, ELECTRON Environmentally Preferred Dielectric Solvent offers a refreshingly simple approach.

ELECTRON Environmentally Preferred Dielectric Solvent is an exceptional solvent degreaser formulated without chlorinated solvents or other hazardous ingredients. The base for ELECTRON is a unique high grade oil distillate which provides its dielectric strength, allowing it to be used safely on all types of electrical apparatus. With its high flashpoint, ELECTRON provides an unprecedented degree of user safety.

ELECTRON Environmentally Preferred Dielectric Solvent is strong enough to remove grease, fuel oil, carbon and organic resins yet safe on most plastic and rubber surfaces. Unlike other solvents, ELECTRON can be used without extensive protective equipment. Only common sense chemical precautions are required, (see MSDS).

Benefits of ELECTRON Environmentally Preferred Dielectric Solvent:

1. Contains NO water
2. High dielectric strength.
   (ASTM D-877 test procedures to 46,000 volts)
3. Fully evaporative, Leaves NO residue.
4. NO hazardous ingredients as defined by the EPA.
5. NOT a flammable liquid, (TCC Flashpoint above 145° F).
6. Contains NO OSHA PEL or ACGIH TLV listed ingredients.
7. NO surface leakage of current in immediate residue tests.

Boiling Point	370-380 ° F
Flash Point	147 ° F
Specific Gravity ($H_2O = 1$)	0.784

EL:0296
02/18/94, Ecolink, Inc. (A Div. of Sentry Chemical)

MATERIAL SAFETY DATA SHEET
ELECTRON DIELECTRIC SOLVENT - PART #0296

ECOLINK, INC. (A DIV. OF SENTRY CHEMICAL CO), 1481 ROCK MTN BLVD., STONE MOUNTAIN, GA 30083
TEL: 800/886-8240 OR 404/621-8240 REVISED 06/06/94

THIS MSDS COMPLIES WITH
OSHA'S HAZARD COMMUNICATION
STANDARD, 29 CFR 1910.1200.
STANDARD MUST BE CONSULTED
FOR SPECIFIC REQUIREMENTS.

U.S. DEPARTMENT OF LABOR
OCCUPATIONAL SAFETY AND
HEALTH ADMINISTRATION.
(NON-MANDATORY FORM)
FORM APPROVED BY OMB

SECTION I - PRODUCT IDENTIFICATION

PRODUCT IDENTITY (AS USED ON LABEL & LIST):

ELECTRON
ENVIRONMENTALLY PREFERRED DIELECTRIC SOLVENT

MANUFACTURERS NAME
SENTRY CHEMICAL CO
1481 ROCK MOUNTAIN BLVD.
STONE MOUNTAIN, GA 30083

EMERGENCY TELEPHONE NUMBERS:
800/886-8240 or 800/877-3339
404/621-8240 or 404/934-4242

SECTION II - HAZARDOUS INGREDIENTS / IDENTITY INFORMATION

COMPONENTS:
(SPECIFIC CHEMICAL IDENTITY; COMMON NAMES & CAS NUMBERS)
OSHA PEL, ACGIH TLV, %, OTHER LIMITS RECOMMENDED

HYDROTREATED LIGHT DISTILLATE
CAS # 64742-47-8 >80.0 % PEL/TLV 300 ppm 5MG/M3 (As Fine Mist)

SEE SECTION VI FOR PEL/TLV INFORMATION

THIS PRODUCT CONTAINS HIGHLY REFINED ALIPHATIC HYDROCARBONS AND TERPENES, WHICH ARE NOT CONSIDERED HAZARDOUS OR RESTRICTED BY EPA RCRA.

ELECTRON, IN ITS PURCHASED FORM, IS NOT REGULATED UNDER SARA TITLE III SECTIONS 311 & 312.

CERCLA (superfund) - N/A HMIS - 0/2/0/B NFPA - 1/2/0

DOT regulated - N/A DOT Proper Shipping Name - N/A DOT hazard class - N/A DOT number- N/A

NOTE: ELECTRON DIELECTRIC SOLVENT IS COMBUSTIBLE (FLASHPOINT BELOW 200 deg F), AND SHOULD BE HANDLED WITH CARE AROUND OPEN FLAME.

SECTION III - PHYSICAL DATA

BOILING POINT : 370-380° F
VAPOR PRESSURE(mm Hg.) : <1
VAPOR DENSITY(AIR=1) : >1

SPECIFIC GRAVITY(H2O=1) : 0.784
MELTING POINT : N/A
EVAPORATION RATE : <1
(BUTYL ACETATE = 1)

SOLUBILITY IN WATER: NEGLIGIBLE
APPEARANCE & ODOR: CLEAR, COLORLESS LIQUID WITH MILD CITRUS ODOR

- continued on page two -
other side

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (TCC METHOD) : 147° F
FLAMMABLE LIMITS : NONE KNOWN
EXTINGUISHING MEDIA : REGULAR FOAM, CO2 OR DRY CHEMICALS
SPECIAL FIRE FIGHTING PROCEDURES: TREAT AS A HYDROCARBON FIRE. WEAR SELF-CONTAINED, NIOSH APPROVED, BREATHING APPARATUS.
UNUSUAL FIRE AND EXPLOSION HAZARDS: NON-TOXIC AND TOXIC FUMES MAY FORM UPON COMBUSTION. STAY UPWIND OF FIRE.

SECTION V - REACTIVITY DATA

STABILITY : STABLE CONDITIONS TO AVOID: EXCESSIVE HEAT
INCOMPATIBILITY (MATERIALS TO AVOID) : AVOID CONTACT WITH STRONG OXIDIZING AGENTS
HAZARDOUS DECOMPOSITION : OXIDES OF CARBON MAY BE FORMED UPON COMBUSTION
HAZARDOUS POLYMERIZATION : WILL NOT OCCUR

SECTION VI - HEALTH HAZARD DATA

PRIMARY ROUTES OF EXPOSURE : ORAL, INHALATION, AND SKIN

INGESTION : CAN CAUSE GASTROINTESTINAL IRRITATION, NAUSEA, VOMITING.
INHALATION : ASPIRATION INTO LUNGS MAY CAUSE INJURY. EXCESSIVE INHALATION OF VAPORS MAY CAUSE DIZZINESS OR HEADACHE. THIS PRODUCT HAS A LOW VAPOR PRESSURE AND IS NOT EXPECTED TO PRESENT AN INHALATION HAZARD. CAUTION SHOULD BE TAKEN TO PREVENT AEROSOLIZATION OR MISTING WITHOUT TAKING SPECIFIC PRECAUTIONS.
EYES : EXPOSURE TO HIGH CONCENTRATION OF VAPORS MAY CAUSE IRRITATION.
SKIN CONTACT: PROLONGED OR REPEATED EXPOSURE MAY CAUSE SKIN IRRITATION. REPEATED LONG-TERM CONTACT MAY CAUSE EXCESSIVE DRYING OR FLAKING OF SKIN.

FIRST AID :

INGESTION: DO NOT INDUCE VOMITING. PRODUCT CONTAINS HYDROCARBON, CALL PHYSICIAN
INHALATION: REMOVE TO FRESH AIR. IF BREATHING DIFFICULT, GIVE OXYGEN, CALL PHYSICIAN.
EYES: IRRIGATE IMMEDIATELY WITH WATER FOR AT LEAST 15 MINUTES. CALL PHYSICIAN.
SKIN: WASH OFF IN FLOWING WATER OR SHOWER USING SOAP AND WATER. REMOVE CONTAMINATED CLOTHING AND WASH BEFORE REUSE.

BECAUSE OF THIS MATERIALS LOW VAPOR PRESSURE IT IS NOT EXPECTED TO PRESENT AN INHALATION HAZARD AT AMBIENT TEMPERATURE.

PEL/TLV INFORMATION:

THE TLV FOR PETROLEUM DISTILLATES IS 300 MG/M3. NIOSH HAS RECOMMENDED A 10-HR TWA OF 100 MG/M3 FOR KEROSENE. SHOULD THIS MATERIAL BE APPLIED UNDER MODERATE TO HIGH PRESSURE, A MIST MAY FORM IN AIR. THE 8 HOUR TWA PEL FOR THIS PRODUCT AS AN OIL MIST IS 5 MG/M3. EXPOSURES BELOW 5 MG/M3 APPEAR TO BE WITHOUT ANY SIGNIFICANT HEALTH RISK. THE SHORT TERM EXPOSURE LIMIT FOR THIS PRODUCT AS AN OIL MIST IS 10 MG/M3. AIR MONITORING MAY BE CONDUCTED WITH AN APPROPRIATE ORGANIC VAPOR (HYDROCARBON) MONITORING SYSTEM.

CARCINOGEN : NTP-NONE IARC MONOGRAPHS-NONE OSHA REGS-NONE

LD 50 INFORMATION, (BASED ON DATA EXTRAPOLATED FROM INGREDIENTS)

ACUTE ORAL TOXICITY (RATS):	4.2 Gms/Kg
ACUTE DERMAL TOXICITY (RATS):	7.0 Gms/Kg

- continued on page three -
attached

SECTION VII - PRECAUTIONS FOR SAFE HANDLING & USE

RESPIRATORY PROTECTION : NOT REQUIRED UNDER CONDITIONS OF NORMAL USE. IF VAPOR MIST IS GENERATED, USE A NIOSH CERTIFIED ORGANIC VAPOR RESPIRATOR WITH A DUST AND MIST FILTER.
VENTILATION : LOCAL EXHAUST/ HOOD OR FAN MECHANICAL/ NONE REQUIRED
PROTECTIVE GLOVES : NITRILE GLOVES ARE RECOMMENDED
EYE PROTECTION : SAFETY GLASSES ARE RECOMMENDED
OTHER PROTECTIVE CLOTHING : NONE REQUIRED
WORK PRACTICES : USE WITH ADEQUATE VENTILATION. WASH HANDS AFTER USE.

SECTION VIII - CONTROL MEASURES

SMALL SPILL : REMOVE ALL SOURCES OF IGNITION! ABSORB LIQUID ON ABSORBENT MATERIAL
LARGE SPILL : REMOVE ALL SOURCES OF IGNITION! PERSONS NOT WEARING PROTECTIVE EQUIPMENT SHOULD BE EXCLUDED FROM AREA. DIKE AREA OF SPILL TO PREVENT SPREADING, THEN PUMP INTO STORAGE TANK/DRUM. PREVENT RUNOFFS TO SEWERS OR BODIES OF WATER. IF RUNOFF OCCURS, NOTIFY PROPER AUTHORITIES.
WASTE DISPOSAL METHOD : TREAT AS SIMPLE OIL WASTE. INCINERATE OR LANDFILL IN MANNER CONFORMING TO STATE, FEDERAL AND LOCAL REGS.
PRECAUTIONS TO BE TAKEN IN HANDLING & STORING : TREAT AS A COMBUSTIBLE LIQUID. AS WITH ANY COMBUSTIBLE OIL OR SOLVENT, ALL RAGS USED IN CONJUNCTION WITH THIS PRODUCT MUST BE PLACED IN A METAL SEALABLE CONTAINER AFTER USE TO AVOID THE POSSIBILITY OF SPONTANEOUS COMBUSTION. KEEP CONTAINER CLOSED. READ LABEL BEFORE USE. AVOID EXCESSIVE CONTACT WITH FUMES OR LIQUID.

SECTION IX - NATIONAL STOCK NUMBERS

NSN 6850-01-375-5555	PART #0296-55 - 55 GALLON DRUM
NSN 6850-01-375-5553	PART #0296-06 - 6 GALLON PAIL
NSN 6850-01-375-5554	PART #0296-01 - 1 GALLON JUG

DISCLAIMER: ECOLINK/SENTRY CHEMICAL BELIEVES THAT THE INFORMATION CONTAINED ON THIS MATERIAL SAFETY DATA SHEET IS ACCURATE. THE SUGGESTED PROCEDURES ARE BASED ON EXPERIENCE AS OF DATE OF PUBLICATION. THEY ARE NOT NECESSARILY ALL INCLUSIVE NOR FULLY ADEQUATE IN EVERY CIRCUMSTANCE. ALSO, THE SUGGESTIONS SHOULD NOT BE CONFUSED WITH, NOR FOLLOWED IN VIOLATION OF APPLICABLE LAWS, REGULATIONS, RULES OR INSURANCE REQUIREMENTS.

END OF MSDS : ELECTRON DIELECTRIC SOLVENT

Ecolink
Environmentally Preferred
Solutions For Industry

ELECTRON TODAY

As we reach the drop-dead date for chlorinated solvents, ELECTRON is proving to be a welcome and necessary alternative cleaner. The power generation community successfully uses ELECTRON, in place of 1,1,1 trichloroethane, for all maintenance activities. While ELECTRON is not exactly the same as 1,1,1 trichloroethane or CFC-113, it can and is being used as an environmentally preferred alternative.

- Utilities using ELECTRON, (for two years or more), include Southern California Edison, Lower Colorado River Authority, Indiana Michigan Public Service, United Illuminating, Potomac Electric Power and Virginia Power.

- In 1990 Westinghouse realized that they needed a safe, effective alternative to 1,1,1 trichloroethane. They began a test program, and studied over 40 alternative products. In 1991, after a year of intensive study, (from environmental to material compatibility), they announced their findings: **ELECTRON was selected as the Westinghouse Power Generation Service Division environmentally preferred alternative of first choice.**

- In 1991, another Westinghouse study began, this time looking at alternatives for non-destructive testing. In 1992, another Westinghouse report was issued, citing one environmentally preferred solvent as their first choice **for non-destructive testing pre-post clean and penetrant removal...ELECTRON.**

- In 1992 the Department of Defense Joint Oil Analysis Program studied 15 alternatives, searching for a critical instrument cleaning solvent to replace CFC-113. The Joint Oil Analysis Program, or JOAP, certifies that critical fluid tests, performed at Army, Navy, Air Force and Allied Facilities worldwide, all meet the same quality specifications. **The JOAP found only one environmentally preferred solvent effective and consistently reliable enough to specify for all critical oil analysis lab use, worldwide...ELECTRON.**

- In 1993, the U.S. Navy released their final military specification revision for eliminating CFC-113 and 1,1,1 trichloroethane in critical hydraulic fluid systems cleaning. **The 1993 NAVSSHIPS Repair Manual for Critical Hydraulic System Maintenance specifies ... ELECTRON.**

ELECTRON isn't a miracle solvent, but it does work. We welcome the opportunity to show it to you.

A DIVISION OF
SENTRY CHEMICAL COMPANY
1481 Rock Mountain Blvd. / Stone Mountain, Georgia 30086 / (404) 621-8240 / 1-800-886-8240 / Fax (404) 621-8245

ECOLINK PRODUCT USE MATRIX

PRODUCT	DESCRIPTION	REPLACES	APPLICATIONS	VOC
ATR - C	Organic Asphalt Extraction Solvent	111 TCA	Asphalt hot mix test extraction, , asphalt removal from equipment.	797 gm/liter
ATR Hi-Flash	Organic Asphalt Extraction Solvent	111 TCA	Asphalt hot mix test extraction, , asphalt removal from equipment.	804 gm/liter
BLEND 300	Quick-dry Aqueous Solvent	111 TCA, MEK, METH	Soil removal/Wipe-down prior to painting or welding	35 gm/liter
COIL WS	All purpose non-corrosive cutting fluid	Chlorinated cutting fluids	Cutting, Boring, Grinding, Milling	0
ECOLINK 2005	Non-flammable aerosol, CFC-Free contact cleaner / electrical solvent	CFC-113 111 TCA	Cleaning electrical contacts and other critical components in spot-cleaning applications	exempt compound
ELECTRON (aerosol & bulk)	Non-Aqueous Dielectric Solvent	111 TCA, CFC-113	Electrical Maintenance, Motors, Generators, General Wipe-down	782 gms/liter Aero: 776 g/l
Electron QED	Fast drying, non-aqueous (also available with terpene = QEDT)	111 TCA, MEK, MIBK, CFC-113	Wipe-down or dip tank when very fast dry, non-aqueous cleaning is required	749 gm/liter
Electron QEDT	Fast drying, non-aqueous solvent, (like QED) w/ distilled terpene	111 TCA, MEK, MIBK, CFC-113	Wipe-down or dip tank when high solvency, very fast dry, non-aqueous cleaning is required.	776 gm/liter
HEAVYWEIGHT Non-Butyl	Aqueous Cleaner Non Alkaline/Non-Butyl	Caustics, Butyl based	Cleans non-ferrous or aluminum parts in dip, wipe or spray.	69 gm/liter
MICROPURE CDF	Electronics Grade De-Flux, Board Solvent	CFC-113, 111 TCA	Printed circuit boards, microcircuits	1000 gms/liter
PARTS PREP	Semi-Aqueous Degreaser	111 TCA, CFC-113 , Vapor Degreasers	Removes carbon, grease, flux, lubricating oils, & uncured epoxy resins	920 gms/liter
PEN-T 22	Non-chlorinated Penetrant	Chlorinated Penetrants	Protect metal, frees nuts, bolts, displaces moisture	56 gm/liter
PREP RITE	Paint & Coatings Remover (gel form)	METH, MEK, Toluene, etc.	Strips most paint & coatings from metal surfaces	960 gms/liter
RIP-TIDE	Aqueous Solvent	Caustics, alkaline, steam	Cleans grease, carbon deposits, coal dust, fuel oil & water based paints	50 gm/liter
RIP-TIDE RI	Rust Inhibited Aqueous Solvent	Caustics, alkaline, steam	Power washing or parts tank cleaning. Cleans grease, carbon deposits, coal dust & fuel oil. Rust inhibited.	50 gm/liter
SAFE STRIP	Paint & Resin Solvent	METH, MEK, Caustics	Immersion stripping of paints, cleaning paint guns & lines	995 gms/liter
UNIVERSAL	Aqueous Steam Cleaner	Solvent cleaning	Large parts cleaning using a steam clean machine	0 gm/liter
VORTEX	Water rinsable citrus terpene blend	111 TCA, CFC-113	Aggressive solvent for cleaning all organic and inorganic soils, (grease cosmoline, rosin flux). Wipe, rinse or steam off after use.	797 gm/liter
VORTEX-NS	Non-rinsable citrus terpene blend	111 TCA, CFC-113	Aggressive solvent for cleaning all organic and inorganic soils, (grease cosmoline, rosin flux). Wipe off after use.	840 gm/liter

FOR MORE INFORMATION: ECOLINK 404/621-8240

FAX FAX FAX FAX FAX FAX FAX FAX FAX FAX FAX FAX FAX

Outside NY
(800) 645-9523

PRIDE
INTERNATIONAL INC

Phone: (516) 752-9595
Fax: (516) 752-7848

110 SCHMITT BLVD. FARMINGDALE, NY 11735-1462

TO: John Bullock

DEPT:

OF: Texas Research Institute

PHONE: FAX: (512) 263-3530.

FROM: Jeff Berlin

DATE: 8-23-94.

NUMBER OF PAGES INCLUDING COVER: Six (6)

COMMENTS: John - "Citrisolv Plus" was designed to take the place of 1,1,1. Pricing is wholesale because I am the manufacturer.

Thank You -

JEFF BERLIN

Jeff Berlin

1-800-645-9198

X 204.

FAX FAX FAX FAX FAX FAX FAX FAX FAX FAX FAX FAX FAX

CITRISOLV PLUS

AN ENVIRONMENTALLY SAFE
CLEANING BREAKTHROUGH
FROM THE CUTTING EDGE
OF
TECHNOLOGY

C
I
T
R
I

DIRECTIONS

Dilute using a ratio of 10:1 with water for light cleaning.
Use undiluted for heavy duty degreasing.
Will safely remove all dirt & grease accumulations
without endangering environmental safety.

FEATURES

HIGHLY CONCENTRATED WITH CITRUS TURPENE
CONTAINS NO DANGEROUS SOLVENTS
CONTAINS NO PETROLEUM DISTALLATES
CONTAINS NO CLORINATED HYDROCARBONS
CONTAINS NO TRICHLOROTHANE
CONTAINS NO CAUSTICS
CONTAINS NO ACIDS

S
O
L
V

PRIDE INTERNATIONAL, INC.
110 SCHMITT BOULEVARD
FARMINGDALE, NEW YORK 11735

TO REORDER
(800) 645-9198, Outside of New York
(516) 752-8600, In New York
~~FAX - (516) 752-7848~~

JEFF BERLIN

(800) 645-9523
(516) 752-9595

PRIDE INTERNATIONAL INC

Facsimile
(516) 752-1705

RE: CITRISOLV PLUS

A product formulated to naturally degrease, penetrate and liquify heavy grease and oil deposits from virtually any surface. This pleasantly scented product is ideal for removing oily films from metal surfaces, cleaning motors and engines, removing adhesives, resins, and as a general replacement for xylene, toluene, benzene, trichloroethane, trichlorethylene, methylene chloride, and many other hazardous solvents.

This formulation contains a high concentration of natural citrus solvents (Terpene). It is non-conductive, non-corrosive to metals, as well as biodegradable, yet possesses a superior solvency and grease dispersion. As with any chemical, use with due care according to the instructions and precautions on the label.

Non-Acid * Non Fuming * Non-caustic * Biodegradable *
*Non-Corrosive to metals *

CAUTION

Combustible. Keep away from heat and open flame. Do not take internally. Avoid contact with eyes. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. If irritation persists, seek medical attention. If swallowed, consult a Physician immediately.

CONTAINS NO PETROLEUM HYDROCARBONS.

NOTE: Citrisolv Plus is a concentrated organic formula that may be harmful to plastics or painted surfaces. Test surface prior to application. Because Citrisolv Plus is a powerful grease solvent, it will defat skin. When using Citrisolv Plus, wearing of rubber gloves is recommended to avoid chapped skin. Keep container tightly closed when not in use.

FOR COMMERCIAL AND INDUSTRIAL USE ONLY.

JEFF BERLIN

110 Schmitt Boulevard ● Farmingdale, NY 11735-1462
P.O. Box 9927, Postal Station "A" ● Toronto, Ontario M5W 2J2

(800) 645-9523
(516) 752-9595

PRIDE
INTERNATIONAL INC

Facsimile
(516) 752-1705

TECHNICAL DATA
CITRISOLV PLUS

Color	Pale Straw
Odor	Citrus
Flash Point	0 F/TCC
Acids	None
Alkali	None
Activity	100 %
Specific Gravity	0.96
Petroleum Distiallates	None
Chlorinated Hydrocarbons	None
Solubility in Water	Emulsifies

Distributed By:

PRIDE INTERNATIONAL, INC.
110 Schmitt Blvd.
Farmingdale, New York 11735

(800) 645 - 9523, Outside New York
(516) 752 - 9595, In New York
(516) 752-7848, FAX

JEFF BERLIN

JEFF BERLIN

Material Safety Data Sheet

PRIDE GROUP INC.
Manufacturer

110 SCHMITT BLVD.
Address

FARMINGDALE, NY 11735

(516) 752-8600
Phone Number (For Information)

(516) 752-8600
Emergency Phone Number

Telex*

CITRISOLV PLUS
Identity (Trade Name As Used On Label)

MSDS Number*

CAS Number*

5/24/89
Date Prepared

RICHARD MEIER
Prepared By*

Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.

SECTION 1 - MATERIAL IDENTIFICATION AND INFORMATION

COMPONENTS — Chemical Name & Common Names (Hazardous Components 1% or greater; Carcinogens 0.1% or greater)	%*	OSHA PEL	ACGIH TLV	OTHER LIMITS RECOMMENDED
CONTAINS NO HAZARDOUS				
INGREDIENTS AS DEFINED BY				
OSHA COMMUNICATION STANDARDS				
Non-Hazardous Ingredients	100			
TOTAL	100			

SECTION 2 - PHYSICAL / CHEMICAL CHARACTERISTICS

Boiling Point	280°F	Specific Gravity (H_2O = 1)	0.96
Vapor Pressure (mm Hg and Temperature)	N/A	Melting Point	N/A
Vapor Density (Air = 1)	N/A	Evaporation Rate butyl acetate = 1)	SLOWER
Solubility in Water	COMPLETE	Water Reactive	NO

Appearance and Odor PALE STRAW COLORED LIQUID - CITRUS ODOR

SECTION 3 - FIRE AND EXPLOSION HAZARD DATA

Flash Point and Method Used	Auto-Ignition Temperature	Flammability Limits in Air % by Volume	LEL	UEL
180° TCC	N/A	N/A		

Extinguisher Media CO_2, DRY CHEMICAL, FOA,

Special Fire Fighting Procedures AS WITH ANY FIRE WHICH MIGHT INVOLVE CHEMICALS.
ALWAYS WEAR SELF-CONTAINED BREATHING APPARATUS.

Unusual Fire and Explosion Hazards COOL EXPOSED CONTAINERS TO PREVENT BURSTING

*Optional

JEFF BERLIN

SECTION 4 - REACTIVITY HAZARD DATA

STABILITY
☒ Stable
☐ Unstable

Conditions To Avoid

Incompatability (Materials to Avoid) STRONG OXIDENTS

Hazardous Decomposition Products

HAZARDOUS POLYMERIZATION
☐ May Occur
☒ Will Not Occur

Conditions To Avoid

SECTION 5 - HEALTH HAZARD DATA

PRIMARY ROUTES OF ENTRY ☐ Inhalation ☐ Skin Absorption ☒ Ingestion ☐ Not Hazardous

CARCINOGEN LISTED IN ☐ NTP ☐ IARC Monograph ☐ OSHA ☒ Not Listed

HEALTH HAZARDS
Acute NOT KNOWN
Chronic NOT KNOWN

Signs and Symptoms of Exposure SKIN REDDENED BY PROLONGED CONTACT

Medical Conditions Generally Aggravated by Exposure NOT KNOWN

EMERGENCY FIRST AID PROCEDURES - Seek medical assistance for further treatment, observation and support if necessary.

Eye Contact FLUSH WITH WATER FOR 15 MINUTES. SEE PHYSICIAN.

Skin Contact WASH WITH SOAP & WATER.

Inhalation REMOVE TO FRESH AIR.

Ingestion DRINK 3-4 GLASSES OF WATER. INDUCE VOMITING. SEEK MEDICAL ATTENTION.

SECTION 6 - CONTROL AND PROTECTIVE MEASURES

Respiratory Protection (Specify Type) NONE

Protective Gloves RUBBER

Eye Protection SPLASH GOGGLES

VENTILATION TO BE USED ☐ Local Exhaust ☐ Mechanical (general) ☐ Special ☐ Other (specify)

Other Protective Clothing and Equipment RUBBER APRON TO PROTECT CLOTHING.

Hygienic Work Practices NORMAL GOOD HOUSEKEEPING PROCEDURES.

SECTION 7 - PRECAUTIONS FOR SAFE HANDLING AND USE / LEAK PROCEDURES

Steps to be Taken If Material Is Spilled Or Released SOAK UP EXCESS WATER WITH ABSORBANT

Waste Disposal Methods IN ACCORDANCE WITH LOCAL, STATE & FEDERAL REGULATIONS.

Precautions to be Taken in Handling and Storage KEEP AWAY FROM EXTREME HEAT, OPEN FIRE OR FLAMES.

Other Precautions and/or Special Hazards KEEP THIS & ALL OTHER CHEMICALS OUT OF CHILDRENS REACH.

NFPA Rating* Health___ Flammability___ Reactivity___ Special___

HMIS Rating* Health___ Flammability___ Reactivity___ Personal Protection___

MacDermid
INCORPORATED
245 Freight Street - Waterbury, Connecticut 06702 - Telephone (203) 575-5700
TELEX 4436011 * DOMESTIC FAX 203-575-5630

FACSIMILE

Date: 8-24-94

 # Pages: 5

To: John Bullock **of** 512-263-3530

From: Bob Griffiths

cc via FAX: **of**

cc:

of

Re:

FAX #:

Information requested on solvent replacements.

AQUEOUS ALKALINE

MacDermid Inc., 245 Freight St., Waterbury, CT, phone: (203) 575-5700, fax: (203) 575-5630

MANUFACTURER'S RECOMMENDATIONS

TARGET SOILS: grease, cutting oils, carbon exhaust, heavy fuel deposits, adhesive residues, hydraulic fluids, ~~wax deposits~~ and coolants. Stamping & Forming Fluids	**CONCENTRATION:** soak 2-5% (vol.) general 5-10% heavy degreasing 10-35%
	PROCESS: parts, pressure and steam cleaners, soak tanks, ultrasonics, scrubbers, brush or spray-on.

COMPOSITION

VOC (g/l)	60.6 0.5 lb/gl	Non-volatile matter (Wt %)	2.8%
Glycol ether (Wt %, identify) (dipropyleneglycolmethylether)	4 - 8	Phosphorus (ppm)	2-6 % wT
BETX (ppm)	0 ppm	Silicon (ppm)	1-3 % wT
Naphthalene (ppm)	0 ppm	Heavy metals (ppm)	0 ppm

CHARACTERISTICS

pH	12.5 ± 2 (conc.)	Odor	mild detergent
Flash point °F	None (TCC)	Appearance	blue liquid
Specific gravity	1.080	Viscosity	water - thin

INDEPENDENT LABORATORY TESTS		RESULTS
Performance:		
Corrosion:	Immersion (ASTM F-483)	Pass (100%, 10%) Mg, Al (bare, anodized) , Ti, 1020 Steel, 410 SS
	Stock Loss (ARP-1775)	
	Sandwich (ASTM F-1110)	Pass Aluminum 2024-T3 (alclad, anodized) 7075-T6 (alclad, anodized)
	Hydrogen embrittlement (ASTM F-519)	Type
	Titanium stress corrosion (ASTM F-945)	
Non-metals:	Acrylic crazing (ASTM F-484)	
	Paint (ASTM F-502)	
Stability:	Accelerated Storage Stability (MIL-C-85570)	
	Hard water (MIL-C-85570)	
	Foam (MIL-C-85570)	
Additional Data:	TOC (g/l)	68
	COD (g/l)	350
	Unpainted Metal Surfaces (ASTM F-485)	Pass for MIL-C-87937

Dibasic Esters (DBE)

Product Description

Refined dimethyl esters of adipic, glutaric and succinic acids. Dibasic Esters are manufactured from a mixed acid co-product stream obtained from Du Pont's three adipic plants. The primary refined ester product is designated DBE.

$CH_3OOC(CH_2)_4COOCH_3$

$CH_3OOC(CH_2)_3COOCH_3$

$CH_3OOC(CH_2)_2COOCH_3$

Du Pont fractionates DBE into other mixtures and pure components to satisfy market needs. In addition to DBE, there are five DBE fractions commercially available for specialty applications. They are DBE-2, DBE-3, DBE-4, DBE-5, DBE-6 and DBE-9. DBE and each of the fractions is a clear, colorless liquid having a mild, agreeable odor. They are readily soluble in alcohols, ketones, ethers and most hydrocarbons, but are only slightly soluble in water and higher paraffinic hydrocarbons.

Applications

- Solvents
  - Industrial coatings
  - Coil/Sheet coatings
  - Waterborne coatings
  - Magnet wire coatings
  - Automotive coatings
  - Industrial cleaners
  - Resin cleanup
  - Hand cleaners
  - Paint removers
  - Foundry core binders
  - Printing inks
  - Textile lubricants
  - Magnetic memory disc coatings
  - Urethane reaction solvents
  - Peroxide solvents
- Plasticizers
  - Fugitive
  - Permanent diester and polyesters
- Polymer Intermediates
  - Polyester polyols for urethanes
  - Wet-strength paper resins
  - Polyester resins
- Specialty chemical intermediates

Specifications

	DBE	DBE-2, DBE-2SPG	DBE-3	DBE-4	DBE-5	DBE-6	DBE-9
Ester content, wt. % min.	99.0	99.0	99.0	98.5	99.5	99.5	99.0
Water content, wt. % max.	0.1	0.1	0.2	0.04	0.1	0.05	0.1
Methanol, wt. % max	0.2	0.1	0.1	0.5	0.1	0.1	0.1
Color, Gardner Scale, max.	1	1	1	1	1	1	1
Acid Number, max.	0.3	1	1	1	1	1	1
Composition Range							
Dimethyl Adipate	10-25	20-35	85-95	-	0.2 (max.)	99.0 (min.)	0.3 (max.)
Dimethyl Glutarate	55-75	65-80	5-15	0.4 (max.)	98.5 (min.)	0-1	65-69
Dimethyl Succinate	15-22	0-3	1.0 (max.)	99.0 (min.)	1.0 (max.)	0.1 (max.)	31-35

Footnotes:

[a] Hansen Solubility Theory.

[b] Δsp.gr./ΔT for the DBEs is–0.0007 per ° over the range 20-50°C.

[c] Ransberg Paint Resistance Tester Model 219C8.

[d] Average for mixture.

[e] Approximate, based on composition.

Storage and Handling

Dibasic Esters are readily available from Du Pont in large quantities (million lbs./yr.) for growth applications.

Freight Classification–Paint and lacquer solvent

DOT Classification–These products are not classified as hazardous materials.

PACKAGES:

Tank Trucks–45,000 lb. net wt.

Tank Car–170,000 lb. net wt. (Jumbo Tanker)

Drums–523 lb. gross wt.
485 lb. net wt.

For Samples and Information

Sally McCoach
Du Pont Chemicals
1007 Market Street
Brandywine Building, 7th Floor
Wilmington, DE 19898
1-800-231-0998 ext. 45987

General Information

Typical Compositions (wt.%'s)	DBE	DBE-2, DBE-2SPG	DBE-3	DBE-4	DBE-5	DBE-6	DBE-9
Dimethyl Adipate	18	28	89		0.1	98.0	0.2
Dimethyl Glutarate	61	71	10	0.3	99	0.5	66
Dimethyl Succinate	20	0.3	0.2	98.4	0.4	<0.1	33
Methanol	0.1	<0.1	<0.1	<0.5	<0.1	<0.1	0.1
Water (max.)	0.1	0.1	0.2	0.04	0.1	<0.1	0.1
Physical Properties							
Molecular weight	159[a]	163[a]	173[a]	146	160	174	156[a]
SP. GR at 20/20°C[b]	1.092[c]	1.081[a]	1.068[a]	1.121	1.091	1.064	1.099[a]
Density at 20°C (lbs/gal.)	9.09[c]	9.00[c]	8.89[c]	9.33	9.08	8.86	9.15[c]
Distillation Range, °C	196-225	210-225	215-225	196	210-215	227-230	196-215
Vapor Pressure at 20°C (Torr)	0.2[c]	0.1[c]	0.06[c]	0.3	0.1	<0.05	0.3[c]
Solubility in water–Wt. % at 20°C	5.3	4.2	2.5	7.5	4.3	2.4	~5
Water Solubility in DBE's–Wt.% at 20°C	3.1	2.9	2.5	3.8	3.2	2.4	~3.5
Freezing Point, °C	-20[c]	-13[c]	8	19	-37	10	-10[a]
Flash Point, Tag Closed Cup °C(°F)	100 (212)	104 (219)	102 (216)	94 (200)	107 (225)	113 (235)	94 (202)
Auto Ignition Temp., °C	370	375	360	365	365	N/A	365
Latent Heat of Vaporization, cal/g	81	80	79	85	81	79	82
Viscosity at 25°C, cst.	2.4	2.5	2.5	2.5	2.5	2.5	2.4
Solvent Properties							
Solubility Parameters[a]							
Non-Polar	8.1	8.3	8.3	8.3	8.3	8.3	8.3
Polar	3.4	2.2	2.1	2.5	2.3	2.1	2.3
Hydrogen Bonding	4.1	4.7	4.5	5.0	4.8	4.5	4.8
Surface Tension at 20°C, dynes/cm	35.6	N/A	N/A	N/A	N/A	N/A	N/A
Electrical Resistance[c] at 24°C, megohms	0.5	N/A	N/A	N/A	N/A	N/A	N/A

DBE SOLVENT

MATERIAL SAFETY DATA SHEET

MATERIAL IDENTIFICATION

DBE

MSDS NUMBER	: 00000004
CORPORATE NUMBER	: DU000276
Revision Date	: 02-Jul-91
Date Printed	: 03-Jul-91

MANUFACTURER/DISTRIBUTOR
Du Pont
1007 Market Street
Wilmington, DE 19898

PHONE NUMBERS
PRODUCT INFORMATION : 1-(800)441-7515
TRANSPORT EMERGENCY : 1-(800)424-9300
MEDICAL EMERGENCY : 1-(800)441-3637

CHEMICAL FAMILY : Aliphatic Dibasic Acid Esters

TRADE NAMES / SYNONYMS
Dibasic Ester

DU PONT REGISTRY NUMBER: DP53-60-5
FORMULA : CH3OOC(CH2)n-COOCH3, n=2,3 and 4
MOLECULAR WEIGHT : Avg. 159
NPCA-HMIS RATINGS : Health: 2 Flammability: 1 Reactivity: 0
Personal Protection rating to be supplied by user depending on use conditions.

COMPONENTS

Material	CAS Number	%
Dimethyl Glutarate	1119-40-0	45-75
Dimethyl Adipate	627-93-0	10-25
Dimethyl Succinate	106-65-0	15-30
Methanol	67-56-1	<0.1
Hydrogen Cyanide	74-90-8	<10ppm

DUPONT

PHYSICAL DATA

Boiling Point : 196 to 225 deg C (385 to 437 deg F)
Vapor Pressure : 0.2 mm Hg at 20 deg C (68 deg F)
Melting Point : ~-20 deg C (~-4.0 deg F)
Evaporation Rate : <0.1 (Butyl Acetate = 1.0)
Water Solubility : 5.3 WT % at 20 deg C (68 deg F)
Odor : Sweet
Form : Liquid
Color : Colorless
Specific Gravity : 1.092 at 20 deg C (68 deg F)

Odor Threshold : 0.1ppm 100% and 0.01ppm 50% of the test panel detected it.

HAZARDOUS REACTIVITY

Instability : Stable.
Incompatibility : Incompatible with strong oxidants, acids, alkalies.
Decomposition : Decomposes with heat.
Polymerization : Polymerization will not occur.

FIRE AND EXPLOSION DATA

Flash Point : 100 deg C (212 deg F)
Method : TCC
Autoignition : 370 deg C (698 deg F)

Explosive Limits in Air, % by Vol. :
LEL : 0.9
UEL : 8.0

FIRE AND EXPLOSION HAZARDS

Vapor forms explosive mixture with air. Hazardous gases/vapors produced in fire are carbon monoxide.

EXTINGUISHING MEDIA

Water Spray. Foam. Dry Chemical. CO2.

SPECIAL FIRE FIGHTING INSTRUCTIONS

Keep personnel removed & upwind of fire. Wear self-contained breathing apparatus. Wear full protective equipment. Cool tank/container with water spray.

HEALTH HAZARD INFORMATION

DBE:

In acute toxicity tests in animals, mixed dibasic esters were of very low toxicity by inhalation, moderately toxic by skin contact and of very low toxicity by ingestion.

They are skin, eye and upper respiratory tract irritants.

ANIMAL DATA:

Inhalation 4 hour LC50: > 11 mg/L in rats
Inhalation 1 hour LC50: > 10.7 mg/L in rats
Skin absorption LD50: > 2,250 mg/kg in rabbits
Oral LD50: 8,191 mg/kg in rats

The compound is a severe skin irritant, is a slight eye irritant, but is not a skin sensitizer in animals. Toxic effects described in animals from exposure by inhalation include upper respiratory tract irritation. Toxicity described in animals from repeated exposure by inhalation include decreased weight gain, absolute and relative liver weight decrease, and degeneration of olfactory epithelium. Toxicity described in animals from repeated exposure by ingestion include weight loss, but there were no pathological abnormalities noted. The compound does not produce genetic damage in animals, or in bacterial cell cultures, but it was positive in one study with cultured mammalian cells. Animal testing indicates that this compound does not have developmental, or reproductive effects.

HUMAN HEALTH EFFECTS:

Skin contact may initially include skin irritation with discomfort or rash. Eye contact may initially include eye irritation with discomfort, tearing, or blurring of vision. Inhalation may initially include irritation of the upper respiratory passages. Significant skin permeation, and systemic toxicity, after contact appear unlikely.

Overexposure may cause blurring of vision.

CARCINOGENICITY

None of the components in this material is listed by IARC, NTP, OSHA, or ACGIH as a carcinogen.

EXPOSURE LIMITS

DBE

AEL * (Du Pont): 1.5 ppm, 10 mg/m3 - 8 Hr TWA
This limit is for DBE.
TLV (ACGIH) : None Established

(HEALTH HAZARD INFORMATION - Continued)

PEL (OSHA) : None Established

OTHER APPLICABLE EXPOSURE LIMITS

Methanol

AEL * (Du Pont): 200 ppm - 8 & 12 Hr. TWA - Skin
TLV (ACGIH) : 200 ppm, 262 mg/m3 - 8 Hr TWA
STEL 250 ppm, 328 mg/m3 - Skin
PEL (OSHA) : 200 ppm, 260 mg/m3 - 8 Hr TWA
STEL 250 ppm, 325 mg/m3 - Skin

Hydrogen Cyanide

AEL * (Du Pont): 10 ppm - 8 Hr. TWA
5 ppm - 12 Hr. TWA - Skin
TLV (ACGIH) : 10 ppm, 11 mg/m3 (Ceiling) - Skin
PEL (OSHA) : STEL 4.7 ppm, 5 mg/m3 - Skin

* AEL is Du Pont's Acceptable Exposure Limit.

SAFETY PRECAUTIONS

Avoid breathing vapors or mist. Avoid contact with eyes, skin, or clothing. Wash thoroughly after handling.

FIRST AID

INHALATION

If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

SKIN CONTACT

Flush skin with water after contact. Wash contaminated clothing before reuse.

EYE CONTACT

In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician.

INGESTION

If swallowed, do not induce vomiting. Immediately give two glasses of water. Never give anything by mouth to an unconscious person. Call a physician.

NOTES TO PHYSICIAN

Activated charcoal slurry may be administered.
To prepare activated charcoal slurry, suspend 50 grams activated charcoal in 400mL water and mix thoroughly.
Administer 5mL/kg, or 350mL for an average adult.

PROTECTION INFORMATION

GENERALLY APPLICABLE CONTROL MEASURES AND PRECAUTIONS

Keep container tightly closed. Do not mix with strong oxidants, acids, alkalies.

Use ventilation that is adequate to keep employee exposure to airborne concentrations below exposure limits.

PERSONAL PROTECTIVE EQUIPMENT

EYE/FACE PROTECTION

Wear safety glasses. Wear coverall chemical splash goggles when the possibility exists for eye contact due to splashing or spraying of material.

RESPIRATORS

A NIOSH/MSHA approved air purifying respirator with a organic vapor cartridge or canister may be permissible under certain circumstances where airborne concentrations are expected to exceed exposure limits. Protection provided by air purifying respirators is limited. Use a positive pressure air supplied respirator if there is any potential for an uncontrolled release, exposure levels are not known, or any other circumstances where air purifying respirators may not provide adequate protection.

PROTECTIVE CLOTHING

Wear impervious clothing, such as gloves, apron, boots or whole bodysuit made from Butyl rubber, as appropriate.

DISPOSAL INFORMATION

AQUATIC TOXICITY

DIBASIC ESTERS:

96 hour LC50, fathead minnows: 18-24 mg/L.
48 hour LC50, Daphnia magna : 112-150 mg/L.

DIMETHYL GLUTARATE:

96 hour LC50, bluegill sunfish: 30.9 mg/L.

SPILL, LEAK, OR RELEASE

NOTE: Review FIRE AND EXPLOSION HAZARDS and SAFETY PRECAUTIONS before proceeding with clean up. Use appropriate PERSONAL PROTECTIVE EQUIPMENT during clean up.
Remove source of heat, sparks, flame, impact, friction or electricity. Dike spill. Prevent liquid from entering sewers, waterways or low areas. Recover free liquid for reuse or reclamation. Recover undamaged and minimally contaminated material for reuse or reclamation. Soak up with sawdust, sand, oil dry or other absorbent material.

(DISPOSAL INFORMATION - Continued)

WASTE DISPOSAL

Treatment, storage, transportation and disposal must be in accordance with applicable Federal, State/Provincial, and Local regulations. Recover nonusable free liquid and dispose of in an approved and permitted incinerator. Recover nonusable free liquid and dispose of in an approved and permitted biological treatment system. Recover contaminated water and dispose of in an approved and permitted biological treatment system. Recover contaminated water and dispose of in an approved and permitted deepwell. Remove nonusable solid material and/or contaminated soil, for disposal in an approved and permitted landfill. Do not flush to surface water or sanitary sewer system.

SHIPPING INFORMATION

DOT

Proper Shipping Name : DIBASIC ESTER MIXTURE
Hazard Class : Not Regulated
Freight Class : Plasticizers & Solvents

DOT/IMO

Proper Shipping Name : DIBASIC ESTER MIXTURE
Hazard Class : Not Regulated

Shipping Containers

Tank Car - 170,000 lbs
Tank Truck - 42,000 lbs
Steel Drums - 485 lbs
BULK WATER (USCG) SHIPPING NAME:
DIBASIC ESTER MIXTURE

STORAGE CONDITIONS

Store in well ventilated area. Keep container tightly closed.

TITLE III HAZARD CLASSIFICATIONS

Acute : Yes
Chronic : No
Fire : No
Reactivity : No
Pressure : No

ADDITIONAL INFORMATION AND REFERENCES

The hydrogen cyanide concentration in DBE is so low as to be toxicologically insignificant when DBE is used as a solvent. However, when DBE is chemically reacted with alcohols, and methanol is recovered from that reaction and purified for reuse by distillation, concentration of highly volatile impurities such as hydrogen cyanide to toxicologically significant levels can occur in the waste stream from this process. Processors using DBE as a raw material should be aware of this potential hazard.

Responsibility for MSDS : DU PONT CHEMICALS
Petrochemicals Department
Environmental Affairs
Wilmington, DE 19880-0723
302/999-4792

# Indicates updated section.

End of MSDS

KLEER-FLO COMPANY 15151 Technology Drive, Eden Prairie, MN 5534

PHONE: (612) 934-2555

Kleer-flo

FAX NO: (612) 934-390

FAX TRANSMITTAL

To: John Bullock FAX #: (512) 263-3530

Company: Texas R.

From: Kevin Raberge

Date: 8-23-94 Total Pages (Including Cover): 5

Comments:

If you have any questions pertaining to this FAX transmittal, please call (612) 934-2555.

MATERIAL SAFETY DATA SHEET

Emergency Phone: (612)934-2555
Information: (612)934-2555

SECTION I GENERAL INFORMATION

Manufacturer's Name: Kleer-Flo Company
Name on label(Identity): Greasoff 2 Aqueous Parts Cleaner
Address: 15151 Technology Drive, Eden Prairie, MN 55344
Chemical Family: Base
HMIS Hazard Codes: Health (2) Flammability (0) Reactivity (0)
NFPA Hazard Codes: Health (2) Flammability (0) Reactivity (0) Special Hazard: NA
Hazard Rating Scale: 4 = Severe 3 = Serious 2 = Moderate 1 = Slight 0 = Minimal

SECTION II HAZARDOUS INGREDIENTS

Principal Hazardous Compounds (Chemical & Common Name(s)	Percent (Optional)	OSHA PEL	ACGIH TLV	CAS #
Sodium Metasilicate (Industry Recommendation)	4.50	2 mg/M^3	2 mg/M^3	6834-92-0

(Other ingredients such as water, surface active agents, detergent polymers are not considered hazardous under the Federal Hazard Communication Standard 29 CFR 1910.1200.)

NA=Not Applicable NE=Not Established

SECTION III PHYSICAL DATA

Boiling Point(°F): 212°F
Specific Gravity(H_2O=1): 1.16
Vapor Pressure (mm Hg): Similar to water
Solubility in Water: Infinite
Evaporation Rate(BuAc =1): < 1
Vapor Density (Air = 1): > 1
Melting Point (°F): NA
Appearance and Odor: Amber clear liquid with pine scent

SECTION IV FIRE AND EXPLOSION HAZARD DATA

Flash Point (Method Used): None (Water Base) (PMCC) Flammable Limits: NA LEL: UEL:

Extinguishing Media: Non-combustible media appropriate for surroundings. Auto-Ignition Temperature: NA

Special Fire Fighting Procedures: Wear goggles and self-contained breathing apparatus. Will not burn or contribute hazard if in fire.

Unusual Fire and Explosion Hazards: None anticipated under conditions of normal use.

SECTION V REACTIVITY DATA

Stability: Unstable____ Stable X Conditions to Avoid: Stable under normal storage conditions.

Incompatibility (Materials to avoid): Strong acids, generate heat on contact.

Hazardous Polymerization: Will not occur X May occur____ Conditions to Avoid: None known.

Hazardous Decomposition Products: Carbon and nitrogen oxides.

SECTION VI HEALTH HAZARD DATA

Route(s) of Entry: Inhalation (dust and mist); skin and eye contact.

Health Hazards: Acute Irritation to skin, mucous membranes and respiratory tract. Severe burns to eyes and skin.

Chronic Repeated or prolonged contact can cause primary skin irritation or dermatitis, defatting of skin tissue.

Greasoff 2

Chemical listed as Carcinogen or Potential Carcinogen: Yes No X

National Toxicology Program: Yes No X

I.A.R.C. Monographs: Yes No X

OSHA: Yes No X

Signs and Symptoms of Exposure: Skin and eye irritation. Irritation to mucous membranes and respiratory tract. Burning sensation to eyes.

Medical Conditions Generally Aggravated by Exposure: Possibly dermal irritation.

Emergency and First Aid Procedures: Object is to seek medical attention immediately.

Eyes: Flush immediately with cool water for 15 minutes. Seek immediate medical attention.

Skin: Flush with soap and water immediately.

Inhalation: Take to fresh air.

Ingestion: Seek immediate medical attention. If swallowed, do not induce vomiting, give large quantities of cool water and citrus juice.

SECTION VII PRECAUTIONS FOR SAFE HANDLING AND USE

Steps to be taken in case material is released or spilled: Wear all protective equipment when handling spills or leaks. Dike and contain major spills. Use absorbent material and transfer to suitable container. Flush remainder to drain with plenty of water.

Waste Disposal Method: Dispose of complying with Local, State, or Federal regulations for alkaline materials.

Precautions to be taken in Handling and Storing: Keep container closed when not in use. Wear all protective equipment when handling product. Store in dry area.

Other Precautions: Do not take internally. Do not get in eyes or on skin. Use with adequate ventilation.

SECTION VIII SPECIAL PROTECTION INFORMATION AND CONTROL MEASURES

Respiratory Protection (Specify Type): NIOSH approved respirator for nuisance dusts or mists TC-21C-202, i.e. 3M #9920.

Ventilation: Local Exhaust: Acceptable Mechanical (General): Recommended Special: None Other: None

Protective Gloves: Rubber or neoprene. Eye Protection: Safety goggles or splash resistant face shield.

Other Protective Clothing or Equipment: Eye wash and safety shower in areas of chemical exposure. Chemical resistant apron, rubber boots.

Work/Hygienic Practices: Use only as directed. Do not get into eyes. Wash thoroughly after handling. Exercise good industrial hygiene when working with product.

SECTION IX REGULATORY INFORMATION

CERCLA 40 CFR 302.4: NA

SARA TITLE III:
Section 302/304: NA
Section 311/312 Hazard Category: Acute
Section 313: NA

T.S.
Prepared by (Optional)

12/6/93
Date Prepared

We believe the information contained herein, including data, recommendations and other items set forth are reliable, but they are given without warranty of any kind, expressed or implied, as to the accuracy, completeness, dependability, or reliability thereof, except that such information is, to the best of Kleer-Flo's knowledge and belief, accurate as of the date indicated.

SAFE, EFFECTIVE WATER-BASED CLEANING.

THE SOLVENT ALTERNATIVE THAT WORKS.

This is the effective alternative to 1,1,1-trichloroethane and other solvents that you've been looking for. A biodegradable multi-metal cleaning solution with high soil tolerance and excellent free rinsing properties. You get clean parts without the environmental, safety and regulatory worries of solvents.

SAFE ON ALL METALS.

Greasoff™ 2 offers exceptional cleaning power for difficult soils such as oils, greases, polishing compounds and metal working fluids. When used in proper concentrations it's safe on nonferrous metals such as brass and aluminum, and is an excellent choice for steel parts because it has a built-in rust inhibitor.

IMMERSION OR SPRAY CLEANING.

Greasoff™ 2 makes it easy to improve workplace and environmental safety and reduce disposal problems in a wide range of applications. You can use it in immersion-type washers, spray cabinets, belt washers and rotary washers.

SUPER CONCENTRATED. SUPER FAST.

This all-purpose concentrate cleans at a fraction of the cost of solvents, as low as $1.00 per gallon. And it attacks soils quickly. Wash cycle times are typically just three to ten minutes, making Greasoff™ 2 as efficient as it is powerful.

GREASOFF™ 2

BIODEGRADABLE CONCENTRATE

Kleer-flo

Greasoff™ 2 Is Friendly To Workers, The Environment And Your Budget.

The move to water-based parts washing is an investment for the future, but only if you have the right solution and the right equipment. Kleer-Flo Company brings more than 60 years of parts cleaning experience to our new aqueous chemistry. We also provide the industry's leading immersion cleaning equipment to use it in. You can count on Greasoff™ 2 to perform at an economical cost, as well as help you enhance workplace safety and environmental quality.

- Moderate pH provides multi-metal safety.
- No odor in use, for a safer and more productive workplace.
- No VOC emissions or associated regulatory concerns.
- Non-flammable, so you don't have to worry about the potential fire hazard of solvents.
- Oils separate easily, allowing trouble-free skimming.
- One-step cleaning for general applications.
- Easily rinsed with water, for precision cleaning applications.

Greasoff 2 Mixes Easily. Use 5% Greasoff 2 (by volume) at 90°F to 120°F with Cleanmaster Models A-30 and A-50. Use 3% to 10% at 130°F to 160°F for immersion cleaning with Powermaster units. Use 1% to 5% at 100°F to 160°F for spray cabinet applications.

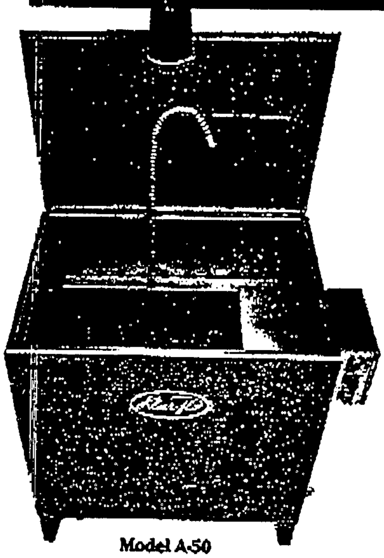
- Non-toxic, improving worker safety.
- Bio-resistant, for longer tank life.
- Works at low to moderate temperatures (70°F to 160°F), saving energy.
- Cleans complex shapes, to efficiently handle difficult applications.

GREASOFF™ 2
BIODEGRADABLE CONCENTRATE

Kleer-Flo

KLEER-FLO COMPANY
15151 Technology Drive, Eden Prairie, MN 55344
1-800-328-7942 (in MN, 1-612-934-2555)
FAX (612) 934-3909

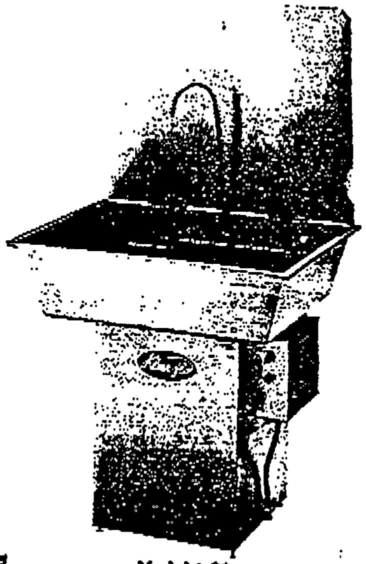
Kleer-Flo Equipment Puts The Advantages Of Greasoff 2 To Work



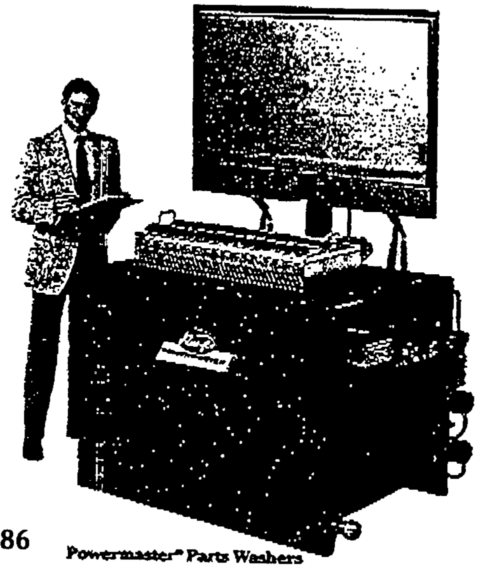
Model A-50

Model A-50
Cabinet-style unit designed for improved cleaning power and productivity. Provides an area for brush or flow cleaning, as well as an agitated immersion chamber for highly-productive, hands-off cleaning. Floating oils are continuously removed from the cleaning tank to prevent re-contamination on parts. Offers room to accommodate larger parts. High solution capacity allows longer periods between clean-outs.

Model A-30
The simplicity and convenience of a proven sink-style design. Excellent for maintenance cleaning. The oversized sink easily accommodates larger parts. The A-30 is economical, yet it doesn't compromise on features or heavy-duty construction. Welded, heavy-gauge stainless steel is used throughout, along with industrial strip heaters, NEMA controls and GFI protection.



Model A-30



Powermaster® Parts Washers

Powermaster® Parts Washers.
Plant-proven agitated immersion cleaners for high-volume production cleaning. An excellent way to replace solvent vapor degreasers. Powerful electro-mechanical agitation offers efficient, heavy-duty cleaning power. Standard units handle loads from 200 to 2000 pounds, and form an ideal building block for complete custom engineered systems with PLC controls and other labor-saving features.

GAF® ENGINEERED products
GAF Chemicals Corporation
1361 Alps Road, Wayne, New Jersey 07470
201 628-3000

PRODUCT INFORMATION BULLETIN

INTRODUCING FOAMFLUSH™ URETHANE REMOVER

THE CURE FOR URETHANE CLEAN-UP

- **More Powerful than Methylene Chloride**
- **More Sensible for the Environment**

New FoamFlush™ Urethane Remover is a proprietary product specifically developed to provide residue free cleaning for equipment used in the urethane foam industry. It is proven effective in penetrating, loosening and removing cured urethane foam deposits and build-up from mixing heads, troughs, conveyor parts, side walls, rollers, foam cutting devices and molds. It works on all urethane systems .... flexible, molded and rigid foams, and even on urethane elastomers. It is a great improvement over methylene chloride, acetone or other problem solvents. Use FoamFlush to clean and flush chemical holding tanks, feed lines, mixing and metering equipment. It dissolves quickly and completely polyols, isocyanates and other urethane intermediates.

Features & Benefits

While FoamFlush™ Urethane Remover is more aggressive than methylene chloride, it has the benefits of being safer in the workplace and friendlier to the environment. FoamFlush is:

- non-carcinogenic
- non-flammable
- biodegradable
- reclaimable
- water rinseable
- non-ozone depleting

Additionally, you can use it for a long period of time, tolerates a high resin loading and will reduce disposal costs.

Urethane clean-up need not be a problem anymore. Hazardous solvents need not be your only choice. FoamFlush™ is the cure for urethane clean-up.

Applications

There are several ways FoamFlush™ Urethane Remover can be used around urethane producing equipment.

1. For flushing mixing heads, chemical holding tanks and feeder lines, spray equipment, etc., use FoamFlush™ as you would normally use any other flushing solvent. Collect the used cleaner in separate labelled containers.

2. For cleaning mixing heads, injector ports, machine parts and any other small parts you normally clean by immersion, simply replace your current solvent with FoamFlush™ Urethane Remover. Parts will emerge cleaned to the bare metal in a few hours --- not in a few days. Little or no scraping is required. Just wipe the parts dry or rinse with water and dry before putting the parts back into service.

Re-Use, Recycling & Disposal

Because FoamFlush™ Urethane Remover has a high tolerance for dissolved materials, it can be used over and over again. When you find it no longer cleans machine parts to your liking, arrangements can be made for its disposal or recycling. FoamFlush™ can be easily reclaimed either on-site or by professional solvent recyclers.

Hazard characterization is the responsibility of the user and must be done by EPA standards and needs to be determined on representative samples of used products. Any disposal must be in accordance with federal, state and local regulations.

Provided you add nothing more, used FoamFlush should be a non-hazardous, non-regulated by-product of your operation. Pick up and disposal will be 1/5 to 1/2 what you normally pay for methylene chloride waste, which is characteristically hazardous. Actual costs will vary.

Materials collected should be stored in a proper container for disposal. Discharge rinse water, or rinse organic solvents according to federal, state and local regulations. This product is free of phosphates and chlorinated solvents.

Comparison With Other Cleaners

FoamFlush™ is an aggressive solvent-based cleaner designed to attack and dissolve urethane polymers and urethane intermediates. Unlike water based cleaners, residual product left on parts will not interfere with urethane chemistry, and so undercure and scrap are not an issue. FoamFlush™ is very slow to evaporate ---- in theory about 480 times slower than methylene chloride and 230 times slower than acetone. What this means in practice is that you will need to use less FoamFlush™ ---- 5 to 10 times less ---- this means less material handling, less risk of exposure and lower real cost for urethane clean-up.

Physical Properties

Appearance	Clear liquid
Odor	Sweet
pH (10 wt% ag.)	4-6
Boiling Point	202-204 deg. C
Vapor Pressure	< 1.00 mmHg at 20 deg. C
Vapor Density	> 3.0 (air = 1.0)
Water Solubility	Complete
Melting/Freezing Point	none to -20 deg. C
Specific Gravity	1.06 at 25 deg. C
Evaporation Rate	0.03 (Butyl Acetate = 1.0)
Flash Point	191 deg. F (Setaflash/CC)

Safety and Handling Precautions

FoamFlush™ Urethane Remover contains organic solvents. It is harmful if inhaled or swallowed. Avoid breathing vapors or mist. Keep away from heat and flame. Avoid contact with eyes and skin. Wear gloves, safety goggles, and protective clothing when handling. Use with adequate ventilation. Consult MSDS for further safety and handling information.

Materials of Construction and Storage

Store in 1020 carbon steel, stainless steel 304 and 316, nickel or aluminum tanks with dessicant-filled breather pipes. FoamFlush is hygroscopic, so store in dry, sheltered areas.

Use proper gasketing materials - Teflon®, silicon rubber, Kalrez®, polypropylene or mild steel.

Materials to avoid: PVC, Viton®, ABS, Buna-N, Kynar®, Lexan®, Noryl EN-265®, PET.

Miscellaneous Handling Precautions

Use safety glasses and neoprene gloves when handling FoamFlush. Any material which contacts the skin or eyes should be washed off with plenty of water. Although Foamflush has a high flash point, combustibility should be considered in elevated temperature applications.

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Kynar® is a registered trademark of Pennwalt.
Lexan® is a registered trademark of General Electric.
Noryl® is a registered trademark of General Electric.

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ASC
Hazardous Material
Alternatives
Guide

Compiled by the ASC
HazMat Elimination Plan IPT
29 September 1993

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1. Introduction

This report is intended to clarify the great confusion about universal substitutes for hazardous materials (HazMats). Unfortunately, there are no "one-for-one drop-in" substitutes. The reason for this is quite simple. No two chemicals have exactly the same characteristics. A one-for-one substitute can be developed that only requires minor process adjustments, but developing such a substitute almost always requires many years of research costing millions of dollars. In most cases an alternative process using a different technique and different chemical can do the same job. Let's look at an example.

1,1,1 Trichloroethane (TCA) is widely used for cleaning. One process it is used in is vapor degreasing. Two frequently argued one-for-one substitutes for TCA are Tetrachloroethylene (better known as Perchloroethylene (PERC)) and Trichloroethylene (TCE). Both of these "substitutes" are on the EPA 17 toxic chemical listing, and should not be considered viable alternatives to TCA. If switching to these one-for-one substitutes, adjustments must be made to the equipment for the process to work properly (e.g. adjust the temperature of the heating coils and the condensing coils). An environmentally safe one-for-one substitute could be found, but it would require many years of research and a good deal of money. Fortunately, for a large majority of parts that are cleaned with vapor degreasing, an aqueous cleaner can be used. A simple example of an aqueous cleaner is Palmolive dish washing liquid, which is presently being used by Duriron Co.'s Pump and Foundry Division in Dayton Ohio. Aqueous cleaners are very effective and can often clean better than the hazardous solvents, but require new equipment and completely new process steps. The trade-off becomes, does the cost of the new equipment, loss of the old equipment, and time required to make the change, outweigh the cost and time required to do the research for finding a one-for-one substitute?

Another example, Halon 1301. Halon 1301 is the best fire suppression chemical we've found in 100 years of research. There are other ways to fight fires, but none better. Halon 1301 is used in fire suppression systems on all aircraft. Substitutes could be used, but the change would require a significant modification to each aircraft adding weight, and the new system would still not be as efficient at putting out fires. In this instance, the cost of the new equipment, loss of the old equipment, and time required to make the change, outweigh the cost and time required to do the research for finding a one-for-one substitute. Wright Laboratories at Wright-Patterson AFB is aggressively looking for this one-for-one substitute.

There are many alternative processes available that can do the job just as good if not better than the currently used hazardous material processes. In almost all cases switching from a HazMat process to a more environmentally friendly substitute brings a nice return on investment. A concern about substitutes is there are many different laws and regulations that govern different chemicals. As mentioned before, changing from TCA to PERC in vapor degreasing eliminates an Ozone Depleting Substance (ODS), but now uses one of the EPA 17. PERC is also a hazardous air pollutant (HAP) which is controlled by the National Emission Standards for Hazardous Air Pollutants (NESHAP). Caution must be taken not to change from one bad chemical to another.

This report is the first consolidation of a long effort to identify alternative products and processes for the HazMats used in Air Force weapon systems. The first section is a listing of the targeted hazardous materials. The second section is a simple review to help readers identify where they might be using HazMats. The other sections are dedicated to 18 general applications of HazMats and known general alternatives Remember, individual substitute materials or processes must be qualified on a case-by-case basis to ensure material compatibility and system performance are maintained. The work to find alternatives has only begun. This listing will grow as more alternatives are identified or developed. Information on application specific alternatives is available from your Environmental Management (EM) representative. The EMV point of contacts for Aeronautical System Center's program offices are:

NA - National Aerospace Plane Program Office
Capt Bill Shelton EMVP 5-5149

RE - Electronic Combat Program Office
Brian Townsend EMVP 5-3059
Capt Bill Shelton EMVP 5-5149

RW - Electronic Reconnaissance Program Office
Brian Townsend EMVP 5-3059
Capt Bill Shelton EMVP 5-5149

SD - Aircraft Systems Program Office
Greg Jarrells EMVP 5-3054

SM - Subsystems Program Office
Capt Bill Shelton EMVP 5-5149

VC - Advanced Cruise Missile Program Office
Capt Robert Gargiulo EMVP 5-3054

VF - F-15 Program Office
Capt Norm LeClair EMVP 5-3054

VJ - Special Projects Office
Brian Townsend EMVP 5-3059
Capt Mike Boucher EMVP 5-5149

VL - LANTIRN Program Office
Capt Robert Gargiulo EMVP 5-3054

XR - Development Planning Office
Greg Jarrells EMVP 5-3054

YC - C-17 Program Office
Capt Bill Shelton EMVP 5-5149
Capt Robert Gargiulo EMVP 5-3054

YF - F-22 Program Office
Capt Mike Boucher EMVP 5-5149

YP - F-16 Program Office
Capt Bill Shelton EMVP 5-5149

YS - B-2 Program Office
Capt Mike Boucher EMVP 5-5149

YT - Flight Training Program Office
Capt Bill Shelton EMVP 5-5149

YX - Program Development Office
Greg Jarrells EMVP 5-3054

EGLIN PROGRAM OFFICES
Brian Townsend EMVP 5-3059
Capt Mike Boucher EMVP 5-5149

or call ASC/EM at DSN 785-3054 (COM 513-255-3054) for more information. (ASC/EMVP 2060 Monahan Way, Bldg 17, Wright-Patterson AFB, OH 45433-7203.)

2. Targeted Hazardous Materials

There has been a great deal of confusion about which Hazardous Materials (HazMats) we are trying to eliminate, and which ones we're trying to minimize. This section is to clarify this issue.

Ozone Depleting Substances (ODSs, some times Ozone Depleting Chemicals, ODCs or Ozone Layer Depleting Substance, OLDS) were determined and listed by the Montreal Protocol and the Clean Air Act. The Act placed ODSs in two "classes". Class I ODSs have the greatest potential for harming the ozone layer, and will be phased out of worldwide production by 31 Dec 1995 (Halon by 1 Jan 1994). Class II ODSs will be phased out of production by 2030 (99% by 2020) or sooner. There are a lot of policies, but the National Defense Authorization Act effective 1 June 1993 is the one causing the most grief right now in DoD. So, what are these horrible chemicals? Here is the latest listing of Class I and Class II ODSs.

Class I: (CFC = Chlorofluorocarbon)

1. CFC-11
2. CFC-12
3. CFC-13
4. CFC-111
5. CFC-112
6. CFC-113
7. CFC-114
8. CFC-115
9. CFC-211
10. CFC-212
11. CFC-213
12. CFC-214
13. CFC-215
14. CFC-216
15. CFC-217
16. Halon 1011
17. Halon 1202
18. Halon 1211
19. Halon 1301
20. Halon 2402
21. Methyl Bromide
22. Methyl Chloroform
23. Carbon Tetrachloride

NOTE: Mixtures of these chemicals are included i.e. CFC-500 & CFC-502 etc.
Methyl Chloroform (MCF) = 1,1,1 Trichloroethane (TCA)
Refrigerants commonly have an 'R' prefix i.e. CFC-12 = R-12

Class II: (HCFC = Hydrochlorofluorocarbon)

1. HCFC-21
2. HCFC-22
3. HCFC-31
4. HCFC-121
5. HCFC-122
6. HCFC-123
7. HCFC-124
8. HCFC-131
9. HCFC-132
10. HCFC-133
11. HCFC-141
12. HCFC-142
13. HCFC-221
14. HCFC-222
15. HCFC-223
16. HCFC-224
17. HCFC-225
18. HCFC-226
19. HCFC-231
20. HCFC-232
21. HCFC-233
22. HCFC-234
23. HCFC-235
24. HCFC-241
25. HCFC-242
26. HCFC-243
27. HCFC-244
28. HCFC-251
29. HCFC-252
30. HCFC-253
31. HCFC-261
32. HCFC-262
33. HCFC-271

NOTE: Some common Class II ODSs are R-21 and R-22

The U.S. Environmental Protection Agency (EPA) is building a program to identify available, economically viable substitutes to class I and class II ODSs. A list of acceptable and unacceptable substitutes will be published. This program is called the Significant New Alternatives Program

(SNAP). Under SNAP regulations, it is illegal to replace a class I or class II substance with any substitute that EPA determines may present adverse effects to human health or the environment, if other substitutes have been identified that reduce overall risk and are currently or potentially available.

So, what about the EPA 17? In 1986 SARA Title III created the Toxic Release Inventory (TRI) reporting requirement for U.S. Industry. It required industry to report to EPA how much of each of over 300 toxic chemicals are released to the air, water, and land. 1987 was the first reporting period. EPA found that of all the toxic chemicals 17 were causing nearly 80% of the problem. The 33/50 Program is EPA's voluntary pollution prevention initiative to reduce national pollution releases and off-site transfers of these 17 toxic chemicals by 33 percent by the end of 1992 and by 50 percent by the end of 1995. At last count, more than 1,000 companies were participating in this program - many government contractors. The 33/50 program started in Feb. 1991. There are no laws that require the elimination of the EPA 17 chemicals... YET, but there is Air Force Policy. The 17 targeted chemicals are:

EPA 17:

1. Benzene
2. Cadmium **and compounds**
3. Carbon Tetrachloride*
4. Chloroform
5. Chromium **and compounds**
6. Cyanide **and compounds**
7. Lead **and compounds**
8. Mercury **and compounds**
9. Methylene Chloride
10. Methyl Ethyl Ketone (MEK)
11. Methyl Isobutyl Ketone (MIBK)
12. Nickel **and compounds**
13. Tetrachloroethylene (PERC)
14. Toluene
15. 1,1,1 Trichloroethane (TCA)*
16. Trichloroethylene (TCE)
17. Xylenes

NOTE: * These two chemicals are also ODSs
Chloroform is not Methyl Chloroform
Tetrachloroethylene = Perchloroethylene

Everyone should notice that adding "and compounds" to six of the chemicals turns the EPA 17 into the EPA 1000+. In addition to all these chemicals Volatile Organic Compounds (VOCs) and Hazardous Air Pollutants (HAPs) are beginning to be strongly regulated by the EPA. There are also a few other chemicals targeted by Air Force Materiel Command.

3. What Do I Use?

Most people are not familiar with the various processes and products that use hazardous materials. This section contains some generalizations of HazMat uses to help the reader understand where he or she might be using HazMats.

Aerosols & propellants: Most aerosols use ODSs as the solvent and inert propelling medium. If you use aerosols or pressurized systems you probably use TCA, CFC-12, CFC-114, HCFC-22 or HCFC-142b. Many cleaners used in parts assembly are used as aerosols. One common example is contact cleaners for electronics.

Batteries: Nearly all batteries use one or more heavy metals. If you use batteries in your system then you use Cadmium, Mercury, Lead, and/or Nickel.

Bonding (Surface Prep & Adhesives): Bonding includes everything from tapes and packaging glues to metal and carbon composite bonded structures. If you use glues anywhere you rely on TCA not only for a solvent in the adhesive, but also to clean the surface (surface prep) prior to bonding.

Cleaning: Almost every traditional cleaning method is under-fire for using hazardous chemicals. TCA, CFC-113, TCE, PERC, MEK, MIBK, toluene, xylene, and methylene chloride are all targeted for elimination. If your system uses metal, contains electronics, or any precision mechanics, then you are using one or more of these hazardous chemicals.

Coatings: Nearly all paints and primers contain hazardous materials. The solvents are either TCA, MEK, toluene, xylene or mixtures of these hazardous materials. The paint and primers themselves contain chromium compounds and sometimes cadmium compounds. Almost all printed wiring boards are covered with conformal coatings. These durable coatings don't usually contain hazardous materials, but almost always require a hazardous solvent for application. Cleaning application equipment (i.e. paint guns) and thinners also uses these chemicals. If you coat any part of your system, you use more than one of these chemicals.

Coating Removal: System repair processes often requires coating removal. Chemical stripping of coatings always involves the use of hazardous chemicals. The most common chemicals are methylene chloride and MEK. The use of methylene chloride to remove paint and other coatings is the largest usage of any hazardous chemical in the Air Force. If you coat any part of your system, you use methylene chloride or MEK in your repair process.

Composites: Composites typically use MEK and Methylene Dianiline (MDA) (a human carcinogen) in the manufacture and repair. Other hazards are associated with improper manufacture and disposal of composites.

Electronics: There are three areas in electronics that are of concern: cleaning, fluxing, and soldering. The electronics industry of necessity has high cleanliness standards. Cleaning electronics uses TCA and CFC-113 often before and after the soldering process. Nearly all fluxes use solvents, usually TCA. All soldering done for DoD still requires lead solders. If you have electronics of any kind in your system, then you use these hazardous materials.

Fire Suppression: All halons are targeted to be eliminated. Production of halon in the U.S. has already stopped. All aircraft, ships, tanks, and computer rooms use halon fire suppression systems. Most hand-held fire extinguishers also contain halon.

Foam Blowing: Foam packaging, foam insulation, foam cushioning and foam floatation all require TCA, CFC-11, CFC-12, CFC-113, or CFC-114 in the manufacture of the foam bubble or cell structure or as the insulating medium.

Fuels, Lubricants, & Hydraulic Fluids: All fuels by nature are hazardous, but benzene as an EPA 17 chemicals is targeted for elimination. JP-4 contains as much as 25% benzene. Hydrazine has been targeted by AFMC for minimization. Many lubricants and greases contain TCA or CFC-113. Many hydraulic fluids contain barium as a corrosion inhibitor. Barium is reported under the EPA Toxic Substances Control Act (TSCA).

Inks: Like paints, inks require a solvent. Nearly all inks use TCA or CFC-113.

Instrumentation & Testing: Laboratory tests often require hazardous materials because of their specific chemical properties. TCA, TCE, benzene, and many other hazardous materials are used daily in testing facilities to maintain quality standards of paint, fuels, and inks etc. Many EPA tests performed to verify compliance require a small amount of a hazardous chemical. Testing instrumentation often uses mercury (i.e. manometers).

Metal Plating: Cadmium, Chromium, and Nickel, plating is done to improve the performance characteristics of materials. All three of these heavy metals and their 1000's of compounds are targeted for minimization. Almost all nut, bolts, and screws are plated with one of these three metals. Cyanide is used extensively in plating and metal stripping baths as the carrier for the heavy metals.

Metal Treatment: If your system uses aluminum, stainless steel, high strength steels, magnesium, or titanium you use hazardous chemicals in the treatment of the metal. Aluminum, for example, uses several hazardous chemicals in deoxidation, etching, chemical conversion coating (Alodine™) and anodizing.

Refrigerants: Refrigerants are used in such applications as refrigerators, freezers, water fountains, air conditioning, avionics cooling systems, and chillers. Refrigerants include such ODSs as R-11, R-12, R-113, R-114, R-22, and others.

Sterilants: CFC-12 is widely used as the diluting agent for ethylene oxide to sterilize medical equipment, and to maintain cleanliness in microcircuit clean rooms.

Other (Deicing, Munitions, LOX, etc.): De-icing agents, munitions, chaff materials, liquid oxygen equipment (LOX), etc., contain or result in hazardous materials for handling or disposal.

4. Aerosols & Propellants

Ozone Depleting Substances (ODSs) being used in aerosol and propellant applications include:

Class I

- CFC-11;
- CFC-12;
- CFC-113;
- CFC-114; and
- methyl chloroform (MCF or TCA).

Class II

- HCFC-22;
- HCFC-142b; and
- HCFC-141b.

In an aerosol package, the contents are stored under pressure in a metal container and dispensed in a controlled manner by activating a valve. The type of propellant used, the shape of the opening in the can, and the composition of the product determine how the product is expelled (i.e. a fine mist or a foamy lather). In general, the components of an aerosol are the active ingredient, the solvent. and the propellant. ODSs have been used extensively because they can be both the solvent and the propellant.

Aerosols are used in a variety of applications from spray paint to electronics cleaning. Electronics conformal coatings are commonly applied using aerosols. A variety of chemicals are currently being used or considered as substitutes for class I and class II ODSs used in noninhalation aerosols and pressurized containers. The suitability of alternatives depends upon the product in which they are used. Each of the HazMats are used because of their unique chemical properties. They have a low boiling point yet are not-flammable, and have very good solvency and propellant properties. However, EPA believes that the majority of the substitutes for ODSs used as propellants or solvents in aerosols or pressurized containers are available and are easily integrated into existing production facilities.

The primary substitutes for propellant uses of HCFC-22 and HCFC-142b are:

- hydrocarbons;
- dimethyl ether;
- HFCs;
- compressed gases; and
- alternative processes.

Substitutes for the uses of CFC-12 and CFC-114 as propellants in medical applications are being developed and will have to undergo FDA approval. Possible substitutes are HFC-134a and HFC-227ea. FDA approval will likely occur over the next several years.

5. Batteries

The Air Force continues to research means to extend the life, reduce the maintenance and lessen the weight of batteries in its systems. This pursuit is now coupled with need to develop light weight, rechargeable batteries which do not contain EPA 17 hazardous materials. Batteries today are typically manufactured with the following EPA 17 hazardous materials which must be disposed properly at the end of the battery life:

Nickel-Cadmium (NiCd)	Rechargeable, multi-purpose batteries
Lead	Maintenance batteries
Mercury	Maintenance batteries

One pollution prevention alternative under development is to extend the maintenance free life of current batteries. WL is investigating coupling maintenance free NiCd batteries with advance microprocessor/charger technology to extend the life to over 20 yrs.

Additionally, batteries based upon lithium-polymer technology (once fully developed) could be used in virtually all battery applications. Industry is also exploring Ni-Metal Hydride (Ni-MHx) materials to replace consumer NiCd batteries. This technology could be expanded to military applications.

Alternatives are:

Extended life/ maintenance free batteries	under development
Lithium-polymer technology	under development
Ni-MHx technology	under development
Lithium Vinyl-Chloride	non rechargeable, large/small scale
Zinc-Manganese Dioxide	non rechargeable, small scale

Lithium Vinyl Chloride batteries are used in ICBM (10000 amps) and are available in large and small scales.

Presently, nearly all batteries can be recycled. Recycling is the best option for reducing hazardous waste generation.

6. Bonding (Adhesives)

Adhesives are used in a variety of applications. Some adhesive applications include:

- tapes and films;
- consumer adhesives;
- packaging and packaging containers;
- transportation;
- non-rigid bonding;
- rigid bonding;
- construction; and
- bonding of metallic and composite air vehicle structures and subsystems.

Clean surfaces are required to achieve high quality, high strength bonds. Contaminants in the bond-line compromise bond integrity. The importance of surface preparation immediately prior to adhesive application varies from being desired for paper and required for packaging, to being absolutely critical for high strength applications such as composite air vehicle structure. Surface preparation is covered in Section 7, Cleaning, and Section 11, Electronics and Precision Cleaning.

The Class I stratospheric Ozone Depleting Substance (ODS) used in adhesives is:

Methyl Chloroform (MCF or TCA).

TCA has been the adhesive solvent of choice because it is nonflammable, dries rapidly, does not contribute to local air pollution, and performs well in a wide range of applications. Adhesives that contain EPA 17 listed substances as the solvent should not be considered viable "substitutes" for TCA formulations. The EPA 17s used in adhesives are:

- Toluene;
- Xylene;
- Ketones;
- Tetrachloroethylene (or perchloroethylene, PERC); and
- Methylene chloride.

A variety of formulations and processes are being used or considered as ODS and EPA 17 free adhesives or processes. Their suitability in a given application depends upon physical, chemical and performance characteristics, and replacement and capital investment costs. The primary substitutes to replace TCA and EPA 17s in adhesives include:

- Petroleum distillates (paraffins, such as hexane and heptane);
- Organic solvents (alcohols, ethers and esters);
- Water-based formulations (such as latexes);
- High-solids formulations; and
- Process alternatives, including:
    - powder formulations (one-part epoxies, urethanes, and resins);

hot melts (thermoplastic binders);
radiation-cure (acrylics, epoxies, urethanes, anaerobic adhesives, and polyesters);
moisture-cured, chemical-cured, and reactive liquid adhesives.

Paraffins, *alcohols*, *ethers* and *esters* function well as adhesive solvents. Many have OSHA standards associated with their use.

Water-based adhesives are effective in flexible foam adhesive applications. These adhesives typically require long set and dry times. They are short-lived in storage. Bacteria-contaminated waste water is often associated with their use. They have not proven effective in binding high-density laminates or in rigid bond applications.

High-solids adhesives typically contain 80% solids and thus a substantially reduced amount of TCA versus traditional formulations. They offer good performance characteristics, including initial bond strength. They can often be applied using existing equipment at normal line speeds with minimal modification. They are effective as flexible foams and for bonding high-pressure laminates; however, since they still contain TCA, they must be considered transitional replacements.

Powder adhesives are effective in higher temperature applications; whereas *hot-melts*, although effective for metals, plastics, and high-pressure laminates, are heat sensitive.

Radiation curing employs UV, IR, gamma or X-ray energy and is effective in electronics and medical applications.

Moisture-cured, chemical-cured and reactive liquids are not widely used due to their lack of maturity and performance problems.

Monochlorotoluene and *chlorobenzotrifluorides* are of interest as adhesive solvents. However, the EPA has not issued a Significant New Alternative Policy (SNAP) program decision regarding their use.

It is important to note that specific application testing may be required when considering an alternative adhesive formulation or bonding process for a military application. The purpose of such testing would be to verify that the adhesive material meets performance requirements or to certify the bonding process.

7. Cleaning

There are three major cleaning applications: metals or surface cleaning, electronics cleaning, and precision cleaning. Electronics and precision cleaning are covered under Section 11.0. Surface cleaning is typically used prior to surface finishing, after surface finishing in preparation for bonding and prior to coating. It is also associated with inspection processes (removal of test compounds) and printing operations. The majority of solvent cleaning is accomplished with CFC-113 and methyl chloroform (1,1,1 trichloroethane), PERC, TCE, MEK, MIBK, and/or toluene.

Cold Cleaning: Part is brushed, dipped, or wiped with solvent. Alternatives are:

Organic solvents (i.e. terpenes, naphthas, paraffins, ethers, & esters)
Aqueous & Semi-aqueous cleaners - Alkaline surfactants, wetting agents, emulsifiers, detergents and organic solvents (terpenes, high boiling point alcohols, petroleum distillates) with varying quantities of water. Requires a wash, rinse and drying phase.
"No-clean" - change of manufacturing process to remove the cleaning stage altogether.
Monochlorotoluene/chlorobenzotriflourides - currently under EPA evaluation.
Volatile Methyl Siloxanes - under EPA evaluation; results look promising.
Enzyme Cleaners - requires a change in process, includes rinse cycle.
CO2 and Bicarbonate soda - surface cleaning using blasting media. Requires process and equipment change.

Vapor Degrease: Vapor phased solvent condenses on part and rinses off contaminant. Alternatives are:

Aqueous & Semi-aqueous cleaners - Alkaline surfactants, wetting agents, emulsifiers, detergents and organic solvents (terpenes, high boiling point alcohols, petroleum distillates) with varying quantities of water. Requires a wash, rinse and drying phase.
"No-clean" - change of manufacturing process to remove the cleaning stage altogether.
Monochlorotoluene/chlorobenzotriflourides - currently under EPA evaluation.
Volatile Methyl Siloxanes - under EPA evaluation; results look promising.

Media Blasting: Removal of grease, oils, baked carbon, and etc. Alternatives are:

High pressure hot water wash - Water jet (detergents may be added) dislodges contaminants.
Dry Ice - CO2 pellets are blasted at surface to remove contaminants - requires expensive equipment and process changes.
Bicarbonate of Soda (BOS) - a water/BOS mixture is blasted at surface to remove contaminants - requires equipment and process change - in use by many.

8. Coatings

The general category of coatings refers to painting, priming, and conformal coatings. Each one of these processes have traditionally used HazMats and ODSs. There are four areas within each of the processes that must be addressed: 1) the coating material itself, 2) the solvent used within the coating, 3) the vapors given off from the application of the coating, and 4) the cleaning of the tools used to apply the coating.

There are hundreds of combinations of paints, primers, tools, techniques and applications used to paint or prime surfaces. Traditionally, the methods in use today were chosen and adopted because of the available technology and the desired level of surface protection (corrosion control) or aesthetic quality. Coatings of all types are used on hardware such as aircraft skins, engines and engine components, ground support equipment, test articles, composite structures such as radomes, turbine blades, heat exchangers and many more items too numerous to mention. Decreasing hazardous materials in this arena can be as simple as consolidating all painting operations to a complex and costly process change. The table shown below can be used as an aid to identify alternatives that may be used during the painting/priming process.

Coating material: Heavy metals are used for pigment and corrosion resistance, and include lead and chromates. Alternatives include:

Do not paint - leave bare metal
Polyester films - developed for F-86 radomes
Polyurethane belly tape - used on RCAF C-130
3M abrasion resistant coatings on wing leading edges - instead of repainting chipped or eroded edges
Self priming top coat - used to reduce quantity of waste stream when depainting
Reduce paint colors that are available
Eliminate lacquer paints - they contain high percentages of volatile organic compounds

Solvent: TCA, MEK, toluene, and xylene are used as solvents in coatings. Alternatives are:

Water based coatings - uses water as a solvent
Two component water based epoxy
Powder coatings - no solvent required because of fluidized bed applications and electrostatic fluidized bed approaches
Solvent recovery systems - using carbon absorption recycling technique
Petroleum distillates, organic solvents (esters, alcohols), high solids formulations (less solvents, more resin)
Thermoplastic plasma spray coatings

Vapors: Most coating applications depend on a solvent used to liquefy the coating for application. After the coating is applied, the solvent evaporates. The main coating solvents include Volatile Organic Compounds (VOCs) like MEK, toluene, and xylene, or ODSs like TCA. Alternatives are:

Electrostatic paint applications
Solvent recovery systems - using carbon absorption recycling technique
High volume low pressure paint guns
Use of paint proportioning systems, paint handling systems and paint monitoring systems to track the efficiency of the painting operation
Dipping, flow coating, airless atomizing, rolling, continuous coating, centrifugal coating and tumbling - instead of spraying

Tool Cleaning: The same solvents used to liquefy the coatings for applications are used to clean the equipment after the job is done.

Use of EP 921 - instead of MEK
Sealed washing units designed to reduce vapors emitted by spraying - also recycles solvent used as a cleaning agent

Conformal coatings are typically used to protect electronic devices from environmental, chemical, electrical and chemical hazards. The environmental hazards associated with conformal coatings are in both the application and the removal of the coating. CFC-113 and TCA are almost always used as the solvent for the coatings. The best way to reduce these hazards are by carefully choosing the conformal coating used in your application. The military specification for coating circuit card assemblies is MIL I-46058. It includes five types of conformal coatings. Type AR (acrylic), Type ER (epoxies), Type SR (silicones), Type UR (urethanes) and Type XY (paraxylenes or parylenes). To decrease the hazardous material output associated with removing the conformal coating, one of these methods must be reviewed in light of the specific application and use of the electronic device. (See also conformal coating removal in the next section.)

9. Coating Removal

The general category of coating removal refers to the removal of paints, primers and conformal coatings. Industry has focused most of its attention on alternatives to traditional methods of paint and primer stripping because of the heavy reliance on methylene chloride - an EPA 17 chemical. The table below can be used as an aid to identify alternatives to traditional paint/primer stripping approaches.

Technology	Description
Plastic media blasting	Use of tiny plastic pellets blasted at a painted surface. The resultant waste stream is easily handled because it is composed of dry plastic pellets and paint chips.
Wheat starch media dry stripping	Uses a dry wheat starch compound blasting technique. The resultant waste stream can be remediated through biodegradation techniques which break down the waste into carbon dioxide, water and metals which were contained in the paint. The metals can then be separated through an ion exchange system.
Sodium bicarbonate blasting	Makes use of a water and baking soda formulation. The slurry is blasted at the painted surface. The resultant waste stream is much less toxic than traditional methylene chloride based strippers.
Increased intervals between stripping	Most paints have undergone testing which assures their effectiveness for a specific number of years. Be sure that the paint or primer being removed has been used to its full extent.
Mechanical abrasion	Makes use of abrasive paper (sand paper) and abrasive cloth used manually or in conjunction with power tools. Typically used for spot removal.
Cryogenic stripping	Use of a liquid nitrogen jet to lower the paint temperature - embrittlement occurs and then plastic media blasts chip the paint off.
Chemical strippers	Used as a wet stripper - similar process as that used when using methylene chloride. Products such as X-Caliber and Citrex have been used. Most are used in conjunction with another technique to assure complete stripping
Water blasting	Uses water blasted at very high pressures (20,000 - 30,000 psi) to remove painted/primed surfaces.
CO_2 pellet blasting	System uses tiny frozen CO_2 (dry ice) blasted at relatively low pressures - approximately 250 psi.
Flash lamp or laser stripping	Makes use of high energy light sources to vaporize the painted/primed coatings.
Crystalline ice pellet blasting	Technique makes use of tiny ice chips blasted at high pressures. The resultant waste stream is a water/paint slurry that can be handled through a filtering technique.
Alcohol based softener and high pressure water blasting combination	Technique uses alcohol to soften the paint/primer before being blasted with water. This allows for a lower pressure blast.

In addition to the technologies described above, there have been a number of attempts to combine two of the techniques to assure complete stripping. Typically one technique is used to soften the paint or primer and a second technique is used to completely strip the coating.

Conformal coating removal poses a special challenge. Each of the five general types of conformal coatings require different removal techniques. The table below describes these techniques and indicates the chemicals and processes available to remove conformal coatings.

Conformal Coating Type	Traditional Removal Technique	Alternative Removal Technique
AR - Acrylic	Chemical scrubs using methylene chloride, trichloroethane and aromatics or ketones	Butyrolactone solvent baths - then rinse with alcohol or de-ionized water
ER - Epoxies	Mechanical sanding, abrading, cutting and scraping. Chemicals have not been successful since they cannot discriminate between the epoxy conformal coating and the epoxy glass printed circuit boards or epoxy potted components	Mechanical means are considered the best alternative.
SR - Silicones	Methylene chloride baths	Hydrocarbon systems - soaking in hydrocarbon solutions and rinsing with alcohol and de-ionized water
UR - Urethanes	Methanol/alkaline activators or ethylene glycol ethers with alkaline activators	Traditional non-hazardous methods are considered the best alternative
XY - paraxylenes & parylenes	Tetrahydrofuran solvents with an alcohol rinse	Traditional non-hazardous methods are considered the best alternative

10. Composites

Composite materials are used in a variety of applications, including:

- aerospace and marine, specifically:
  - non-structural, such as subsystems housing;
  - structural, such as wing skins, bulkheads, and cargo flooring;
- automotive and mass transit;
- construction;
- electronics housing; and
- recreation, such as tennis rackets, golf clubs, and children's toys.

Composite materials include prepregs, adhesives and core materials. Prepregs consist of a fiber matrix, such as fiberglass, quartz glass, carbon/graphite, or aramids, covered with a resin material, such as epoxy, vinyl ester, polyester, phenolic, or bismaleimide.

The hazardous materials of primary concern used in composite materials manufacture and support are:

- Methyl ethyl ketone (MEK), an EPA 17 listed substance; and
- Methylene dianiline (MDA), a human carcinogen.

There are several environmental issues associated with the use of composite materials in the manufacturing and repair processes. MEK is used in the production of a number of prepreg and adhesive systems. MDA is a constituent in a number of composite resin materials, such as PMR-15 and similar resins. People who prepreg composite materials are therefore at risk of exposure to these hazardous substances. Precautionary measures, such as protective clothing and ventilation systems, are required. Expensive clean rooms are also necessary to ensure the quality of composite manufacturing. Personnel associated with the repair of composite structures face the same risks as those who work with raw composite materials.

Curing of composite materials, using an autoclave or oven, is necessary to set the desired material properties for the intended application. During cure, MEK is driven off and the MDA is captured in the solid matrix reducing the potential for exposure. If the material is cured improperly, specifically at too high a temperature, the composite material itself could be consumed resulting in other more hazardous materials evolving like acidic hydrogen fluoride gas.

Substances such as hydrogen fluoride can also evolve as a result of burning composites at high temperatures, such as might happen as a result of an aircraft crash. Another potential hazard with regard to the burning of composites is the release of very small fiber strands into the atmosphere. There is some evidence to suggest such fibers could behave similarly to asbestos when inhaled, resulting in a risk of developing fibrosis from exposure.

At this time, there are certain applications, including most military, for which there are no suitable substitutes. Research and development to resolve these issues is on-going. The toxicity of MDA-free materials is not fully understood. Toxicological testing is either on-going or being planned.

There are also efforts on-going regarding demilitarization and disposal techniques. Currently waste scrap is either incinerated, landfilled as a non-hazardous waste or landfilled as a hazardous waste. Other efforts are focused on developing recycling methods and the minimization of waste scrap. Thermoplastic composite materials are very amenable to recycling. The construction industry has taken advantage of this and has made available roofing tiles made from recycled thermoplastic composite material. Waste scrap can be minimized through improved purchasing techniques (just-in-time purchasing), effective inventory management, and efficient material usage (material conservation, process modification, and handling). For example, Gerber cutting machines are typically 65% to 80% efficient. New software codes are being developed to improve this efficiency rating that will result in the generation of less scrap.

11. Electronics and Precision Cleaning

CFC-113 and methyl chloroform (TCA) are used extensively in the electronics and aerospace industry in cleaning printed circuit boards (PCBs) and the precision cleaning of special components. These chemicals are used because of their ability to remove organic soils, low surface tension to penetrate small spaces, volatility, low toxicity, non-flammability, and ability to clean surfaces without leaving a residue. In electronics applications, CFC-113 and TCA are used to clean rosin fluxes and other contaminants from PCBs. In precision cleaning applications, CFC-113 and TCA are used when critical cleanliness standards on sensitive, intricate components must be met, or when components have physical characteristics (geometry).

Unfortunately, alternative materials and processes for electronics and precision cleaning do not possess the "universal applicability" of CFC-113 and TCA. Each individual substitute material or process must be qualified on a case-by-case basis on systems to ensure material compatibility and system performance is maintained.

In addition, lead (Pb) is used extensively in the electronics industry as a component of solder (the most common is 65% tin and 35% Pb). Since Pb (and associated compounds) is one of the EPA 17 industrial toxic chemicals and AFMC has set goals for its elimination, the Air Force is interested in solders which do not contain Pb.

There are many alternatives for CFC-113 and TCA in electronics and precision cleaning operations. Such alternatives range from "no-clean" technologies to semi-aqueous and aqueous cleaning. The following table lists alternative materials and processes for both the electronics and precision cleaning processes. For each alternative, a brief description of substitutes with advantages and disadvantages will be covered.

Alternatives for Electronics Cleaning

Technology	Description	Advantages	Disadvantages
Alkaline Saponified Water Cleaning	Used to clean fluxes & other contaminants from PCBs	Low surface tension, ability to emulsify contaminants	Foaming, various detergents w/ diff. cleaning properties
Semi-Aqueous Cleaning	Hydrocarbon solvent to clean, water rinse to remove hydrocarbon (HC) solvent residue	Excellent for cleaning surface mount technology, removes polar & non-polar contaminants	Could be incompat. w/ plastics & rubbers, odor & toxicity concerns
Underbrush Cleaning	Scrubs the fluxed solder side of the PCB assembly, uses detergent, HC solvent, or surfactant	In-line batch process can be used, solvent, detergent, or hydrocarbon/surfact. can be used	Must periodically replace wash solutions, design conveyor system to suit the product
Hydrocarbon/Surfactant Spray Cleaning	Cleaner (solvent & surfactant) dissolve the soils, water rinse is used	Concentrated HC-surfactants more effective than CFCs, excellent for SMT	Flammability concerns, hydrocarbon mist formation (VOCs)

Technology	Description	Advantages	Disadvantages
In-Line Aqueous Cleaning	Spray oleaning using water & saponifiers, relies on spray nozzles to clean PCBs	Process is cost-effective if no water pre-treatment, various saponifiers can be used	SMT processing has limitations, requires filtering of water, must monitor waste stream
Batch Aqueous Cleaning	Dishwasher "batch" spray machines are used w/ several cleaning stages	Less than 25% water consumption than in-line systems, electricity usage is 20% lower	Effective, but tend to operate on long cycles, high throughput machines cost $$$$
Controlled Atmosphere Soldering (CAS) - No Clean Method	Inert gas, usually N_2, is used to reduce the level of oxygen; reduces amt of flux needed to produce an acceptable joint	Better cosmetics, better wetting characteristics, improved joint quality, less dross, may eliminate flux	Increased bridging related to board design, equipment changes must be made
Use of Low Solids - No Clean Fluxes	Low solids, low residue fluxes which contain 0.5 to 4% solids	Reduced solids content results in less post solder residue, eliminating cleaning; spray fluxers are used	Amount of flux applied is critical, may require adjustment of amount & pattern of flux applied
High Solids-No Clean Fluxes	Contain only 15-40% solids; used in Europe & Japan, not in U.S.	Residues provide a method for controlling long-term corrosion	May result in increased tackiness and reduced testability
No-Clean Solder Pastes	Low-residue no-clean solder pastes used which can be left on the PCB	Eliminates the need for cleaning after the reflow soldering processes	May require a controlled atmosph. to produce adequate solder joints
Use of Water Soluble Fluxes	Fluxes are used that can be dissolved using a simple DI water rinse (e.g. HF-1189)	Eliminates the need for ODS containing solvents in the cleaning step, cycle time reduction	Requires minor equip. changes, hand soldering requires practice, may need PCB redesign
HCFC and other Fluorinated Solvents	Fluorinated organic solvents (e.g. penta-fluoropropanol, HCFC-123, HCFC-141b, etc.)	Chemicals have polar solvency for removing ionic soils, low surface tension, cleans SMT, some "drop-ins"	Many are Class II ODSs, toxicity testing is in process
Isopropyl Alcohol - Water Cleaning	Alcohol-water mixture used as a solvent to clean PCBs	Alcohol reduces the surface tension allowing solution to circulate freely	Cleaner is VOC, flammable, may need to treat waste water
Ice Particle Cleaning of PCBs	Spray of ice particles (0.1 to 300 um), hardness and size of the particles are controlled	Eliminates cleaning of PCBs with ODS containing chemicals, pressure and angle of cleaning is controlled	New technology without a lot of test data, requires installation of new equipment

Reactive Aqueous Defluxing System (RADS)	An aqueous cleaning solution with an oxidizer is sprayed on to the PCBs, rinse w/ DI water	RADS is non-toxic, biodegradable and has no ODP	Requires equipment changes

Alternatives for Precision Cleaning

Technology	Description	Advantages	Disadvantages
Aqueous Precision Cleaning	Water is the primary cleaning solvent with various additives; process consists of washing, rinsing, & drying steps; uses immersion, spray, and ultrasonics	A non-flammable, non-toxic cleaner for multiple contams., good for inorganic or polar soils, can use ultrasonics, chemicals are inexpensive	Difficult to clean parts with blind holes & small crevices, requires careful process control, difficult to rinse, waste water disposal could be a problem
Semi-Aqueous Precision Cleaning	Hydrocarbon/surfactant cleaners; cleaners are either emulsified in water or rinsed with water; uses immersion or spray	Good for cleaning grease, tar, & waxes; compatible w/ most metals & plastics; low evaporative loss	Recycling or disposal of wastewater can be costly; flammability is a concern in spray cleaners; some are VOCs or have odors
Use of Pressurized Gases	Pressurized gases such as air, rare gases, CO_2, N_2, and HCFC-22 are blown on parts to remove contaminants	Low viscosity, low toxicity, high diffusivity, non-flammability, low capital cost	Low density, high pressures can rupture seals, hard to clean critical components, often not effective for microscopic particles
Supercritical Fluid (SCF) Cleaning	Fluids (normally gases) that are above their critical values for temp. & pressure; powerful solvent ability	Effective in removing substances of low molecular weight and low polarity; properties of the solvent can be altered	Need to operate at high pressures, significant up-front capital costs, can adversely affect substrates
Plasma Cleaning	Electrically charged gas containing ionized atoms, electrons, & free radicals; in a vacuum chamber, cold plasmas contact PCBs; RF energy is used to create plasma	Process gases are inexpensive; only small amounts of process gases are used; cleaning time ranges from a few seconds to a few hours; parts are cleaned evenly	Capital costs for equipment are high (up to $130K); plasma is not formed efficiently in hidden areas of parts; can produce a film on parts; must remove gross contam. first

Technology	Description	Advantages	Disadvantages
Ultraviolet Light/ Ozone Cleaning Method	Exposure of the contaminated surface to UV light in the presence of ozone; cleaning occurs due to photosensitized oxidation; used in photoresist removal, cleaning vacuum chamber walls, silicon wafers, etc.	Good in removing thin organic films from different surfaces; used prior to thin film deposition	Poor cleaning of particles & inorganic contamination; can damage certain substrates; staining and discoloration of certain materials
Use of HCFCs in Precision Cleaning	HCFCs and HCFC blends are used as solvents for heavy grease & water soluble oils	Some of these solvents have good cleaning performance & are close to being "drop-ins"	HCFCs have an ODP & are targeted for phase-out in 2030; may require process changes
Alcohol Cleaning w/ Perfluorocarbons (PFCs)	Methyl, ethyl, and isopropyl alcohols are used as solvents; use of a perfluorocarbon "blanket" to protect against flammability	Alcohol (being polar) has great solvency and can remove particulate & inorganic contams.; mixture allows continual distillation	Alcohol not effective in removing nonpolar contams. like grease; PFCs are global warmers; high capital cost for equipment
N-Methyl-2-Pyrrolidone (NMP) as a Solvent	NMP is effective as a solvent especially in ultrasonics applications (at room & elevated temp.)	NMP is miscible w/ water & most other organic solvents; it has high solvency, high purity, high flash point, & low volatility	Polymeric materials such as epoxy-urethane are sensitive to NMP
Perfluoroalkanes (PFAs) as Solvents	A group of cmpds in which all of the hydrogen atoms are substituted by fluorine; PFAs are used in medical applications & are safe in contact w/ pure O_2 at hi press.	Where no substitutes are yet available, PFAs offer solutions for cleaning parts for high accuracy gyros	PFAs are expensive due to their synthetic production processes; PFAs have a significant global warming potential; low solvency & are unlikely to remove oils

Alternatives for Lead (Pb) in Soldering

Technology	Description	Advantages	Disadvantages
Non-Pb Solders	Various non-Pb solders are available for use including Tin-Silver, Tin-Zinc, and Tin-Copper solders	These solders do not contain Pb and therefore do not present the same environmental & health concerns	Materials do not possess the "global" applicability of Sn-Pb solder & must be tested for each use, require process changes

Alternatives for ODS Chemicals in Testing Electronics

Technology	Description	Advantages	Disadvantages
Cooling Electronic Equipment Using HFC-134a	HFC-134a is used to cool down electronic components during testing for thermally intermittent failures	HFC-134a is very close to being a "drop-in" substitute for R-12 in this application	HFC-134a has global warming potential and has limited availability; HFC-134a is relatively expensive
Cooling Electronic Equipment Using Liquid Nitrogen	Liquid nitrogen is used to cool down components during testing for thermally intermittent failures	Liquid nitrogen is less expensive than using CFC-containing refrigerants; no environmental problems	Liquid nitrogen presents a potential risk of thermal shock to components; safety hazards assoc. w/ using liquid nitrogen
Vortex-Cooled Compressed Air	Compressed air is split into two streams, one cold & one hot; cold stream is directed at components	Compressed vortex air coolers are inexpensive;	Hazardous noise may be produced by the compressed air coolers; these coolers require longer times to cool equipment
Compressed Air Used to Replace Aerosol Dusters in Electronics Testing	Compressed air with appropriate filters & dryers is used to blow off PCBs	Compressed air is easy to obtain and relatively inexpensive to use; no operator exposure hazards	Requires initial investment for in-line filters & dryers

12. Fire Suppression

Ozone Depleting Substances (ODSs) used in fire suppression:

Class I	Halon 1211 - Hand-held/manual
	Halon 1301 - Total flooding/automatic systems
	Halon 2402 - Limited use in engine nacelles

Worldwide production of these substances will cease 1 Jan 94 by direction of the Montreal Protocol. Production has already ceased in the U.S.

Substitutes for Halon as fire suppression agents must meet the following criteria:

- They must be effective fire protection agents
- They must have an acceptable environmental impact
- They must have low toxicity
- They must be relatively clean or volatile

Human safety factors to be met are the No-Observed-Adverse-Effect-Level (NOAEL) and the Lowest-Observed-Adverse-Effect-Level (LOAEL). These factors measure cardiotoxicity of a material. Generally, accepted safety levels are NOAEL of 1 percent and LOAEL of 2.5 percent. If a substance requires concentration greater than indicated above to be a good fire suppressant, the system must be designed to allow evacuation of personnel prior to released agent exceeding these concentration levels.

Weight and volume are critical factors when used as aircraft on-board fire and explosion suppressant.

HBFCs: HBFC -22B1 is the only HBFC expected to be commercially available. This substance is a good fire suppressant at slightly greater weight and volume than Halons. However, with an Ozone Depleting Potential (ODP) of 0.74, it has been added to the production phase out list, effective 1 Jan 96.

HCFCs - Class II ODSs: HCFCs are effective fire suppressants, but not as effective as Halons. Toxicity levels are higher than allowable; therefore, use is limited in occupied spaces.

HFCs: Less effective than Halons, HFCs are useful in applications with greater weight and volume limits. HFCs can potentially contribute to global warming. EPA will prohibit discharge testing and training with these agents.

There are many substitutes for the Halon group of fire suppressants; however, all have some limitation which makes them unsuitable for long-term use in the USAF. Wright-Laboratories and many companies in the fire suppression industry are actively involved in research and development to identify or create suitable substitutes which more closely fulfill our requirements.

13. Foam Blowing

The manufacture of foam plastics relies on the use of gas or volatile blowing agents to create bubbles or cells in the plastic foam structure. Suitable blowing agents must be soluble in liquid but not in solid plastic, possess a suitable boiling point and vapor pressure, and not react with the plastic. Other factors to consider for alternatives include toxicity, flammability, environmental concerns (exposure levels and pending regulation) and in the case of insulating foams, the insulating efficiency (thermal conductivity). Foams are used for cushioning, floatation devices, packaging, and thermal insulation. Cushioning foams and packaging foams are primarily made from flexible polyurethane, polyolefin, and polystyrene foams. Insulating foams are primarily made from polyurethane foam, polystyrene, and phenolic insulation board. Foam production blowing agents are primarily comprised of the following five ODSs:

Class I:	CFC-11 & CFC-113	polyurethane and phenolic foams
	CFC-12 & CFC-114	polyolefin and polystyrene foams
	Methyl Chloroform (TCA)	some flexible foams

In the short term, most CFC blowing agents can be replaced with HCFCs and HFCs with either no or minor process changes. Others will require major changes as well as performance considerations (lower insulating potentials). However, HCFCs, HFCs, and hydrocarbons have their drawbacks for long term solutions. HCFCs have varying degrees of ozone depleting potential. HCFCs and HFCs have global warming potential. Other potential alternatives (especially hydrocarbons) are Volatile Organic Compounds (VOCs).

Existing Blowing Agent	Potential Alternatives	Comment
CFC-11	- HCFC-123, HCFC-141b	virtual short term drop in
CFC-113	- HCFC-22, HCFC-142b	requires technical & process mods
	- Carbon Dioxide	long term
	- 2-Chloropropane	proprietary development
	- HFC-134a	under development (ud)
	- HFC-152a	(ud), flammable
	- Hydrocarbons	(ud), flammable, major VOC source
	- AB Technology	generates carbon monoxide (regulated by OSHA)

Existing Blowing Agent	Transitional Alternatives	Comment
CFC-12	- HCFC-22, HCFC-142b	technology under development for short term
CFC-114		
	- HFC-124, 125, 143a	under development
	- Carbon Dioxide	long term

Alternative products: Expanded polystyrene, fiberboard, fiberglass, vacuum panels, new polyol technology, paper, cardboard, latex foams,
Pending blowing agent: Nitrogen gas, HFC-227ea/pentane, HFC-227ea/methylpropane
Alternative process: Electroset process

14. Fuels, Lubricants, & Hydraulic Fluids

Fuels: Fuels serve as an energy source for internal combustion, turbine, and jet engines. Such engines are typical of military applications, in:

ground equipment
ground vehicles (cars, trucks, tanks, etc.);
air vehicles (drones, aircraft, etc.); and
ships.

The hazardous material of most concern in gasoline, diesel fuel and JP-4 is benzene. Benzene is an aromatic hydrocarbon. JP-4 can be as much as 25% benzene (10% on average). Benzene is an EPA 17 listed substance and a human carcinogen.

Improperly controlled combustion of these fuels contributes to local air pollution. This results in emissions of hazardous carbon monoxide. Other emissions include carbon dioxide (a greenhouse gas), and oxides of sulfur and nitrogen. This contributes to the formation of hazardous ground-level ozone, smog and acid rain.

Flexible fuel engines, especially for ground fleet vehicles (i.e., car and light truck fleets), are an alternative which are becoming more and more practical as the technology is perfected. For example, many gas stations now offer gasoline-methanol blends. Some blends, such as 10% methanol, can be safely used in normal internal combustion engines with no modification. Development and refinement of *alternative fuel engines* and *electric vehicles* is underway. In California, the state which typically leads the nation in environmental regulations, the USAF has begun the transition to cars which can operate on alternative fuel, like methanol. Methanol combusts at a lower temperature resulting in a reduction in emissions out the exhaust pipe. The tradeoff is in horsepower and miles per gallon of fuel, both of which are lower than comparable gasoline engines.

An alternative to JP-4 is *JP-8*. JP-8 contains less than 100 parts per million (ppm) benzene, significantly less than that contained in JP-4. The USAF is encouraging the use of JP-8, especially for new acquisition programs where designs can be influenced without the burden of modifying existing equipment. The transition to JP-8 from JP-4 in existing air vehicles/weapon systems is more difficult as it would require engineering changes for seals, gaskets and O-rings.

Hydrazine is another substance used as fuel, specifically in the F-16 program. It is used as a EPU propellant of chaff. It is highly flammable and extremely toxic. Hydrazine should not be required in new systems.

Lubricants: Lubricants are used in a variety of applications, including:

lubricant/cleaner blends which leave a thin lubricant layer behind;
greases for fittings, bushings, etc.;
general purpose

In many but not all cases, Technical Orders specify the use of MIL-L-63460 lubricant/cleaner blend. MIL-L-63460 through version D specifies 5% to 15% *trichlorotrifluoroethane* (CFC-113) and *methyl chloroform*, MCF (or 1,1,1 trichloroethane, TCA). Both are Class I ODSs.

Picatinny Arsenal, Pa, is performing tests on CFC-free, non-chlorinated solvent lubricants to met MIL-L-63460 and expects to have an acceptable alternative in the very near term. Alternative general purpose lubricants are available where MIL-L-63460 are used but not specified. In some cases, a two-step cleaning and lubricating process may be needed.

Some current lubricants are available in aerosol containers. Non aerosol alternatives are available. Non CFC, non-chlorinated solvent products are currently qualified to NSN 9150-00-458-0075, NSN 9150-00-823-7860 (limited availability), and NSN 9150-01-064-6511 (one alternative).

It has been discovered that the burning of waste lubricant oil produces the toxin trycresylphosphate, TCP. Similar toxins are generated in high temperature, low oxygen environments. The combinations of conditions, additions and formulations which generate TCP toxins in turbine engine lubricants is not thoroughly understood. Environmental studies are being developed to assess present and substitute lubricant formulations with the goal of developing a TCP-free lubricant.

Hydraulic fluids: The fluid, MIL-H-46170 Type II, used in hydraulic systems uses a *barium* additive as a corrosion inhibitor. Although barium is not listed as an Ozone Depleting Substance (ODS) or an EPA 17 substance, it is reported under the EPA Toxic Substances Control Act (TSCA) as a hazardous material. Barium is explosive and poisonous.

A low temperature, non-barium fluid is being developed by the Army which uses calcium as the corrosion inhibitor but it has a flash point below acceptable USAF standards. The USAF has proposed work to the Army to execute development of a low temperature, non-barium, high flash point hydraulic fluid.

15. Inks

Ozone Depleting Substances (ODSs) being used in ink formulations include:

Class I:

- Methyl Chloroform (MCF or TCA)
- CFC-113 (negligible use)

TCA is the only ODS currently used in ink formulations

The primary use of inks in the industrial environment is packaging and marking of circuit cards and chassis.

The most acceptable substitutes for TCA in ink are:

- Water Base
- Water Solution (water 80 percent/alcohol and ethyl acetate 20 percent)
- Terpenes

A problem experienced with pure water base formulations is the existence of high surface tension. This prevents good penetration into the product surface. This has been overcome by use of additives (alcohol, ethyl acetate, etc.) which greatly reduce surface tension.

There are many other substitutes that are not ODSs; however, the toxicity levels in most of these substances make their use unacceptable.

16. Instrumentation & Testing

Instrumentation: Mercury is the main hazardous material used in instrumentation. Thermometers and manometers are examples. Many testing facilities are changing to digitized calibration and measuring equipment to replace their mercury instrumentation.

Testing: The hundreds of chemical testing procedures we use daily to control product quality or to verify EPA regulation compliance are dependent on various hazardous materials. TCA, TCE, benzene, and many other hazardous materials are used in testing facilities to maintain quality standards for paint, fuels, and inks etc. Laboratory tests require hazardous materials because of their specific chemical properties. Many test facilities are also dependent on hazardous cleaners like TCA and MEK. Due to the small relative quantities used and the extensive R&D required to develop new tests not requiring hazardous materials, no substitutes are available nor will there likely be substitutes in the near future.

17. Metal Plating

Metal plating is sometimes combined with metal treatment, the next category, and called surface finishing. When taken as a group, surface finishing is the largest source of hazardous waste in aircraft production. Metal plating most commonly refers to electroplating, which deposits metals such as chromium, cadmium, nickel, (all on the EPA 17), silver or zinc on another metal surface. The purpose of the plating is normally to enhance the corrosion resistance or hardness of the base metal. In addition to the problems caused by the plating materials themselves, waste streams from plating baths typically contain cyanide, which is also an EPA 17 and extremely poisonous.

In zinc plating, alternatives to the plating baths containing cyanide include ammonium or potassium chloride, and acid sulfate, chloride, or fluoroborate. For cadmium plating, alternatives include cadmium oxide, sulfuric acid, distilled water, and various anionic compounds. A promising substitute for cadmium plating is ion vapor deposition (IVD) of aluminum. The biggest problem with IVD aluminum is that it cannot be used where very precise tolerances are required or in small diameter openings. Other alternatives for cadmium plating include a zinc and nickel plating, and aluminum ceramic. For chromium plating, many processes have substituted trivalent chromium for hexavalent chromium. This is because trivalent chromium is less toxic than hexavalent chromium. Note that this is a step in the right direction, but still does not get rid of the chromium. Nickel is a common alternative for both cadmium and chrome, but note that all three of these are on the EPA 17.

Stripping of the plating (typically for inspection or repair) also generates similar hazardous wastes to the plating processes. Cyanide based strippers are typically used. Chemicals such as hydrochloric, sulfuric, and nitric acid, ammonium hydroxide, and potassium and sodium nitrate are being used as replacements. Oklahoma City ALC has researched use of non cyanide containing alternatives for silver plating and stripping.

Plating alternatives to electroplating include electroless plating, flame spray, spray casting, and plasma spraying. Electroless plating has been used for nickel plating for a number of years and does reduce disposal quantities, but is expensive. Flame spay is a process used in some areas to give thin coatings of meltable metals. Due to high temperature and line-of-sight restrictions , flame spraying has limited applications. Spray casting eliminates baths and can be used to spray any material that can melt, but requires lower temperatures than flame spraying. It is currently in the late stages of R&D and shows promise. It is limited to line-of-sight applications. Plasma spraying is similar to spray casting in that it eliminates baths, is line-of-sight limited, and is currently being researched.

18. Metal Treatment

Metal treatment covers a wide variety of processes including passivation, conversion coatings, deoxidizing, etching, chemical milling, and anodizing. When considered as a group with metal plating, surface finishing is the largest source of hazardous waste in aircraft production.

Deoxidizing, as its name implies, is a surface prep operation which removes the oxides from the metal. Etching is also a surface prep operation which roughens the metal for operations such as bonding. Chromic acid is typically used for etching and deoxidizing because of its anti corrosion properties, benign nature toward aluminum, and its ease of use. However, it is on the EPA 17. Substitutes for chromic acid currently under development include nitric, hydrofluoric, and sulfuric acids. Corrosion protection and adverse effects on aluminum are concerns. Laser etching is in the early stages of R&D for etching. It is line of sight limited.

Anodizing treatment is a process in which the aluminum parts to be treated act as the anode in an electrolytic bath (chromic, sulfuric, or oxalic acid). This produces a tough, adherent coating of aluminum oxide. Alternatives being looked at include sulfuric, phosphoric, and boric acids. As with the substitutes for deoxidizing and etching, corrosion protection and adverse effects on aluminum are concerns. Oklahoma City ALC currently has research projects underway for both aluminum and magnesium which reduce or eliminate the use of chromium.

Conversion coatings are used to enhance the corrosion resistance of a material. The process typically involves the use of a hazardous heavy metal, usually a chromate. There have been two major efforts documented which describe alternatives to chromate based conversions of aluminum (Alodine™). One effort was completed by Boeing Aerospace Corporation. The technique uses a cobalt-nitrite based conversion rather than one based on chromates. A second effort has been completed by Hughes Aircraft Corporation. They have developed a substitute for MIL-C-5541. The use of chromates pose life cycle environmental problems, from the conversion process to disposing of the treated material. The difference between anodizing and conversion coating is that anodizing requires an electrified bath with the part being treated acting as the anode (hence "anod"izing). Conversion coating is done without electric current and is done on entire aircraft surfaces.

Passivation is a process done to iron surfaces to make them "passive" to corrosion. The most common methods of passivating are immersion of the metal in nitric acid after it has been highly polished. Other methods require immersion in fuming sulfuric acid, potassium ferrocyanide, or potassium chromate solution, or in chromic acid; coating with a manganese dioxide paint; cathodic pickling in a weak acid solution. This condition of passivity is temporary, and, thus far has been of doubtful value, except for stainless steel for which it is regularly practiced.

19. Refrigerants

Ozone Depleting Substances (ODSs) used in refrigerant applications include:

Class I:

- CFC-11
- CFC-12
- CFC 113
- CFC 114
- CFC 115
- CFC 500 (CFC mixture)
- CFC 502 (CFC mixture)

Class II:

- HCFC-22
- HCFC-123

Alternatives:

Chemicals are currently being used or considered for Class I and Class II substances as alternative refrigerants. The suitability of an alternative depends on the specific application. The alternatives discussed below contain information from EPA studies and analysis under the Significant New Alternatives Program (SNAP) and the Ozone Depleter Compliance Guide. Alternative refrigerants include:

HCFCs - Have a potential role as transitional refrigerants. The disadvantage is that HCFCs contribute to the destruction of stratospheric ozone. The destruction of ozone by HCFCs is to a much lesser extent than CFCs. EPA believes the alternative use of HCFCs will have environmental and health benefits over continued use of CFCs until equipment using another alternative is available. HCFCs are chemically similar to CFCs and their thermophysical properties are similar to CFCs. In some instances, equipment designed to use CFCs can be retrofitted to operate with CFCs. Because they contain hydrogen, HCFCs break down easier in the atmosphere. Therefore, HCFCs have lower ozone depletion potential than CFCs. Production of HCFCs is controlled by the Clean Air Act and, initially, was scheduled to be phased out by 2030. EPA may propose earlier phase out for some of the HCFCs.

HFCs - These substances do not contain chlorine and do not contribute to destruction of stratospheric ozone. HFCs have zero ozone depleting potential; however, some contribute to global warming. HFC-134a and HFC-152a hold the most promise as current available replacements for Class I and Class II refrigerants.

Ammonia - Has been used in vapor compression cycles for over 100 years. Ammonia is used when moderate to low temperatures are required. Ammonia has no long-term atmospheric drawbacks; however, ammonia is moderately flammable and toxic, but is not a cumulative poison.

Hydrocarbons - These substances do not contribute to ozone depletion because they don't contain chlorine or bromine propane Ethane and butane are used as refrigerants in specialized industrial applications. Existing standards limit the use of flammable refrigerants in many applications.

Perfluorocarbons (PFCs) - PFCs are fully fluorinated compounds, unlike CFCs, HCFCs, or HFCs. The primary environmental characteristics of concern for PFCs is that they have extremely long atmospheric lifetimes, often orders of magnitude longer than CFCs. Long lifetimes cause the PFCs to have very high global warming potentials. Technology for containment and recycling of PFCs is commercially available and is recommended to offset possible adverse environmental effects. PFCs do not contribute to atmospheric ozone depletion. These chemicals are essentially non-toxic, non-flammable, and are exempt from federal volatile organic compound regulations since they do not contribute to ground level ozone formation. Due to global warming concerns, EPA has found only certain narrowly defined uses of PFCs to be acceptable. Any use of PFCs should be coordinated with EPA for possible submittal for review and approval under SNAP.

Absorption Refrigeration Systems - These systems are the only major existing alternatives to systems which are based on vapor compression cycles. Ammonia is sometimes used in absorption refrigeration and air conditioning systems.

New Technology - Will be identified as a result of SNAP.

20. Sterilants

CFC-12 is widely used in applications to sterilize medical equipment and devices. CFC-12 is primarily used as a dilute agent in a 12% ethylene oxide (EtO) mixture. EtO is the active sterilant in this mixture -- commonly referred to as "12/88." Pure ethylene oxide is not widely used due to its hazardous characteristics: flammability and toxicity (carcinogenicity). 12/88 has widespread use in hospitals and accounts for approximately 95% of all sterilization of medical equipment.

There are several alternatives available for the 12/88 sterilant mixture, however, none possess the "universal applicability" of 12/88. Such alternatives may be incompatible with many materials now sterilized by 12/88, and they will have to be tested on a case by case basis.

Various halocarbon substitutes have been proposed as viable substitutes for CFC-12 in EtO blends. These chemicals are mainly hydrochlorofluorocarbons (HCFCs) or hydrofluorocarbons (HFCs). The properties of these proposed alternatives make them virtual drop-in substitutes for CFC-12 in the 12/88 mixture. The following chemicals have been proposed as alternatives:

HCFC-123
HCFC-124
HFC-125
HCFC-141b
HFC-134a
HFC-227ea

Presently, only HCFC-124 and HFC-227ea have been proposed as near-term candidates for replacing CFC-12 as diluents in the 12/88 mixture. Only HCFC-124 has been approved as a substitute in the EPA's Significant New Alternative Program (SNAP) regulations.

Other alternative sterilizing processes which can be used include:

CO_2 as diluent in "10/90" blend with EtO. Requires higher operating pressures.
Steam sterilizers. This alternative is only for materials that can resist high temperatures.
Gamma radiation
Peracetic acid
Glutaraldehyde
Chlorine Dioxide
Gaseous Ozone
Vapor-Phase Hydrogen Peroxide
Ionized Gas Plasma
Pure Ethylene Oxide

Remember, many of the above alternatives may adversely affect the equipment or materials currently using 12/88 as a sterilant. Each individual sterilant or sterilizing process will have to be tested on a case by case basis to ensure compatibility. In addition, all of the above alternatives will require equipment or technical process changes.

21. Other (Deicing, Munitions, LOX, etc.)

Deicing: The Wright Laboratory and NASA Ames are currently conducting joint development and testing of non-glycol based runway and aircraft deicing/anti-icing chemicals. Successful candidates must meet minimum performance with regards to environmental/toxicology, deicing/anti-icing performance and materials compatibility.

A more common application of deicing is the use of anti-freeze in cars, trucks, and system equipment. Nearly all types of anti-freeze are ethylene glycol with rust inhibitors. There are few alternatives, but there is relatively inexpensive equipment commercially available to recycle the anti-freeze indefinitely. Recycling is the best method of reducing hazardous waste generation.

Munitions: At present, there is no viable demilitarization, disposal or recycle process for reactive fragment explosive mixtures or depleted uranium munitions. Environmental work in this area is being proposed by the Wright Laboratory. There is, however, a new recycling process to reclaim solid rocket fuel.

Chaff: An environmentally acceptable chaff substitute material based on fiber forming polymers that are ultraviolet degradable, biodegradable or digestible (by animals) is being investigated. These materials include:

gelatin;
polyactic acid;
stabilized polypropylene;
cellulose; and
wheat starch.

These alternatives are not yet available for use.

Liquid Oxygen Equipment (LOX): Oxygen equipment has extremely sensitive cleaning standards. All oxygen equipment is being cleaned with CFC-113 and TCA. The Navy is aggressively searching for approved substitutes for cleaning oxygen equipment. Aqueous cleaning combined with ultrasonics looks favorable.

Honeycomb: The manufacture and repair of honeycomb structures requires high quality surface prep cleaning prior to bonding. Presently, these processes use TCA and CFC-113. There are several projects on-going at SM-ALC to test alternatives.

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Appendix - Hazardous Material Alternatives Listing

This is an AFMC list of processes that use products containing hazardous material and potential non-hazardous alternatives with points of contact for more information. This listing is intended to be used as a starting point in your search for alternatives. The inclusion of a product on this list is not intended to endorse its use or imply that adequate testing has been accomplished. The identification of acceptable substitutes will depend upon the critical part and process characteristics of each specific application. The manager(s) of the end item(s) or weapon system(s) must consider performance, materials compatibility, and other factors in selecting the best alternative.

ASC/EM has reviewed this listing and included recommendations on each of the alternatives. The column labeled "ASC" contains a code R, E, or N which means:

"R" - ASC/EM recommends alternative for SPO evaluation.
"E" - Alternative requires ASC/EM evaluation.
"N" - Not approved by ASC/EM for ASC applications.

PROCESSES AND SUBSTITUTES

CHEMICAL	EPA	APPLIC	SPECIFIC PROCESS	SUBSTITUTE	ASC	POINT OF CONTACT
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING BEARINGS	HSHID-5 & HSSF-5	E	Cary Roque/NADEP Jacksonville/DSN 942-3444
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING BONDING SHOP	Brulin GD	R	Susie Barney OO-ALC/TIELM DSN 924-2994
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING BONDING SHOP	GPC-R86	E	Susie Barney OO-ALC/TIELM DSN 924-2994
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING HONEYCOMB	ART-96	E	Alan Rockwold SM-ALC/EMP DSN 633-3672 Ex165
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING HONEYCOMB PARTS	Aqueous Immersion System	E	Sara Jane Blubaugh SM-ALC/TIME 916 643-2704
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING LANDING GEAR	D-Limonene	E	Susie Barney OO-ALC/TIELM DSN 924-2994
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING LANDING GEAR	Daraclean 282	R	Susie Barney OO-ALC/TIELM DSN 924-2994
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING LANDING GEAR	Eliminate Cleaning Process	R	Susie Barney OO-ALC/TIELM DSN 924-2994
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	ADL Enhanced	R	Orange-Sol Inc 800 877-7771
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Aerowash	R	Wyandotte Chemicals Corp
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Aliphatic Hydrocarbons (AXAREL 52)	E	Du Pont 800 237-2374
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Aliphatic Hydrocarbons (AXAREL 56)	E	Du Pont 800 237-2374
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Aliphatic Hydrocarbons (AXAREL 6000)	E	Du Pont 800 237-2374
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Aliphatic Hydrocarbons (AXAREL 6100)	E	Du Pont 800 237-2374
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Allied-Kelite 28	E	Allied-Kelite Products Division, Richardson Chem Co
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Ambersolve 3000	R	Innovative Organics 714 771-9225
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Ardrox 180-BH	R	Ardrox 714 739-2821
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Brulin 815 GD	R	Sara Jane Blubaugh SM-ALC/TIME 916 643-2704
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Cee Bee A-7X7, LF	E	Cee Bee Div, McGean-Robco, Inc.
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Desoto 112	R	Desoto 714 848-7051
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Diversey 909	E	
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	EARTH3 Cleaners	E	Ashland Chemical 614 889-3333
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Ecoclean 81S	E	Durr Industries Inc 313 459-6800
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	GMC 528B	E	Greater Mountain Chemical Company
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Hurri Safe (6850-01-369-2474 OESKI)	E	Bobbie Pettit HURRI-SAFE 703 257-1331
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Isopropyl Alcohol	R	Brent Baumgartner/WR-ALC/468-1422
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Jet Clean C	E	Turco 714 890-3600
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	N-methylpyrrolidone	R	Brent Baumgartner/WR-ALC/468-1422
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Oxsol 100	E	Brent Baumgartner/WR-ALC/468-1422
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Plasma	E	EPA 401 M St, NW Washington, D.C. 20460
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	ReBOUND 4	E	XXCEL Technology Ltd (714) 492-3559
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	ReBOUND 7	E	XXCEL Technology Ltd (714) 492-3559
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Super Critical Fluids	E	EPA 401 M St, NW Washington, D.C. 20460
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Trans LC	E	Brent Baumgartner/WR-ALC/468-1422
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Trichloroethylene	N	EPA 401 M St, NW Washington, D.C. 20460
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	Turco 4215 NCLT	R	Turco 714 890-3600
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING METAL PARTS	UV/Ozone	E	EPA 401 M St, NW Washington, D.C. 20460
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING OF TUBING	Brulin 815 GD	R	Tony Phillips Lockheed 817 777-3758
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING TOOLING & EQUIPMENT	Axarel 9100	E	Tony Phillips Lockheed 817 777-3758

PROCESSES AND SUBSTITUTES

CHEMICAL	EPA	APPLIC	SPECIFIC PROCESS	SUBSTITUTE	ASC	POINT OF CONTACT
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING TOOLING & EQUIPMENT	Hydrocarbon Cleaner	R	Tony Phillips Lockheed 817 777-3758
1,1,1 TRICHLOROETHANE	ODC	CLEANING	CLEANING TOOLING & EQUIPMENT	Petroferm Bioact DG-1	E	Tony Phillips Lockheed 817 777-3758
1,1,1 TRICHLOROETHANE	ODC	CLEANING	COLD TANK SOAK	Citrikleen	R	Penetone Corp 1-800-631-1652
1,1,1 TRICHLOROETHANE	ODC	CLEANING	DEGREASING METAL PARTS	BMS 3-2 Type I	E	
1,1,1 TRICHLOROETHANE	ODC	CLEANING	DEGREASING METAL PARTS	Furnace & Vacuum Equipment	E	Mr McQuire/Nippondenso Auto Plant 616 965-3322
1,1,1 TRICHLOROETHANE	ODC	CLEANING	ELECTRONICS CLEANING	Citra Safe	R	Inland Technology Inc 1-800-552-3100
1,1,1 TRICHLOROETHANE	ODC	CLEANING	ELECTRONICS CLEANING	Citra Safe	R	Inland Technology Inc 1-800-552-3100
1,1,1 TRICHLOROETHANE	ODC	CLEANING	ELECTRONICS CLEANING	Perchloroethylene	N	EPA 401 M St, NW Washington, D.C. 20460
1,1,1 TRICHLOROETHANE	ODC	CLEANING	ELECTRONICS CLEANING	Plasma	E	EPA 401 M St, NW Washington, D.C. 20460
1,1,1 TRICHLOROETHANE	ODC	CLEANING	ELECTRONICS CLEANING	Proclean Alcohol	E	Brent Baumgartner/WR-ALC/468-1422
1,1,1 TRICHLOROETHANE	ODC	CLEANING	ELECTRONICS CLEANING	Super Critical Fluids	E	EPA 401 M St, NW Washington, D.C. 20460
1,1,1 TRICHLOROETHANE	ODC	CLEANING	ELECTRONICS CLEANING	Teksol EP	E	Inland Technology Inc 1-800-552-3100
1,1,1 TRICHLOROETHANE	ODC	CLEANING	ELECTRONICS CLEANING	Teksol EP	E	Inland Technology Inc 1-800-552-3100,
1,1,1 TRICHLOROETHANE	ODC	CLEANING	ELECTRONICS CLEANING	UV/Ozone	E	EPA 401 M St, NW Washington, D.C. 20460
1,1,1 TRICHLOROETHANE	ODC	CLEANING	ELECTRONICS LUBRICATE & CLEAN	LPS Lubricant & Cleaner	R	Brent Baumgartner/WR-ALC/468-1422
1,1,1 TRICHLOROETHANE	ODC	CLEANING	PRECISION & METAL CLEANING	Aliphatic Hydrocarbons (Actrel Solvents)	E	Exxon Chemical Co 800 526-0749 ext 6955
1,1,1 TRICHLOROETHANE	ODC	CLEANING	PRECISION CLEANING.	Alcohol/Iso-hexane	R	Patrick Reust/SM-ALC/LICF/DSN 633-3787
1,1,1 TRICHLOROETHANE	ODC	CLEANING	PRECISION CLEANING	Methylene Chloride	N	EPA 401 M St, NW Washington, D.C. 20460
1,1,1 TRICHLOROETHANE	ODC	CLEANING	PRECISION CLEANING	Plasma	E	EPA 401 M St, NW Washington, D.C. 20460
1,1,1 TRICHLOROETHANE	ODC	CLEANING	PRECISION CLEANING	Super Critical Fluids	E	EPA 401 M St, NW Washington, D.C. 20460
1,1,1 TRICHLOROETHANE	ODC	CLEANING	PRECISION CLEANING	Supercritical CO2	R	Patrick Reust/SM-ALC/LICF/DSN 633-3787
1,1,1 TRICHLOROETHANE	ODC	CLEANING	PRECISION CLEANING	UV/Ozone	E	EPA 401 M St, NW Washington, D.C. 20460
1,1,1 TRICHLOROETHANE	ODC	CLEANING	VAPOR DEGREASING	ART-210 Terpene	E	Juliana MacPherson SM-ALC/TI-5 DSN 633-2920
1,1,1 TRICHLOROETHANE	ODC	CLEANING	VAPOR DEGREASING	Bicarbonate of Soda	R	Charles Williams SA-ALC/EMP DSN 945-3100 ext331
1,1,1 TRICHLOROETHANE	ODC	CLEANING	VAPOR DEGREASING	Mark Power Washer & Turco Aviation	R	Tommy Hunnicutt WR-ALC/TIMP DSN 468-4782
1,1,1 TRICHLOROETHANE	ODC	CLEANING	VAPOR DEGREASING	Medium Pressure Water Aquamizer	R	Charles Williams SA-ALC/EMP DSN 945-3100 ext331
1,1,1 TRICHLOROETHANE	ODC	CLEANING	VAPOR DEGREASING	Parts Washers with Cee Bee A54LF	R	Carlos Nazario OC-ALC/LIPEB DSN 336-7246
1,1,1 TRICHLOROETHANE	ODC	CLEANING	WIPE CLEANING OPERATIONS	PF 16	E	PT Tecnologies 800 441-7874
1,1,1 TRICHLOROETHANE	ODC	CLEANING	WIPEDOWN PRIOR TO PAINT	Denatured Alcohol	R	Paul Hughes SA-ALC/EMP DSN 945-3100
FREON CFC-113	ODC	CLEANING	CLEANING AIR ACCESSORIES	Turco 6780	E	Carlos Nazario OC-ALC/LIPEB DSN 336-7246
FREON CFC-113	ODC	CLEANING	CLEANING AVIONICS	Isopropyl Alcohol	R	Carlos Nazario OC-ALC/LIPEB DSN 336-7246
FREON CFC-113	ODC	CLEANING	CLEANING CANOPIES	Isopropanol 50% in Water	E	Tony Phillips Lockheed 817 777-3758
FREON CFC-113	ODC	CLEANING	CLEANING LIQUID OXYGEN EQUIP	Alkaline Cleaner	R	Neil Antin Naval Sea Sys Command 703 602-5553
FREON CFC-113	ODC	CLEANING	CLEANING METAL PARTS	Aqueous	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	CLEANING METAL PARTS	Brominated Hydrocarbons	N	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	CLEANING METAL PARTS	Daraclean 282	R	Glenn Anderson/Corpus Christi Army Depot/861-2660
FREON CFC-113	ODC	CLEANING	CLEANING METAL PARTS	EC-7 Terpene	E	Glenn Anderson/Corpus Christi Army Depot/861-2660
FREON CFC-113	ODC	CLEANING	CLEANING METAL PARTS	Electron	E	Brent Baumgartner/WR-ALC/468-1422
FREON CFC-113	ODC	CLEANING	CLEANING METAL PARTS	Hurrisafe HK 288-A	R	Glenn Anderson/Corpus Christi Army Depot/861-2660

PROCESSES AND SUBSTITUTES

CHEMICAL	EPA	APPLIC	SPECIFIC PROCESS	SUBSTITUTE	ASC	POINT OF CONTACT
FREON CFC-113	ODC	CLEANING	CLEANING METAL PARTS	Monochlorotoluene/Benzotrifluorides	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	CLEANING METAL PARTS	Organic (esters, ketones,ethers, etc.)	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	CLEANING METAL PARTS	Pensolv 805	E	Brent Baumgartner/WR-ALC/468-1422
FREON CFC-113	ODC	CLEANING	CLEANING METAL PARTS	Semi-Aqueous (alcohols)	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	CLEANING METAL PARTS	Semi-Aqueous (petroleum hydrocarbon)	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	CLEANING METAL PARTS	Semi-Aqueous (terpene/surfactant)	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	CLEANING METAL PARTS	Solvall 5234	E	Glenn Anderson/Corpus Christi Army Depot/861-2660
FREON CFC-113	ODC	CLEANING	CLEANING METAL PARTS	TPC Solvent	E	Brent Baumgartner/WR-ALC/468-1422
FREON CFC-113	ODC	CLEANING	CLEANING METAL PARTS	Volatile Methyl Siloxanes	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	CLEANING OXYGEN REGULATORS	Aqueous Ultrasonics	E	Carlos Nazario OC-ALC/LIPEB DSN 336-7246
FREON CFC-113	ODC	CLEANING	De-FOD	Boraxo Hand Soap 10% in Water	R	Tony Phillips Lockheed 817 777-3758
FREON CFC-113	ODC	CLEANING	De-FOD RINSE	Isopropanol 10% in Water	R	Tony Phillips Lockheed 817 777-3758
FREON CFC-113	ODC	CLEANING	DEGREASING METAL CLEANING	Simple Green	E	
FREON CFC-113	ODC	CLEANING	DEGREASING METAL PARTS	BIO ACT EC7	E	Petroferm Inc 904 261-8286
FREON CFC-113	ODC	CLEANING	DEGREASING METAL PARTS	Coors Bio T	E	
FREON CFC-113	ODC	CLEANING	DEGREASING METAL PARTS	Quaker 624 GD	R	
FREON CFC-113	ODC	CLEANING	ELEC & ELECTROMECH CLEANING	Isoparaffin Hydrocarbons	R	Carlos Nazario OC-ALC/LIPEB DSN 336-7246
FREON CFC-113	ODC	CLEANING	ELECTRONIC CONTACT CLEANING	ART-201 Electronic & Prec Comp Cleaner	E	Brent Baumgartner/WR-ALC/468-1422
FREON CFC-113	ODC	CLEANING	ELECTRONIC CONTACT CLEANING	LPS Electro Contact Cleaner	R	Brent Baumgartner/WR-ALC/468-1422
FREON CFC-113	ODC	CLEANING	ELECTRONIC CONTACT CLEANING	Pensolv L605	E	Brent Baumgartner/WR-ALC/468-1422
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Alcohol	R	Glenn Anderson/Corpus Christi Army Depot/861-2660
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Allied Genesolv 2004	E	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Allied Genesolv 2010	E	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Alpha 2110	E	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Aqueous	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Aqueous Cleaner w/Mechanical Agitation	R	Glenn Anderson/Corpus Christi Army Depot/861-2660
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Blue Wave Ultrasonic Cleaner	E	Glenn Anderson/Corpus Christi Army Depot/861-2660
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Brominated Hydrocarbons	N	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Church & Dwight Armakleen 2001	E	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Dupont Axarel 32	E	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Dupont Axarel 32	E	Patrick Reust/SM-ALC/LICF/DSN 633-3787
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Dupont Axarel 38	E	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Dupont Freon SMT	E	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Dupont Vertrel 245	E	Clare Vinton/Nat'l Ctr for Mfg Sciences/313 995-0300
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Dupont Vertrel 434	E	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Environsolv KNI-2000	E	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Envirosolv 655	R	Patrick Reust/SM-ALC/LICF/DSN 633-3787
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Exxon Actrel ED11 & Actrel ES	E	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	High Pressure Water	R	Glenn Anderson/Corpus Christi Army Depot/861-2660

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CHEMICAL	EPA	APPLIC	SPECIFIC PROCESS	SUBSTITUTE	ASC	POINT OF CONTACT
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Hughes RADS	R	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Isopropyl Alcohol Clean w/Batch Soldering	R	Michael J. Leake/Texas Instruments/214 480-7030
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	ISP Micropure CDF	E	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Kyzen Ionox MC	R	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Low Residue (No-clean) Fluxes	R	John Fisher/Naval Air Warefare Ctr/DSN 437-1798
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Low Residue (No-clean) Fluxes	R	Michael J. Leake/Texas Instruments/214 480-7030
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Martin Marieta Marclean R	E	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	No Clean	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Organic (esters, ketones,ethers, etc.)	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Perfluorocarbons	N	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Petroferm EC-5	E	Clare Vinton/Nat'l Ctr for Mfg Sciences/313 995-0300
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Petroferm Bioact EC-7	E	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Petroferm Bioact EC-7R	E	Bill Vuono/Elec Mfg Productivity Fac/317 226-5604
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Semi-Aqueous (alcohols)	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Semi-Aqueous (petroleum hydrocarbon)	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Semi-Aqueous (terpene/surfactant)	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Semi-aqueous Cleaner	R	Glenn Anderson/Corpus Christi Army Depot/861-2660
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Semi-aqueous Cleaning w/rosin flux	R	Michael J. Leake/Texas Instruments/214 480-7030
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Spectrum 1A	E	XXCEL Technology Ltd (714) 492-3559
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Water Based Solder Fluxes	R	Patrick Reust/SM-ALC/LICF/DSN 633-3787
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Water Soluble Flux, HF 1189	R	John Fisher/Naval Air Warefare Ctr/DSN 437-1798
FREON CFC-113	ODC	CLEANING	ELECTRONICS CLEANING	Water Soluble Fluxes	R	Michael J. Leake/Texas Instruments/214 480-7030
FREON CFC-113	ODC	CLEANING	PRECISION CLEANING	Aqueous	R	Don Hunt/AGMC/CN/DSN 346-7712
FREON CFC-113	ODC	CLEANING	PRECISION CLEANING	Aqueous	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	PRECISION CLEANING	Brominated Hydrocarbons	N	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	PRECISION CLEANING	HCFC-123	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	PRECISION CLEANING	HCFC-225	N	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	PRECISION CLEANING	Organic (esters, ketones,ethers, etc.)	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	PRECISION CLEANING	Perfluorocarbons	N	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	PRECISION CLEANING	Semi-Aqueous (alcohols)	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	PRECISION CLEANING	Semi-Aqueous (petroleum hydrocarbon)	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	PRECISION CLEANING	Semi-Aqueous (terpene/surfactant)	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-113	ODC	CLEANING	WIPING PRODUCTION PARTS	DS-104	R	Tony Phillips Lockheed 817 777-3758
FREON CFC-12	ODC	CLEANING	HAND WIPE PARTS CLEANING	LIXTON (Soak Rinse & Dry) System	R	Chem Tech International Inc 703 549-1001
FREON CFC-12	ODC	CLEANING	HAND WIPE PARTS CLEANING	Sno Gun	E	Jim Sloan Va-Tran Systems Inc 619 423-4555
METHYL ETHYL KETONE	EPA-17	CLEANING	CLEANING METAL PAINT SHOP	UBIX 0092	R	Susie Barney OO-ALC/TIELM DSN 924-2994
METHYL ETHYL KETONE	EPA-17	CLEANING	CLEANING METAL PARTS	Acetone	N	Glenn McCall WR-ALC/TIELC DSN 468-4930
METHYL ETHYL KETONE	EPA-17	CLEANING	CLEANING METAL PARTS	Acidic Cleaner	R	Glenn McCall WR-ALC/TIELC DSN 468-4930
METHYL ETHYL KETONE	EPA-17	CLEANING	CLEANING METAL PARTS	Aliphatic Esters (Exxate Solvents)	E	Exxon Chemical Co 800 526-0749 ext 6955

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METHYL ETHYL KETONE	EPA-17	CLEANING	CLEANING METAL PARTS	Calla 800 (alkaline water based cleaner)	R	Calla Chemical Operations 713 599-7473
METHYL ETHYL KETONE	EPA-17	CLEANING	CLEANING METAL PARTS	DOT-111/113	R	Capt Poon SA-ALC/TIESM DSN 945-8745
METHYL ETHYL KETONE	EPA-17	CLEANING	CLEANING METAL PARTS	Isopropyl Alcohol	R	Lt Jay Gendron SA-ALC/TIESM DSN 945-8745
METHYL ETHYL KETONE	EPA-17	CLEANING	CLEANING METAL PARTS	Parts Washers	R	Martin Chatanatt OC-ALC/LPPNP DSN 336-2635
METHYL ETHYL KETONE	EPA-17	CLEANING	CLEANING METAL PARTS	UBIX 0092	R	Gus Zacharjades SA-ALC DSN 945-7613
METHYL ETHYL KETONE	EPA-17	CLEANING	CLEANING METAL PARTS	World Enzyme Cleaner 109	E	Glenn McCall WR-ALC/TIELC DSN 468-4930
METHYL ETHYL KETONE	EPA-17	CLEANING	CLEANING PAINT GUNS	FORMULA RX 700PLC	E	XXCEL Technology Ltd (714) 492-3559
METHYL ETHYL KETONE	EPA-17	CLEANING	CLEANING PAINT GUNS & EQUIPMENT	EP921	R	Inland Technology Inc 206 922-8932
METHYL ETHYL KETONE	EPA-17	CLEANING	HAND WIPE PARTS CLEANING	DS-104 Wipe Solvent	R	Dynamold Solvents Inc 817 335-0862
METHYL ETHYL KETONE	EPA-17	CLEANING	REMOVAL OF GASKETS & SEALANTS	Benzyl Alcohol	R	Paul Hughes SA-ALC/EMP DSN 945-3100
METHYL ETHYL KETONE	EPA-17	CLEANING	REMOVAL OF GASKETS & SEALANTS	Ethanolamine	E	Paul Hughes SA-ALC/EMP DSN 945-3100
METHYL ETHYL KETONE	EPA-17	CLEANING	REMOVAL OF GASKETS & SEALANTS	N-methylpyrrolidone	R	Paul Hughes SA-ALC/EMP DSN 945-3100
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	3D Supreme	R	3D Inc
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Amberclean L12	R	Innovative Organics 714 771-9225
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Ardrox 405-V	R	Ardrox 714 739-2821
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	BIO ACT 240	R	Petroferm Inc 904 261-8286
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	BIO T MAX	R	Petroferm Inc 904 261-8286
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Brulin 1291	R	Brulin Co 714 751-4853
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Citra Safe	R	Inland Technology 800 552-3100
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	De-Solve-it 241	R	Orange-Sol Inc 800 877-7771
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Desoclean 20	R	Desoto 714 848-7051
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Desoclean 45	R	Desoto 714 848-7051
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Diana HS1000	R	Diana 800 343-5325
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Dynasolve 108	R	Dynamold 314 872-3191
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	EPA 2000	N	Western Chemical Intl 602 990-9467
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Hurrisafe	R	O.C.S. MFG Co 818 458-2471
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Metalube 4U	E	Metalube 310 869-7273
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	PF 145 HP	E	PT Tecnologies 800 441-7874
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	RB Degreaser	N	Environmental Tech 407 321-7910
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Shopmaster	R	Buckeye 314 291-1900
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE CLEANING OPERATIONS	Turco 3878	N	Turco 714 890-3600
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPE PRIOR TO PAINT	Citra Safe	R	Inland Technology Inc 206 922-8932
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	Acidic Cleaner	R	John Lindsey WR-ALC/TIELN DSN 468-1267
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	ADL Enhanced	R	Orange-Sol Inc 800 877-7771
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	Ardrox 1900-BD	R	Ardrox 714 739-2821
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	Deso Clean 50 Organic Cleaner	R	Eric Gardner SM-ALC/SGB DSN 633-0311
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	DS-108 Wipe Solvent	R	Steven Evenoff Lockheed 817 777-3772
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	Enzyme Cleaner	R	Capt Poon SA-ALC/TIESM DSN 945-8745
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	PENAIR PSA-2	E	John Vidic OO-ALC/LAOPE DSN 458-2050

PROCESSES AND SUBSTITUTES

CHEMICAL	EPA	APPLIC	SPECIFIC PROCESS	SUBSTITUTE	ASC	POINT OF CONTACT
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	Safety Prep	E	Inland Technology Inc 1-800-552-3100
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN AIRCRAFT FOR PAINTING	X-Caliber	R	Inland Technology Inc 1-800-552-3100
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	77X004	E	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Axarel 2200	E	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Axarel 6100	E	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Citra Safe	R	Inland Technology Inc 1-800-552-3100
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Citra Safe	R	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Citrikleen HD & Isopropyl Alcohol	R	Carlos Nazario OC-ALC/LIPEB DSN 336-7246
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	DOT-111/113	R	Susie Barney OO-ALC/TIELM DSN 924-2994
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	DOT-111/113	R	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	DS-104	R	Susie Barney OO-ALC/TIELM DSN 924-2994
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	DS-104	R	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	DS-108	R	Susie Barney OO-ALC/TIELM DSN 924-2994
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	DS-108	R	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Envirosolv 655	R	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	FO 425Q	E	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Isopar L	E	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Isopar M	E	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	PF Degreaser	E	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Primaclean 3600	E	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Safety Prep	E	Inland Technology Inc 1-800-552-3100
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Shopmaster	R	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Teksol EP	E	Inland Technology Inc 1-800-552-3100
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	TPC	E	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYL ETHYL KETONE	EPA-17	CLEANING	WIPEDOWN PRIOR TO PAINT	Turco 6226	E	Cary Roque/NADEP Jacksonville/DSN 942-3444
METHYLENE CHLORIDE	EPA-17	CLEANING	CARBON REMOVAL	Abrasive Flow Cleaning	R	Nick Neeley OC-ALC/LIPEB DSN 336-7246
METHYLENE CHLORIDE	EPA-17	CLEANING	CARBON REMOVAL	N-methyl Pyrrolidone (NMP)	R	Jeff Mamix OC-ALC/LPPNP DSN 336-3819
METHYLENE CHLORIDE	EPA-17	CLEANING	CARBON REMOVAL	Parts Washers	R	Brad Christensen OO-ALC/LICT DSN 458-2341
METHYLENE CHLORIDE	EPA-17	CLEANING	CARBON REMOVAL	Potassium Permanganate	R	Jeff Mamix OC-ALC/LPPNP DSN 336-3819
METHYLENE CHLORIDE	EPA-17	CLEANING	CARBON REMOVAL	Terpenes	R	Jeff Mamix OC-ALC/LPPNP DSN 336-3819
METHYLENE CHLORIDE	EPA-17	CLEANING	COLD TANK SOAK	Citrex	R	Inland Technology Inc 1-800-552-3100
METHYLENE CHLORIDE	EPA-17	CLEANING	COLD TANK SOAK	X-Caliber	R	Inland Technology Inc 1-800-552-3100
METHYLENE CHLORIDE	EPA-17	CLEANING	RESIN REMOVAL	Citrex	R	Inland Technology Inc 1-800-552-3100
METHYLENE CHLORIDE	EPA-17	CLEANING	RESIN REMOVAL	X-Caliber	R	Inland Technology Inc 1-800-552-3100
METHYLENE CHLORIDE	EPA-17	CLEANING	RESIN REMOVAL, EPOXY	Z-Strip	E	Inland Technology Inc 1-800-552-3100
METHYLENE CHLORIDE	EPA-17	CLEANING	SEALANT REMOVAL	Carbon Dioxide Pellets	R	Robin Stearns OC-ALC/LAPEP DSN 336-5986
METHYLENE CHLORIDE	EPA-17	CLEANING	SEALANT REMOVAL	CO2 Blasting with Waterpick	R	John Lindsey WR-ALC/TIELN DSN 468-1287
METHYLENE CHLORIDE	EPA-17	CLEANING	SEALANT REMOVAL	High Pressure Water Jet	R	Robin Stearns OC-ALC/LAPEP DSN 336-5986
PD 680 TYPE I & II	AFMC	CLEANING	CLEAN/DEGREASE METAL PARTS	BREAKTHROUGH	R	Inland Technology Inc 1-800-552-3100

PROCESSES AND SUBSTITUTES

CHEMICAL	EPA	APPLIC	SPECIFIC PROCESS	SUBSTITUTE	ASC	POINT OF CONTACT
PD 680 TYPE I & II	AFMC	CLEANING	CLEAN/DEGREASE METAL PARTS	Isopropyl Alcohol	R	Lt Jay Gendron SA-ALC/TIESM DSN 945-8745
PD 680 TYPE I & II	AFMC	CLEANING	CLEAN/DEGREASE METAL PARTS	P-D-680 Type III	R	Brian Ballew SA-ALC/TIESM DSN 945-8745
PERCHLOROETHYLENE	EPA-17	CLEANING	COLD CLEANING	Alkaline	R	Paul Hughes SA-ALC/EMP DSN 945-3100
PERCHLOROETHYLENE	EPA-17	CLEANING	COLD CLEANING	Citrikleen	R	Paul Hughes SA-ALC/EMP DSN 945-3100
PERCHLOROETHYLENE	EPA-17	CLEANING	DEGREASING OF METAL PARTS	Advanced Vapor Degreaser	N	Brian Ballew SA-ALC/TIESM DSN 945-8745
PERCHLOROETHYLENE	EPA-17	CLEANING	DEGREASING OF METAL PARTS	ART-141 Terpene	E	Russ Denny SM-ALC/SGB DSN 633-0311
PERCHLOROETHYLENE	EPA-17	CLEANING	DEGREASING OF METAL PARTS	Bicarbonate of Soda	R	Ed Wasson SA-ALC/TIESM DSN 945-4984
PERCHLOROETHYLENE	EPA-17	CLEANING	DEGREASING OF METAL PARTS	Parts Washers	R	Jeff Mamix OC-ALC/LPPNP DSN 336-3819
TOLUENE	EPA-17	CLEANING	CLEANING PARTS & TOOLS	Acetone	N	Glenn McCall WR-ALC/TIELC DSN 468-4930
TOLUENE	EPA-17	CLEANING	CLEANING PARTS & TOOLS	Acidic Cleaner	R	John Lindsey WR-ALC/TIELN DSN 468-1287
TOLUENE	EPA-17	CLEANING	SPOT CLEANING AIRCRAFT	Acetone	N	Glenn McCall WR-ALC/TIELC DSN 468-4930
TOLUENE	EPA-17	CLEANING	SPOT CLEANING AIRCRAFT	Acidic Cleaner	R	John Lindsey WR-ALC/TIELN DSN 468-1287
TRICHLOROETHYLENE	EPA-17	CLEANING	REMOVAL OF COSMOLENE	Petroferm Bioact DG-1	E	Tony Phillips Lockheed 817 777-3758
PD 680 TYPE I & II	AFMC	CORROSION	RUST PROTECTION COATING	P-D-680 Type III	R	Mathew Chathanatt OC-ALC/LPPNP DSN 336-2635
HALON 1211	ODC	FIRE SUPP	JET ENGINE FIRE EXTINGUISHING	Animal Protein	E	J. Johnston HQ ATC/LGMAJ DSN 487-4981
HALON 1211	ODC	FIRE SUPP	JET ENGINE FIRE EXTINGUISHING	Detergent Foam	E	J. Johnston HQ ATC/LGMAJ DSN 487-4981
HALON 1211	ODC	FIRE SUPP	JET ENGINE FIRE EXTINGUISHING	Dry Chemical Spray	R	J. Johnston HQ ATC/LGMAJ DSN 487-4981
HALON 1211	ODC	FIRE SUPP	MILITARY APPLICATION	Carbon Dioxide	R	EPA 401 M St, NW Washington, D.C. 20460
HALON 1211	ODC	FIRE SUPP	MILITARY APPLICATION	CFC-Blend (NAF P)	N	EPA 401 M St, NW Washington, D.C. 20460
HALON 1211	ODC	FIRE SUPP	MILITARY APPLICATION	Dry Chemical	R	EPA 401 M St, NW Washington, D.C. 20460
HALON 1211	ODC	FIRE SUPP	MILITARY APPLICATION	FC-5-1-14	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1211	ODC	FIRE SUPP	MILITARY APPLICATION	FE-232 (CHCL2-CF3)	E	
HALON 1211	ODC	FIRE SUPP	MILITARY APPLICATION	FM-100 (CF2BrH)	N	
HALON 1211	ODC	FIRE SUPP	MILITARY APPLICATION	Foam	R	EPA 401 M St, NW Washington, D.C. 20460
HALON 1211	ODC	FIRE SUPP	MILITARY APPLICATION	HBFC-22B1 (FM-100)	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1211	ODC	FIRE SUPP	MILITARY APPLICATION	HBFC-22B1/HFC-227ea	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1211	ODC	FIRE SUPP	MILITARY APPLICATION	HCFC Blend B (Halotron I)	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1211	ODC	FIRE SUPP	MILITARY APPLICATION	HCFC-123	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1211	ODC	FIRE SUPP	MILITARY APPLICATION	HFC-227ea (FM-200)	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1211	ODC	FIRE SUPP	MILITARY APPLICATION	Perfluorohexane (C6F14)	N	
HALON 1211	ODC	FIRE SUPP	MILITARY APPLICATION	Water	R	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	AIRCRAFT FIRE EXTINGUISHING	FC-116 (C2F6)	E	Maj Samuel Carbaugh WL/FIVS DSN 785-6823
HALON 1301	ODC	FIRE SUPP	AIRCRAFT FIRE EXTINGUISHING	FC-218 (C3F8)	E	Maj Samuel Carbaugh WL/FIVS DSN 785-6823
HALON 1301	ODC	FIRE SUPP	AIRCRAFT FIRE EXTINGUISHING	FC-3-1-10 (C4F10)	E	Maj Samuel Carbaugh WL/FIVS DSN 785-6823
HALON 1301	ODC	FIRE SUPP	AIRCRAFT FIRE EXTINGUISHING	FC-318 (CYCLO-C4F8)	E	Maj Samuel Carbaugh WL/FIVS DSN 785-6823
HALON 1301	ODC	FIRE SUPP	AIRCRAFT FIRE EXTINGUISHING	Fluoroiodocarbon & Other Chem Blends	E	Lance Lankford SM-ALC/EMPW DSN 633-3672
HALON 1301	ODC	FIRE SUPP	AIRCRAFT FIRE EXTINGUISHING	HCFC-124 (C2HF4CL)	E	Maj Samuel Carbaugh WL/FIVS DSN 785-6823
HALON 1301	ODC	FIRE SUPP	AIRCRAFT FIRE EXTINGUISHING	HFC-125 (FE-25) (C2HF5)	E	Maj Samuel Carbaugh WL/FIVS DSN 785-6823
HALON 1301	ODC	FIRE SUPP	AIRCRAFT FIRE EXTINGUISHING	HFC-134a (C2H2F4)	E	Maj Samuel Carbaugh WL/FIVS DSN 785-6823

PROCESSES AND SUBSTITUTES

CHEMICAL	EPA	APPLIC	SPECIFIC PROCESS	SUBSTITUTE	ASC	POINT OF CONTACT
HALON 1301	ODC	FIRE SUPP	AIRCRAFT FIRE EXTINGUISHING	HFC-22 (CHF2CL)	E	Maj Samuel Carbaugh WL/FIVS DSN 785-6823
HALON 1301	ODC	FIRE SUPP	AIRCRAFT FIRE EXTINGUISHING	HFC-227 (FM-200) (C3HF7)	E	Maj Samuel Carbaugh WL/FIVS DSN 785-6823
HALON 1301	ODC	FIRE SUPP	AIRCRAFT FIRE EXTINGUISHING	HFC-32 (CH2F2)	E	Maj Samuel Carbaugh WL/FIVS DSN 785-6823
HALON 1301	ODC	FIRE SUPP	AIRCRAFT FIRE EXTINGUISHING	HFC-32/HFC-125 (CH2F2/CHF2CF3)	E	Maj Samuel Carbaugh WL/FIVS DSN 785-6823
HALON 1301	ODC	FIRE SUPP	EXPLOSION INERTING	HCFC Blend (NAF SIII)	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	TOTAL FLOOD & EXPLOSION INERTING	HBFC-22B1 (FM-100)	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	TOTAL FLOOD & EXPLOSION INERTING	HFC-23 (FE-13)	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	TOTAL FLOOD & EXPLOSION INERTING	Inert Gas Blend (Inergen)	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	TOTAL FLOOD OCC & UNOCCUPIED	Carbon Dioxide	R	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	TOTAL FLOOD OCC & UNOCCUPIED	HCFC Blend (NAF SIII)	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	TOTAL FLOOD OCC & UNOCCUPIED	HCFC-124	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	TOTAL FLOOD OCC & UNOCCUPIED	HCFC-22	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	TOTAL FLOOD OCC & UNOCCUPIED	HFC-134a	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	TOTAL FLOOD OCC & UNOCCUPIED	Water	R	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	TOTAL FLOOD OCC & UNOCCUPIED	Water Mist/Fog	R	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	TOTAL FLOOD OCCUPIED	HFC-125	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	TOTAL FLOOD OCCUPIED	HBFC-22B1(FM-100)/HFC-227ea(FM-200)	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	TOTAL FLOOD OCCUPIED	HFC-32	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	TOTAL FLOOD OCCUPIED & EXP INERT	SF6 (Discharge Test)	E	EPA 401 M St, NW Washington, D.C. 20460
HALON 1301	ODC	FIRE SUPP	TOTAL FLOOD UNOCC & EXP INERTING	HFC-125	E	EPA 401 M St, NW Washington, D.C. 20460
CADMIUM & COMPOUNDS	EPA-17	PLATING	PLATING OF METAL PARTS	Ion Vapor Deposition (IVD)	R	Marty Sedgwick WR-ALC/TIBO DSN 468-4800
CADMIUM & COMPOUNDS	EPA-17	PLATING	PLATING OF METAL PARTS	Zinc Nickel Plating	R	Nancy Strapper SA-ALC/TIESM DSN 945-5338
CYANIDES	EPA-17	PLATING	PLATING SOLUTIONS	Electroless Nickel	R	Mike Patry OC-ALC/LPPNP DSN 336-5185
CYANIDES	EPA-17	PLATING	PLATING SOLUTIONS	Electromagnetic Powder Deposition	E	Glen Graham OC-ALC/LPPNP DSN 336-2635
CYANIDES	EPA-17	PLATING	PLATING SOLUTIONS	Ion Vapor Deposition (IVD)	R	Marty Sedgwick WR-ALC/TIBO DSN 468-4800
CYANIDES	EPA-17	PLATING	PLATING SOLUTIONS	Non-cyanide Solutions	E	Debra Mital SM-ALC/SGB DSN 633-0311 ext 312
CYANIDES	EPA-17	PLATING	PLATING SOLUTIONS	Plasma Spray	E	Nancy Strapper SA-ALC/TIESM DSN 945-5338
FREON CFC-11	ODC	REFRIG	CENTRIFUGAL CHILLERS	Ammonia	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-11	ODC	REFRIG	CENTRIFUGAL CHILLERS	Ammonia-Water	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-11	ODC	REFRIG	CENTRIFUGAL CHILLERS	HCFC-123	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-11	ODC	REFRIG	CENTRIFUGAL CHILLERS	HCFC-22	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-11	ODC	REFRIG	CENTRIFUGAL CHILLERS	HFC-134a	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-11	ODC	REFRIG	CENTRIFUGAL CHILLERS	Lithium Bromide-Water	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-11	ODC	REFRIG	SHORE FACILITIES AIR CONDITIONING	HCFC-123	E	
FREON CFC-113	ODC	REFRIG	EQUIPMENT COOLANT	R-134A	R	Mike Zatz ICF Inc (202) 862-1105
FREON CFC-114	ODC	REFRIG	CENTRIFUGAL CHILLERS	HCFC-124	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-114	ODC	REFRIG	CENTRIFUGAL CHILLERS	HCFC-142b	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-114	ODC	REFRIG	CENTRIFUGAL CHILLERS	HFC-227 ea	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-114	ODC	REFRIG	CENTRIFUGAL CHILLERS	R200b,c,d,e,f,g,i,j	E	EPA 401 M St, NW Washington, D.C. 20460

PROCESSES AND SUBSTITUTES

CHEMICAL	EPA	APPLIC	SPECIFIC PROCESS	SUBSTITUTE	ASC	POINT OF CONTACT
FREON CFC-114	ODC	REFRIG	FACILITY AIR CONDITIONING	E-134	E	
FREON CFC-12	ODC	REFRIG	CENTRIFUGAL CHILLERS	Ammonia	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	CENTRIFUGAL CHILLERS	Ammonia-Water	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	CENTRIFUGAL CHILLERS	HCFC-123	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	CENTRIFUGAL CHILLERS	HCFC-22	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	CENTRIFUGAL CHILLERS	HFC-134a	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	CENTRIFUGAL CHILLERS	HFC-227 ea	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	CENTRIFUGAL CHILLERS	Lithium Bromide-Water	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	COLD STORAGE WAREHOUSE	Ammonia	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	COLD STORAGE WAREHOUSE	HCFC-22	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	COLD STORAGE WAREHOUSE	HCFC-22/HFC-152a/HCFC-124	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	COLD STORAGE WAREHOUSE	HFC-134a	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	COLD STORAGE WAREHOUSE	HFC-227 ea	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	COLD STORAGE WAREHOUSE	High to Low Pressure Stepdown Process	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	GRD FLIGHT LINE AIR CONDITIONING	Dupont Suva MP39	E	Lance Lankford SM-ALC/EMPW DSN 633-0228
FREON CFC-12	ODC	REFRIG	INDUST PROCESS REFRIGERATION	Ammonia	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	INDUST PROCESS REFRIGERATION	Butane	N	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	INDUST PROCESS REFRIGERATION	Chlorine	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	INDUST PROCESS REFRIGERATION	HCFC-22	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	INDUST PROCESS REFRIGERATION	HCFC-22/HFC-152a/HCFC-124	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	INDUST PROCESS REFRIGERATION	HFC-134a	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	INDUST PROCESS REFRIGERATION	Propane	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	MOBILE AIR CONDITIONING	CO2	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	MOBILE AIR CONDITIONING	Evaporative	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	MOBILE AIR CONDITIONING	HCFC-22/HFC-152a/CFC-124	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	MOBILE AIR CONDITIONING	HCFC/HFC/FC Blend	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	MOBILE AIR CONDITIONING	HFC-134a	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	RECIPROCATING CHILLERS	HCFC-142b	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	RECIPROCATING CHILLERS	HCFC-22	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	RECIPROCATING CHILLERS	HFC-134a	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	RECIPROCATING CHILLERS	HFC-227 ea	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	RETAIL FOOD REFRIGERATION	Ammonia	E	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	RETAIL FOOD REFRIGERATION	HCFC-22	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	RETAIL FOOD REFRIGERATION	HCFC-22/HFC-152a/HCFC-124	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	RETAIL FOOD REFRIGERATION	HFC-134a	R	EPA 401 M St, NW Washington, D.C. 20460
FREON CFC-12	ODC	REFRIG	RETAIL FOOD REFRIGERATION	HFC-227 ea	E	EPA 401 M St, NW Washington, D.C. 20460
R-500	ODC	REFRIG	CENTRIFUGAL CHILLERS	Ammonia	E	EPA 401 M St, NW Washington, D.C. 20460
R-500	ODC	REFRIG	CENTRIFUGAL CHILLERS	HCFC-123	E	EPA 401 M St, NW Washington, D.C. 20460
R-500	ODC	REFRIG	CENTRIFUGAL CHILLERS	HCFC-22	R	EPA 401 M St, NW Washington, D.C. 20460

PROCESSES AND SUBSTITUTES

CHEMICAL	EPA	APPLIC	SPECIFIC PROCESS	SUBSTITUTE	ASC	POINT OF CONTACT
R-500	ODC	REFRIG	CENTRIFUGAL CHILLERS	HCFC-22/HFC-152a/HCFC-124	R	EPA 401 M St, NW Washington, D.C. 20460
R-500	ODC	REFRIG	CENTRIFUGAL CHILLERS	HFC-134a	R	EPA 401 M St, NW Washington, D.C. 20460
R-500	ODC	REFRIG	CENTRIFUGAL CHILLERS	Lithium Bromide-Water	E	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	COLD STORAGE WAREHOUSE	Ammonia	E	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	COLD STORAGE WAREHOUSE	HCFC-22	R	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	COLD STORAGE WAREHOUSE	HCFC-22/Propane/HFC-125	E	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	COLD STORAGE WAREHOUSE	HFC-125	E	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	COLD STORAGE WAREHOUSE	HFC-125/HFC-143a/HFC-134a	E	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	COLD STORAGE WAREHOUSE	R-200a	E	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	INDUST PROCESS REFRIGERATION	Ammonia	E	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	INDUST PROCESS REFRIGERATION	Chlorine	E	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	INDUST PROCESS REFRIGERATION	HCFC-22	R	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	INDUST PROCESS REFRIGERATION	HCFC-22/Propane/HFC-125	E	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	INDUST PROCESS REFRIGERATION	HFC-125/HFC-143a/HFC-134a	E	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	INDUST PROCESS REFRIGERATION	HFC-134a	R	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	INDUST PROCESS REFRIGERATION	HFC-143a	E	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	RETAIL FOOD REFRIGERATION	Ammonia	E	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	RETAIL FOOD REFRIGERATION	HCFC-22	R	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	RETAIL FOOD REFRIGERATION	HCFC-22/Propane/HFC-125	E	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	RETAIL FOOD REFRIGERATION	HFC-125	E	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	RETAIL FOOD REFRIGERATION	HFC-125/HFC-143a/HFC-134a	E	EPA 401 M St, NW Washington, D.C. 20460
R-502	ODC	REFRIG	RETAIL FOOD REFRIGERATION	HFC-143a	E	EPA 401 M St, NW Washington, D.C. 20460
LEAD & COMPOUNDS	EPA-17	SEALING	COMPONENT OF SEALANT	Lead Free Sealants	R	John Vidic OO-ALC/LAOPE DSN 458-2050
METHYL ETHYL KETONE	EPA-17	STRIPPING	RADOME STRIPPING/REPAIR	Laser Stripping	E	John Vidic OO-ALC/LAOPE DSN 458-2050
METHYL ETHYL KETONE	EPA-17	STRIPPING	RADOME STRIPPING/REPAIR	Wheat Starch	R	John Vidic OO-ALC/LAOPE DSN 458-2050
METHYLENE CHLORIDE	EPA-17	STRIPPING	PAINT STRIPPING	Benzyl Alcohol	R	Robin Stearns OC-ALC/LAPEP DSN 336-5986
METHYLENE CHLORIDE	EPA-17	STRIPPING	PAINT STRIPPING	Carbon Dioxide Pellets	R	John Lindsey WR-ALC/TIELN DSN 468-1287
METHYLENE CHLORIDE	EPA-17	STRIPPING	PAINT STRIPPING	Citrex	R	Inland Technology Inc 1-800-552-3100
METHYLENE CHLORIDE	EPA-17	STRIPPING	PAINT STRIPPING	Citrex	R	Inland Technology Inc 1-800-552-3100
METHYLENE CHLORIDE	EPA-17	STRIPPING	PAINT STRIPPING	High Pressure Water	R	Robin Stearns OC-ALC/LAPEP DSN 336-5986
METHYLENE CHLORIDE	EPA-17	STRIPPING	PAINT STRIPPING	Medium Pressure Water	R	John Lindsey WR-ALC/TIELN DSN 468-1287
METHYLENE CHLORIDE	EPA-17	STRIPPING	PAINT STRIPPING	Plastic Media Blast	R	John Vidic OO-ALC/LAOPE DSN 458-2050
METHYLENE CHLORIDE	EPA-17	STRIPPING	PAINT STRIPPING	Wheat Starch	R	Richard Slife WR-ALC/CNC 912 926-3284
METHYLENE CHLORIDE	EPA-17	STRIPPING	PAINT STRIPPING	X-Caliber	R	Inland Technology Inc 1-800-552-3100
METHYLENE CHLORIDE	EPA-17	STRIPPING	PAINT STRIPPING	X-Caliber	R	Inland Technology Inc 1-800-552-3100
FREON CFC-113	ODC	TESTING	PARTS COOLING	Vortex Air Guns	R	Patrick Reust/SM-ALC/LICF/DSN 633-3787
FREON CFC-12	ODC	TESTING	PARTS COOLING	Exair Cold Gun	R	Brent Baumgartner/WR-ALC/468-1422
FREON CFC-12	ODC	TESTING	PARTS COOLING	HF-134 Microfreeze	E	Brent Baumgartner/WR-ALC/468-1422

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7.0 Summary

At the commencement of this effort we had hoped to clearly define three or four viable options to TCA for NDI applications. Three or four alternatives are contained within the listing of alternatives in Sections 3 and 4. However, the only truly acceptable alternatives must be derived empirically by testing the article of a specified configuration with specified alternative solvent. Although no clear drop in replacement for TCA exists, the wide variety of alternatives solvents provide an adequate supply such that an adequate replacement can be obtained in most cases.

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1. E.M. Kirschner, "Environment, Health Concerns Force Shift In Use Of Organic Solvents", C.&E. News, 13, June 20, 1994.

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3. S. Robinson, "1,1,1-Trichloroethane Here Today, Gone Tomorrow! Replacing 1,1,1-Trichloroethane in the Penetrant Process", National Fall Conference for Nondestructive Testing, September 17, 1991.

4. R. Gallagher and H. Jackson, "DBE purges Polyurethane Equipment without Methylene Chloride Risks, Elastomerics, 56, October, 1990.

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Section 3:

Downsizing of Alternatives Through Initial Testing

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The comprehensive listing of candidate cleaners for adhesive bonding and NDI revealed more cleaners than could possibly be tested within the time constraints of this program. Therefore, both lists were shortened based upon a variety of performance and environmental factors. ARL-MD contracted Rensselaer Polytechnic Institute (RPI) to perform most of the initial qualification testing. The University of Connecticut was also contracted to perform auger and x-ray photoelectron spectroscopy (XPS) of the cleaners. These reports are included within this section.

The candidates for cleaning prior to adhesive bonding were compared against the requirements of MIL-C-87937 Rev A and B. These tests included residue rinsibility, water break free, unacceptable materials, pH value, cold stability, heat stability, cleaning efficiency, hard water stability, biodegradability, flash point, and volatility. In addition, the alternative chemical compositions were checked against the EPA Hazardous Materials Cross Index, and the overall cleaning ability of the candidates were tested with the surface analysis techniques of auger electron spectroscopy (AES) and XPS, which was performed by the University of Connecticut in Storrs, CT. The results of the XPS testing are contained at the end of this section. The candidates for cleaning prior to NDI were more difficult to screen. There existed a Qualified Products Listing (QPL) for the inspection penetrant materials, MIL-T-25135; a liquid penetrant standard for the process, MIL-STD-6866; and a Federal specification for solvents, P-D-680. However, due to the intricacies inherent to the processes, concern remained about interactions between the pre-cleaner, the QPL penetrants, and their removers. With Class 1 ODC solvent removers taken off the QPL due to their ozone-depleting effects, Class 2 solvent removers were the obvious choice for replacement. Since Class 2 solvent removers do not have the same characteristics of Class 1 solvent removers, certain aspects of the inspection process must be altered to achieve the same results. This work investigated the feasibility of utilizing compliant solvents categorized as a maximum of Class 2 ODC during the NDI process in an attempt to replace the widely accepted qualities of 1,1,1 trichloroethane. The reports generated on results of the screening testing performed by RPI and UCONN as well as the testing procedures are presented on the following pages.

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Qualification of Alternatives to 1,1,1 Trichloroethane

Submitted to:
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The purpose of the research effort was to determine feasible replacements for 1,1,1 trichloroethane with respect to cleaning prior to adhesive bonding and Non-Destructive Inspection. Some individual alternatives had compatibility difficulties with some of the testing procedures and were therefore, not tested against all screening tests. Some cleaners were tested at the direction of the US Army Research Laboratory - Materials Directorate in Watertown, MA.

TESTS

The following tests were performed to qualify the alternatives according to the military specification Mil-C-87937 A and B.

- Residue Rinsibility
- Water Break Free
- Unacceptable Materials
- pH Value
- Cold Stability
- Cleaning Efficiency
- Hard Water Stability
- Biodegradability
- Flash Point
- Heat Stability
- Volatility

In addition to these tests, the compounds contained within the alternatives were checked against the EPA Hazardous Materials Chemical Cross Index, and an Auger analysis was performed to rank the cleaning efficiency of the alternatives. Each individual testing procedure, and the results are described below. Each cleanser was prepared according to the manufacturer's direction for use dilution utilizing standard tap water. For each test that required further dilution, de-ionized water was utilized. Thus, a concentrated solution as written in Mil-C-87937 is the use dilution stated by the manufacturer. A diluted sample as stated by Mil-C-87937 was prepared by mixing the use dilution with the de-ionized water unless otherwise noted.

The following two compounds were required for more than one test. Therefore, they are listed here to avoid redundancy:

MoS_2 Grease: molybdenum disulfide grease was prepared by blending MoS_2 with KSL performance grease from Keystone Lubricants Inc. (MIL-G-81322 or MIL-G-21164). The cleaning efficiency test required adding carbon black according to Mil-C-87937 and thorough mixing with a mechanical grease worker. For the Auger testing, the grease without carbon black was mixed with Mobil 25 hydraulic fluid (MIL-H-83282) at a ratio of two parts hydraulic fluid to one part grease.

Hard Water : Reagent grade calcium acetate $[Ca(C_2H_3O_2O)_2{*}2H_2O]$ was mixed with reagent grade magnesium sulfate $[MgSO_4{*}7H_2O]$ and 1 liter de-ionized water, according to the Mil-C-87937.

Residue Rinsibility

10 ml of a 25% by volume solution of each cleanser in standard hard water was placed in three Fisher 57 mm aluminum weigh pans. The dishes were dried for 7.5 hours in a circulating oven at 68 ± 2 °C. After drying the dishes were placed in a desiccator and cooled overnight. The dishes were weighed, rinsed under running de-ionized water for one minute, then brushed in a cleansing fashion with a sash type brush for one minute. The dishes were then placed in an oven for another 7.5 hours, cooled in a desiccator, and re-weighed. 10 ml of a standard hard water solution in each of the three dishes was utilized as a basis for comparison. The average weight change of the aluminum dishes containing cleanser was recorded and compared to that of the hard water. Any changes in appearance of the dishes were also noted.

A pass indicates that the cleanser left less residue than the hard water, as well as having no detrimental effects on the appearance of the dishes. A pass with color change (PC on the data sheet) indicates that less cleanser residue remained , however, the appearance of the aluminum dish was altered. The extent of the change is noted in the data for this test. If the cleanser residue weighed more than that of the hard water the cleaner failed this test.

Water Break Free

Mica blanks having a minimum ASTM quality of V6 as described in Specification DMI 351 were utilized to test for contaminants in the equipment. The mica was cleaved on both sides, exposing fresh mica surface. The sheet was then dipped in the test container overflowing with de-ionized water and vertically withdrawn. The time for the water layer to break was then measured. 1,1,1 trichloroethane was then tested to obtain a testing base. Aluminum plates of dimension 1 inch by 2 inches were cleaned with standard 1,1,1 trichloroethane, dipped into a container overflowing with de-ionized water, and withdrawn vertically. The time for the water to break was then recorded.This procedure was repeated for each alternative cleaner, cleaning the aluminum plates with 1,1,1 trichloroethane after each use. The test was considered successful if the draining water remained as a thin film over the surface without breaking for one minute after removal from the overflow container.

Unacceptable Materials

The constituents of each alternative were checked against the following listing of unacceptable materials. If the solution had a component from Section A, it was considered a failure. If the solution had a component from Section B, it failed unless the component was considered an essential active ingredient. The sections are defined as follows:

Section A

- Hazardous compounds as defined by CFR 261
- Chemicals currently listed as known carcinogens as part of NTP
- Abrasives
- Chromates
- Cadmium

- Lead
- Mercury
- Phenols
- Cresols
- Ketones
- Chlorinated Compounds
- Ozone Depleting Substances

Section B

- Sodium Chloride
- Urea
- Sodium Sulfate
- Nitrates
- Nitrites
- Sucrose or any Sugars

pH Value

The standard pH of each cleaner was measured in concentrated form utilizing a standard pH meter and there respective values were recorded.

Cold Stability

50 ml of each alternative cleaner was placed in a test tube and cooled to 0 °C and maintained at that temperature for one hour. The tube was then allowed to reach room temperature and then re-cooled to 0 °C. This cycle of cooling and warming was repeated a total of five times. At the end of the fifth cycle, the cleaners were examined for homogeneity, allowing for a slight turbidity provided no precipitate was present.

Cleaning Efficiency

Control Formula: The control formula utilized in the cleaning efficiency test was prepared by mixing 30 wt % d-limonene, 5 wt. % diethanolamine, 5 wt % Triton X-100 (a non-ionic surfactant), and 60 wt % de-ionized water.

Preparation of Test: The panels were cleaned with reagent grade acetone utilizing a clean tissue, dried to constant weight, and weighed to the nearest 0.1 mg. Subsequently, 200 mg. of the standard contaminant grease was applied with a bristle brush over a 2 x 7 inch area in the center of the panel. Excess soil was removed by covering the panel with an absorbent tissue and rolling a five pound Nylon cylinder over the tissue. This blotting was performed twice, then the panels were baked at 105 ± 5 °C for one hour. The panels were cooled to room temperature and utilized within four hours. Only panels with more than 50 mg. of contaminant were accepted.

Cleaning: Each candidate was diluted with one part cleaner to nine parts de-ionized water.Subsequently, 100 Ml of dilution was applied to a cellulose sponge, then to the soiled test panel so it was completely covered with solution. After 30 seconds dwell time, the test panel was cleaned with de-ionized water, then heated to 105 ± 5 °C for ten minutes. After cooling to room temperature, the panels were weighed to the nearest 0.1 mg. The cleaning efficiency was reported as the average of three tests compared to the control formula as follows:

$$\% \, CleaningEfficiency = \frac{\left(\dfrac{a-b}{a-c}\right)}{\left(\dfrac{x-y}{x-z}\right)} x100\%$$

where:

a = weight of soiled panel before cleaning with product
b = weight of soiled panel after cleaning with product
c = weight of unsoiled panel used with test cleaner
x = weight of soiled panel before cleaning with control cleaner
y = weight of spoiled panel after cleaning with control
z = weight of unsoiled panel used with control

C) Materials Compatibility

In addition to the alternatives functional ability as cleaners, they must also not react adversely with the materials upon which they are being utilized. A series of materials compatibility tests were performed with commonly bonded Army aviation materials. The materials included 7075-T6 Aluminum, Ti-6Al-4V, AM-355 stainless steel, Maraging C-250 steel, PH 13-8 steel, and 4340 steel. The compatibility tests performed on these materials included Total Immersion Corrosion ASTM-F-483, Effects on Unpainted Surfaces ASTM-F-485, Sandwich Corrosion ASTM-F-1110, Hydrogen Embrittlement of Cadmium Plated Steel ASTM-F-519, and Stress Corrosion utilizing various ARP and ASTM specifications as guidelines.

Hard Water Stability

Five ml of a 25% by volume dilution of each cleaner was added to 45 ml of standard hard water. Each solution was well mixed and allowed to rest undisturbed for 24 hours. Each cleanser was then visually examined for precipitation. The turbidity of the cleaners was measured utilizing a Hach model 18900 Ratio Turbidimeter. The units measured are found by utilizing the Nephelometric method for determining turbidity, and are abbreviated as NTU's for Nephelometric Turbidity Units. The turbidity of the cleaners was determined by the average of three test, each test calculated as the following:

$$NTU = \frac{Ax(B + C)}{C}$$

where:
A = NTU found in the diluted sample
B = Volume of dilution water, ml
C = Sample volume taken for dilution, ml

Biodegradability

The supplier of the cleaner compound shall furnish certification that the surfactants are readily biodegradable in accordance with 40 CFR, part 796, subpart D.

Flash Point

The flash point of each candidate cleaner was determined by the manufacturer and was recorded from the Material Safety Data Sheets (MSDS).

Heat Stability

Steel strips conforming to Mil-S-7952 were abrasively polished to remove scale and corrosion, then immersed in P-D-680 for one minute followed by one minute immersion in TT-I-735 grade A isopropyl alcohol. The cleaning compound was placed into each bottle according to Mil-C-87937. One bottle was sealed with a screw type cap and stored in a dark place at standard conditions for 6 days (144 hours). The steel strip was then placed into the second bottle of solution and shaken thoroughly for one minute. The bottle was maintained at 46 ± 2 °C for five hours in a water bath. Once removed, the bottle was allowed to cool for 19 hours. The steel strip was then removed and inspected. Any pitting, corrosion, or discoloration constituted failure. The bottle was resealed and shaken for one minute. It was then placed back into the oven. This cycle was repeated five times. Any marked change in color, precipitation, layering, or separation constituted failure.

Volatility

The comparative weight loss of a 10 % by volume solution of each cleaner to distilled water was recorded by exposing two petri dishes to a draft free atmosphere for one hour. One petri dish was filled with cleanser, the other with distilled water. A ‘p’ indicates that the volatility was less than distilled water, an ‘f’ constituted the contrary.

Auger Analysis

An auger analysis was performed to determine how well the cleaners worked on a microscopic basis. The test panels were 1 cm x 1 cm aluminum squares. The panels were cleaned ultrasonically with 1,1,1 trichloroethane and dried. They were then covered with the grease prepared for this test and baked at 130 °C for two hours. The samples were then cleaned ultrasonically with each of the alternative cleaners. The manufacturer’s suggested temperature was utilized when provided, otherwise room temperature was used. The results were reported as a percentage of element detected compared to 1,1,1 trichloroethane. The more aluminum and the less carbon, the more effective the cleaner. The results listed on the summary data sheet rank the performance of the individual cleaners.

EPA Cross Index Listing

The constituents of the cleaners were checked against the EPA Hazardous Materials Chemical Cross Index. If any of the constituents are indicated on this listing, it was noted by check mark on the data summary sheet. This listing summarizes recent development in compounds that are currently being restricted or have a potential for future restriction. A listing of this cross index can be found in Appendix E.

Results:

The data acquired is presented on the following pages. The testing procedures, conditions, and parameters utilized were all developed in conjunction with ARL-MD. In addition, ARL-MD assisted in data acquisition and analysis of the results. A summary of the results can be found in tabular form at the end of the section.

Residue Rinsibility
Summary Data

key to comments:

a heavy
b moderate
c light
d sides
f film
p spots

s stripes
g gray
w white
y yellow
l liquid after first dry
r rainbow

shaded areas represent chemicals not received

solvents not tested

non solvent	Sample #	weight of dish only (g)	weight after first drying (g)	weight of 1st residue (g)	weight after second drying (g)	weight of 2nd residue (g)	average weight change (mg)	pass 1=yes 0=no	comments
y	HW 1	0.9924	0.9989	0.0065	0.9937	0.0013			by
	HW 2	0.9937	0.9997	0.0060	0.9954	0.0017	1.10	1	ay
	HW 3	0.9966	1.0020	0.0054	0.9969	0.0003			cwf
y	1 a	0.9925	1.0309	0.0384	0.9951	0.0026			
	b	0.9927	1.0321	0.0394	0.9956	0.0029	2.93	0	
	c	0.9952	1.0344	0.0392	0.9985	0.0033			
y	3 a	0.9967	1.0130	0.0163	0.9964	-0.0003			
	b	0.9902	1.0246	0.0344	0.9907	0.0005	-0.03	1	by
	c	0.9932	1.0268	0.0336	0.9929	-0.0003			
y	4 a	0.9951	1.0434	0.0483	0.9944	-0.0007			
	b	0.9939	1.0565	0.0626	0.9928	-0.0011	-0.77	1	
	c	0.9953	1.0279	0.0326	0.9948	-0.0005			
y	2nd 4 a	0.9961	1.0110	0.0149	0.9965	0.0004			cp
	b	0.9896	1.0073	0.0177	0.9907	0.0011	0.50	1	
	c	0.9929	1.0074	0.0145	0.9929	0.0			
y	5 a	0.9988	1.1844	0.1856	1.0026	0.0038			l
	b	0.9932	1.1812	0.1880	0.9985	0.0053	3.30	0	l
	c	0.9960	1.1810	0.1850	0.9968	0.0008			l
y	6 a	0.9913	1.0201	0.0288	0.9926	0.0013			
	b	0.9904	1.0183	0.0279	0.9906	0.0002	0.50	1	
	c	0.9937	1.0223	0.0286	0.9937	0.0			
	9 a								
	b								
	c								
y	14 a	0.9984	1.3960	0.3976	0.9992	0.0008			cwp
	b	0.9932	1.0338	0.0406	0.9942	0.0010	0.57	1	
	c	0.9930	1.0331	0.0401	0.9929	-0.0001			cwp
	15 a								
	b								
	c								
y	18 a	0.9976	1.0646	0.0670	0.9974	-0.0002			bwf
	b	0.9906	1.0563	0.0657	0.9906	0.0	-1.27	1	by
	c	0.9958	1.0575	0.0617	0.9922	-0.0036			bwf
y	2nd 18 a	0.9943	1.0593	0.0650	0.9948	0.0005			cp
	b	0.9950	1.0587	0.0637	0.9940	-0.0010	0.00	1	
	c	0.9918	1.0594	0.0676	0.9923	0.0005			cp

Residue Rinsibility
Summary Data

non solvent	Sample #	weight of dish only (g)	weight after first drying (g)	weight of 1st residue (g)	weight after second drying (g)	weight of 2nd residue (g)	average weight change (mg)	pass 1=yes 0=no	comments
	19 a								
	b								
	c								
y	20 a	0.9950	2.7596	1.7646	0.9942	-0.0008			l
	b	0.9945	2.7616	1.7671	0.9948	0.0003	0.10	1	l
	c	0.9925	2.6831	1.6906	0.9933	0.0008			l
y	23 a	0.9975	1.4674	0.4699	0.9988	0.0013			cwf
	b	0.9917	1.4602	0.4685	0.9940	0.0023	1.67	0	awf
	c	0.9956	1.4820	0.4864	0.9970	0.0014			wp
y	23.1 a	0.9945	1.4696	0.4751	1.0220	0.0275			cwf
	b	0.9957	1.4660	0.4703	1.0013	0.0056	12.97	0	cwf
	c	0.9985	1.4824	0.4839	1.0043	0.0058			
y	24 a	0.9927	1.0282	0.0355	0.9931	0.0004			
	b	0.9939	1.0315	0.0376	0.9975	0.0036	1.63	0	
	c	0.9941	1.0291	0.0350	0.9950	0.0009			
y	2nd 24 a	0.9941	1.0333	0.0392	0.9965	0.0024			
	b	0.9913	1.0310	0.0397	0.9907	-0.0006	0.60	1	p
	c	0.9929	1.0401	0.0472	0.9929	0.0			
y	24.1 a	0.9945	1.0580	0.0635	0.9947	0.0002			rs
	b	0.9899	1.0571	0.0672	0.9895	-0.0004	-0.13	1	rs
	c	1.0	1.0654	0.0654	0.9998	-0.0002			rs
y	2nd 24.1 a	0.9961	1.0726	0.0765	1.0003	0.0042			ws
	b	0.9919	1.0673	0.0754	0.9949	0.0030	3.80	0	ws
	c	0.9935	1.0680	0.0745	0.9977	0.0042			ws
	25 a								
	b								
	c								
y	26 a	0.9966	1.7481	0.7515	0.9975	0.0009			l,ay
	b	0.9994	3.0572	2.0578	0.9996	0.0002	0.30	1	l,ay
	c	0.9985	3.0691	2.0706	0.9983	-0.0002			l
y	28.1 a	1.0024	1.5174	0.5150	1.0044	0.0020			
	b	0.9984	1.5667	0.5683	1.0001	0.0017	1.33	0	bwf
	c	0.9964	1.5245	0.5281	0.9967	0.0003			

Residue Rinsibility
Summary Data

non solvent	Sample #	weight of dish only (g)	weight after first drying (g)	weight of 1st residue (g)	weight after second drying (g)	weight of 2nd residue (g)	average weight change (mg)	pass 1=yes 0=no	comments
y	29 a	0.9907	1.0066	0.0159	0.9910	0.0003			
	b	0.9917	1.0072	0.0155	0.9912	-0.0005	0.03	1	
	c	0.9958	1.0123	0.0165	0.9961	0.0003			
y	32 a	0.9931	1.0204	0.0273	0.9941	0.0010			
	b	1.0021	1.0288	0.0267	1.0034	0.0013	1.17	1	
	c	0.9956	1.0216	0.0260	0.9968	0.0012			
y	32.1 a	0.9948	1.0859	0.0911	1.0035	0.0087			
	b	0.9933	1.0848	0.0915	1.0025	0.0092	9.73	0	
	c	0.9926	1.0853	0.0927	1.0039	0.0113			
y	2nd 32.1 a	0.9945	1.0894	0.0949	1.0013	0.0068			ad
	b	0.9934	1.0953	0.1019	1.0024	0.0090	7.57	0	ad
	c	0.9931	1.0902	0.0971	1.0	0.0069			ad
y	33 a	0.9931	1.3040	0.3109	0.9549	-0.0382			
	b	0.9950	1.3143	0.3193	0.9552	-0.0398	-39.13	1	awf
	c	0.9952	1.3046	0.3094	0.9558	-0.0394			
y	34 a	0.9996	1.1265	0.1269	1.0019	0.0023			
	b	0.9972	1.1260	0.1288	0.9994	0.0022	2.30	0	
	c	0.9941	1.1107	0.1166	0.9965	0.0024			
y	38 a	0.9951	1.0191	0.0240	0.9951	0.0			
	b	0.9949	1.0359	0.0410	0.9953	0.0004	0.30	1	
	c	0.9977	1.0444	0.0467	0.9982	0.0005			
y	39 a	0.9941	1.5391	0.5450	0.9946	0.0005			
	b	0.9916	1.6397	0.6481	0.9923	0.0007	0.30	1	
	c	0.9979	1.6124	0.6145	0.9976	-0.0003			
y	42 a	0.9951	1.0437	0.0486	0.9954	0.0003			
	b	0.9972	1.0466	0.0494	0.9976	0.0004	0.43	1	
	c	0.9971	1.0467	0.0496	0.9977	0.0006			
y	43 a	0.9987	1.6917	0.6930	0.9995	0.0008			ay
	b	0.9962	1.6953	0.6991	0.9972	0.0010	0.87	1	ay
	c	0.9972	1.5736	0.5764	0.9980	0.0008			ay
y	44 a	0.9931	1.2344	0.2413	0.9961	0.0030			
	b	0.9957	1.2236	0.2279	0.9984	0.0027	2.77	0	
	c	0.9920	1.1751	0.1831	0.9946	0.0026			
	45 a	0.9970	1.0741	0.0771	0.9988	0.0018			
	b	0.9978	1.0782	0.0804	0.9993	0.0015	1.63	0	
	c	0.9975	1.0822	0.0847	0.9991	0.0016			
	48 a								
	b								
	c								

Residue Rinsibility
Summary Data

non solvent	Sample #	weight of dish only (g)	weight after first drying (g)	weight of 1st residue (g)	weight after second drying (g)	weight of 2nd residue (g)	average weight change (mg)	pass 1=yes 0=no	comments
	49 a								
	b								
	c								
y	52 a	1.0005	1.3521	0.3516	1.0006	0.0001			I
	b	0.9999	1.4235	0.4236	0.9997	-0.0002	-1.33	1	I
	c	1.0004	1.3677	0.3673	0.9965	-0.0039			I
y	53 a	0.9981	1.0714	0.0733	0.9985	0.0004			
	b	0.9974	1.0538	0.0564	0.9975	0.0001	0.17	1	
	c	0.9948	1.0447	0.0499	0.9948	0.0			
y	53.1 a	0.9952	1.3302	0.3350	0.9952	0.0			
	b	0.9983	1.3285	0.3302	0.9982	-0.0001	0.00	1	
	c	0.9954	1.2821	0.2867	0.9955	0.0001			
y	53.2 a								
	b								
	c								
y	55 a								
	b								
	c								
y	56 a								
	b								
	c								

Cleaning Efficiency
Summary Data

leane	Pane	weight of grease	empty weight	weight with grease	weight after cleaning	cleaning efficiency	**avg. cleaning efficiency**
C	1	100.3E-3	34.2974	34.3977	34.2906	1.0000	
C	2	116.2E-3	34.3250	34.4412	34.3187	1.0000	
C	6	131.7E-3	34.4246	34.5563	34.4258	1.0000	
3	5	123.1E-3	34.4503	34.5734	34.4455	1.0013	**98.03%**
3	8	126.6E-3	34.3185	34.4451	34.3169	0.9759	
3	7	119.7E-3	34.4218	34.5415	34.4218	0.9637	
4	3	104.7E-3	34.5263	34.6310	34.5370	0.8652	**91.35%**
4	4	180.5E-3	34.3863	34.5668	34.3878	0.9557	
4	1	122.1E-3	34.2894	34.4115	34.2950	0.9195	
6	4	117.5E-3	34.3838	34.5013	34.3843	0.9596	**94.75%**
6	1	154.8E-3	34.2917	34.4465	34.2921	0.9612	
6	5	121.6E-3	34.4472	34.5688	34.4525	0.9217	
14	5	120.3E-3	34.4500	34.5703	34.4477	0.9822	**98.00%**
14	6	67.7E-3	34.3853	34.4530	34.3830	0.9965	
14	8	128.9E-3	34.3183	34.4472	34.3186	0.9615	
20	2	92.0E-3	34.3198	34.4118	34.3225	0.9354	**94.94%**
20	6	143.9E-3	34.4216	34.5655	34.4222	0.9597	
20	7	90.1E-3	34.4210	34.5111	34.4220	0.9530	
23	6	121.3E-3	34.424	34.545	34.426	0.9455	**96.52%**
23	3	119.3E-3	34.498	34.617	34.497	0.9653	
23	4	119.6E-3	34.3887	34.5083	34.3861	0.9847	
23.1	1	129.8E-3	34.267	34.397	34.261	1.0098	**93.69%**
23.1	5	9.1E-2	34.446	34.537	34.458	0.8417	
23.1	8	105.6E-3	34.3211	34.4267	34.3216	0.9592	
25	1	128.6E-3	34.2875	34.4161	34.2961	0.8993	**94.52%**
25	5	124.3E-3	34.4512	34.5755	34.4520	0.9575	
25	4	127.4E-3	34.3852	34.5126	34.3832	0.9789	
26	3	194.9E-3	34.5258	34.7207	34.5266	0.9598	**92.52%**
26	5	153.8E-3	34.4465	34.6003	34.4610	0.8729	
26	1	129.8E-3	34.3845	34.5143	34.3873	0.9429	
32	8	130.9E-3	34.3192	34.4501	34.3205	0.9542	**95.98%**
32	4	137.2E-3	34.3853	34.5225	34.3859	0.9595	
32	5	147.6E-3	34.4512	34.5988	34.4509	0.9657	
39	4	120.3E-3	34.3845	34.5048	34.3955	0.8756	**86.67%**
39	3	136.2E-3	34.4939	34.6301	34.5111	0.8420	
39	1	118.4E-3	34.2623	34.3807	34.2723	0.8823	
42	8	127.7E-3	34.3194	34.4471	34.3189	0.9675	**96.15%**
42	7	113.4E-3	34.4211	34.5345	34.4219	0.9569	
42	3	131.2E-3	34.5240	34.6552	34.5245	0.9601	

Cleaning Efficiency
Summary Data

43	4	117.5E-3	34.3807	34.4982	34.3863	0.9178	
43	8	133.8E-3	34.3192	34.4530	34.3260	0.9148	**92.30%**
43	7	123.2E-3	34.4025	34.5257	34.4060	0.9364	
46	8	125.6E-3	34.3170	34.4426	34.3271	0.8862	
46	2	142.9E-3	34.3146	34.4575	34.3273	0.8781	**91.18%**
46	3	116.8E-3	34.5036	34.6204	34.5027	0.9712	
52	1	94.0E-3	34.2875	34.3815	34.2903	0.9350	
52	2	102.0E-3	34.3250	34.4270	34.3196	1.0148	**96.44%**
52	2	128.7E-3	34.3216	34.4503	34.3243	0.9435	
53	8	135.8E-3	34.3206	34.4564	34.3187	0.9772	
53	2	120.4E-3	34.3212	34.4416	34.3212	0.9637	**96.88%**
53	7	107.2E-3	34.4005	34.5077	34.4003	0.9655	
53.1	1	100.8E-3	34.2919	34.3927	34.2924	0.9590	
53.1	2	119.7E-3	34.3226	34.4423	34.3221	0.9678	**84.17%**
53.1	6	191.7E-3	34.3596	34.5513	34.4323	0.5982	
55	3	135.0E-3	34.5262	34.6612	34.4950	1.1865	
55	7	133.8E-3	34.4198	34.5536	34.3990	1.1135	**117.05%**
55	1	132.7E-3	34.2914	34.4241	34.2573	1.2114	
56	7	119.3E-3	34.398	34.518	34.418	0.8046	
56	1	149.5E-3	34.266	34.416	34.267	0.9566	**90.02%**
56	4	139.0E-3	34.3903	34.5293	34.3938	0.9395	

Auger
Summary Data Sheet

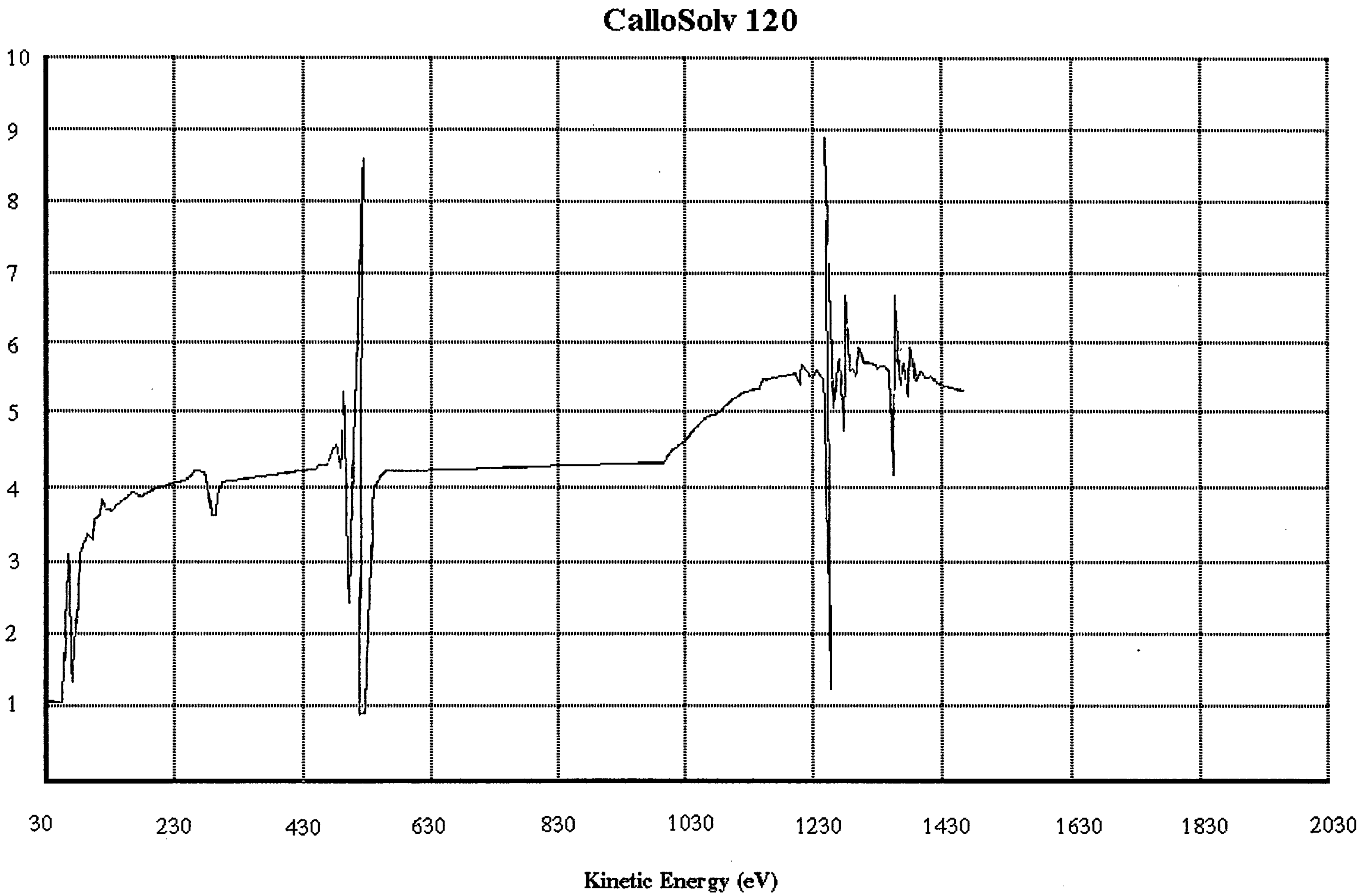
	values are tenth of inch						
#	C	O	Mg	Al	other	%C	%Al
TCE	36.5	14	16.5	11.5	####	1.00	1.00
3	38.9	5.5	0	1	####	1.07	0.09
4	36	0	0	0	####	0.99	0.00
6					####	0.00	0.00
14	43.9	1	2	1.5	####	1.20	0.13
20	18.25	25.5	10.25	21.5	####	0.50	1.87
23	0	31.75	0	24.5	####	0.00	2.13
23.1	18	32.9	9.5	21.5	####	0.49	1.87
25	15.25	33.9	14	26	####	0.42	2.26
26	22	38	23	26.75	####	0.60	2.33
29	37.5	4	3.75	4	####	1.03	0.35
32	45.9	2.5	2	3	####	1.26	0.26
39	5	25	0	25.5	####	0.14	2.22
42	22	24	6.25	16.5	####	0.60	1.43
43	4	29.9	12.75	38.5	####	0.11	3.35
46	24.5	27.5	12.75	23.5	####	0.67	2.04
52	26.5	0	0	0	####	0.73	0.00
53	38.9	17.25	6	16	####	1.07	1.39
53.1	38.9	8.5	8	6.5	####	1.07	0.57
55	35.9	0	0	0	####	0.98	0.00
56	19	30	24	15.75	####	0.52	1.37

Heat Stability
Summary Data

Cleanser #	Metal in Vapor	Metal in Liquid	Solution in Heat Before Shakin	Solution in Heat After Shaking	Result
3	ok	ok	Same as Room Temp Solution	No Change	pass
4	Rainbow of Stains at Vap/Liq Interfac		Cloudy, Very Dark Brown Solutio	No Change (Though Room Temp wa	fail
6	Corrosion	Blue Stain	Same as Room Temp Solution	No Change	fail
14	ok	ok	Same as Room Temp Solution	No Change	pass
20	ok	ok	Same as Room Temp Solution	No Change	pass
25	ok	ok	Same as Room Temp Solution	No Change	pass
26	ok	ok	Same as Room Temp Solution	No Change	pass
29	ok	ok	Same as Room Temp Solution	No Change	pass
32	Thick, Spotty, R	ok	Same as Room Temp Solution	No Change	fail
39	Corrosion	Yellow and Grey St	2 Layers Separated	No More Separation-Same as Room	fail
42	ok	ok	Same as Room Temp Solution	No Change	pass
52	ok	ok	Slightly Less Cloudy Than Room	No Change	pass
53.1	ok	ok	Less Cloudy Than Room Temp	Still Less Cloudy	pass
55	mild corrosion	ok	Same as Room Temp Solution	No Change	fail

Volatility
Summary Data

					After One Hour	After One Hour			
Cleaner	**Cleanser Dish (g)**	**Water Dish (g)**	**Cleanser (g)**	**Water (g)**	**Cleanser & Dish (g)**	**Water & Dish (g)**	**% Cleanser Vaporized**	**% Water Vaporized**	**Pass/Fail**
3	4.411	4.409	3.001	3.002	7.164	7.138	8.26	9.09	p
4	4.539	4.401	2.498	2.495	6.803	6.648	9.37	9.94	p
6	4.401	4.492	2.308	2.302	6.504	6.582	8.88	9.21	p
14	4.401	4.388	2.975	2.973	7.142	7.102	7.87	8.71	p
20	4.401	4.492	1.782	1.781	5.975	6.054	11.67	12.30	p
23	4.401	4.491	3.263	3.266	7.433	7.517	7.08	7.35	p
23.1	4.541	4.41	3.149	3.148	7.449	7.314	7.65	7.75	p
25	4.387	4.354	2.824	2.82	6.958	6.931	8.96	8.62	f
26	4.401	4.401	2.264	2.262	6.46	6.457	9.05	9.11	p
32	4.355	4.402	2.494	2.498	6.649	6.684	8.02	8.65	p
39	4.402	4.541	2.304	2.302	6.511	6.638	8.46	8.91	p
42	4.496	4.398	2.94	2.939	7.173	7.071	8.95	9.05	p
43	4.388	4.492	2.458	2.461	6.616	6.732	9.36	8.98	f
52	4.356	4.402	2.674	2.676	6.788	6.811	9.05	9.98	p
53	4.355	4.388	1.917	1.914	6.076	6.1	10.22	10.55	p
53.1	4.403	4.402	2.236	2.233	6.397	6.381	10.82	11.37	p
55	4.408	4.392	2.052	2.051	6.24	6.205	10.72	11.60	p
56	4.401	4.354	2.565	2.567	6.752	6.724	8.34	7.67	f
46	4.492	4.543	2.717	2.718	7.004	7.064	7.55	7.25	f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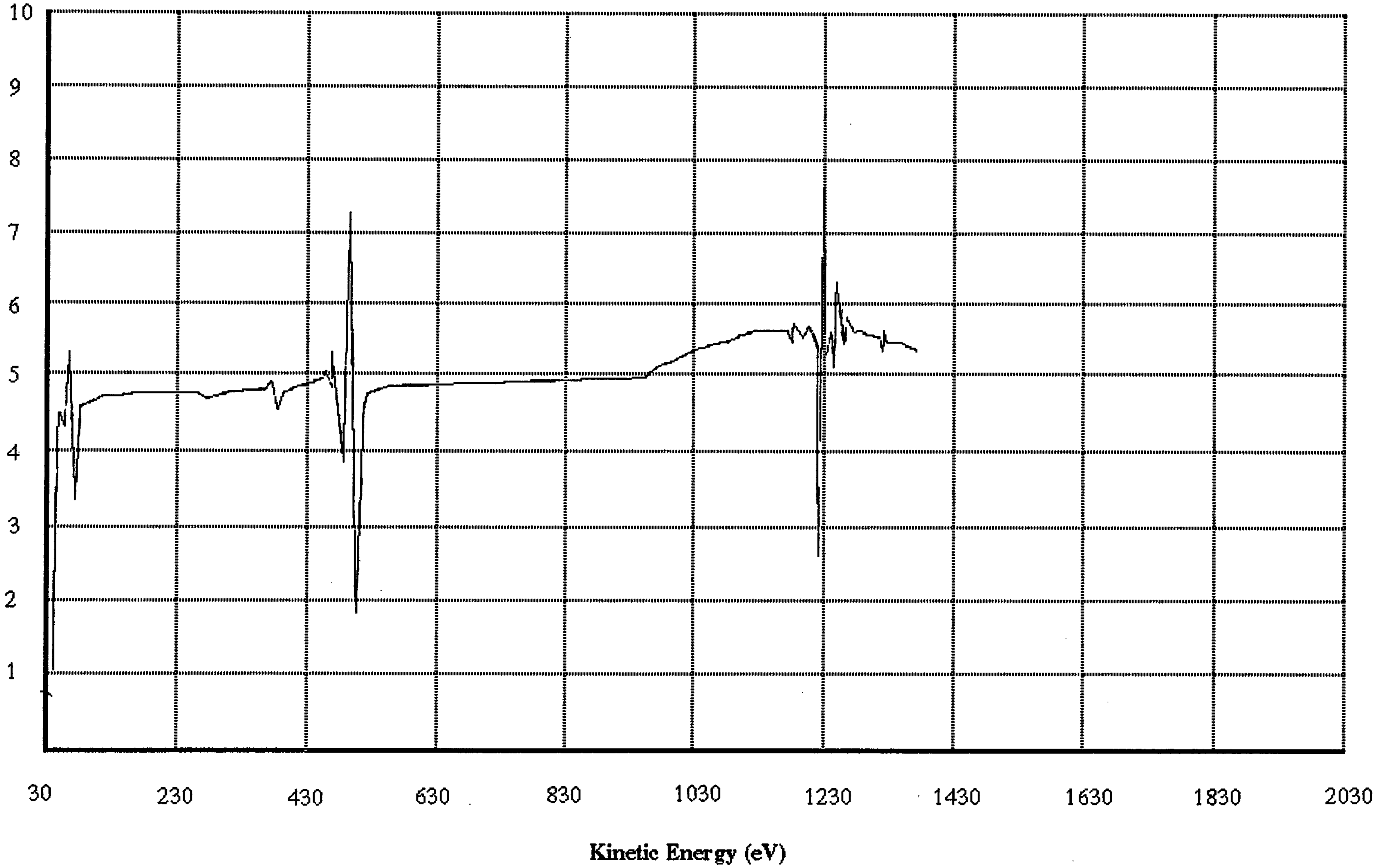
Kinetic Energy (eV)

Aerosolve 2000



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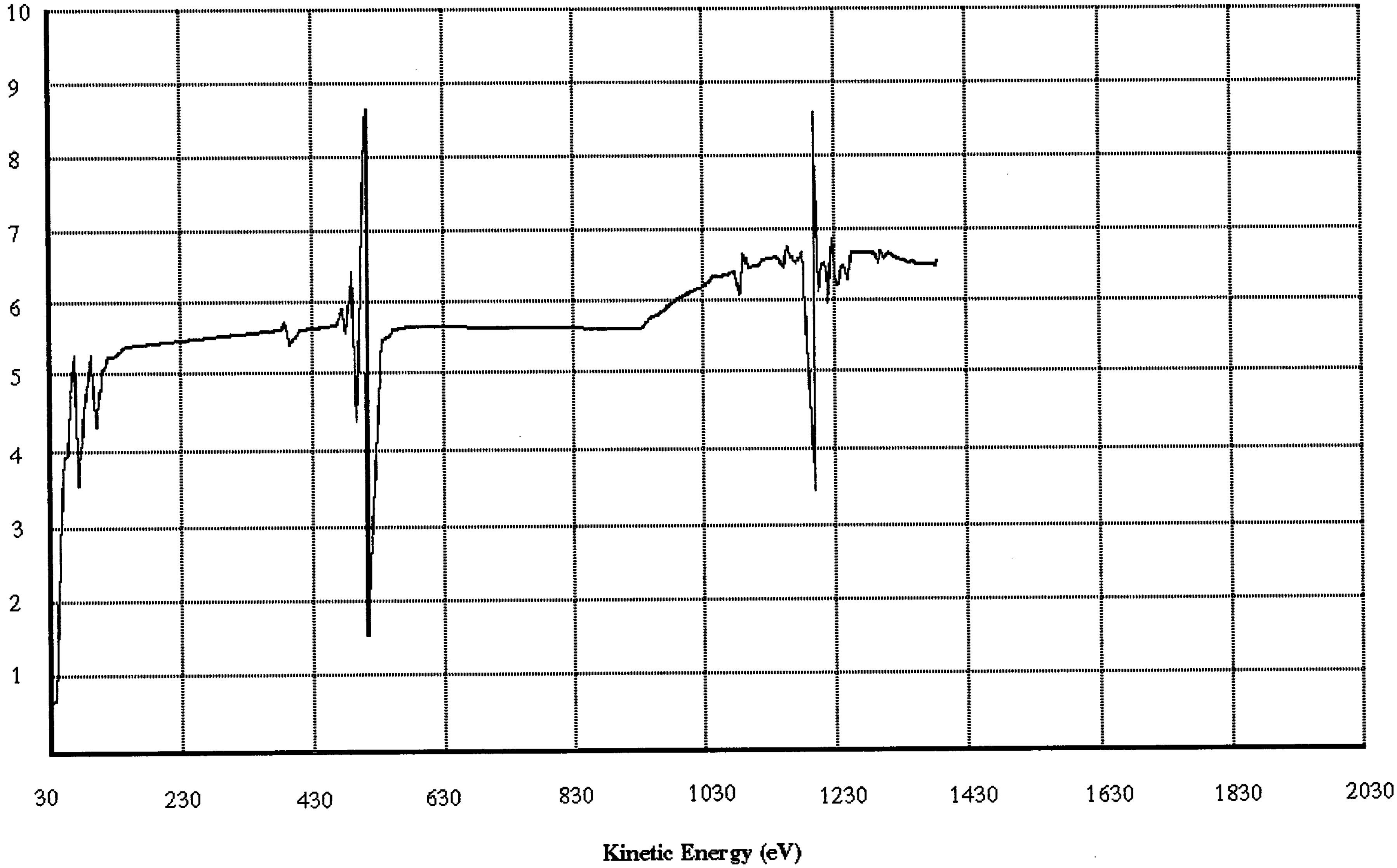

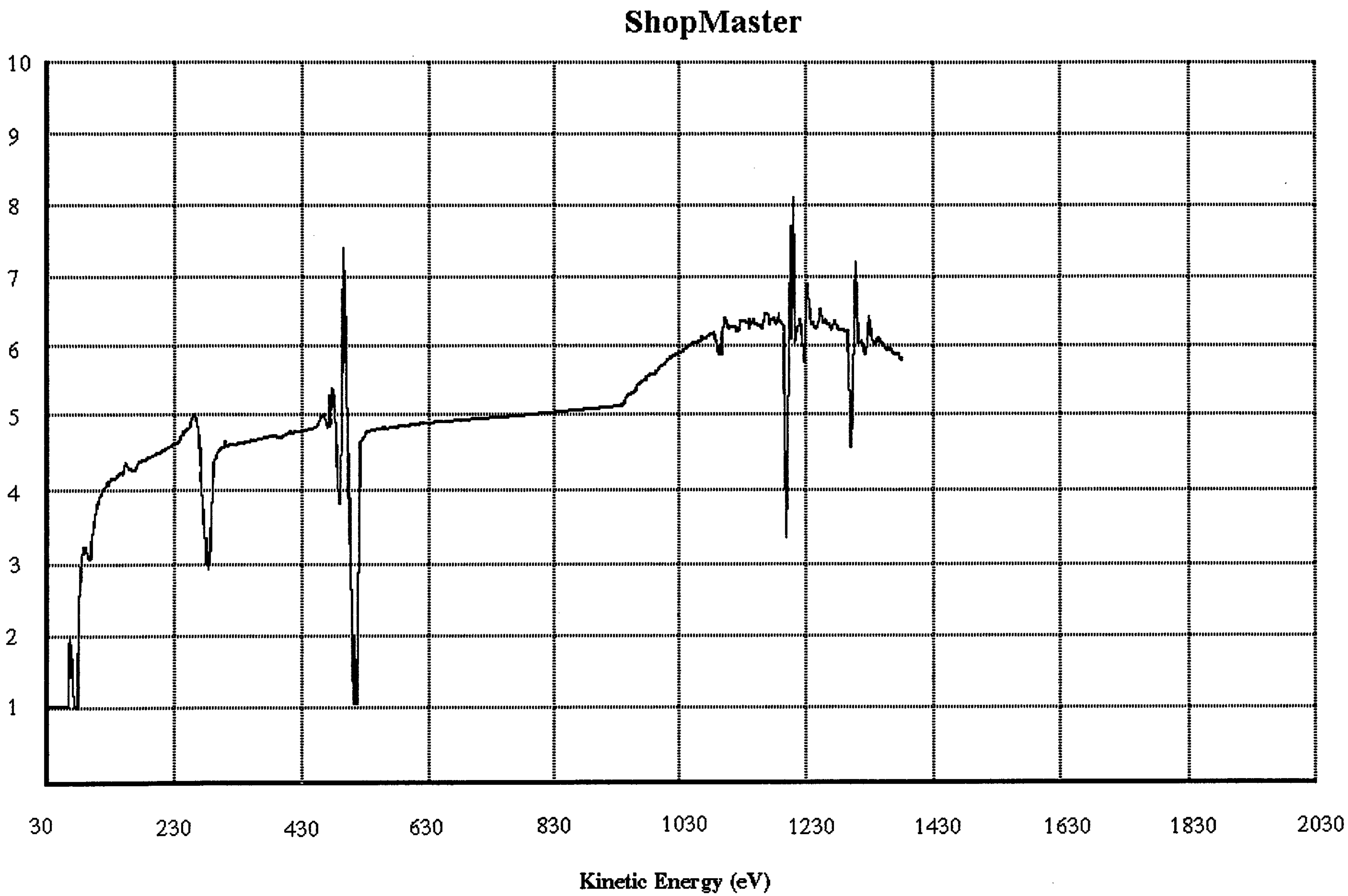
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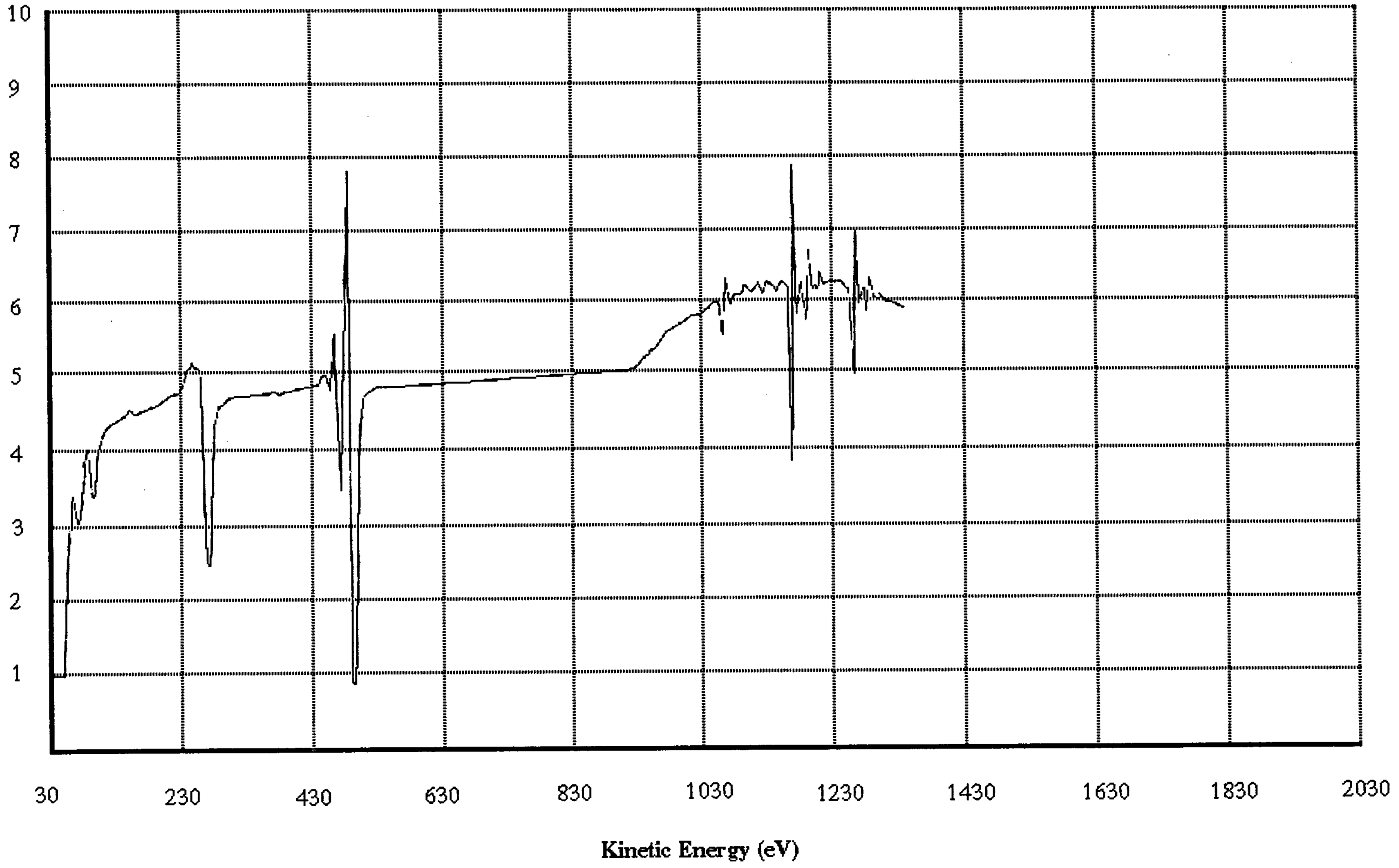
Kinetic Energy (eV)

Quaker 697UT



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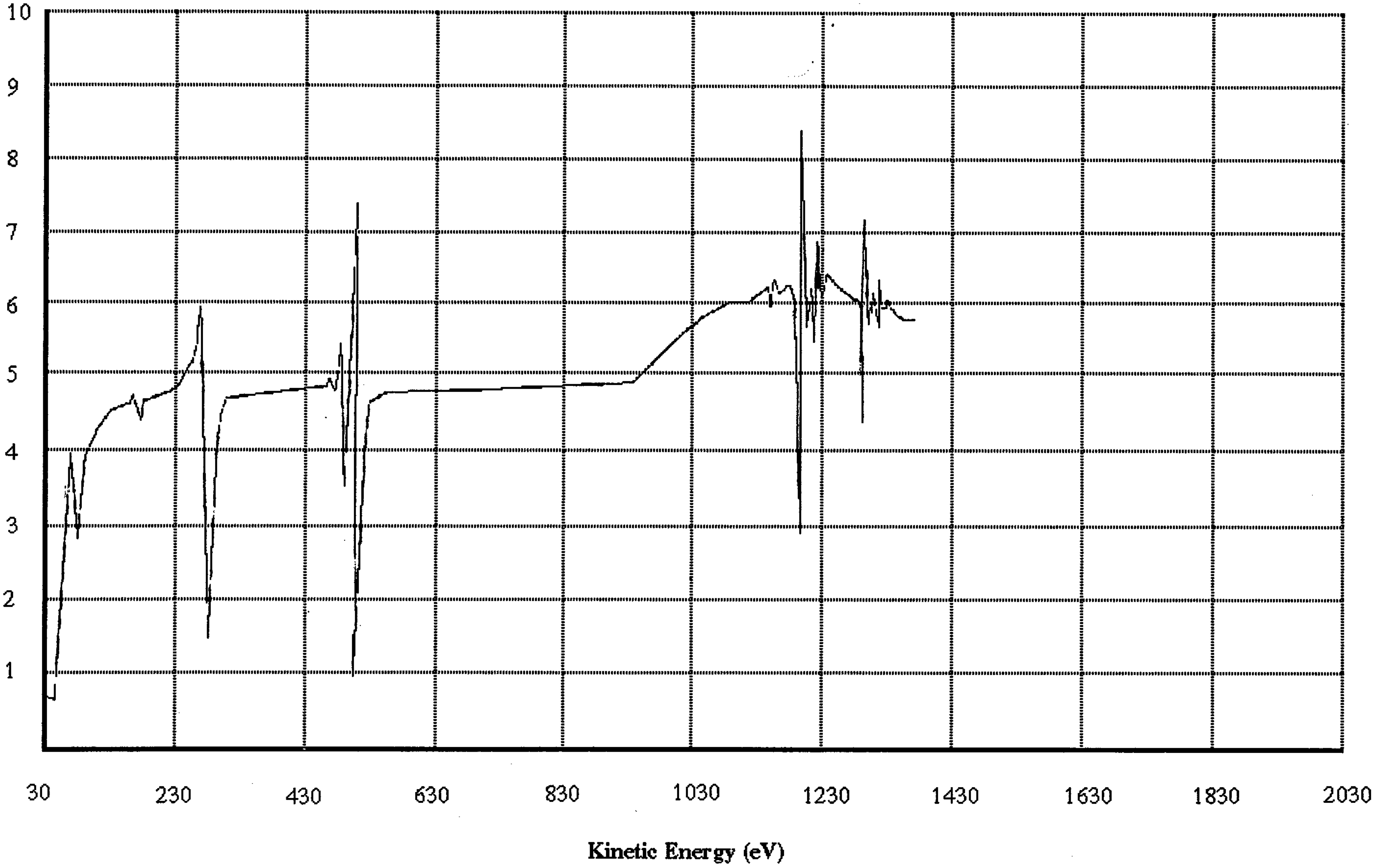
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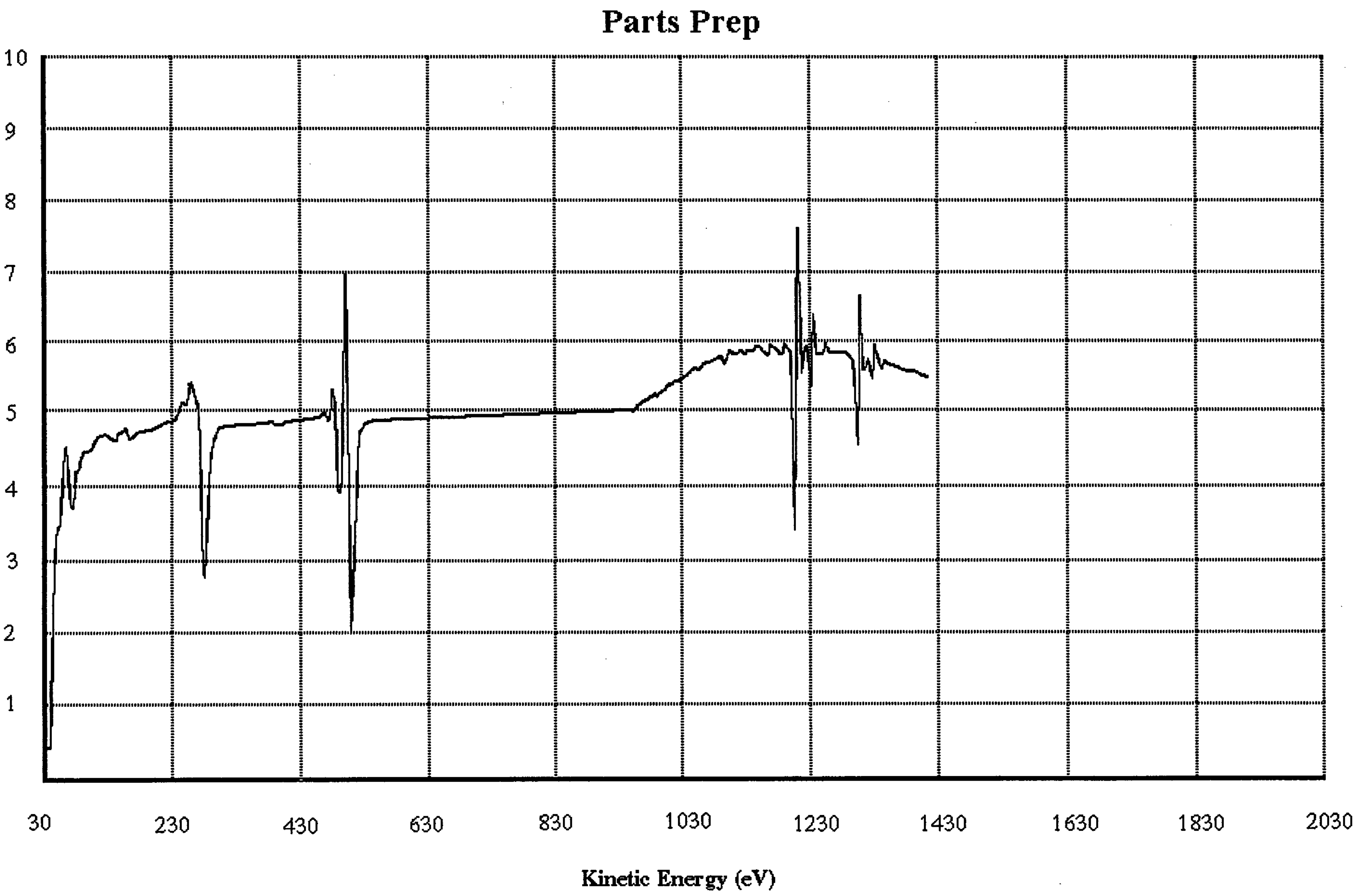
Kinetic Energy (eV)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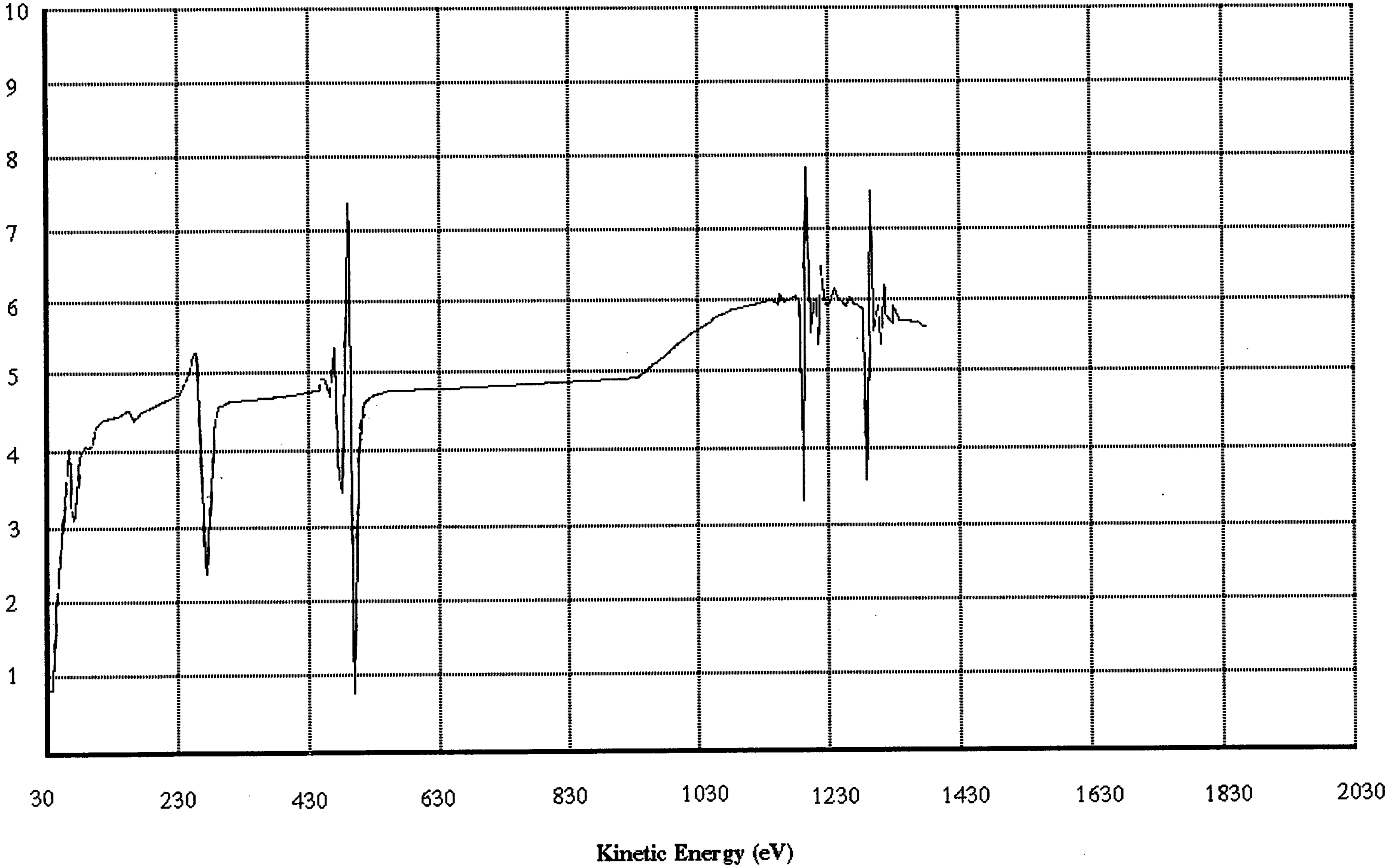
Kinetic Energy (eV)

Solvall 5234



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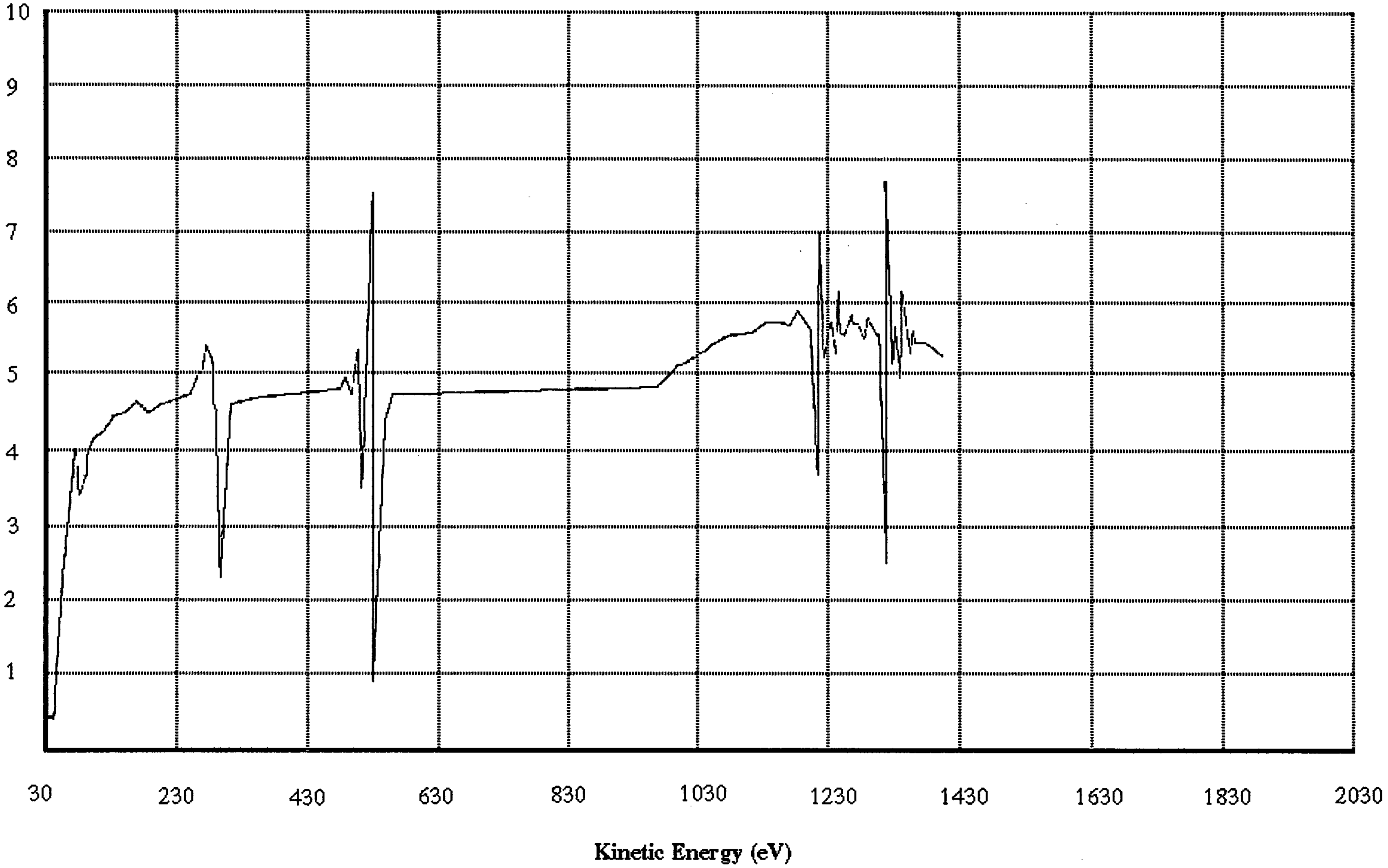
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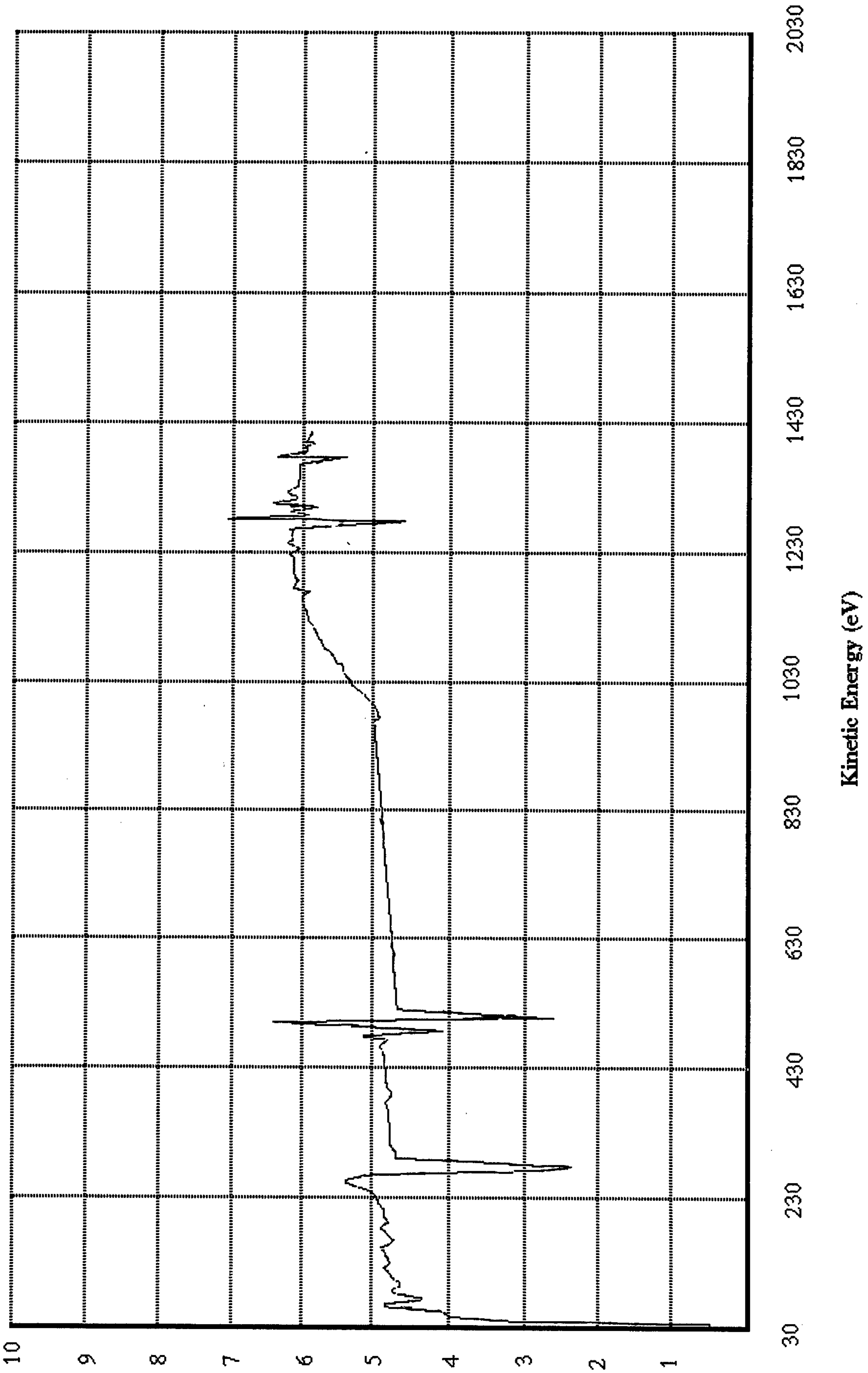
Kinetic Energy (eV)

Cee-Bee Cleaner A-7x7



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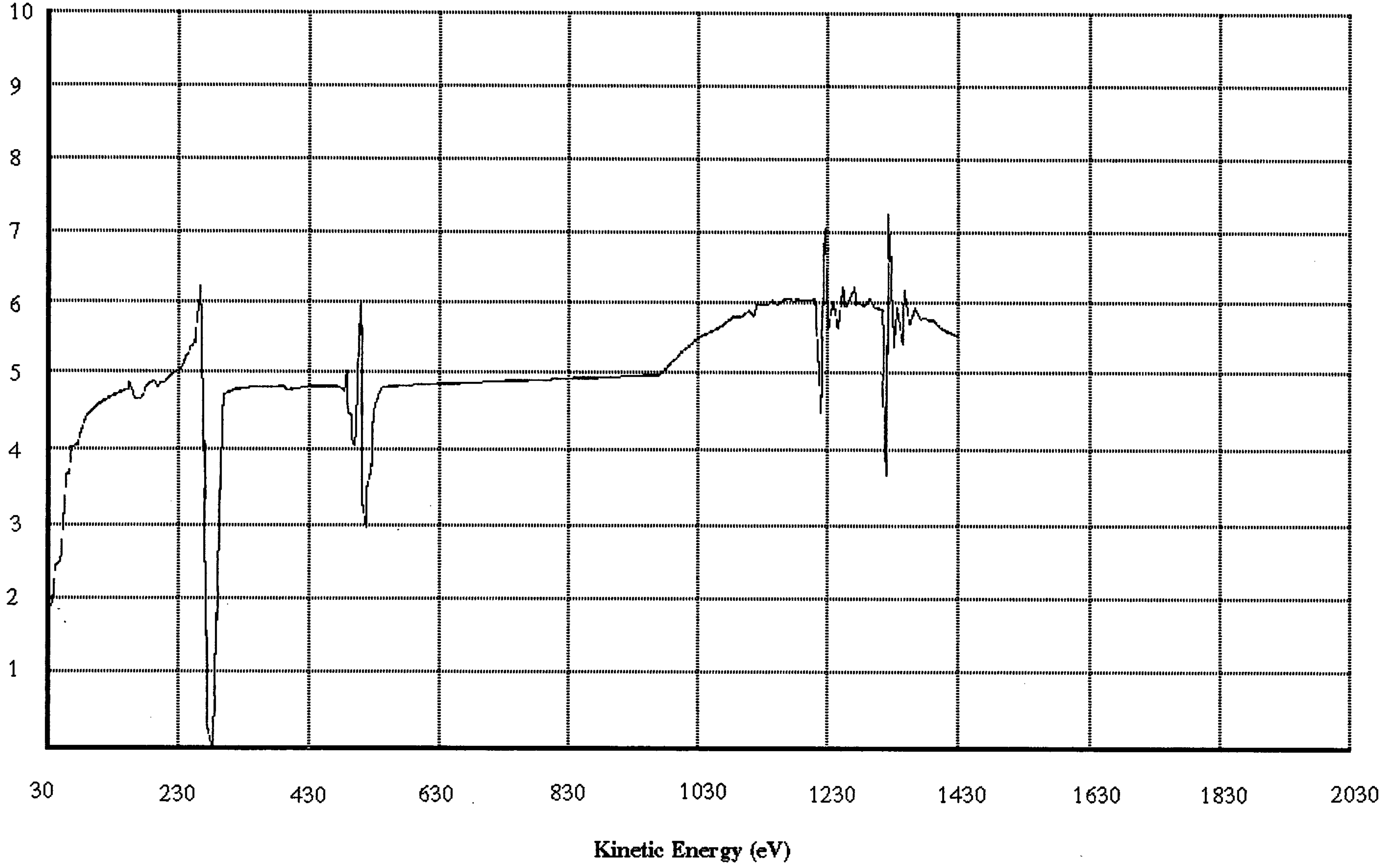
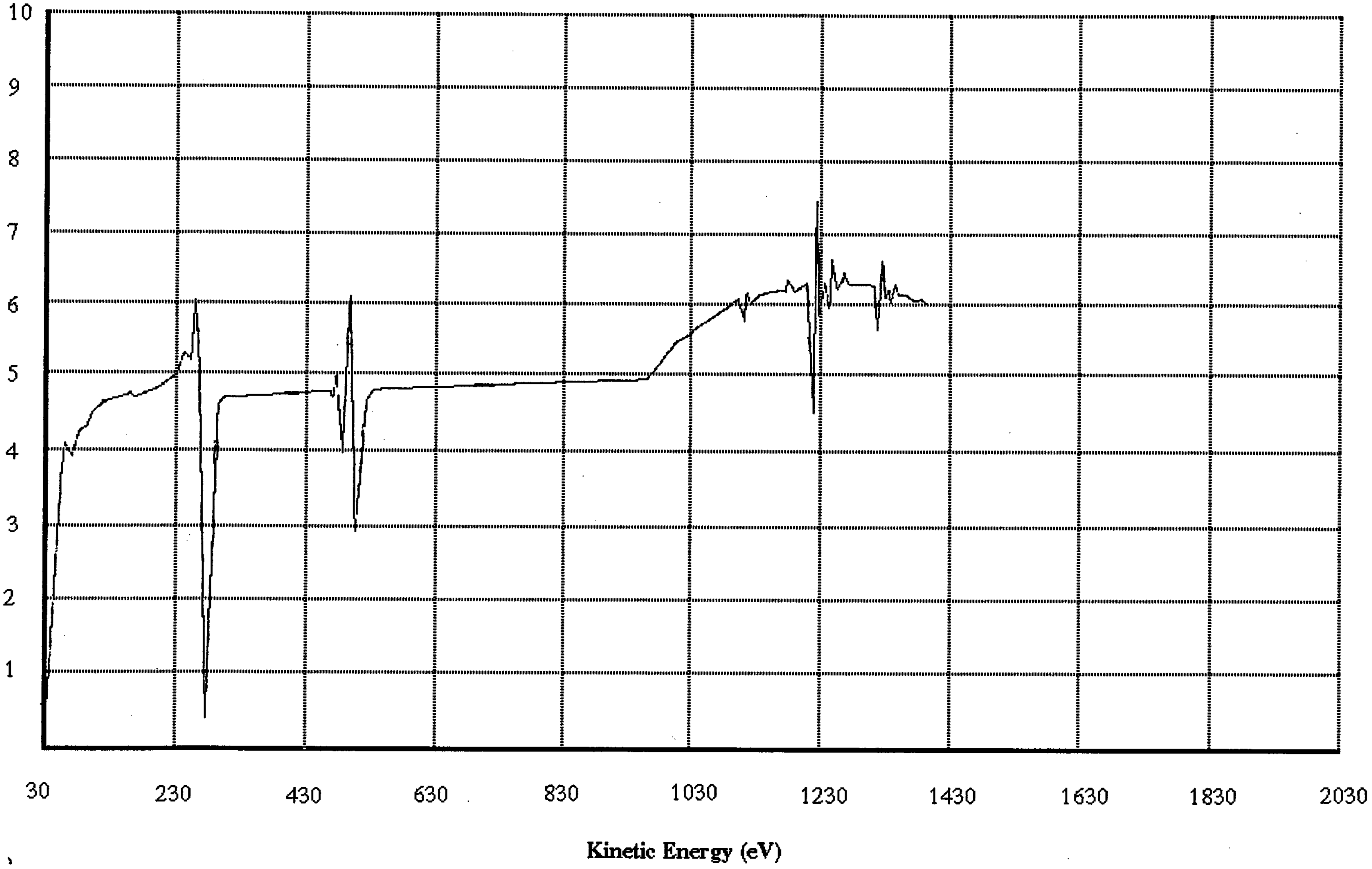


Power Cleaner 310L



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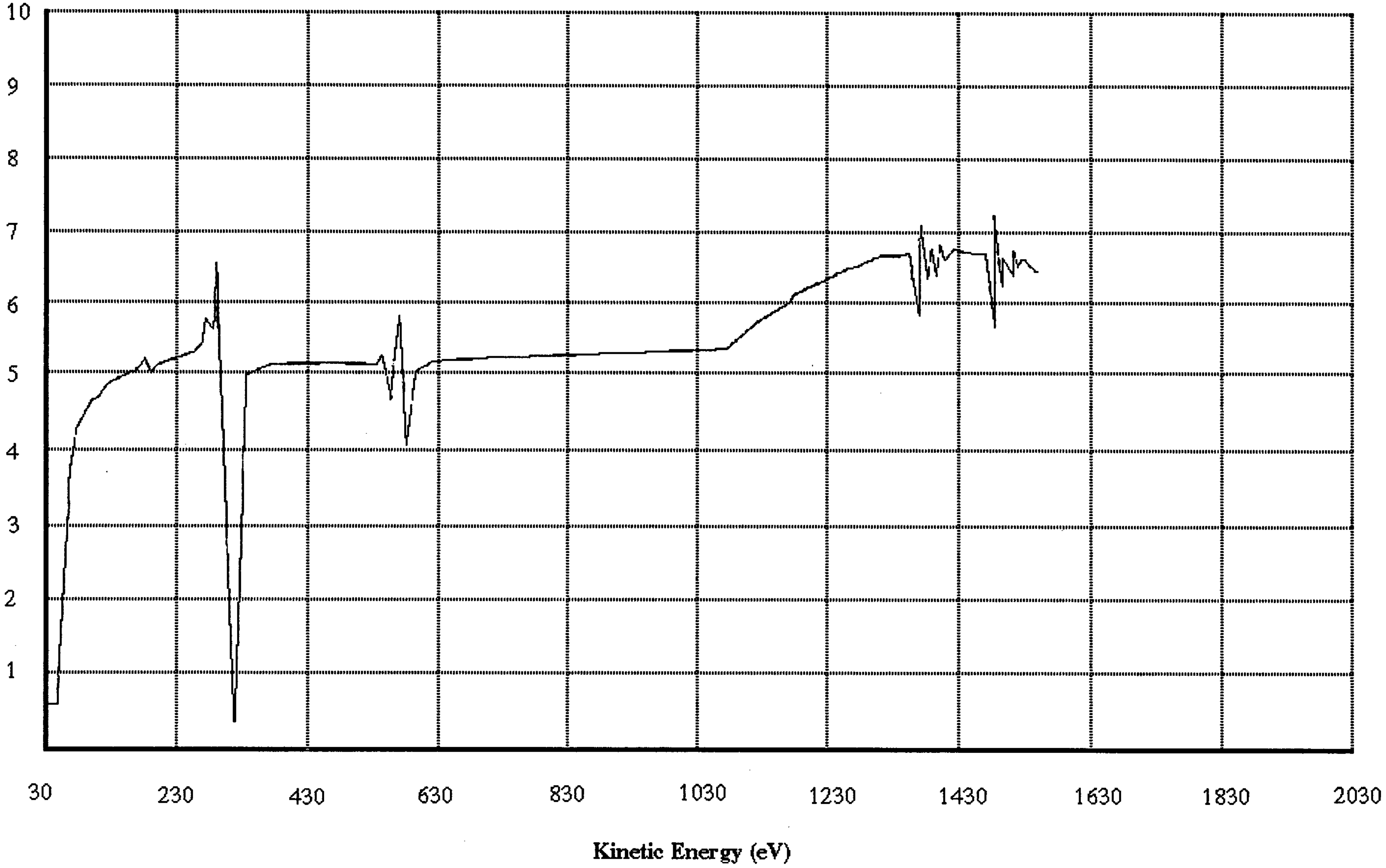
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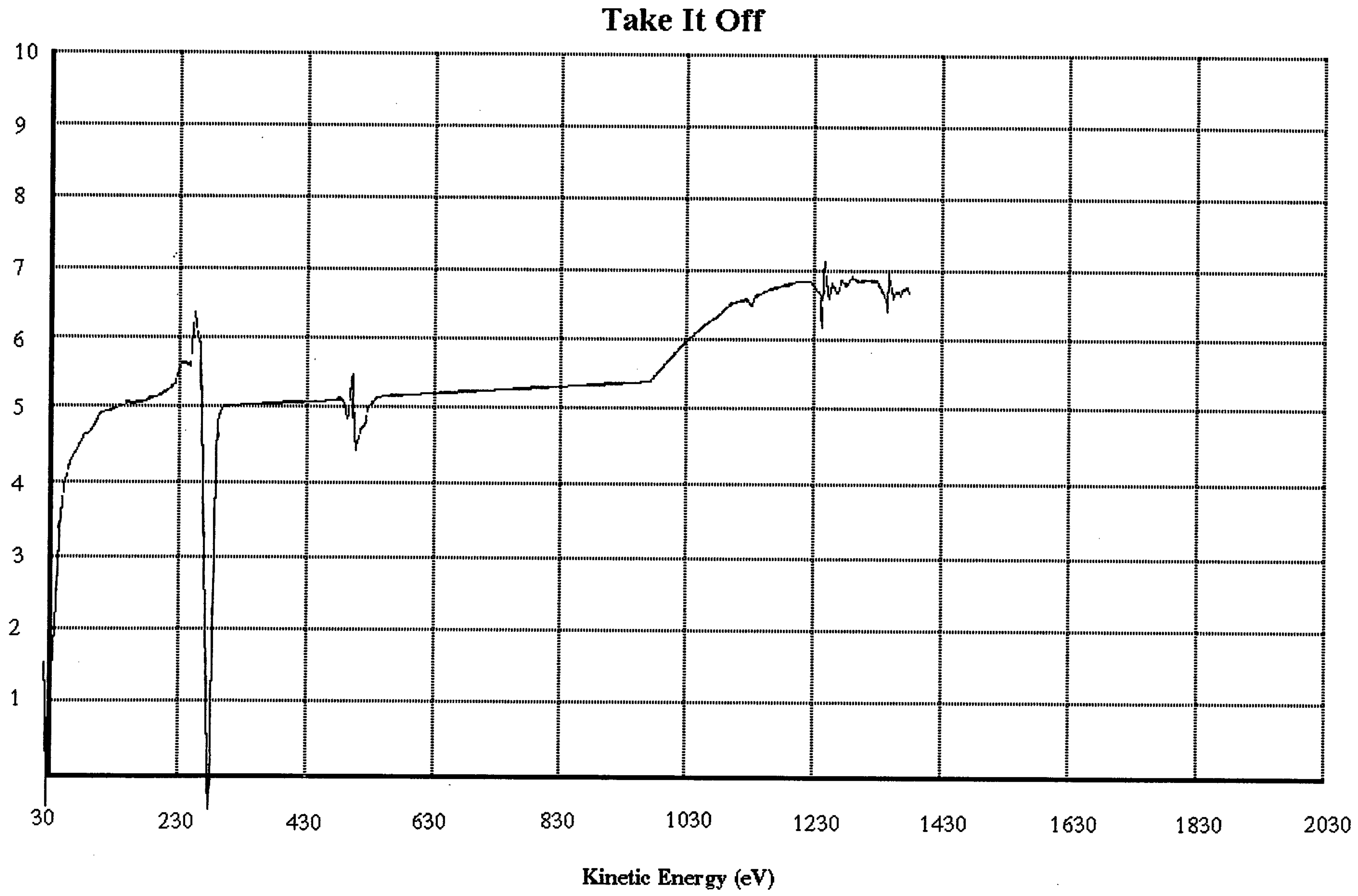
Kinetic Energy (eV)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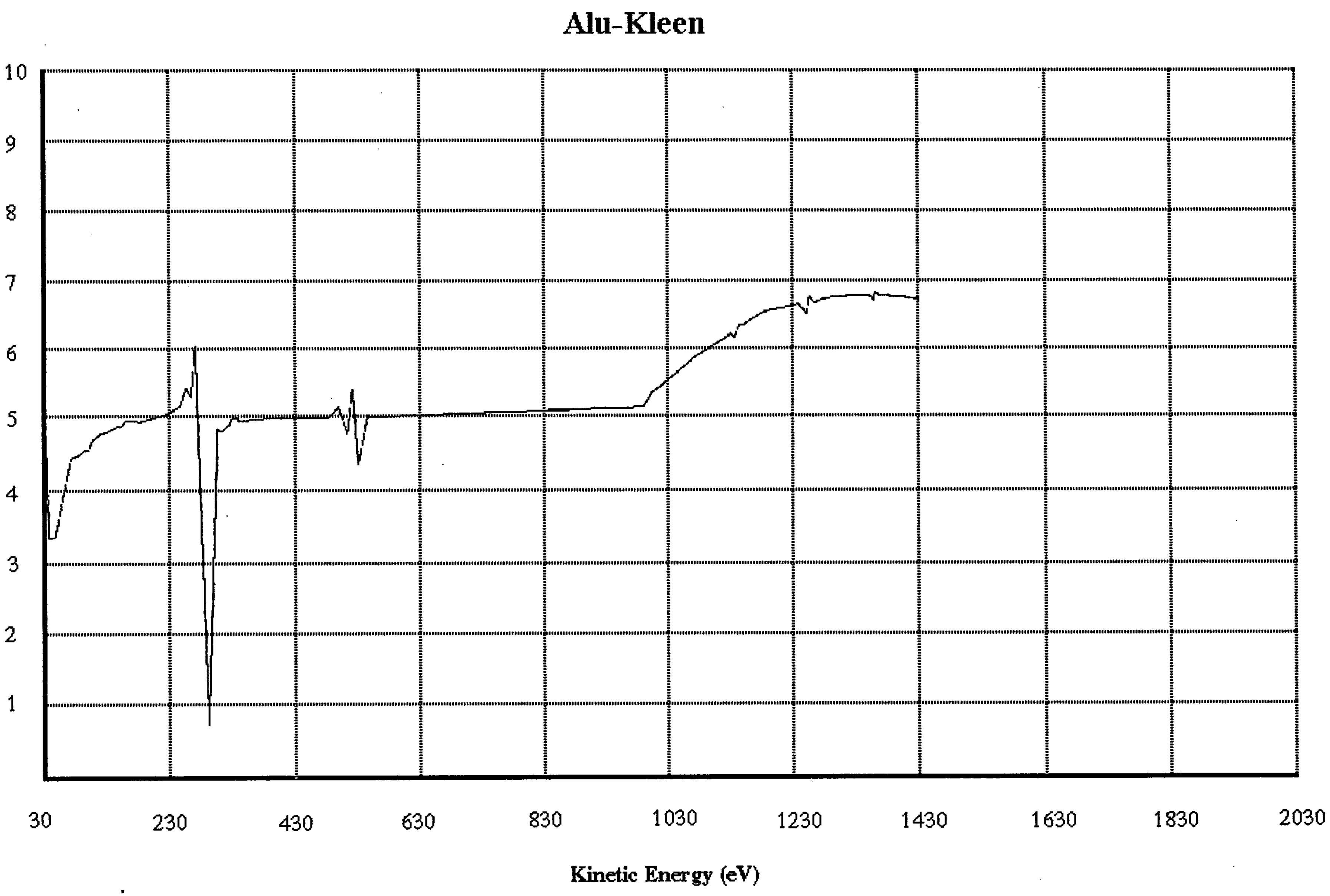
Kinetic Energy (eV)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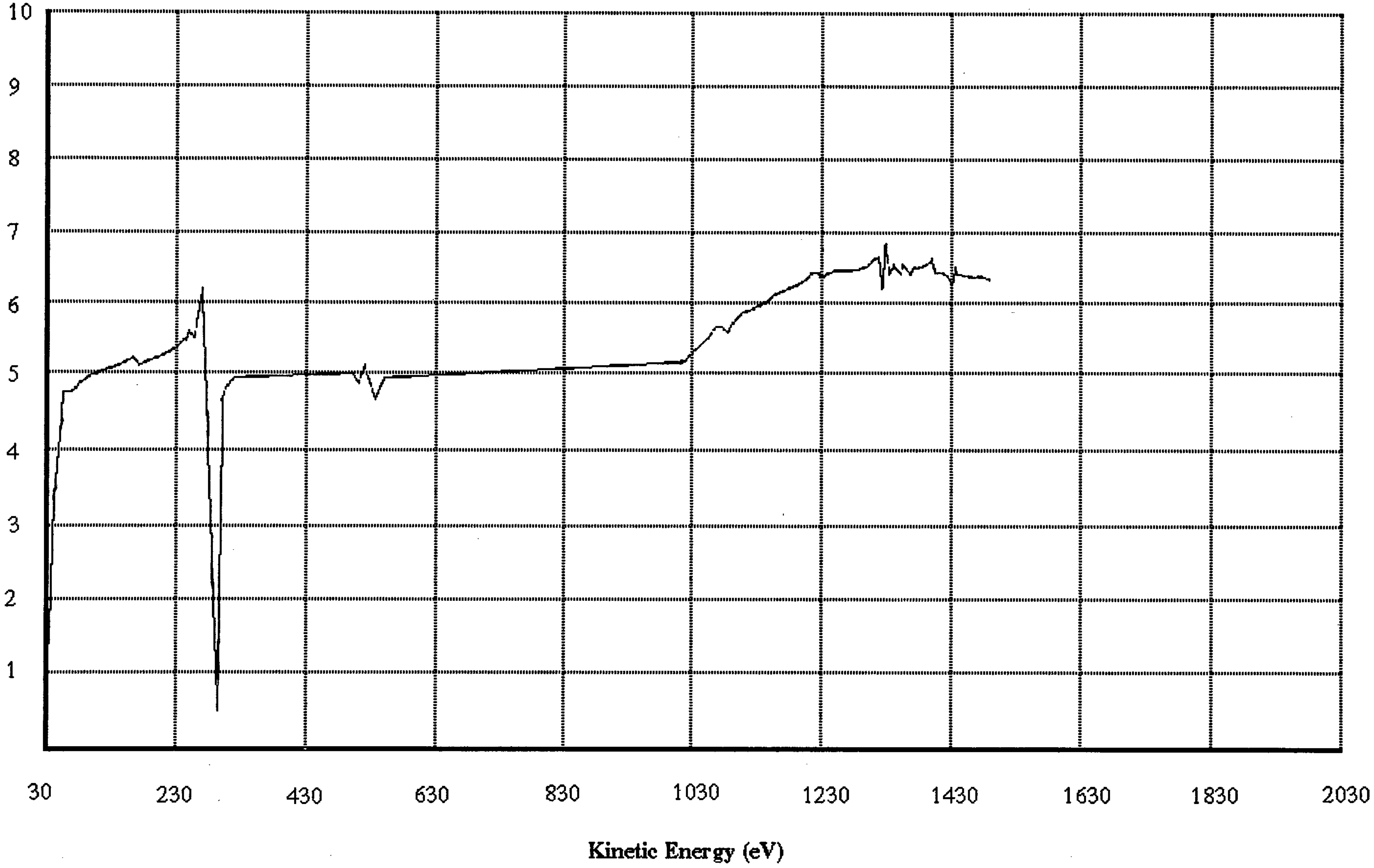
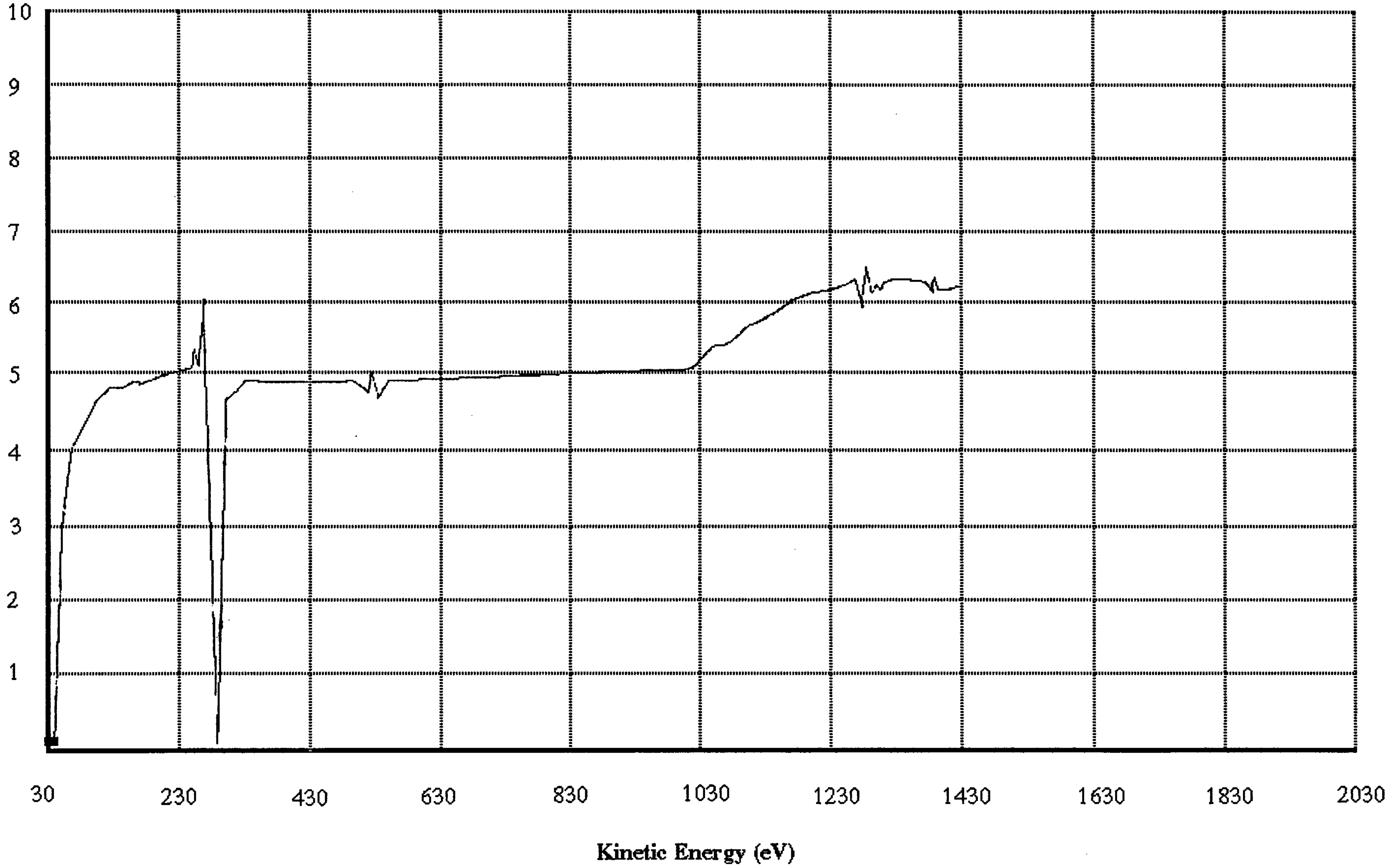
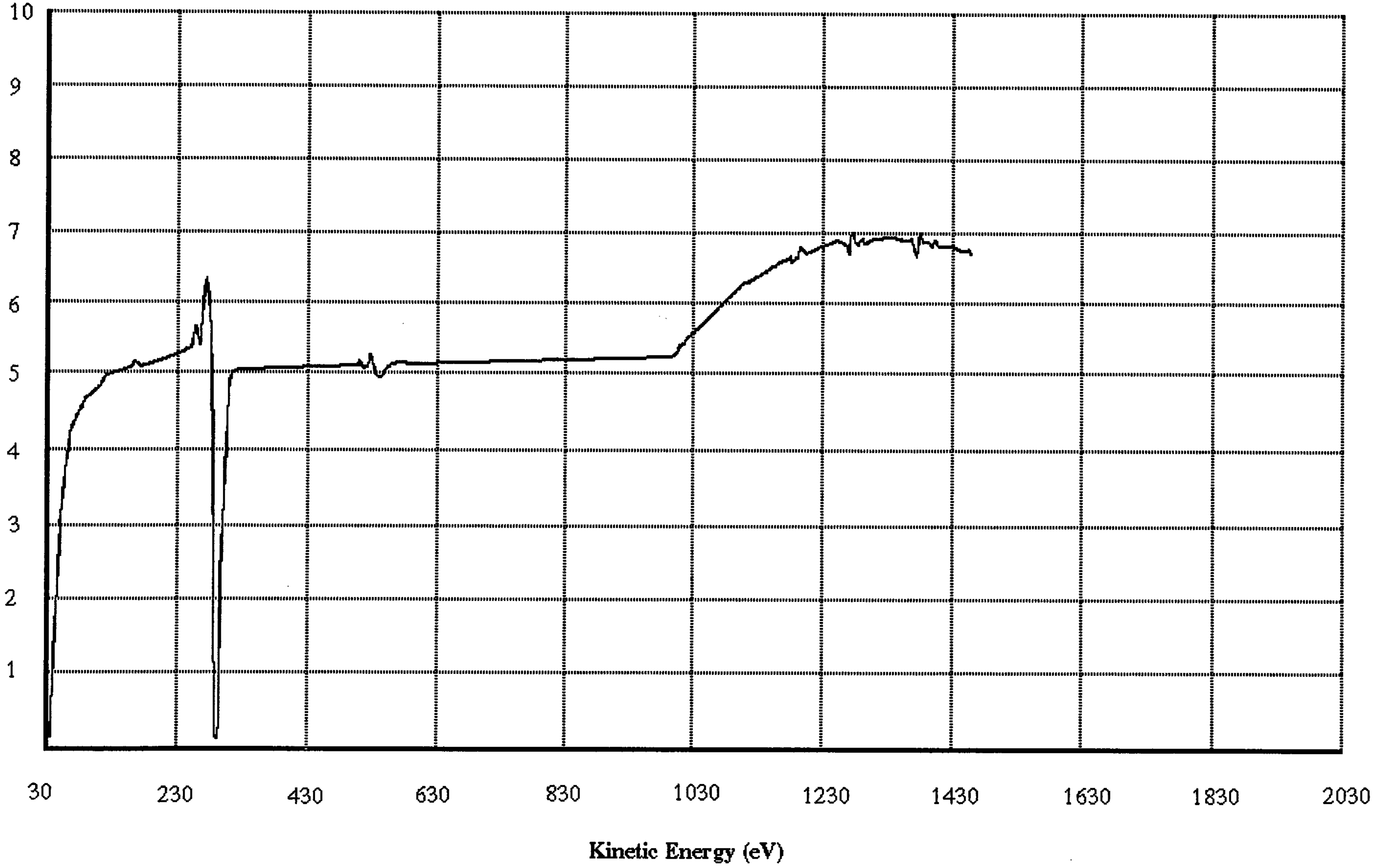
Kinetic Energy (eV)

Daraclean 282



Turco 4215 NCLT





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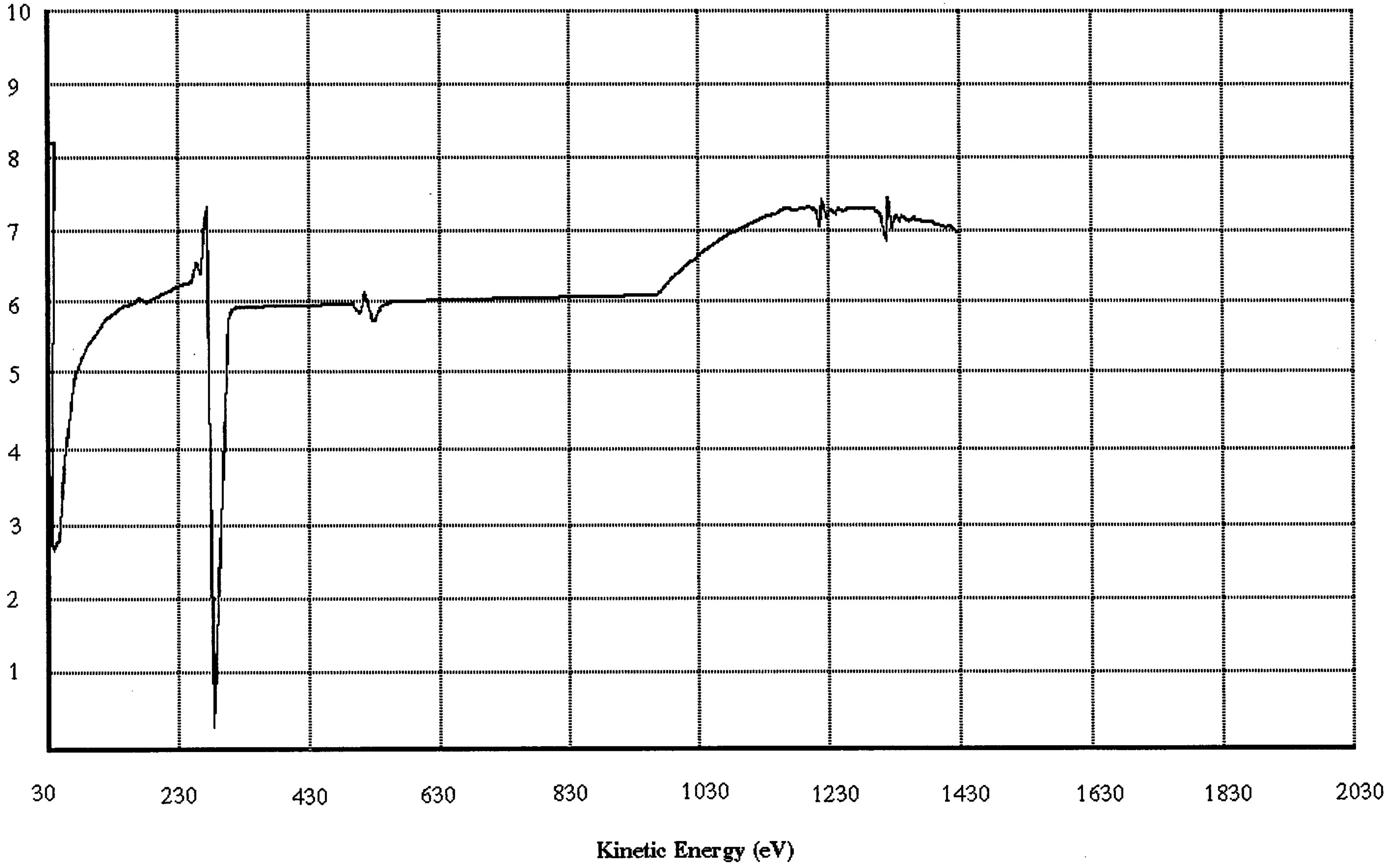
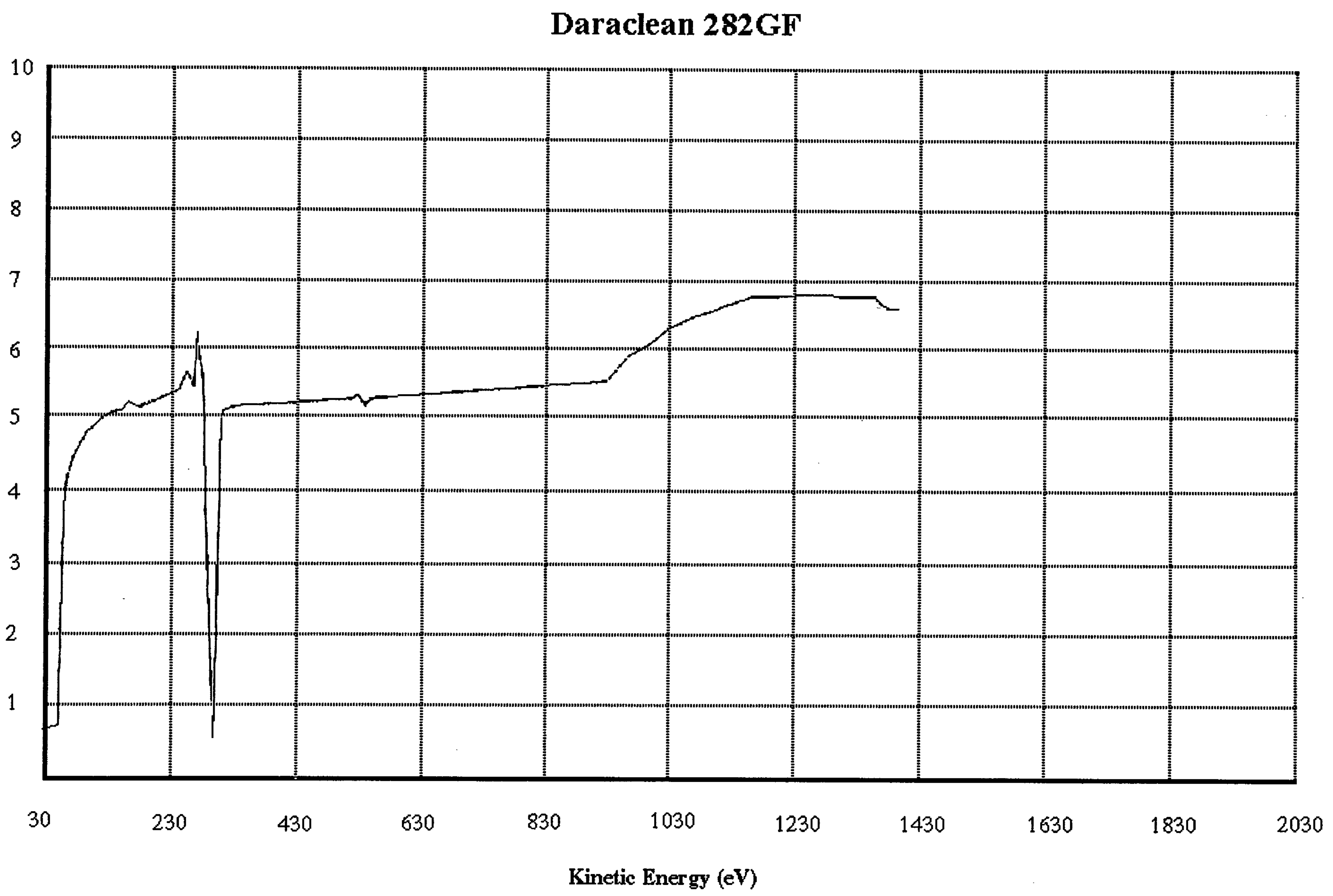
Kinetic Energy (eV)

Brulin 815 GD

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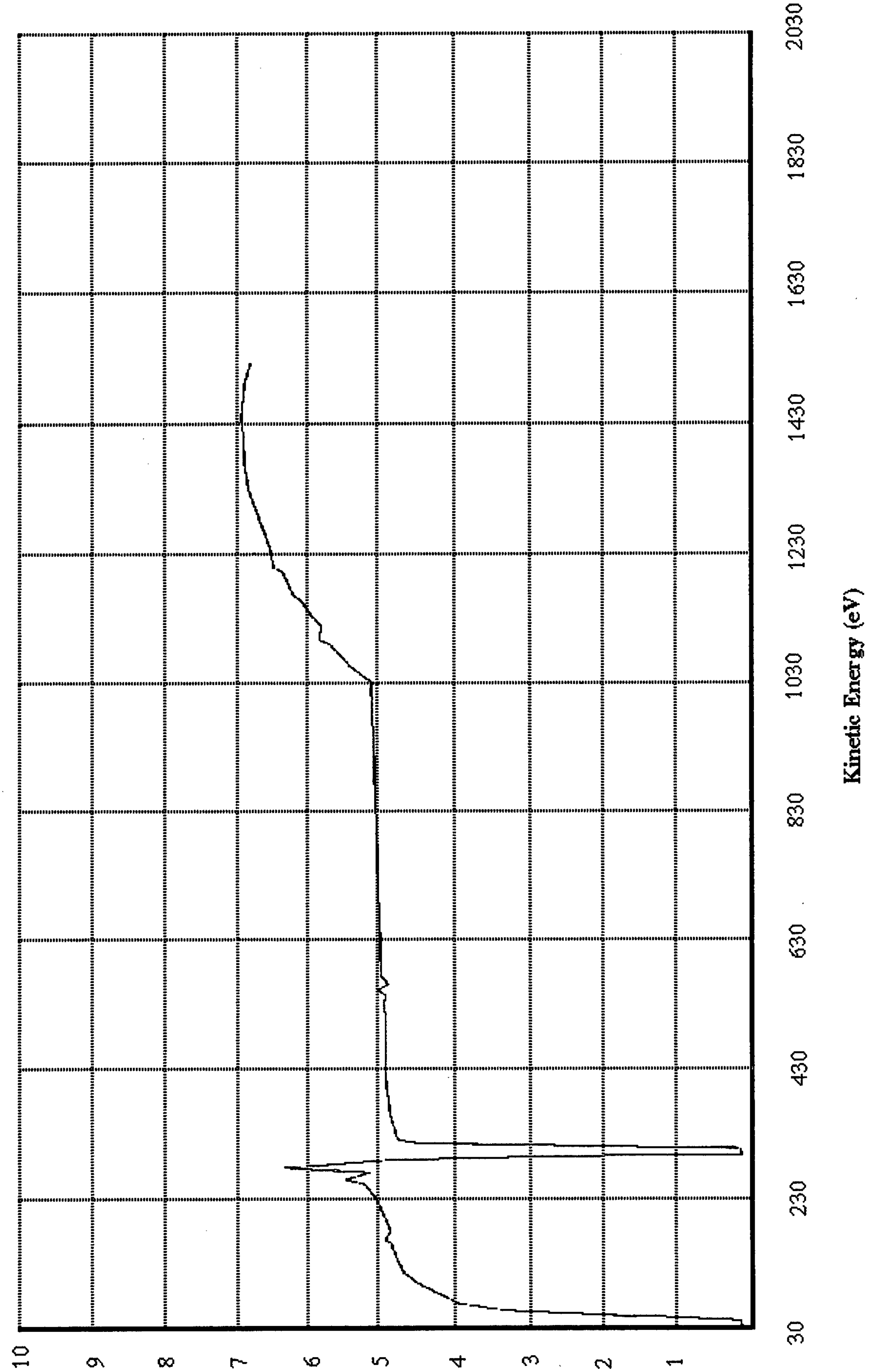
Kinetic Energy (eV)

Metal Aid - DR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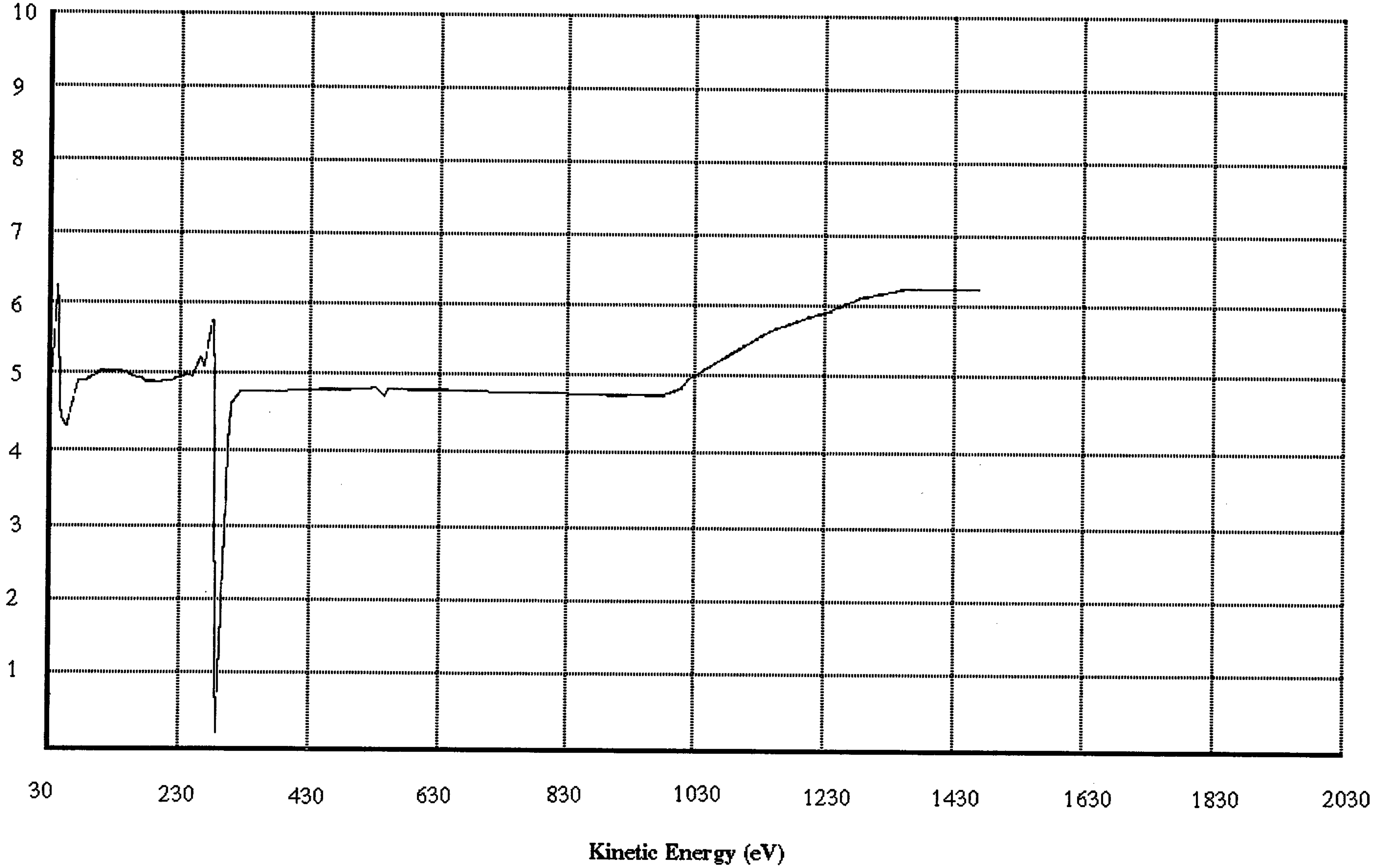
Kinetic Energy (eV)

BioAct 40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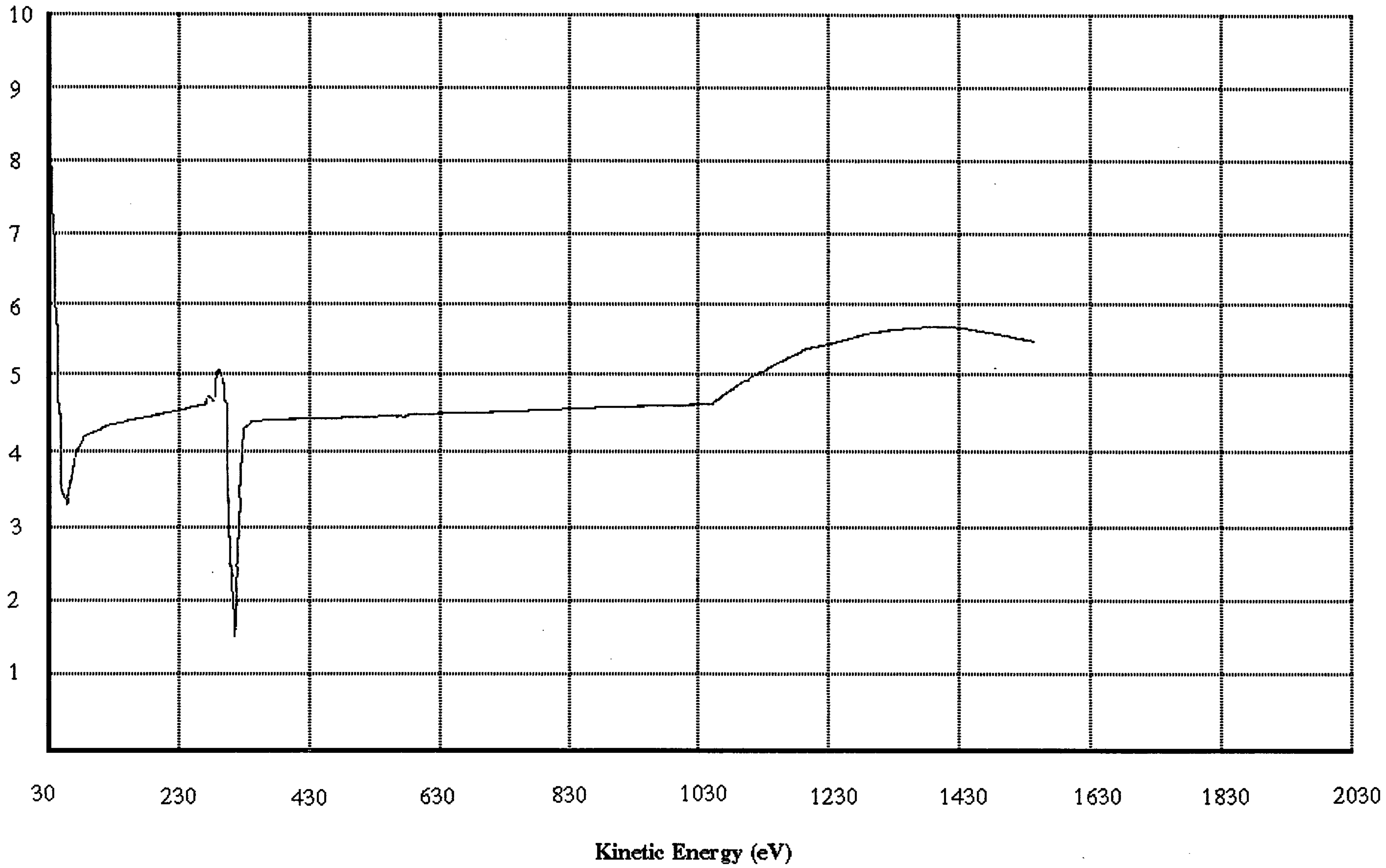
Kinetic Energy (eV)

DOT 111-113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Kinetic Energy (eV)

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FINAL REPORT TO:

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General Research Corporation
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Dr. Scott Grendahl
CDR USA ATC
Attn: Steac ts pm
Building 400
Scott Grendahl
Aberdeen Proving Ground, MD 21005-5059

Steven L. Suib, University of Connecticut
Storrs, CT 06269-3060

August 7, 1995

Table of Contents:

I. SUMMARY ON XPS.

X-ray photoelectron spectroscopy (XPS) is summarized on the next few pages. In addition, we have included general information about surface analysis and the details of our specific surface instrumentation. Finally, a summary of the conditions that were used for XPS analyses is given.

Any questions regarding this summary or any part of this report may be addressed by either Steven L. Suib, University of Connecticut, Storrs, CT, 06269-3060, (203) 486-2797 or 486-0502, (203) 486-2981 (FAX) or Dr. William S. Willis, University of Connecticut, Storrs, CT, 06269-3060, (203) 486-3223 or 486-0502, or 486-4719 or 3434, (203) 486-2981 (FAX).

This handout is to advise users and potential users of the Surface Science Facility what the capabilites are of various surface science spectrometers at the University of Connecticut. The basic principles of each spectroscopic method will be discussed. This handout is not meant as a substitute for training to learn to use the spectrometers or for data interpretation but as a starting point.

Specific details concerning the policies, operator training, user fees, and data manipulation can be obtained from the Technical Director at (203) 486-3434.

Areas of Application:

Biology	- Toxicity, Artificial Life Sustaining Devices
Chemical Engineering	- Catalysis
Chemistry	- Chemical Bonding, Semiconductors
Industrial	- Microelectronics, Polymers
Materials Science	- Polymers, Interfaces
Metallurgy	- Corrosion, Adsorption
Physics	- Denisty of States, Alloys

I. Available Equipment

1. One combined Auger, X-ray photoelectron, secondary ion mass spectrometer, ion scattering spectroscopy system with a preparatory chamber and a catalysis chamber.

   Catalysis chamber → T → Room T to 650°C

   P → Atmospheric to 10 atm.

   Analysis Chamber

   Mg/Al Kα X-ray Anode
   Static Auger
   Differentially Pumped Ion Gun
   Electron Flood Gun
   Quadrupole Mass Spectrometer
   Hemispherical Analyzer
   Base Pressure ≈ 1×10^{-10} mbar

2. One combined X-ray photoelectron, ion scattering spectroscopy system.

   Preparatory Chamber, Atmospheric → UHV
   Mg Kα X-ray anode
   Hemispherical Analyzer
   Penning Ion Gun for Etching
   Residual Gas Analysis
   Heatable-Coolable Rod -190°C → 450°C
   Angular Resolved XPS Capability
   Temperature Programmed Desorption

3. Instrumental Parameters, for UCONN Surface Science Facility

	XPS	AES	ISS	SIMS
Spot sizes	1.5 cm diameter circle	0.5 mm diameter circle	0.5 mm diameter circle	0.5 mm diameter circle
Area Analyzed	1 cm x 1mm	1 cm x 1mm	1 cm x 1mm	variable
Resolution	FWHM=0.7eV MgKα Au	0.4eV 3 Kv e^-beam Au	FWHM=14eV using Ne^{20} Cs	1 2-500 m/e range
Operating Pressure	$5x10^{-9}$ mbar	$5x10^{-9}$mbar	$1x10^{-7}$mbar	$1x10^{-7}$mbar

Sample Rods

1. 4 sided, nonheatable
2. 2 sided, oil cooled, resistively heated
3. Coolable, to liquid nitrogen temperature

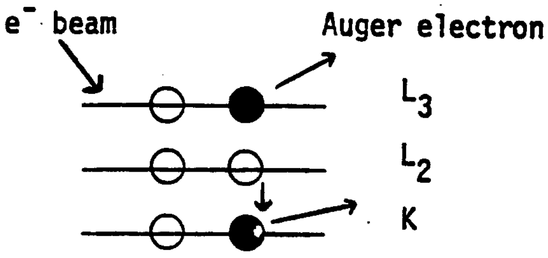
II. Experimental Techniques

AES

AUGER ELECTRON SPECTROSCOPY

Incoming Particle - electron beam

Detected Particle - secondary electrons



Auger KLL transition

In the Auger process an e⁻ beam is used to eject core level (K) electrons from a solid sample. A vacancy is left in this level and is filled by an e⁻ in an upper level (L_2). There is excess energy associated with this deexcitation and this can be given to an e⁻ in an upper level L_3. If the e⁻ is close enough to the surface of the solid it can escape the material as a secondary electron (an Auger electron). The Auger electron has an energy related to the atom it came from. The signal is derivatized to accentuate the transition. A good reference book for identifying Auger transitions is the Phi Manual of Auger Electron Spectroscopy[1]. Other references concerning AES are available.[2-4]

A depth profile of a NiAl alloy was determined by ion etching and collecting Auger spectra. An Auger spectrum in the nickel region is shown below in Figure (a). The depth profile is given in Figure (b) and shows that the surface of the alloy is oxygen rich. Such information is useful for adsorption and corrosion.

AES

Sample Considerations

Insulators - charging problems

Thin films, powders, crystals, interfaces

Should be thermally stable, UHV stable.

Detection Limits

1 atomic % sensitivity (.01% monolayer)

$Z \geq 3$

Volume of Analysis

Static - ∿10 atomic layers, 10-40 Å deep

1mm lateral resolution

Data Collection Time

10-20 minutes for survey

30 minutes to several hours for depth profiles

Areas of Application

Lateral analysis

Semiconductors, metals, alloys, corrosion, catalysis

Information Obtained

Semiquantitative analysis

Impurity detection

Interfaces, depth profiles

Interferences

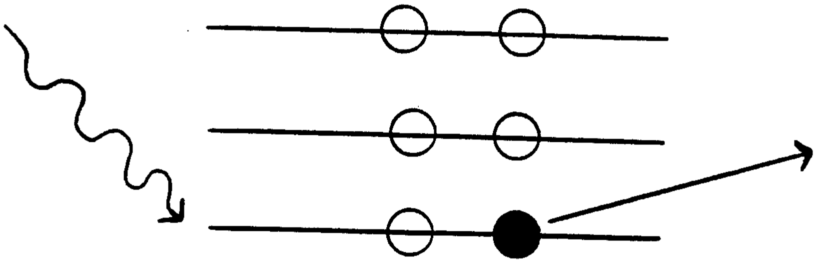
Few

XPS

X-RAY PHOTOELECTRON SPECTROSCOPY

Incoming Particle - X-ray

Detected Particle - photoelectrons



XPS is also known as ESCA, electron spectroscopy for chemical analysis. In XPS, X-rays are used to eject photoelectrons. The energy of the ejected photoelectron is related to the incident energy ($h\nu$) minus the binding energy of the electron (B.E.) minus the work function (ϕ) of the sample. The binding energy depends on the nature of the bonding of the atomic species. The work function of the spectrometer is calibrated by setting the Au $4f_{7/2}$ transition at 83.8 eV and the Cu $2p_{3/2}$ at 932.4 eV. Energy resolution is obtained by the widths of the entrance and exit slits. References for binding energies can be obtained from the Phi Manual[11]. Articles on XPS are given in the reference section.[12-14]

Polymers like Kapton can be analyzed by XPS methods. A wide scan, as shown below, is used to determine what elements are present in a sample. Note that the elements C, N, O, Cu and Al are detected in the wide scan. For semiquantitative information and binding energy information a narrow scan is done over a smaller energy window. The narrow scan given in figure (b) shows that in the C 1s region there are three types of carbon. These 3 types of carbon can be assigned to 3 chemically different types of carbon in Kapton.

XPS

Sample Considerations

Almost any solid

Grease free

Detection Limits

$Z \geq 3$

0.1 atomic % (dependent on photoionization cross section)

Volume of Analysis

10 layers deep

10-40 Å depth resolution

Data Collection Time

10-20 minutes survey

Areas of Application

Semiquantitative analysis

Depth profiles

Contaminants, thin films, interfaces, polymers, corrosion

Information Obtained

Oxidation states of elements, bonding information

Interferences

For trace work

Overview of Surface Spectroscopies

Method	Purpose of Experiment
AES*	Microanalysis
ISS**	General Information Depth Profile Information
SIMS**	Structural Information
XPS	Microanalysis General Information Chemical Bonding

* Electron beams can reduce the sample.

** Ion beam techniques are destructive to sample.

III. REFERENCES

AES

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12. T. L. Barr, Appl. Surf. Sci., 15, 1-35 (1983).

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XPS Conditions

Samples were secured by pairs to opposite sides of a two-sided sample rod, then introduced into the photoemission spectrometer. An Al anode was used as the X-ray source. Survey data for all samples were collected using a fixed retarding ratio of 3. Detail data were collected using a fixed analyser transmission energy of 200 eV.

II. CLEANING PROCEDURES.

The following pages concern the cleaning procedures that were used for treating all samples. These procedures were discussed with Dr. Scott Grendahl prior to treatment of the samples.

ALTERNATIVE CLEANERS: EXPERIMENTAL SUMMARY

Preparation and Use of the Standard Contamination Mixture

Aeroshell Grease 17 (MIL- G- 211 64D, Code 70017, Shell Oil Company, mass used = 25.57 g) was stirred with Royco 782 (H- 537 hydraulic fluid, MIL- H- 83282, mass used = 51.14 g). Whenever a cleaner was to be tested, this contamination test mixture was freshly stirred with a glass rod, and a test panel cleaned in Trichlor (see below) was held with forceps and immersed in the contamination test mixture for approximately 1 second. After the immersion step, the test panel was withdrawn vertically to allow the excess test mixture to drain off. The test panel was placed in and Al foil- covered 16 X 150 mm test tube for subsequent baking at 130F.

Baking of Contaminated Test Panels

Test panels were contaminated by pairs, then stored according to the procedure given above. The test tubes containing the test panels were placed in a tube furnace heated at 54C (129F). After 2 hours, the test tubes were removed from the tube furnace and allowed to cool to room temperature. Except for the XPS analysis of 'Bare 7075 Al', all the test panels were contaminated and baked prior to cleaning and XPS analysis.

CLEANING PROCEDURES FOR 7075 Al SAMPLES

Initial 1,1,1- trichloroethane Cleaning (All Test Panels)

Trichlor (1,1,1-trichloroethane, Service Chemical Corporation) was added to fill an utrasonic cleaning bath (volume = 2.0- 2.5 L). Ultrasonic cleaning followed for 15 minutes, during which time the test panels were moved at intervals of 2- 3 minutes. The test panels were individually removed from the bath and blow- dried with air at room temperature using clean forceps. The test panels were stored by pairs in 2 dram sample vials for later use. One pair was selected to represent the 'Bare 7075 Al Test Panels' in the XPS analysis.

Preparation and Use of Alternative Cleaners: Common Steps

In most cases, the following three steps were taken when testing cleaners, and are mentioned here to avoid redundance: (1) Two test panels contaminated accoriding to the procedure outlined above were ultrsonically cleaned for 15 minutes in the cleaner to be evaluated. During the cleaning step, the test panels were moved with a glass rod at intervals of approximately 2 minutes. (2) The test panels were removed from the cleaning bath, then were ultrasonically rinsed in deionized water for 5 minutes. During the rinse step, the test panels were moved with a glass rod at intervals of approximately 1 minute. (3) The test panels were sequentially blow- dried in air at room temperature, and stored in clean Al foil- covered test tubes for transfer to the XPS instrument. Since the above three steps are to be generally assumed, the description of the procedures used for individual cleaners appearing below will be confined to cleaner dilution procedures, cleaning temperatures and deviations from the three steps as needed.

Solvall 5234

Solvall 5234 was used neat at room temperature.

Trichlor

Trichlor (1,1,1-trichloroethane) was used omitting step 2 (i.e., the deionized water rinse) of the three common steps (above). It was used neat at room temperature.

PARTSPREP

PARTSPREP was used neat at room temperature. This cleaning was repeated for a second set of test panels with particular attention paid to maintaining a 'face up' orientation for both test panels during the ultrasonic rinse step (number 3 of common steps). Also, the test panels were kept separated during both the cleaning and rinsing so that they did not make face-to-face contact.

ALK 660

ALK 660 (200 mL) was thoroughly mixed with deionized water (200 mL). The resulting mixture was used at room temperature.

Penair HD-1

Penair HD-1 (800 mL) was thoroughly mixed with deionized water (1600 mL). The resulting mixture was used at room temperature.

Rebound 7

Rebound 7 (1300 mL) was thoroughly mixed with deionized water (1300 mL). The resulting mixture was used at a temperature of 78- 82C.

DOT-111/ 113

DOT-111/ 113 was used neat at room temperature.

Metal Aid Dr

Metal Aid Dr concentrate (104 mL) was mixed with deionized water (2496 +/- 10 mL) and 74.41 g NaOH. The resulting mixture was thoroughly stirred. The mixture was then used at 40- 42C. Since one of the test panels was contaminated by dropping, both faces of the uncontaminated test panel were analysed by XPS.

Shopmaster

Shopmaster (1400 mL) was mixed with deionized water (1400 mL). The resulting mixture was used at room temperature.

Aerosolv 2000

Aerosolv 2000 was used neat at room temperature.

Brulin 815 GD

Brulin 815 GD (250 mL) was thoroughly mixed with deionized water (2500 mL). The resulting mixture was used at a temperature of 78- 82C. This cleaning was repeated for a second set of test panels with particular attention paid to maintaining a 'face up' orientation for both test panels during the ultrasonic rinse step (number 3 of common steps). Also, the test panels were kept separated during both the cleaning and rinsing so that they did not make face-to-face contact.

Power Cleaner 310L

Power Cleaner 310L (260 mL) was thororoughly mixed with deionized water (2340 +/- 10 mL). The resulting mixture was used at a temperature of 77- 82C.

Jettacin

Jettacin (180 mL) was thororoughly mixed with deionized water (2520 +/- 10 mL). The resulting mixture was used at room temperature.

Cee Bee A 7 X 7

Cee Bee A 7 X 7 was used neat at room temperature.

Turco 4215- NC- LT

Turco 4215- NC- LT (19.7001 g) was thororoughly mixed with deionized water (2630 +/- 10 mL). The resulting mixture was used at room temperature.

Callasolv 120

Callasolv 120 was used neat at room temperature.

Dilution and Temperature of Use of Cleaners

Cleaner	Dilution	Temperature
Trichlor	Neat	Room T.
Solvall 5234	Neat	Room T.
PARTSPREP	Neat	Room T.
ALK 660	1 part cleaner (volume) with 10 parts (volume) H_2O	Room T.
Penair HD-1	1 part cleaner (volume) with 2 parts (volume) H_2O	Room T.
Rebound 7	50% cleaner (by volume) in H_2O	180F
DOT-111/ 113	Neat	Room T.
Metal Aid-Dr	Follow manufacturer's formulation (Note below)	40C
Shopmaster	50% cleaner (by volume) in H_2O	Room T.
Aerosolv 2000	Neat	Room T.
Brulin 815 GD	1 part cleaner (volume) with 10 parts (volume) H_2O	180F
PowerCleaner 310L	10% cleaner (by volume) in H_2O	180F
Jettacin	1 part cleaner (volume) with 14 parts (volume) H_2O	Room T.
Cee Bee A 7 x 7	Neat	Room T.
Turco 4215-NC-LT	Mass of cleaner = 7.49 g in 1.00 liter H_2O	Room T.
Callasolv 120	Neat	Room T.

Note: Metal Aid-Dr: Cleaner (104 mL) + deionized water (2496 mL) + NaOH (74.41 g).

III. RAW DATA.

The following Data Sheeets contain all of the raw XPS data that were collected on this project. For each sample there is a survey spectrum. For each sample there is also a Table summarizing the atomic concentrations of all samples. In addition, conditions used during all experiments are given on these raw data sheets.

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Bare 7075 Al Test Panel 1

Method: XPS
Mounting: Secured with single gold- covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN001.R1	None	Survey	RF = 3
ALPAN002	1.9346	Detail	PE = 200
ALPAN005	1.9326	Detail	PE = 200

SUMMARY OF ANALYSIS

Run number: 1 Excitation: Al Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN002.R1	Mg 1s	1303.94	52043.0000	38.76
2	ALPAN002.R2	Zn $2p_{1/2}$	1045.03	3979.4860	2.04
3	ALPAN002.R2	Zn $2p_{3/2}$	1021.85		
4	ALPAN002.R2	See comments	1016.87		
5	ALPAN002.R3	O 1s	531.65	74985.0000	747.81
6	ALPAN002.R4	C 1s	284.80	27299.0000	1196.56
7	ALPAN002.R5	Mg 2s	88.65		
8	ALPAN002.R5	Al 2p	74.22	2381.1230	100.00

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

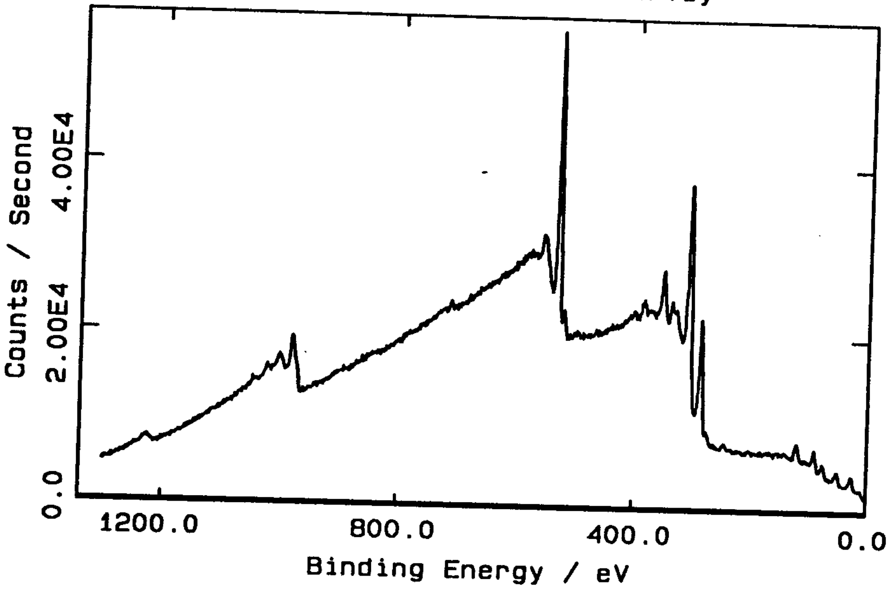
Sample: Bare 7075 Al Test Panel 1

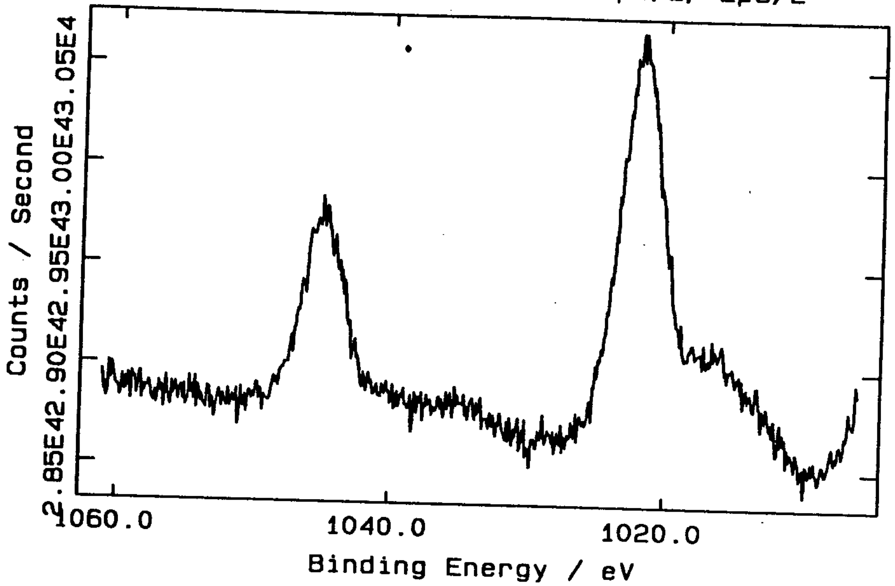
SUMMARY OF ANALYSIS (Continued): Run number: 2, Excitation: Al, Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN005.R1	Mg 1s	1303.94	53208.0000	38.76
2	ALPAN005.R2	Fe $2p_{1/2}$	723.68		
3	ALPAN005.R2	Fe $2p_{3/2}$	710.81		
4	ALPAN005.R2	Fe 2p		5576.7000	2.60

COMMENTS

Peak 4 of Run 1 assigned to satellite of O KL_1L_1 peak.


Bare 7075 Al. Panel 1 Survey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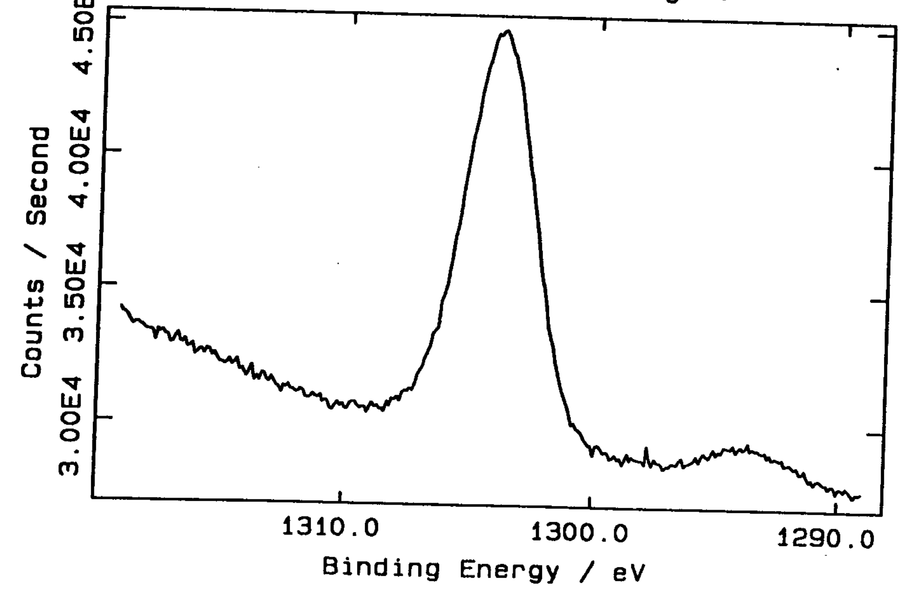
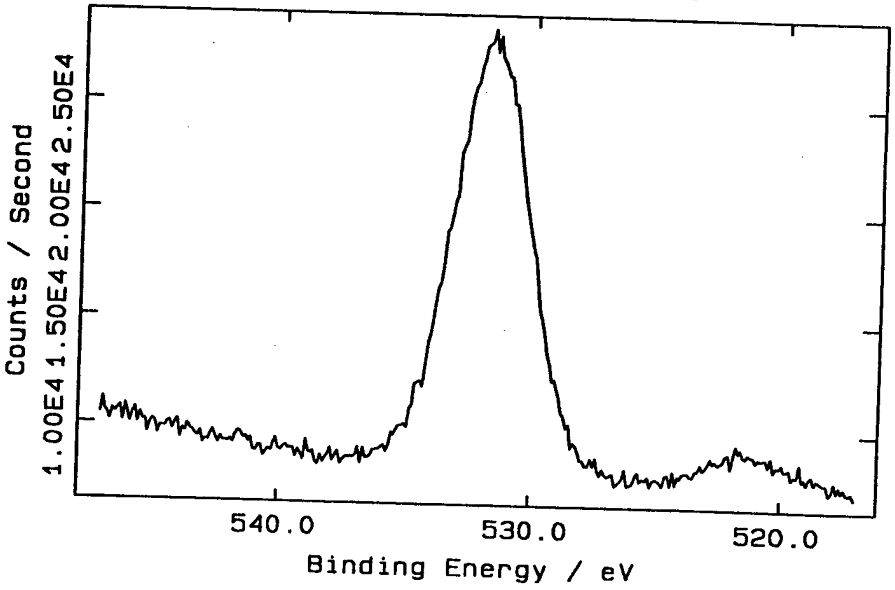
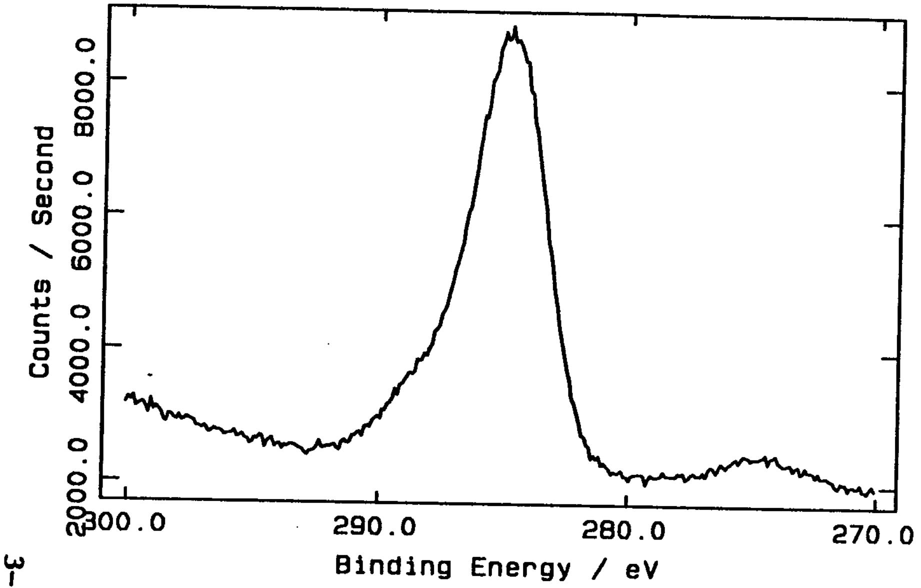
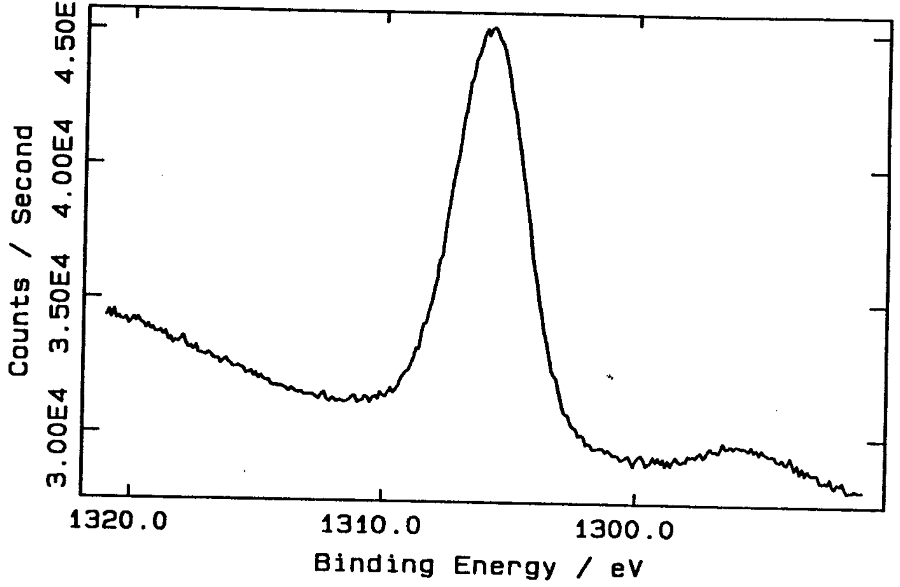

Bare 7075 Al. Panel 1 Mg 1s


Bare 7075 Al. Panel 1 O 1s


Bare 7075 Al, Panel 1 C 1s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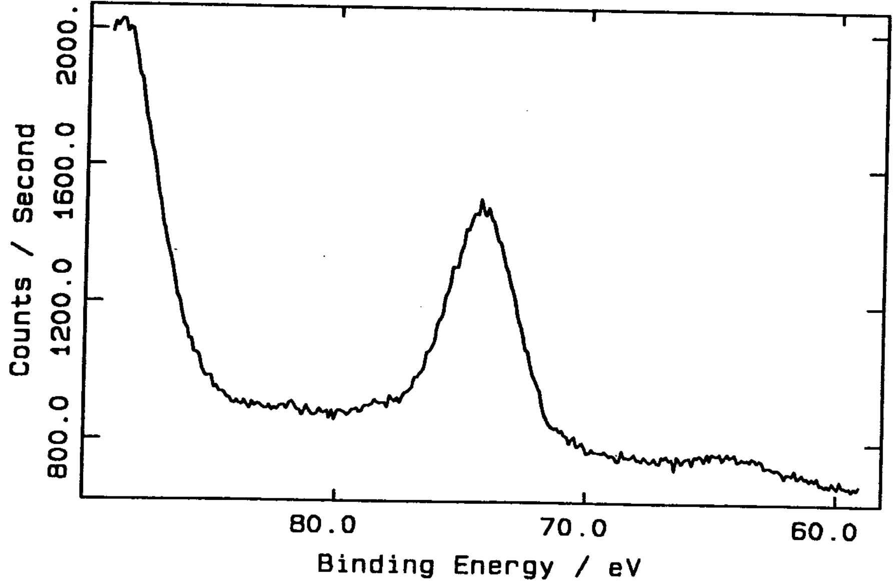
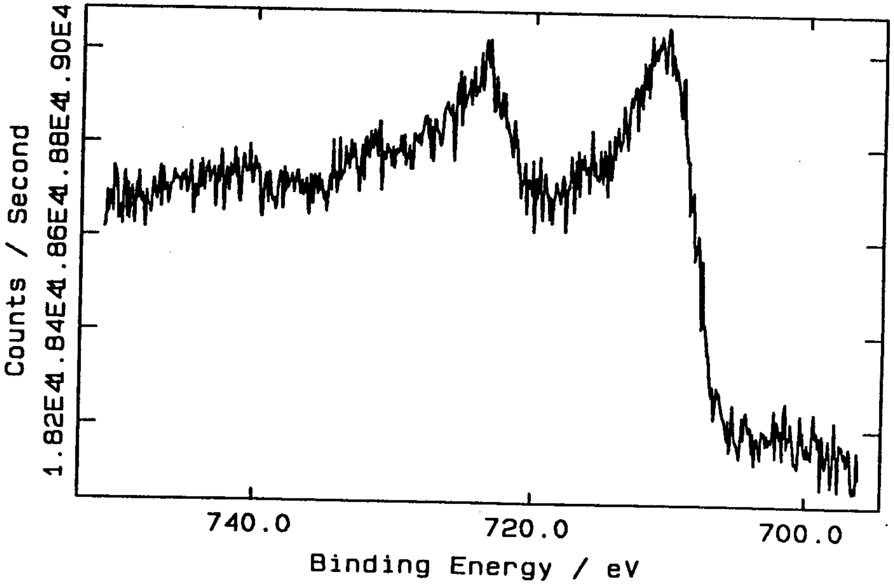
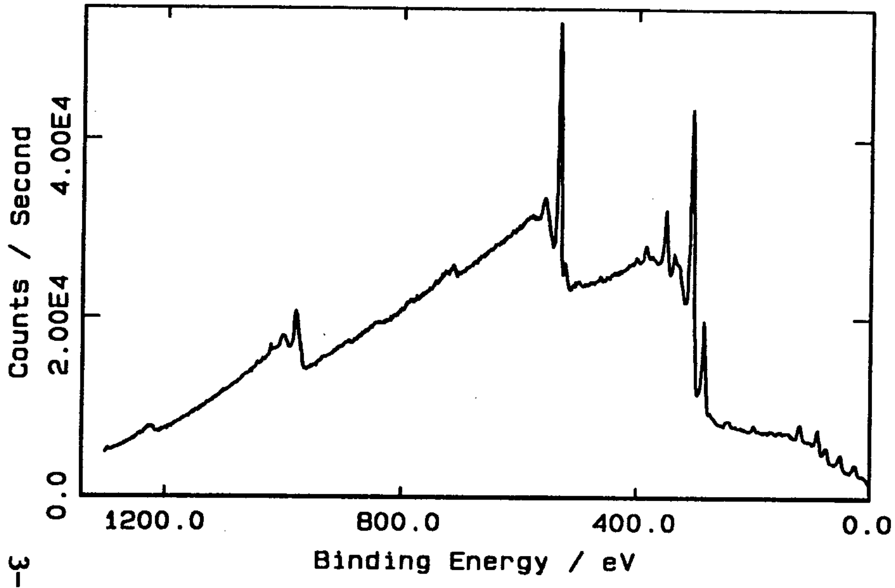
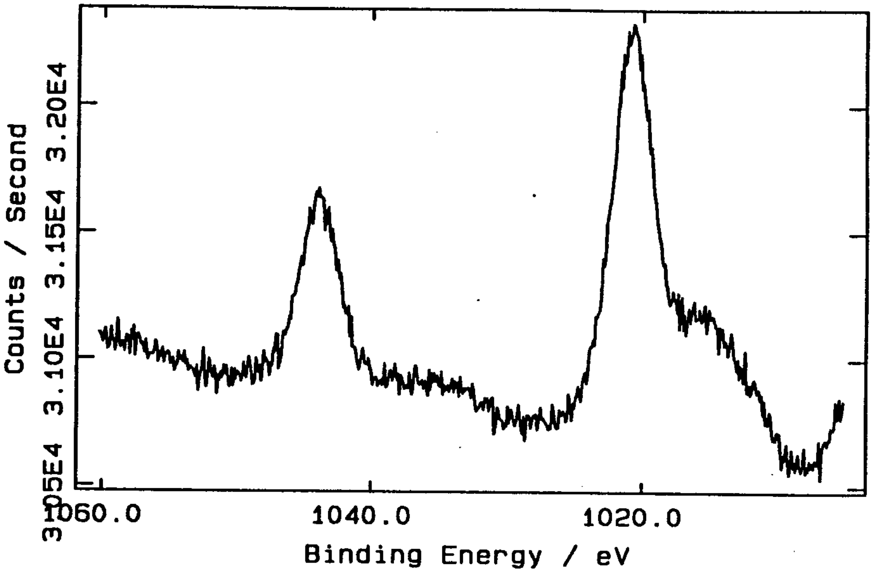

Bare 7075 Al, Panel 1 Al 2p

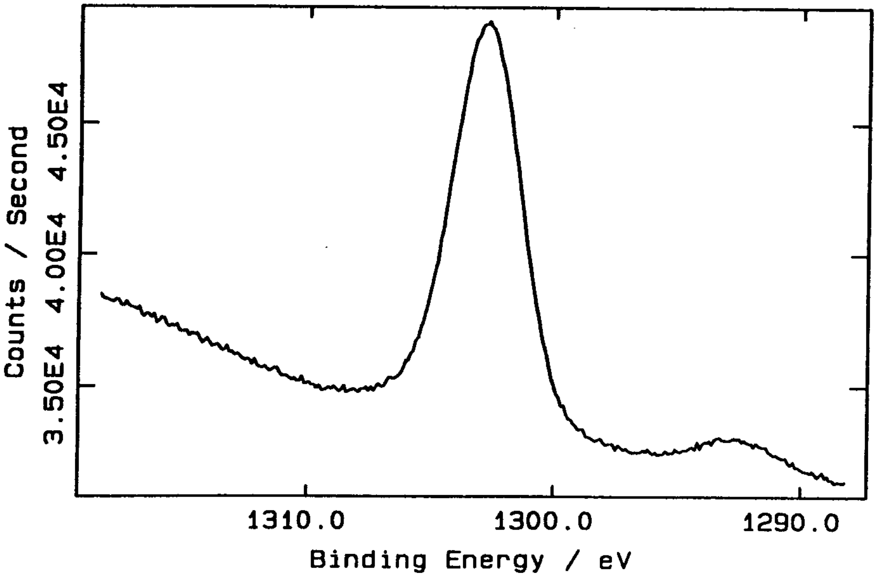

Bare 7075 Al, Panel 1 Fe 2p1/2, 2p3/2



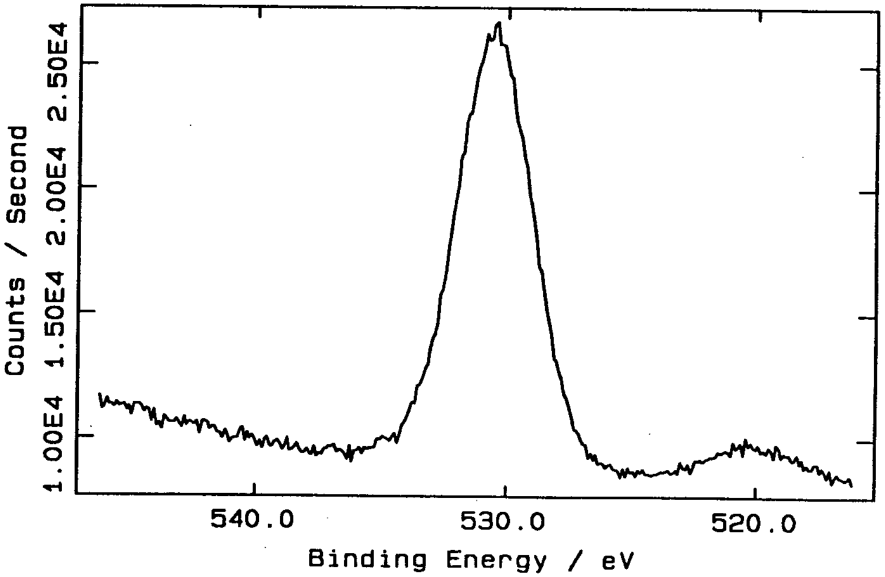
Bare 7075 Al, Panel 2 Survey



Bare 7075 Al, Panel 2 Zn 2p1/2, 2p3/2

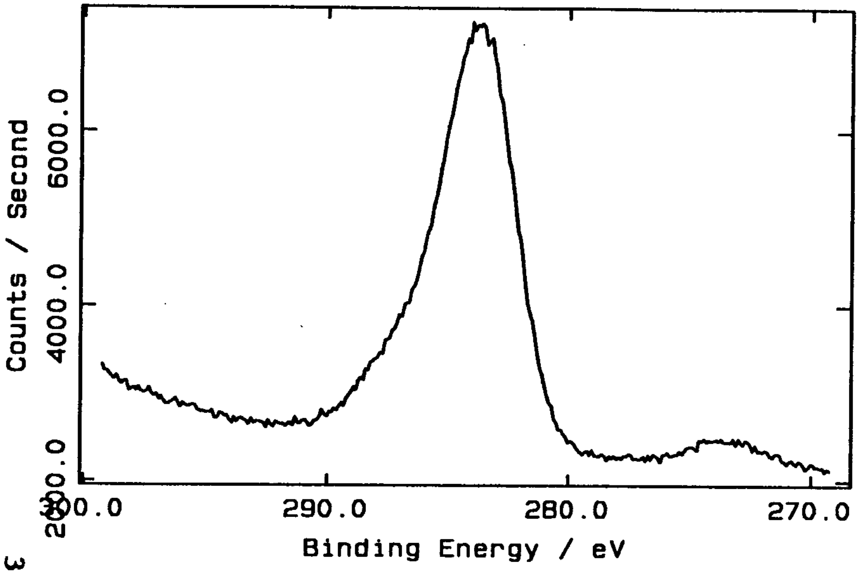


Bare 7075 Al, Panel 2 Mg 1s

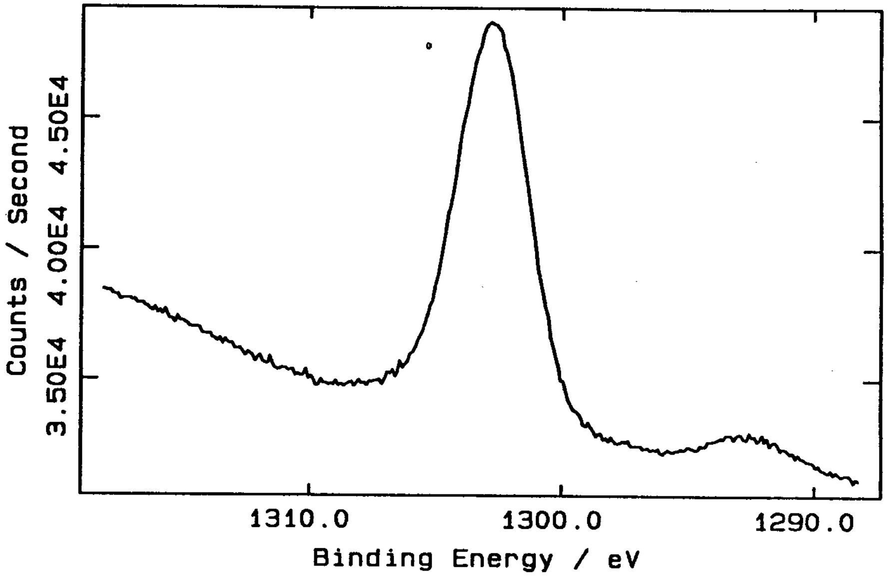


Bare 7075 Al, Panel 2 O 1s

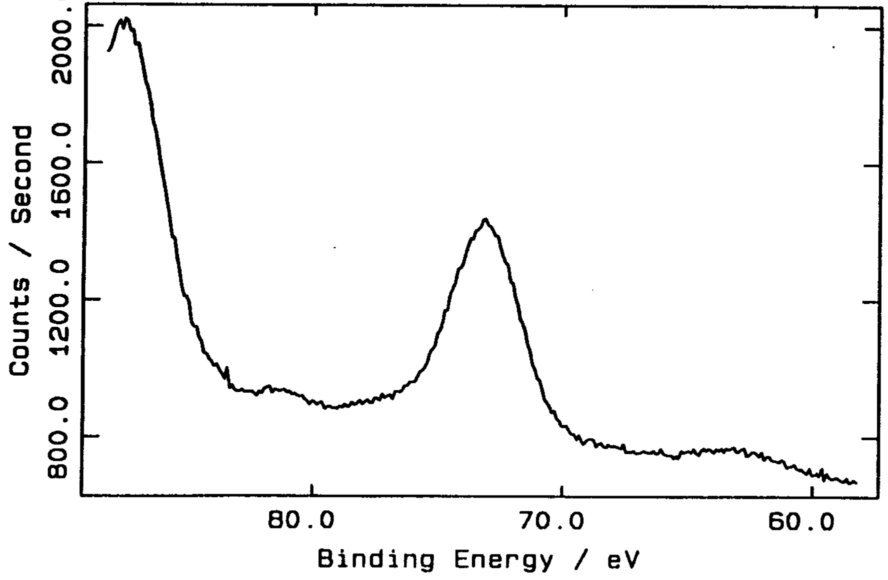
Bare 7075 Al. Panel 2 C 1s



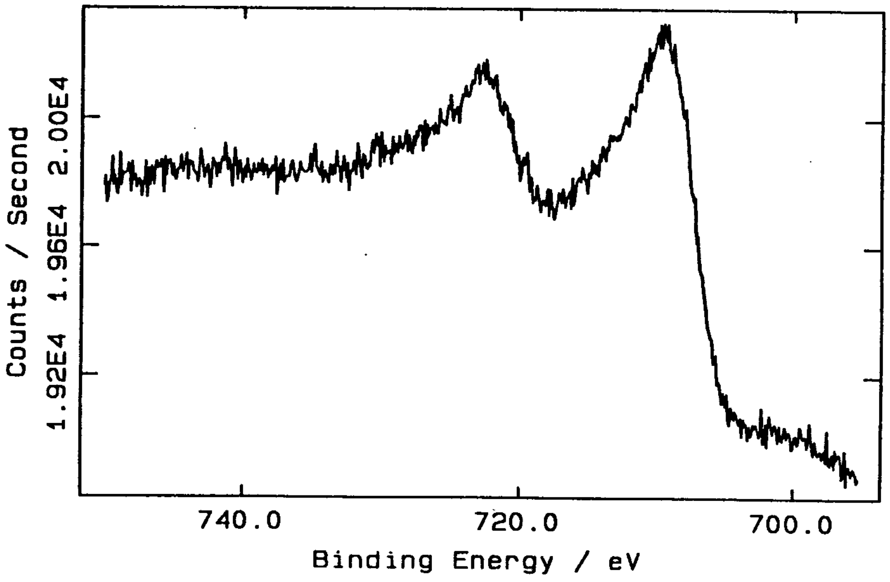
Bare 7075 Al. Panel 2 Mg 1s



Bare 7075 Al. Panel 2 Al 2p



Bare 7075 Al. Panel 2 Fe 2p1/2. 2p3/2



Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Bare 7075 Al Test Panel 2

Method: XPS
Mounting: Secured with single gold- covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN003.R1	None	Survey	RF = 3
ALPAN004	2.7732	Detail	PE = 200
ALPAN006	2.7512	Detail	PE = 200

SUMMARY OF ANALYSIS

Run number: 1   Excitation: Al   Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN004.R1	Mg 1s	1302.81	54069.0000	44.63
2	ALPAN004.R2	Zn 2p$_{1/2}$	1043.92	2742.2850	1.56
3	ALPAN004.R2	Zn 2p$_{3/2}$	1020.77		
4	ALPAN004.R2	See comments	1015.42		
5	ALPAN004.R3	O 1s	530.56	64909.0000	715.64
6	ALPAN004.R4	C 1s	284.80	20765.0000	1005.65
7	ALPAN004.R5	Mg 2s	87.55		
8	ALPAN004.R5	Al 2p	73.16	2154.2380	100.00

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Bare 7075 Al Test Panel 2

SUMMARY OF ANALYSIS (Continued): Run number: 2, Excitation: Al, Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN006.R1	Mg 1s	1302.81	54662.0000	44.63
2	ALPAN006.R2	Fe $2p_{1/2}$	722.81		
3	ALPAN006.R2	Fe $2p_{3/2}$	709.53		
4	ALPAN006.R2	Fe 2p		10082.0000	5.26

COMMENTS

Peak 4 of Run 1 assigned to satellite of O KL_1L_1 peak.

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Solvall 5234 Cleaned 7075 Al Test Panel 1

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

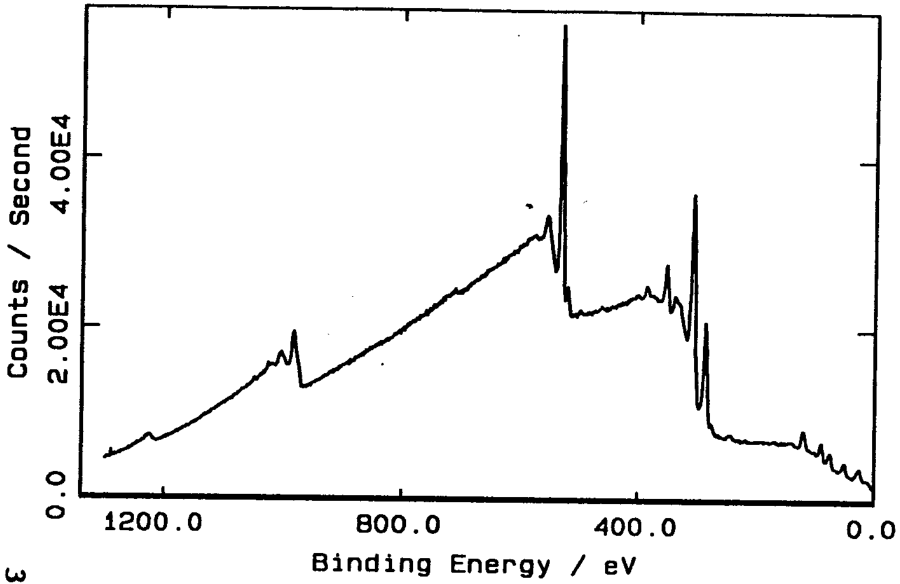
File name	Charge correction	Type	Instrument settings
ALPAN010.R1	None	Survey	RF = 3
ALPAN011	2.1505	Detail	PE = 200

SUMMARY OF ANALYSIS

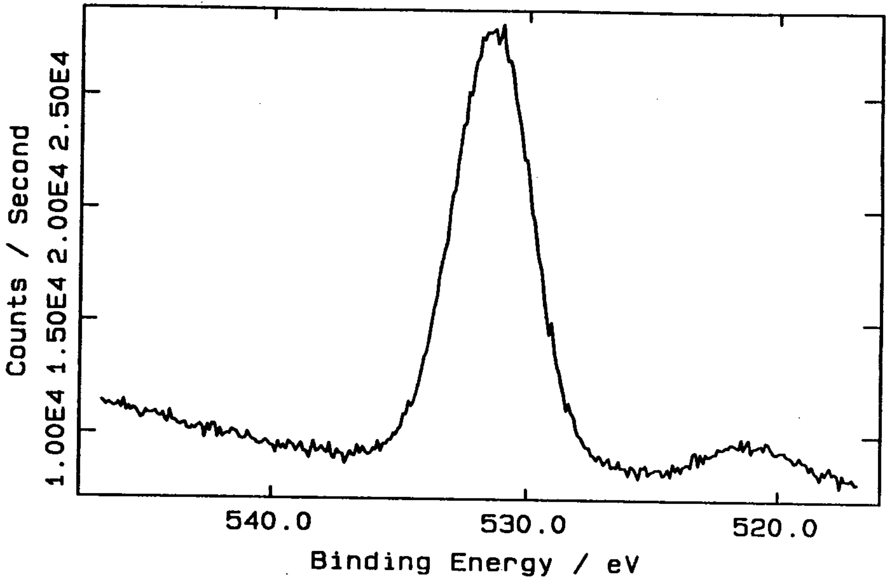
Run number: 1   Excitation: Al   Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN011.R1	Mg 1s	1303.53	42012.0000	27.65
2	ALPAN011.R2	O 1s	531.40	23324.0000	205.51
3	ALPAN011.R3	C 1s	284.80	23742.0000	919.30
4	ALPAN011.R4	Mg 2s	88.32		
5	ALPAN011.R4	Al 2p	73.93	2695.1600	100.00

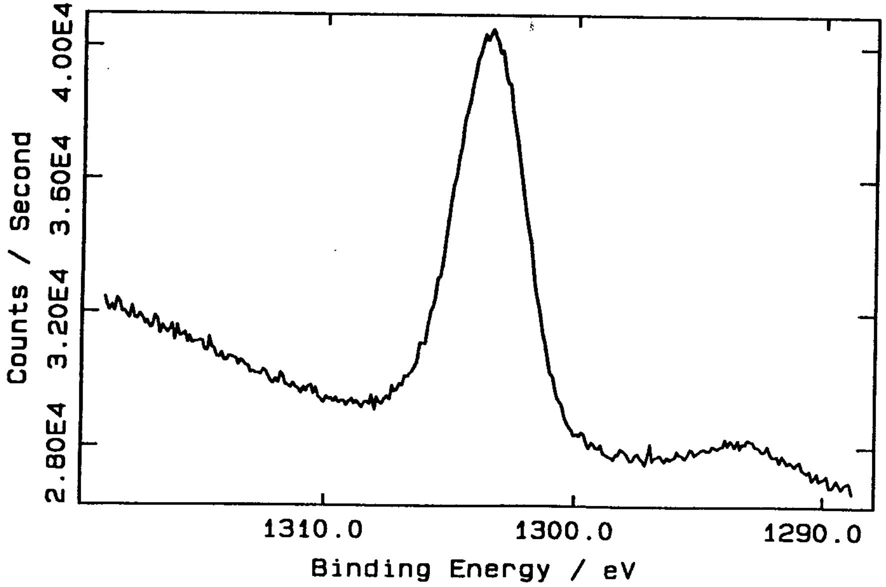
Solvall 5234, Panel 1 Survey

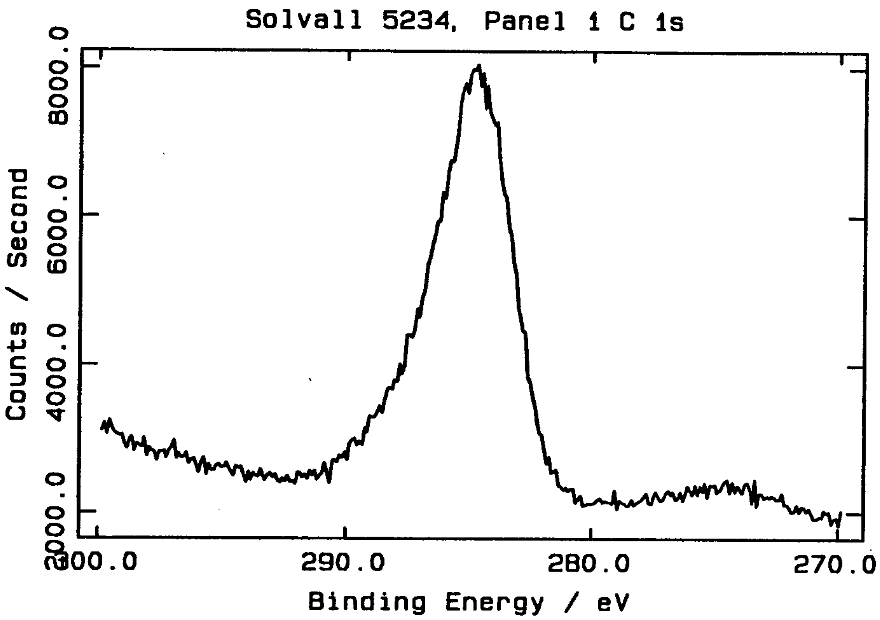


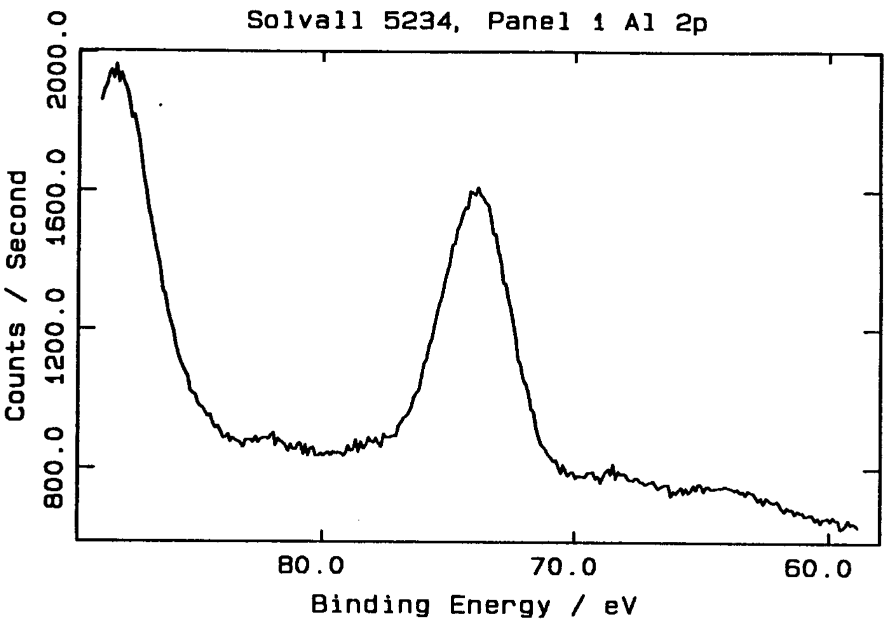
Solvall 5234, Panel 1 O 1s



Solvall 5234, Panel 1 Mg 1s




Solvall 5234, Panel 1 C 1s


Solvall 5234, Panel 1 Al 2p

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Solvall 5234 Cleaned 7075 Al Test Panel 2

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

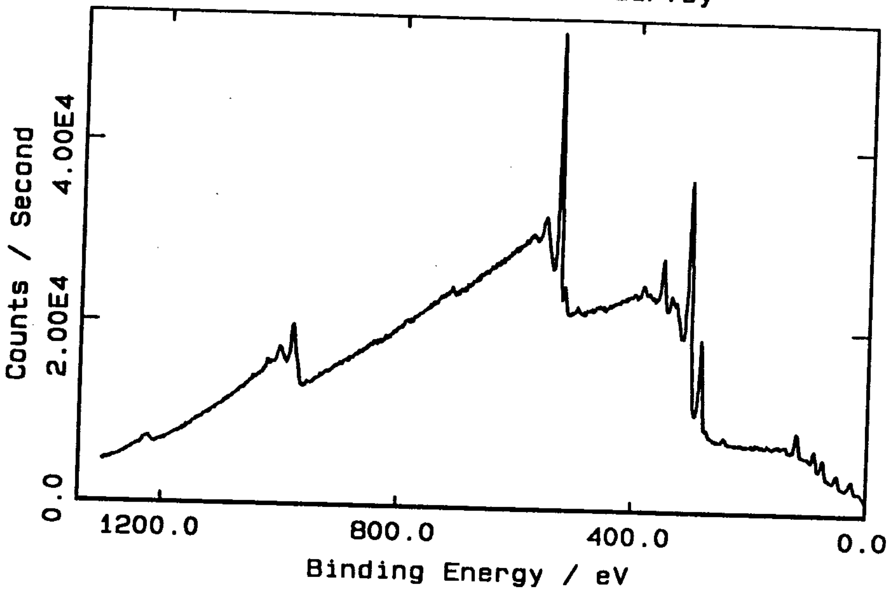
File name	Charge correction	Type	Instrument settings
ALPAN012.R1	None	Survey	RF = 3
ALPAN013	1.8564	Detail	PE = 200

SUMMARY OF ANALYSIS

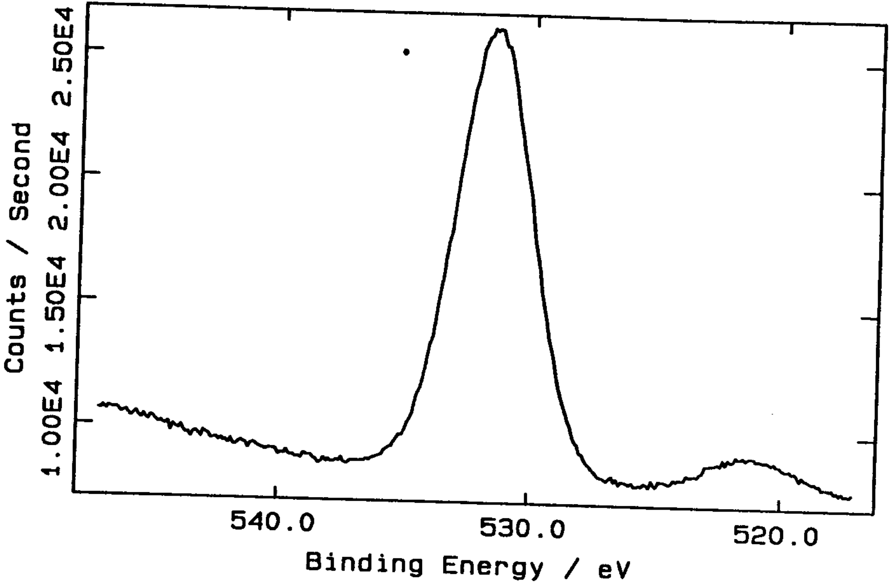
Run number: 1   Excitation: Al   Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN013.R1	Mg 1s	1303.70	36929.0000	24.05
2	ALPAN013.R2	O 1s	531.53	67837.0000	591.74
3	ALPAN013.R3	C 1s	284.80	19884.0000	762.28
4	ALPAN013.R4	Mg 2s	88.57		
5	ALPAN013.R4	Al 2p	74.10	2722.3380	100.00

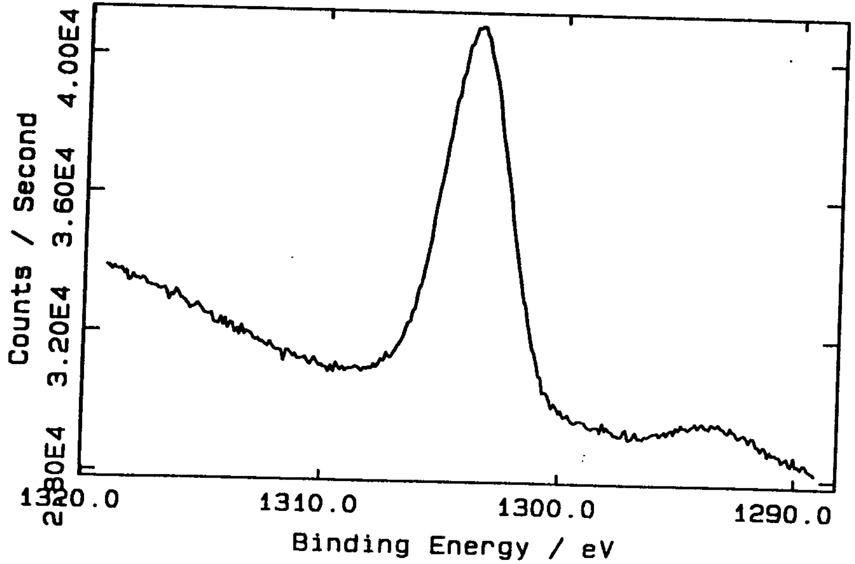
Solvall 5234, Panel 2 Survey



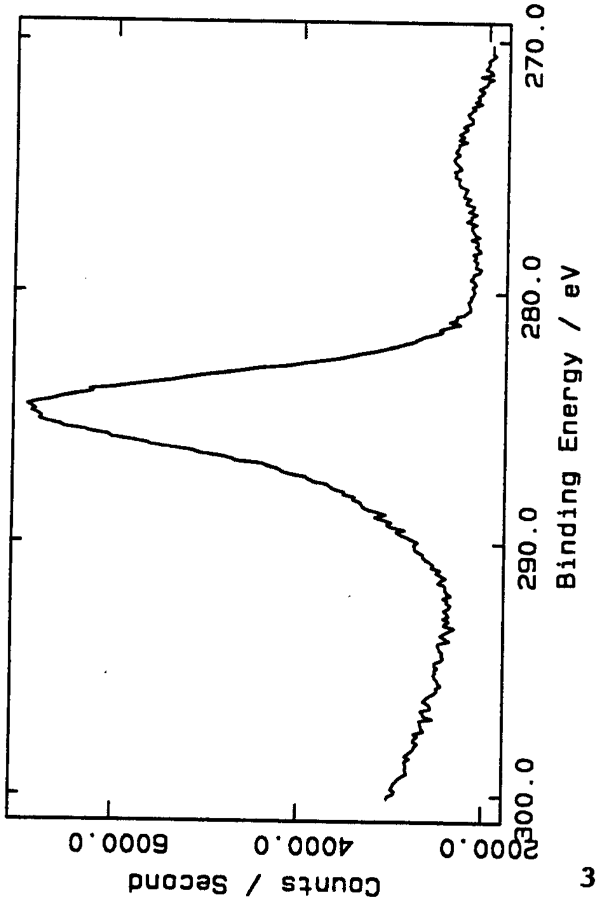
Solvall 5234, Panel 2 O 1s



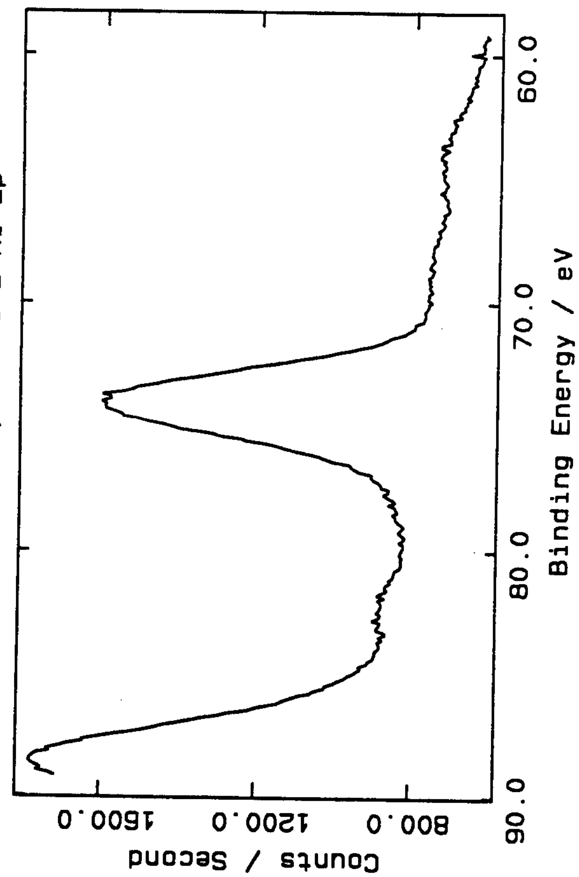
Solvall 5234, Panel 2 Mg 1s



Solvall 5234, Panel 2 C 1s



Solvall 5234, Panel 2 Al 2p



Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: PARTSPREP Cleaned 7075 Al Test Panel 1

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN014.R1	None	Survey	RF = 3
ALPAN015	2.2957	Detail	PE = 200

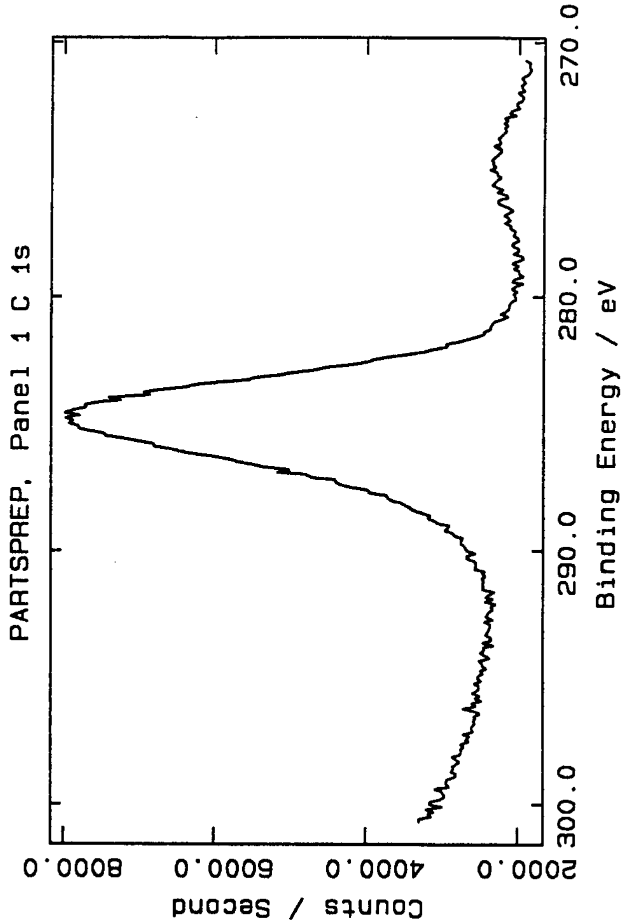
SUMMARY OF ANALYSIS

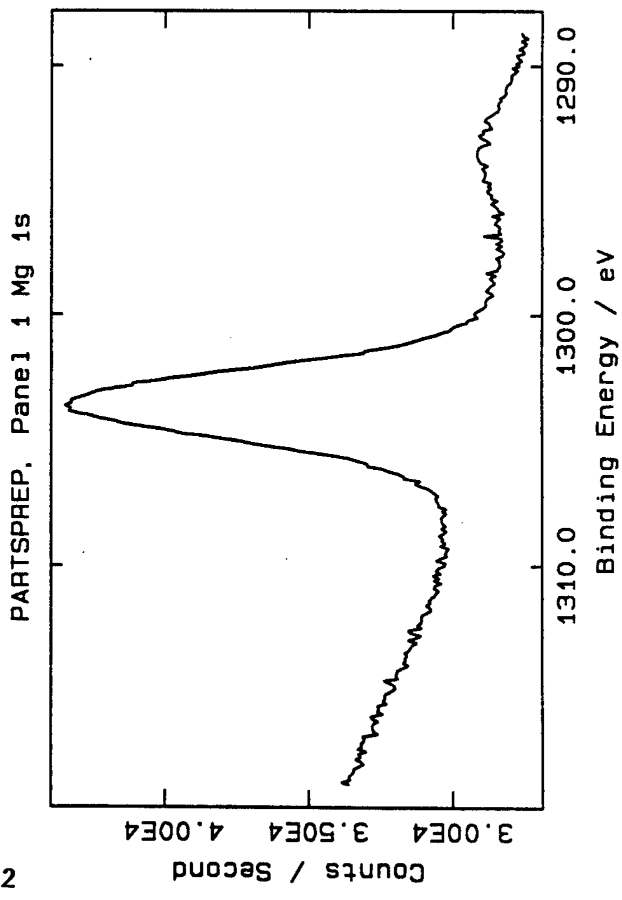
Run number: 1   Excitation: Al   Pass energy: 200 eV

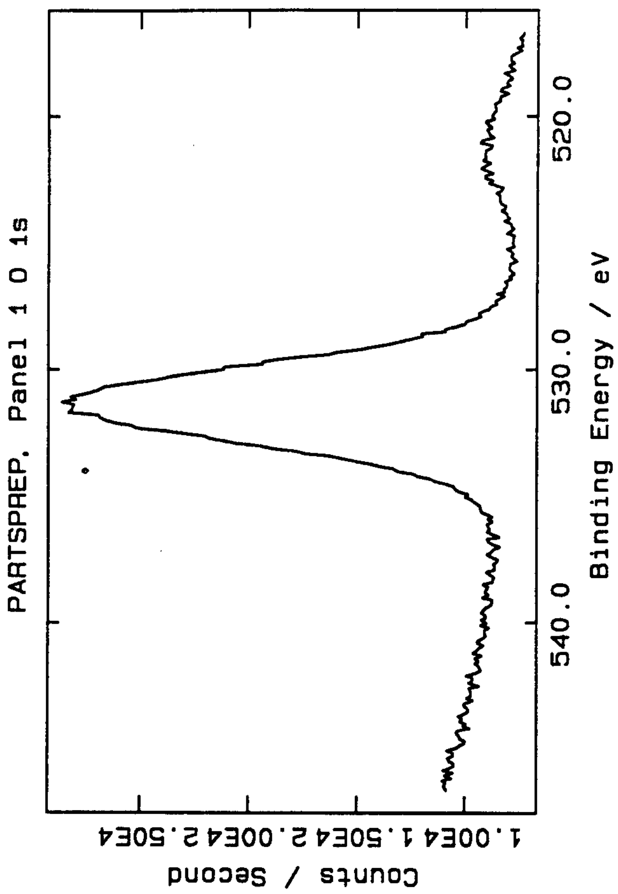
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN015.R1	Mg 1s	1303.57	48432.0000	39.19
2	ALPAN015.R2	O 1s	531.37	75672.0000	819.82
3	ALPAN015.R3	C 1s	284.80	24338.0000	1158.71
4	ALPAN015.R4	See comments	139.53		
5	ALPAN015.R4	P 2p	133.36	860.7104	14.93
6	ALPAN015.R5	Mg 2s	88.36		
7	ALPAN015.R5	Al 2p	73.95	2191.9770	100.00

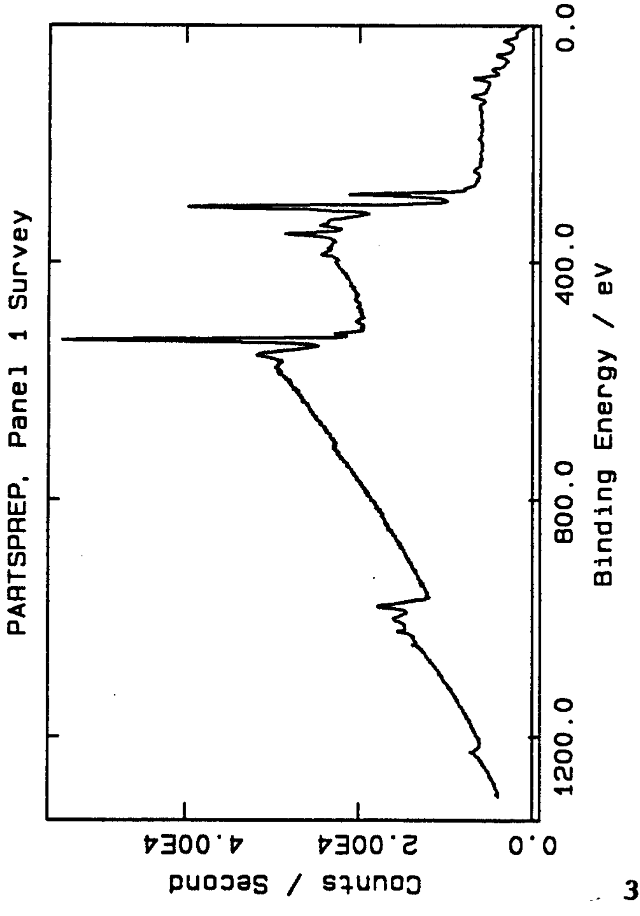
COMMENTS

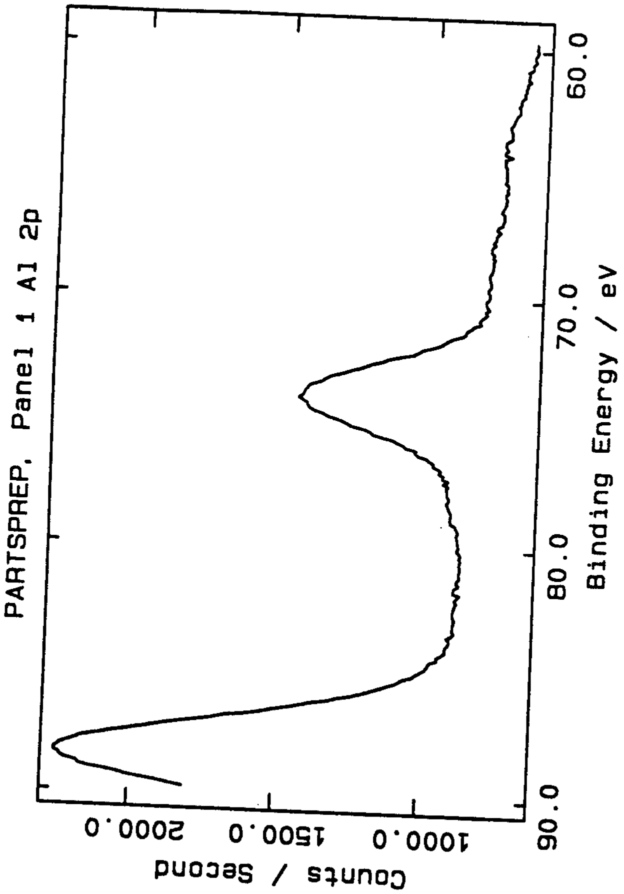
Peak 4 assigned to Zn 3s or to Al 2s shakeup or plasmon energy loss.

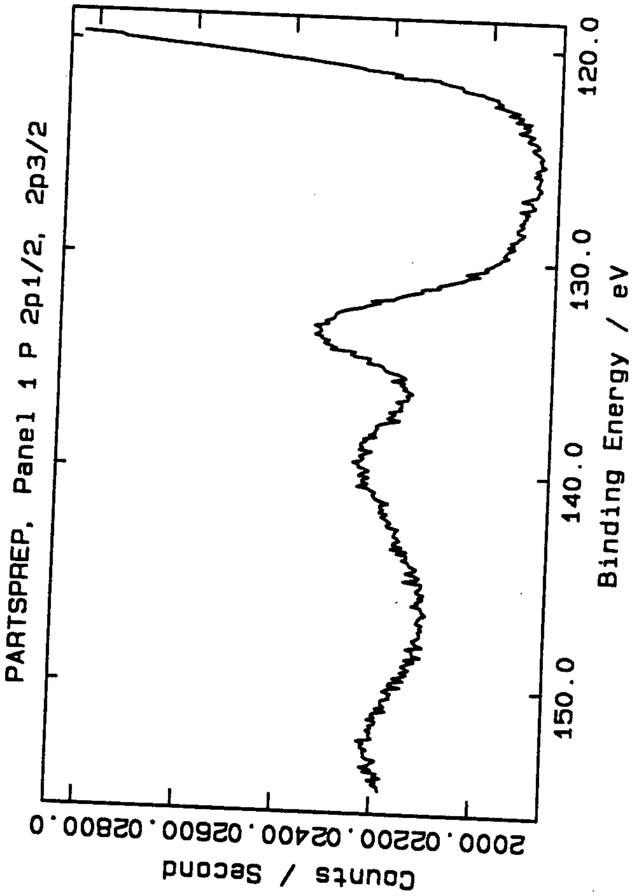

PARTSPREP, Panel 1 C 1s


PARTSPREP, Panel 1 Mg 1s


PARTSPREP, Panel 1 O 1s


PARTSPREP, Panel 1 Survey


PARTSPREP, Panel 1 Al 2p
Counts / Second
1000.0
1500.0
2000.0
Binding Energy / eV
90.0
80.0
70.0
60.0


PARTSPREP, Panel 1 P 2p1/2, 2p3/2
Counts / Second
2000.02200.02400.02600.02800.0
Binding Energy / eV
150.0
140.0
130.0
120.0

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: PARTSPREP Cleaned 7075 Al Test Panel 2

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN016.R1	None	Survey	RF = 3
ALPAN017	1.8889	Detail	PE = 200

SUMMARY OF ANALYSIS

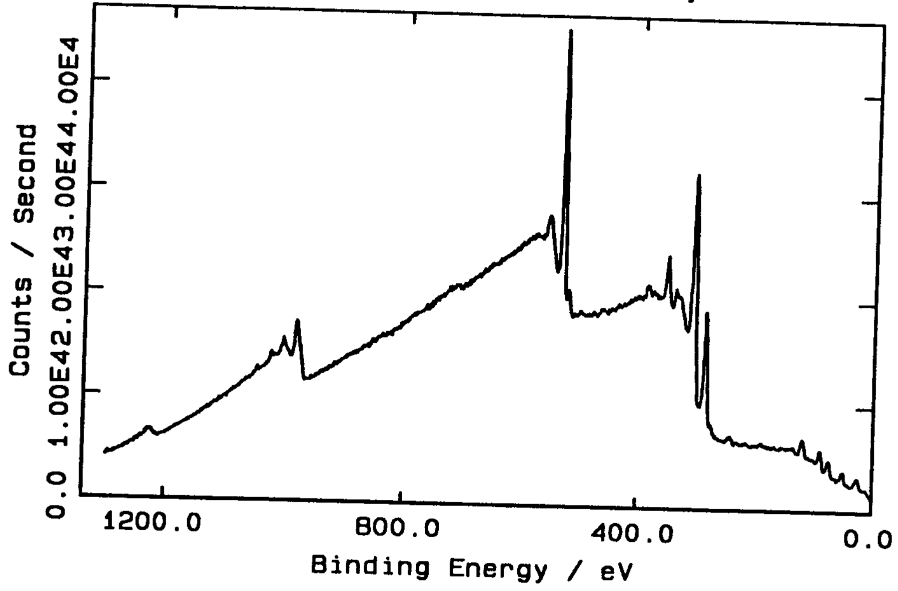
Run number: 1   Excitation: Al   Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN017.R1	Mg 1s	1303.66	41413.0000	30.49
2	ALPAN017.R2	O 1s	531.44	60921.0000	600.70
3	ALPAN017.R3	C 1s	284.80	21528.0000	932.86
4	ALPAN017.R4	See comments	139.53		
5	ALPAN017.R4	P 2p	133.55	902.5029	14.25
6	ALPAN017.R5	Mg 2s	88.47		
7	ALPAN017.R5	Al 2p	74.02	2408.3850	100.00

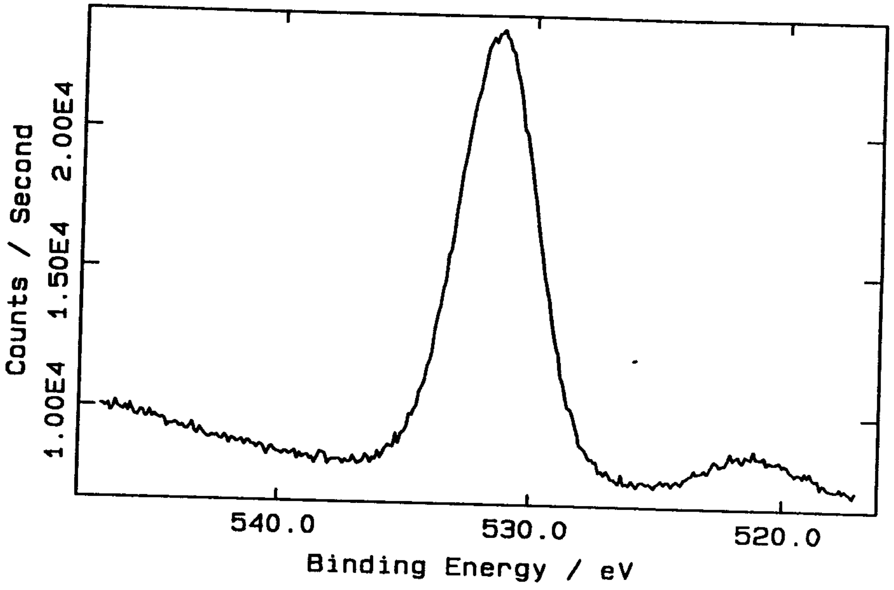
COMMENTS

Peak 4 assigned to Zn 3s, Al 2s shakeup or plasmon energy loss.

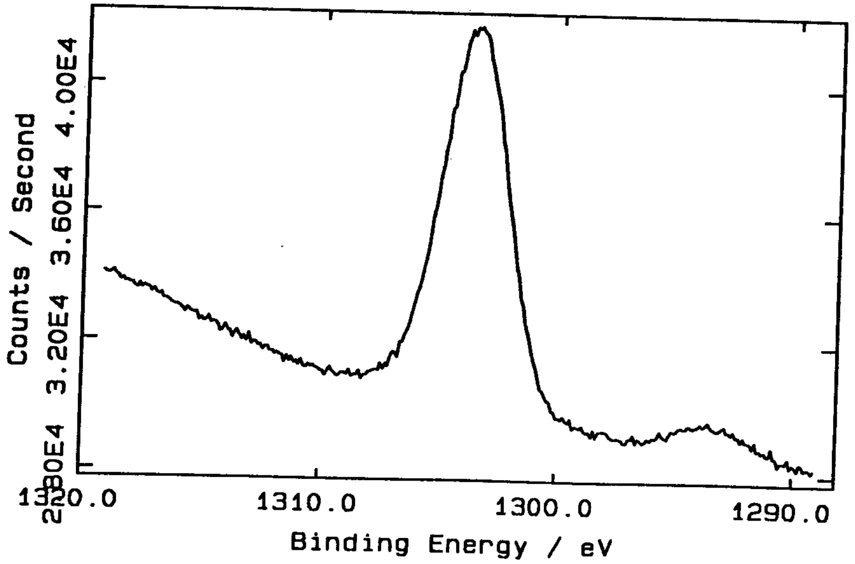
PARTSPREP, Panel 2 Survey



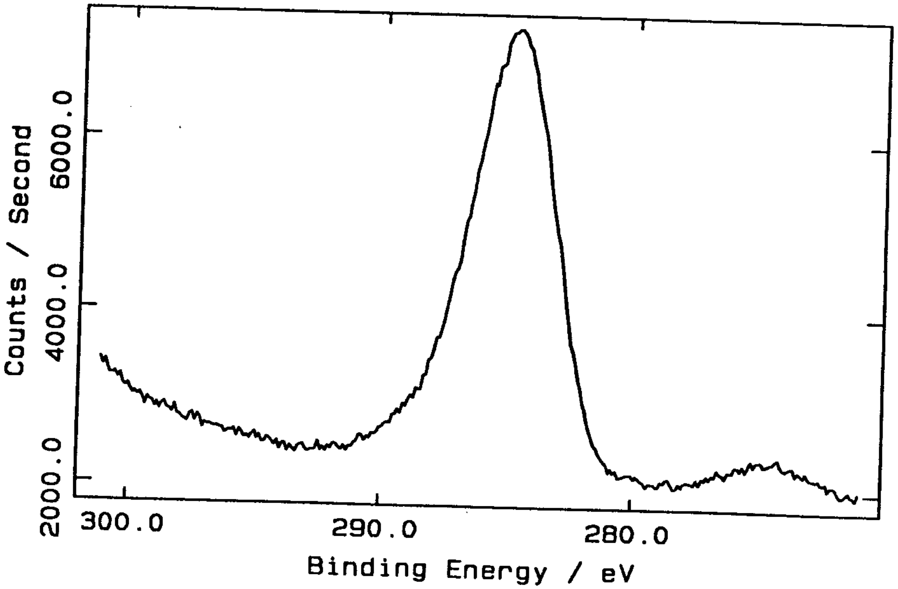
PARTSPREP, Panel 2 O 1s



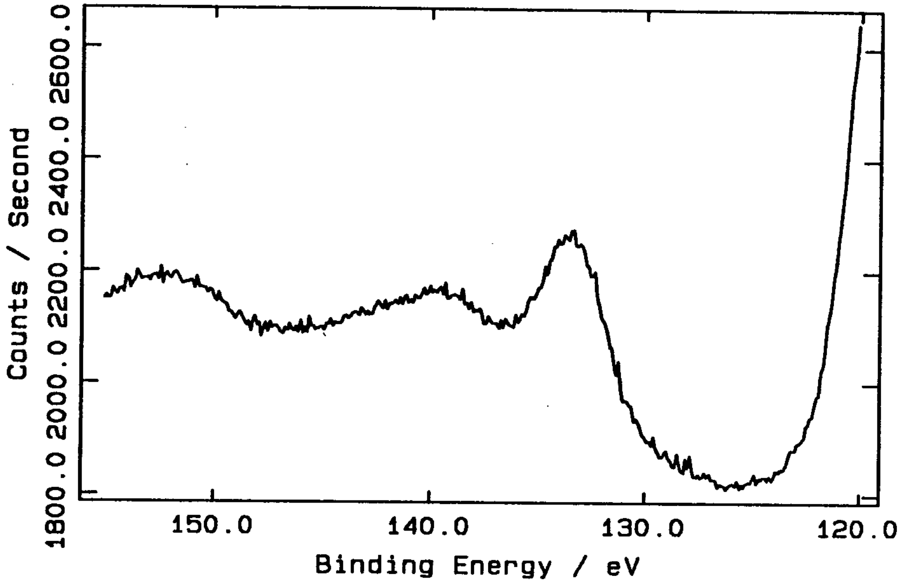
PARTSPREP, Panel 2 Mg 1s



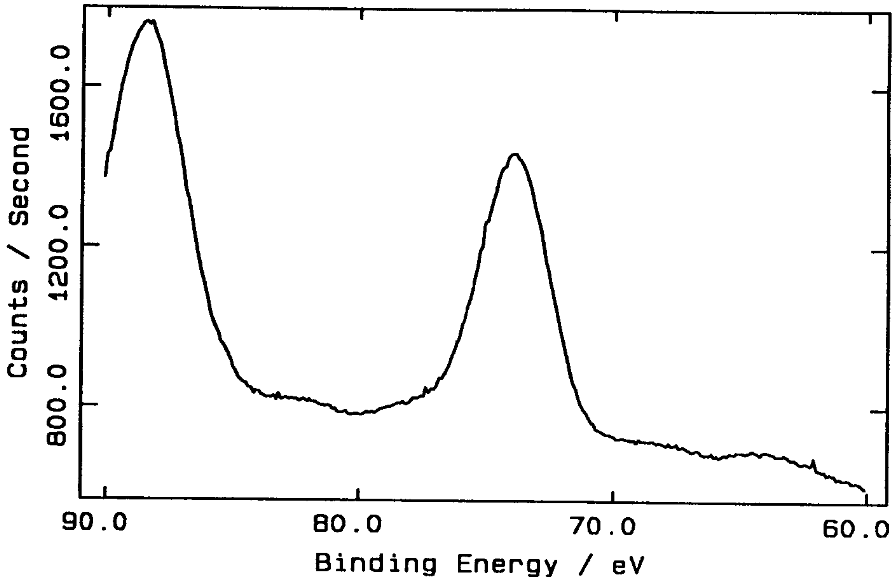
PARTSPREP, Panel 2 C 1s



PARTSPREP, Panel 2 P 2p1/2, 2p3/2



PARTSPREP, Panel 2 Al 2p



Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Contaminated 7075 Al Test Panel 1

Method: XPS
Mounting: Secured with single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN018.R1	None	Survey	RF = 3
ALPAN019	1.5812	Detail	PE = 200
ALPAN020	1.6032	Detail	PE = 200
ALPAN021	1.5933	Detail	PE = 200

SUMMARY OF ANALYSIS

Run number: 1 Excitation: Al Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN019.R1	See comments			
2	ALPAN019.R2	O 1s	533.19	55746.0000	63.41
3	ALPAN019.R3	C 1s	284.80	19985.0000	100.00

Run number: 2 Excitation: Al Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN020.R1	O 1s	533.18	55772.0000	65.21
2	ALPAN020.R2	C 1s	284.80	19444.0000	100.00

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Contaminated 7075 Al Test Panel 1

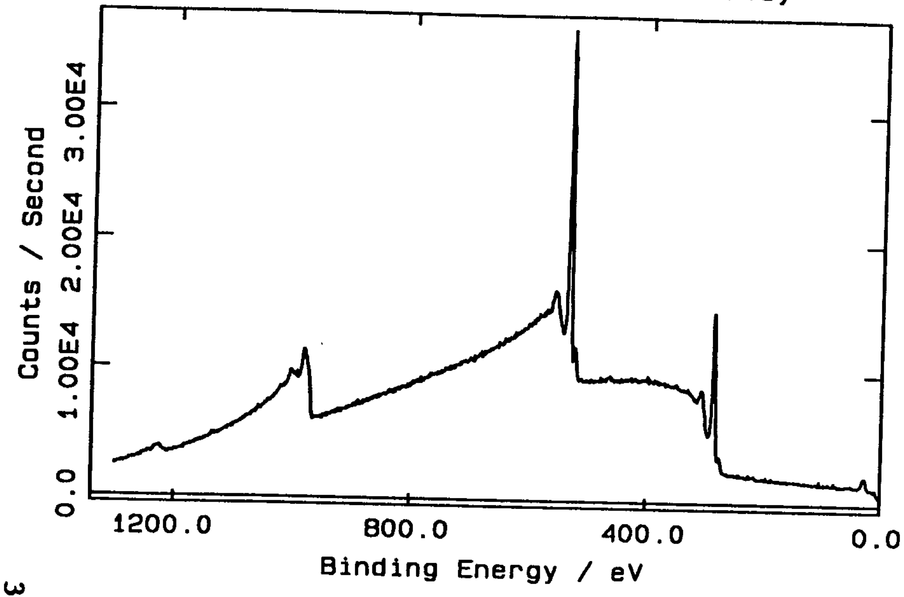
SUMMARY OF ANALYSIS (Continued): Run number: 3, Excitation: Al, Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN021.R1	C 1s	284.80		
2	ALPAN021.R2	See comments			

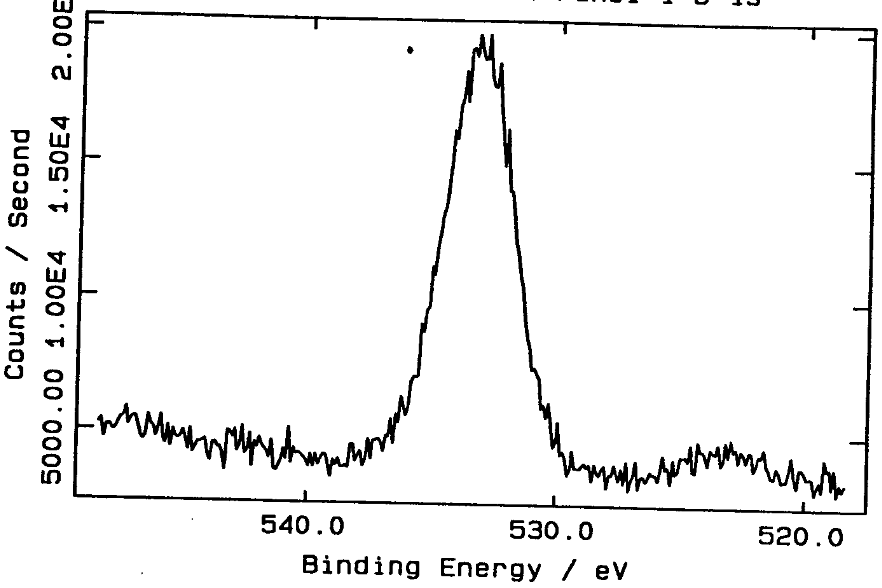
COMMENTS

Mg 1s not observed (corresponds to peak 1, run 1).
Mo $3d_{3/2}$ and Mo $3d_{5/2}$ not observed (corresponding to peak 2, run 3).

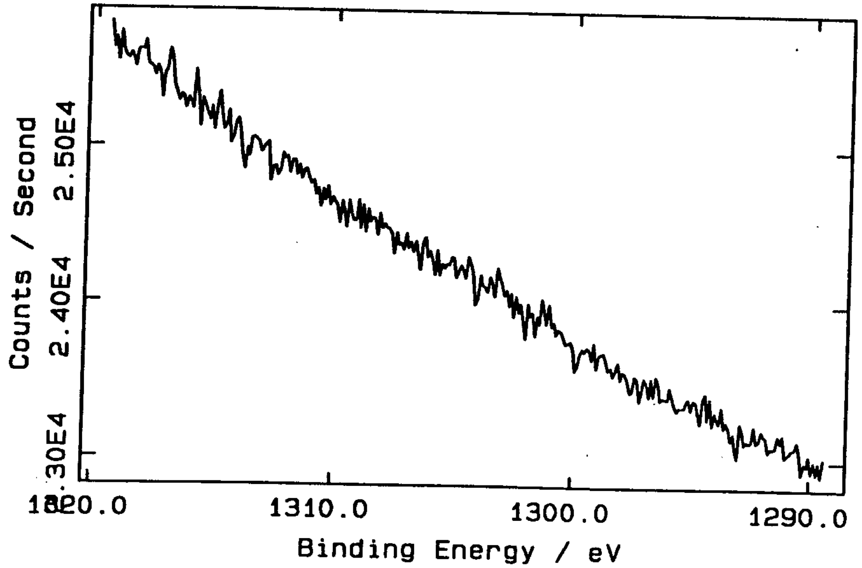
Contaminated 7075 Al Panel 1 Survey



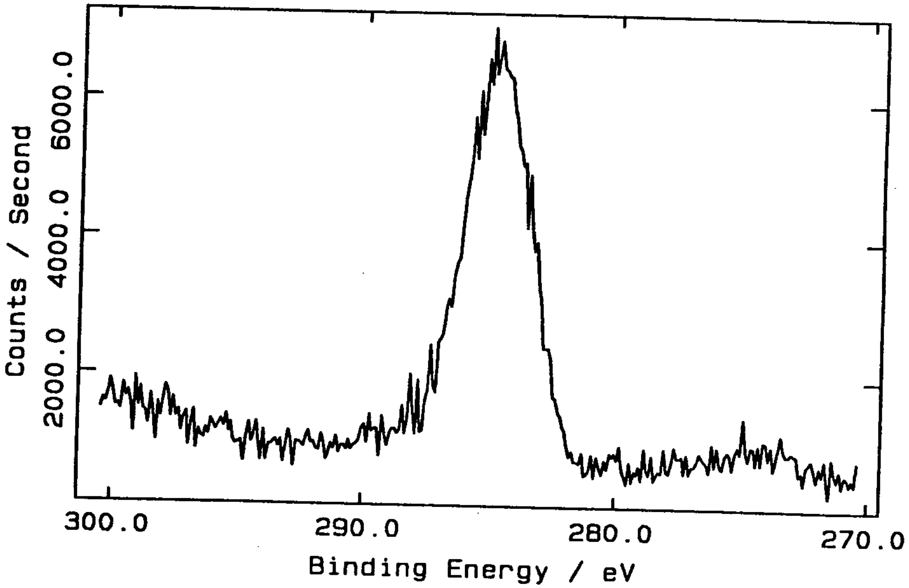
Contaminated 7075 Al Panel 1 O 1s



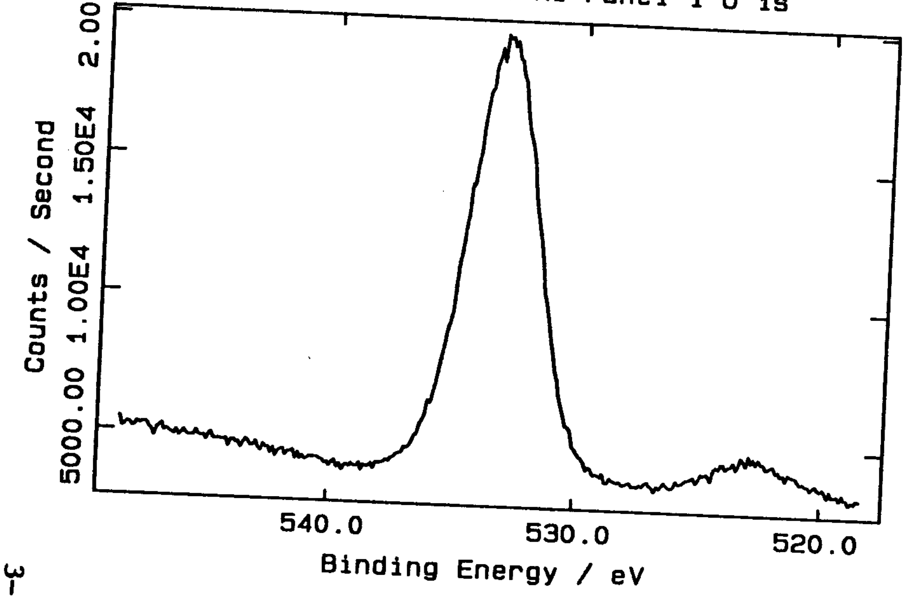
Contaminated 7075 Al Panel 1 Mg 1s



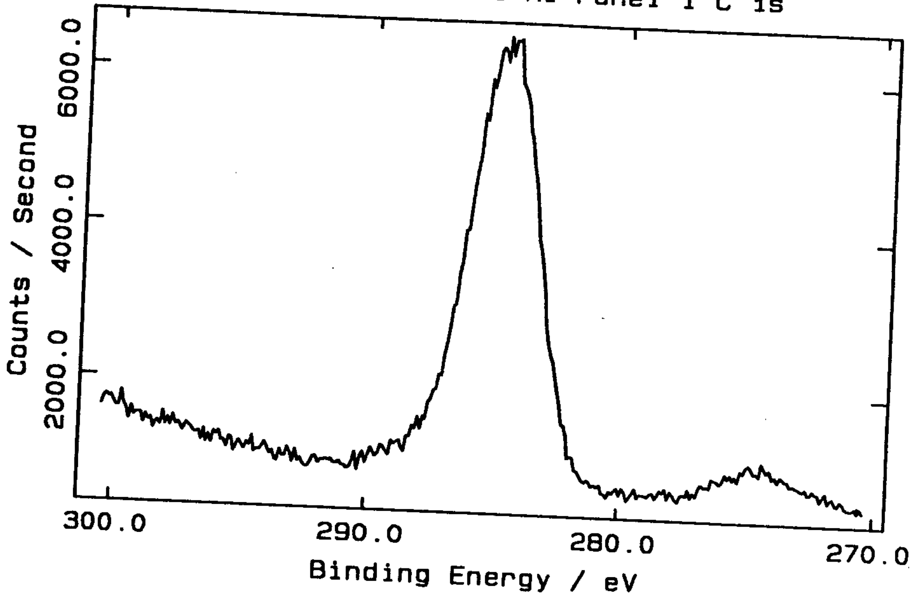
Contaminated 7075 Al Panel 1 C 1s



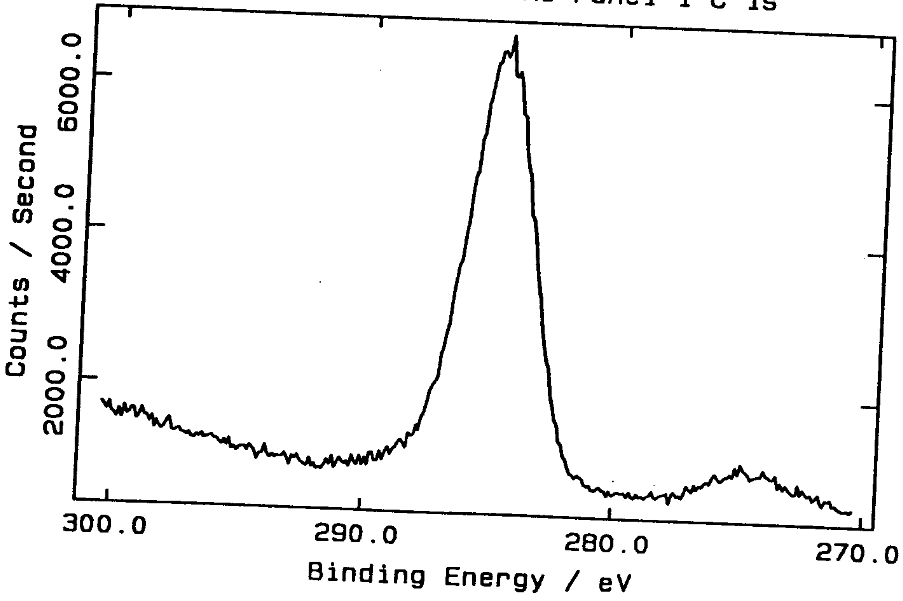
Contaminated 7075 Al Panel 1 O 1s



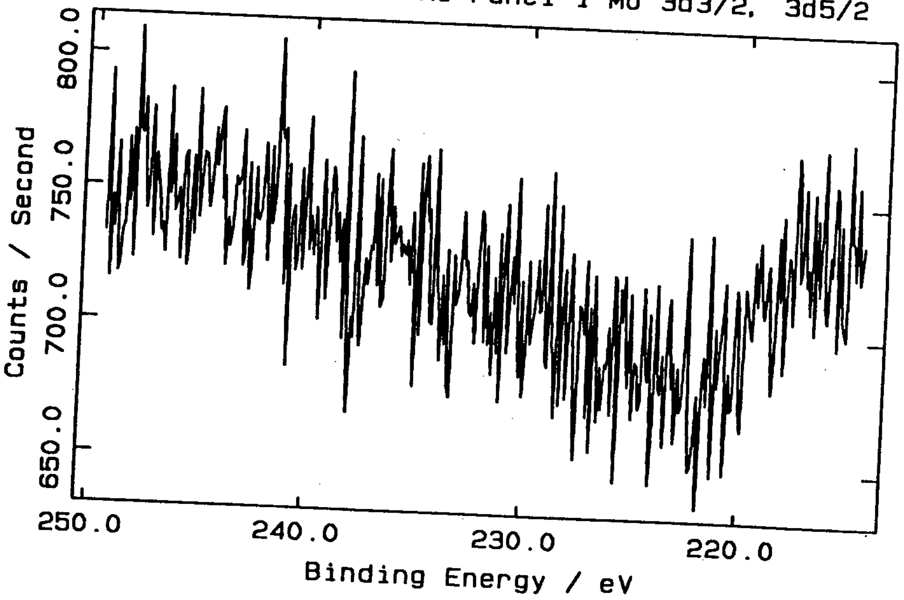
Contaminated 7075 Al Panel 1 C 1s



Contaminated 7075 Al Panel 1 C 1s



Contaminated 7075 Al Panel 1 Mo 3d3/2, 3d5/2



Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Contaminated 7075 Al Test Panel 2

Method: XPS
Mounting: Secured with single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN022.R1	None	Survey	RF = 3
ALPAN023	1.3707	Detail	PE = 200
ALPAN024	1.3304	Detail	PE = 200
ALPAN025	1.3308	Detail	PE = 200

SUMMARY OF ANALYSIS

Run number: 1 Excitation: Al Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN023.R1	See comments			
2	ALPAN023.R2	O 1s	533.13	29412.0000	23.05
3	ALPAN023.R3	C 1s	284.80	29007.0000	100.00

Run number: 2 Excitation: Al Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN024.R1	O 1s	532.66	8643.1020	5.73
2	ALPAN024.R2	C 1s	284.80	34292.0000	100.00

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

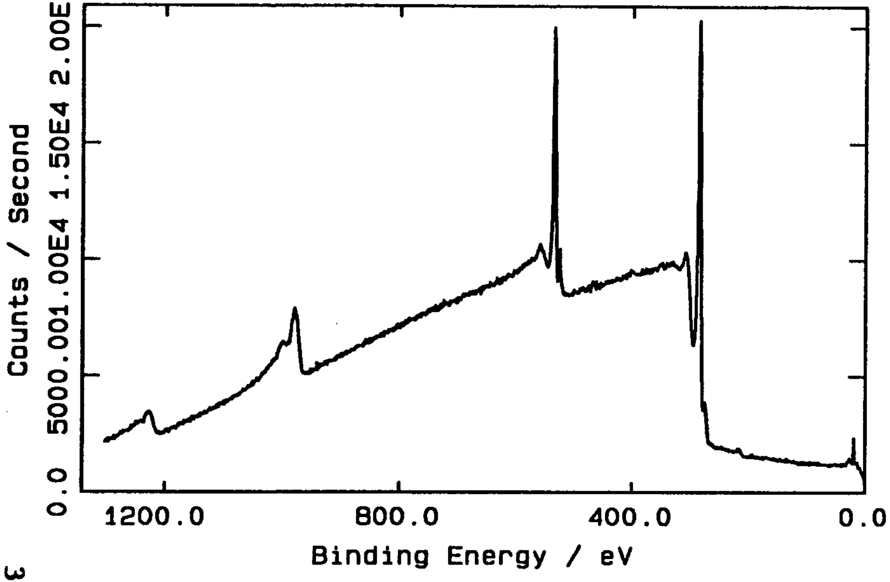
Sample: Contaminated 7075 Al Test Panel 2

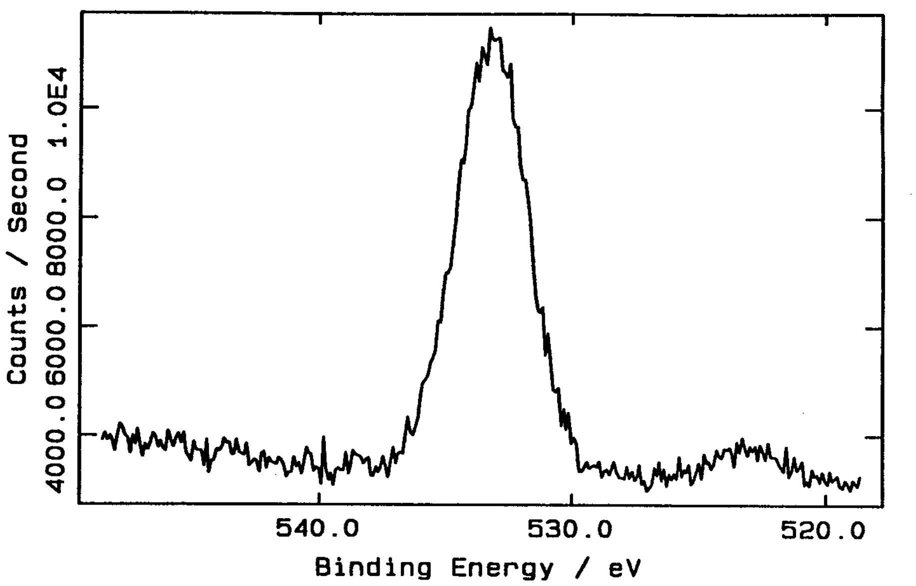
SUMMARY OF ANALYSIS (Continued): Run number: 3, Excitation: Al, Pass energy: 200 eV

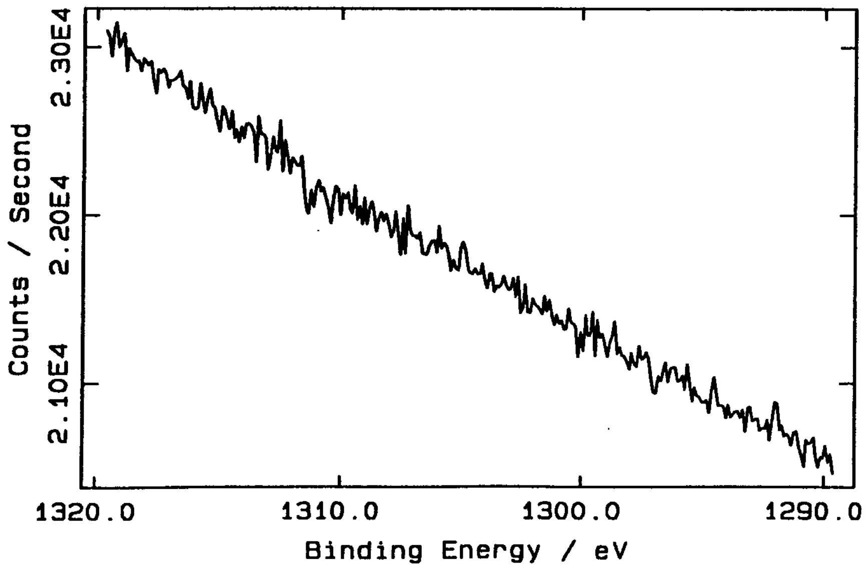
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN025.R1	C 1s	284.80		
2	ALPAN025.R2	See comments			

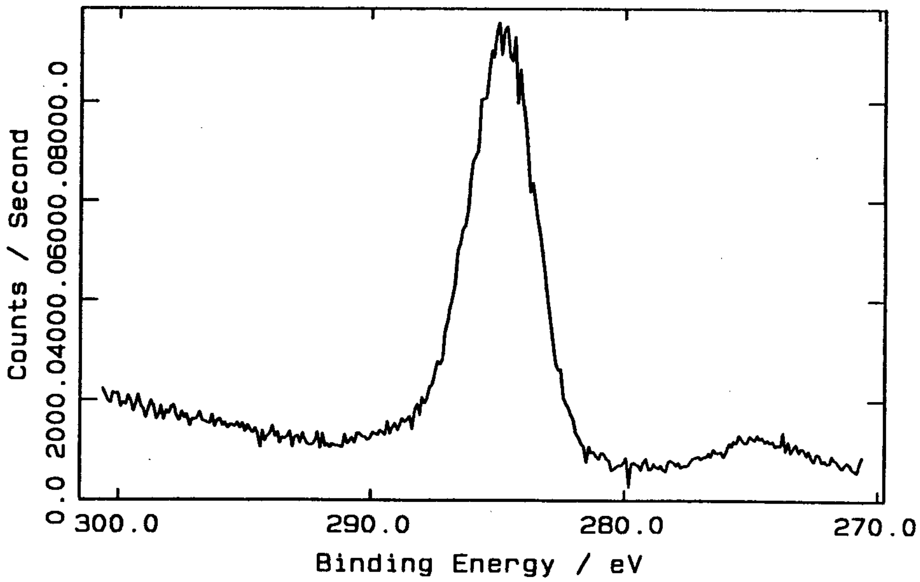
COMMENTS

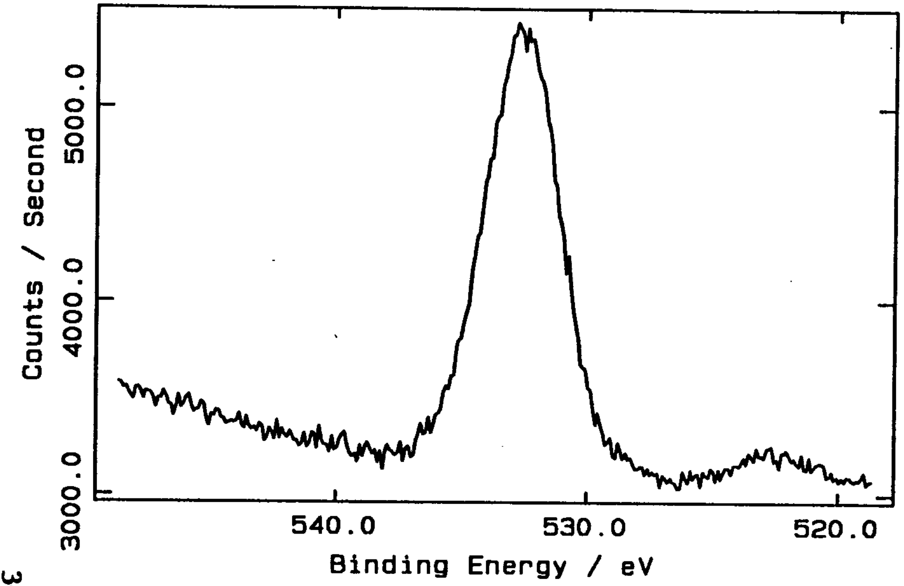
Mg 1s not observed (corresponds to peak 1, run 1).
Mo $3d_{3/2}$ and Mo $3d_{5/2}$ not observed (corresponding to peak 2, run 3).

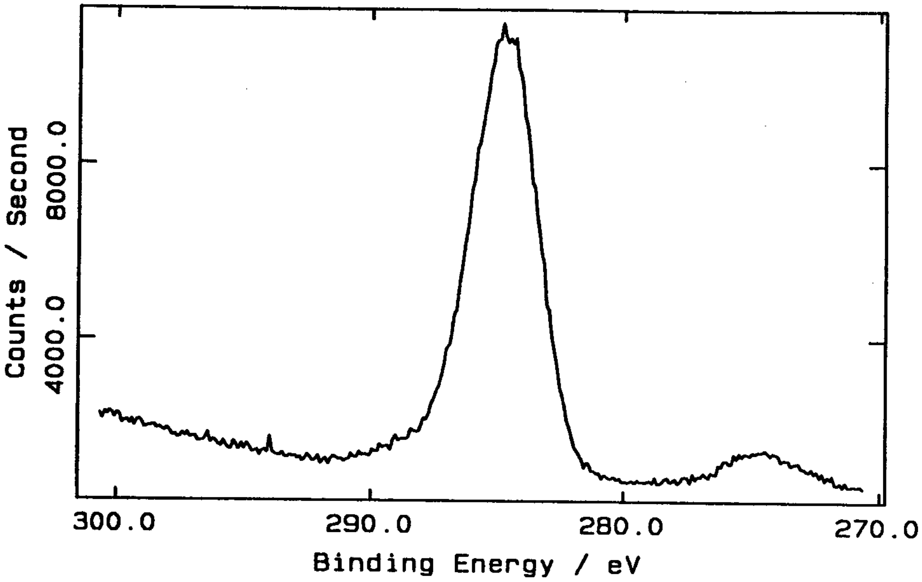

Contaminated 7075 Al Panel 2 Survey

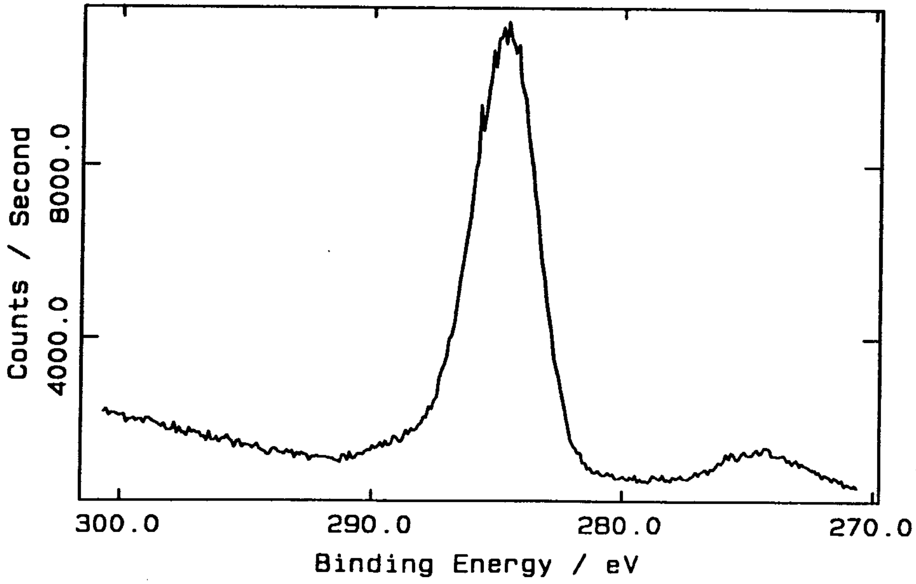

Contaminated 7075 Al Panel 2 O 1s

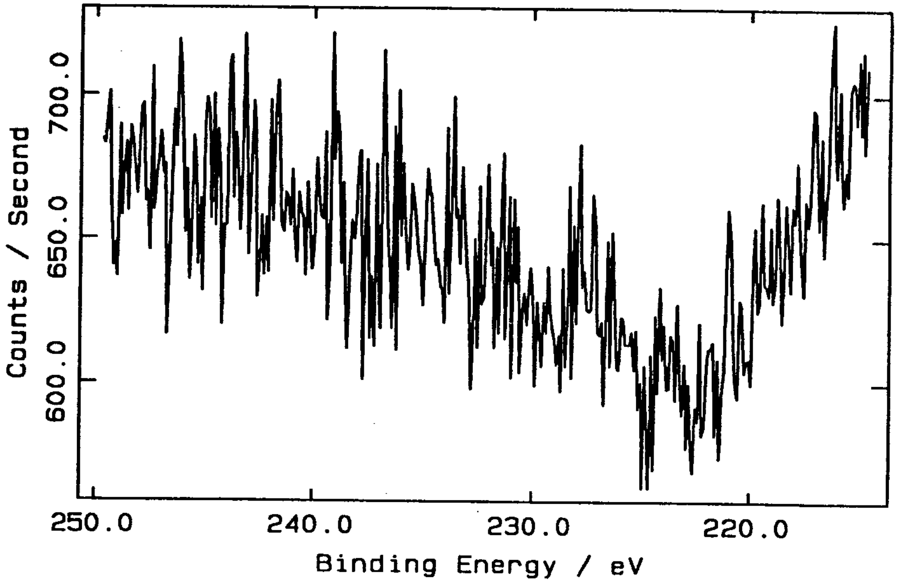

Contaminated 7075 Al Panel 2 Mg 1s


Contaminated 7075 Al Panel 2 C 1s


Contaminated 7075 Al Panel 2 O 1s


Contaminated 7075 Al Panel 2 C 1s


Contaminated 7075 Al Panel 2 C 1s


Contaminated 7075 Al Panel 2 Mo 3d3/2, 3d5/2

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: ALK 660 Cleaned 7075 Al Test Panel 1

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN026.R1	None	Survey	RF = 3
ALPAN027	1.9860	Detail	PE = 200
ALPAN028	1.8031	Detail	PE = 200

SUMMARY OF ANALYSIS

Run number: 1   Excitation: Al   Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN027.R1	Mg 1s	1303.94	50664.0000	15.30
2	ALPAN027.R2	O 1s	531.36	87799.0000	355.19
3	ALPAN027.R3	C 1s	284.80	16292.0000	289.63
4	ALPAN027.R4	Si 2s	152.14	1372.6831	11.42
5	ALPAN027.R4	See comments	140.31		
6	ALPAN027.R4	P 2p	134.31	1002.0650	6.49
7	ALPAN027.R5	Mg 2s	88.71		
8	ALPAN027.R5	Al 2p	74.01	5870.3480	100.00

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

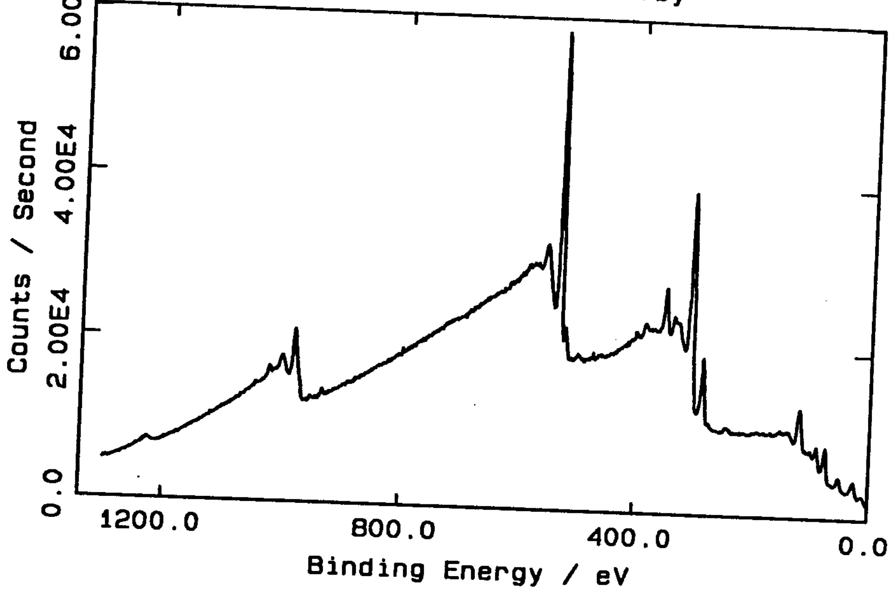
Sample: ALK 660 Cleaned 7075 Al Test Panel 1

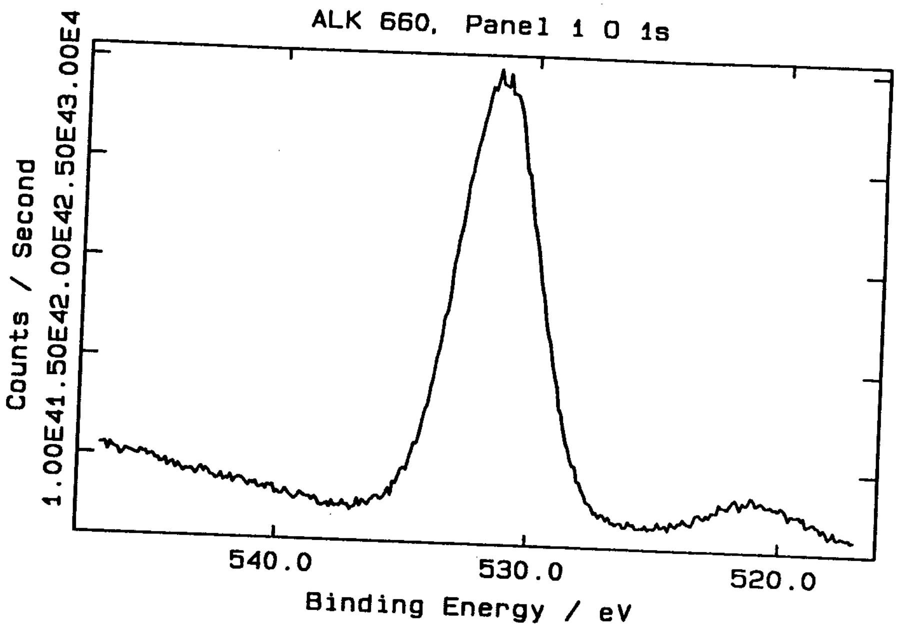
SUMMARY OF ANALYSIS (Continued): Run number: 2, Excitation: Al, Pass energy: 200 eV

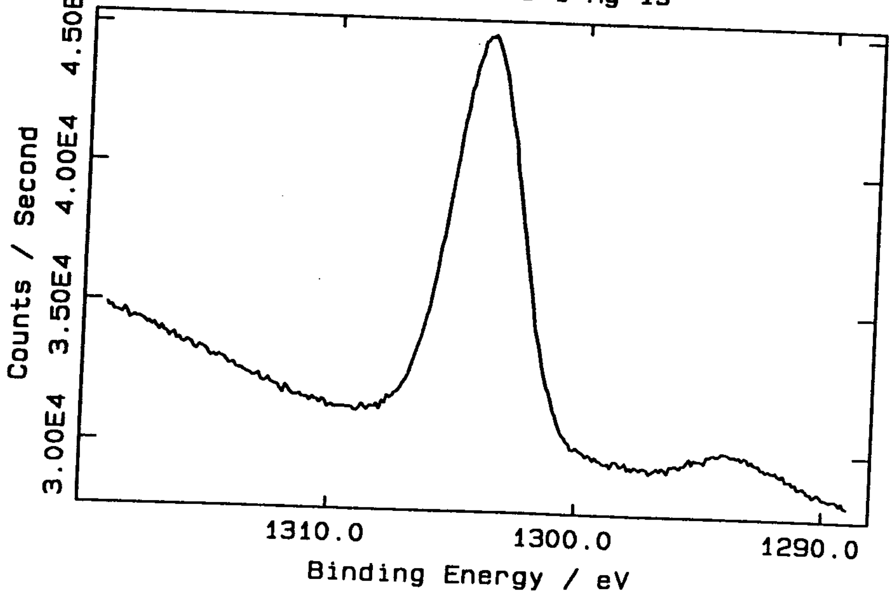
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN028.R1	N 1s	399.45	2566.0970	18.47
2	ALPAN028.R2	C 1s	284.80	18221.0000	289.63

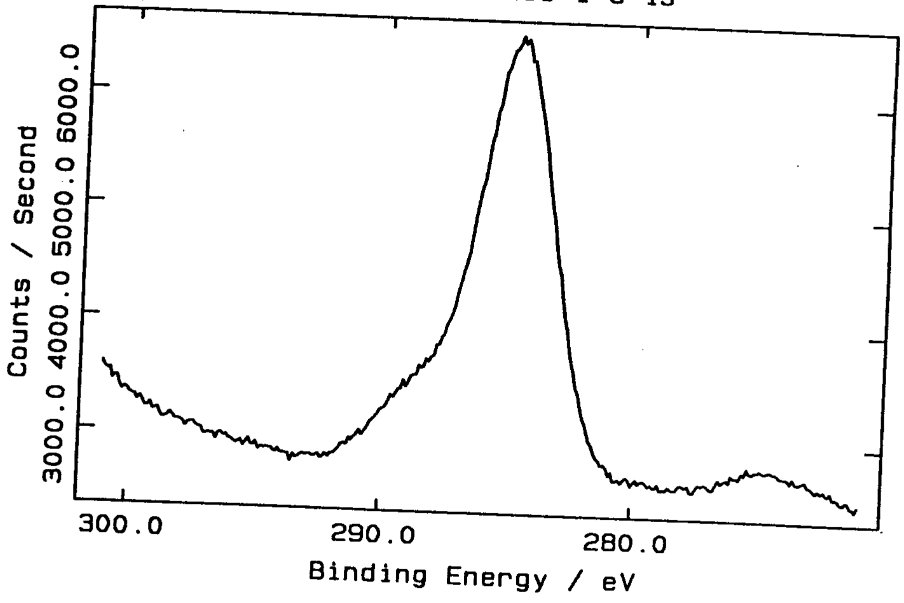
COMMENTS

1. Area of Si 2s peak estimated by curve-fitting.
2. Peak 5, run 1 may be assigned to Al 2s shakeup or to Zn 3s.

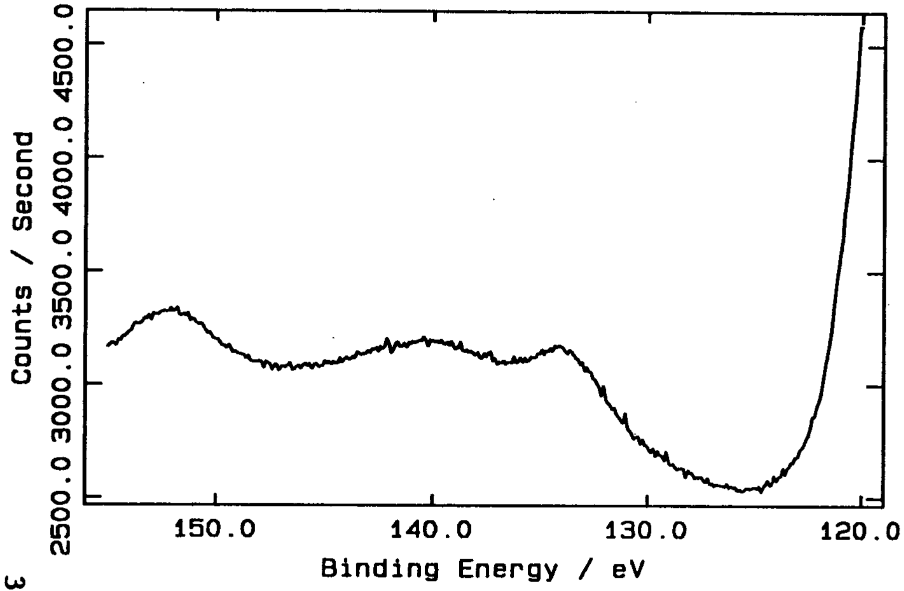

ALK 660, Panel 1 Survey


ALK 660, Panel 1 O 1s

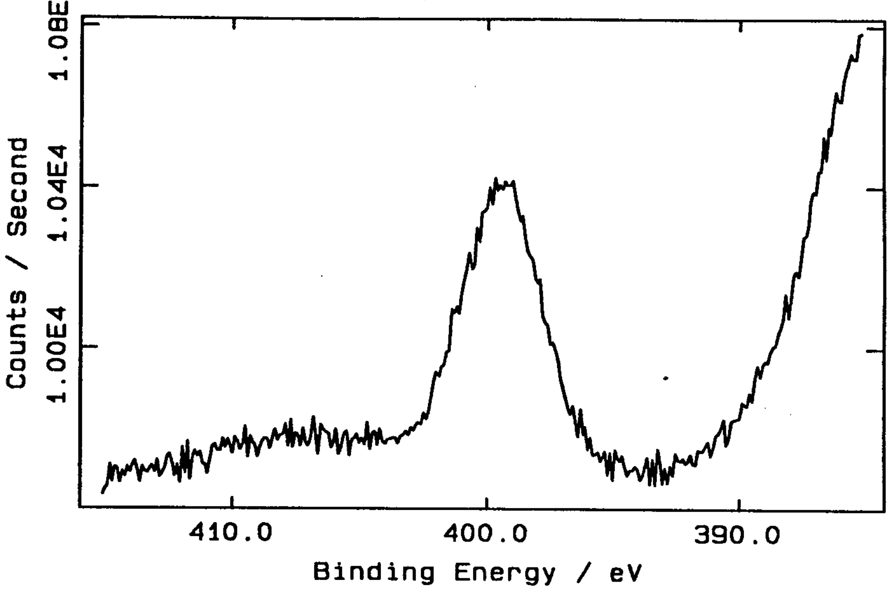

ALK 660, Panel 1 Mg 1s


ALK 660, Panel 1 C 1s

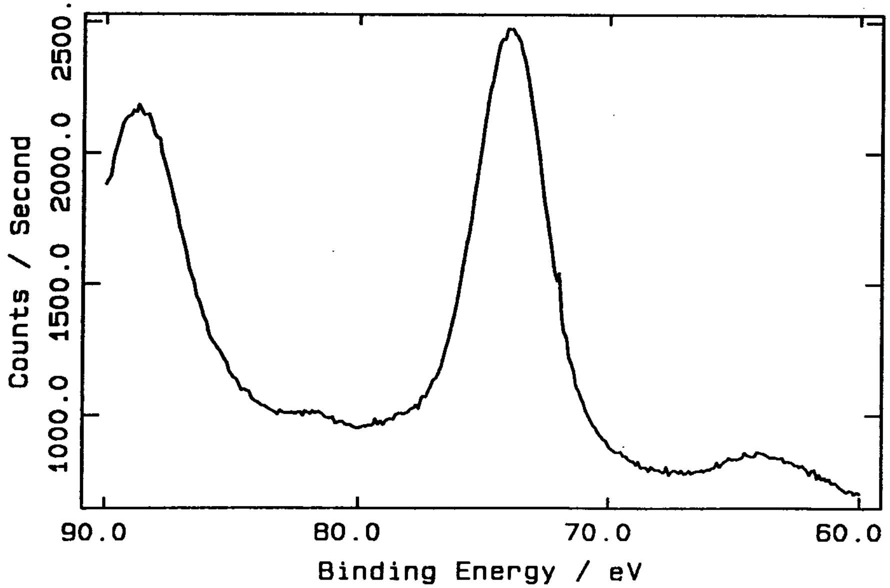
ALK 660, Panel 1 P 2p1/2, 2p3/2



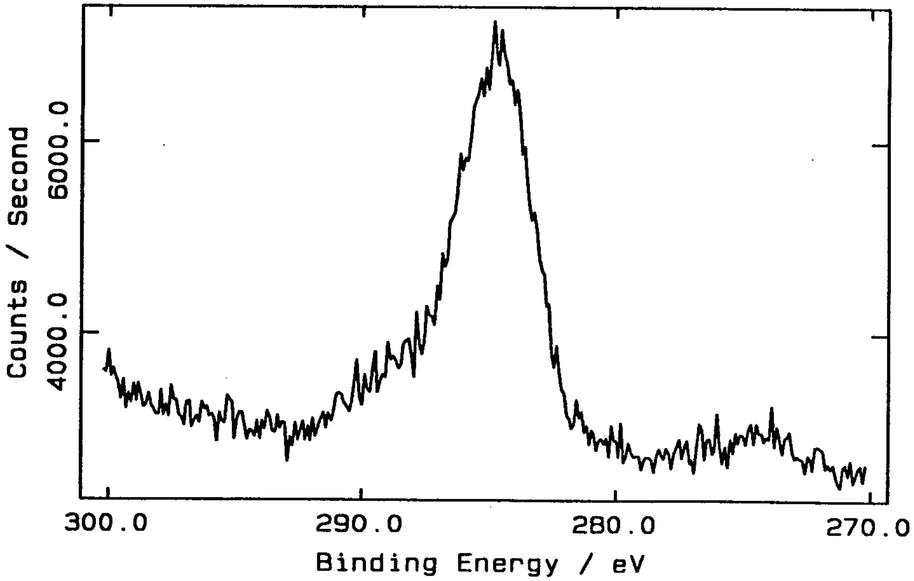
ALK 660, Panel 1 N 1s



ALK 660, Panel 1 Al 2p



ALK 660, Panel 1 C 1s



Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: ALK 660 Cleaned 7075 Al Test Panel 2

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN029.R1	None	Survey	RF = 3
ALPAN030	2.1148	Detail	PE = 200

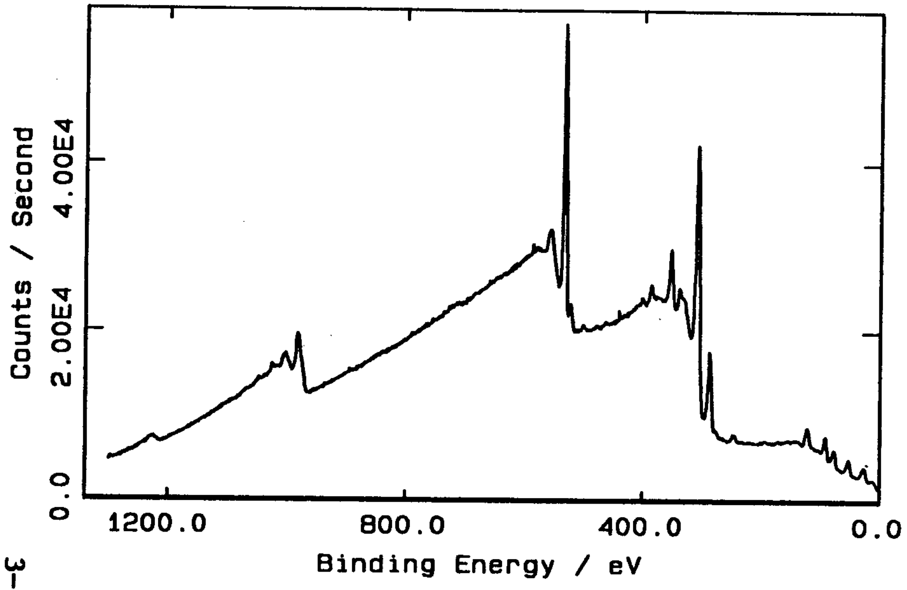
SUMMARY OF ANALYSIS

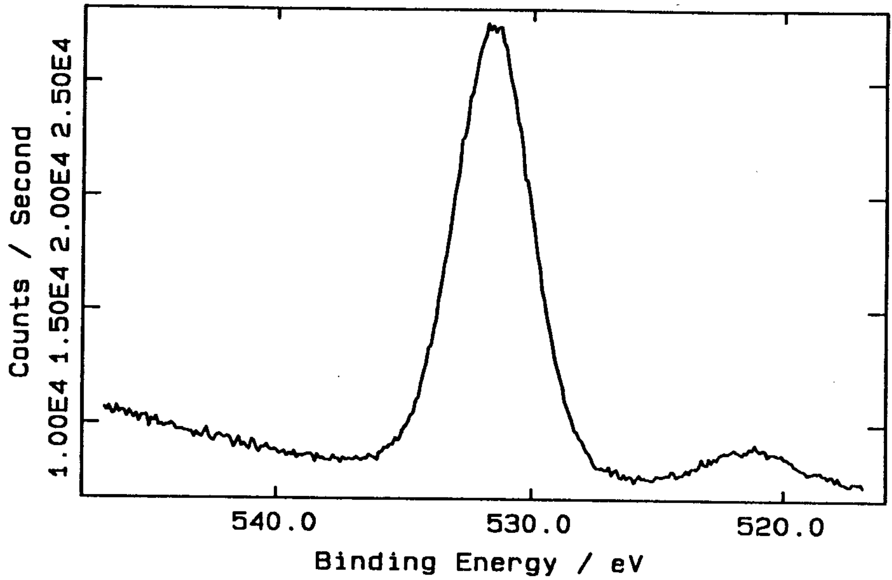
Run number: 1   Excitation: Al   Pass energy: 200 eV

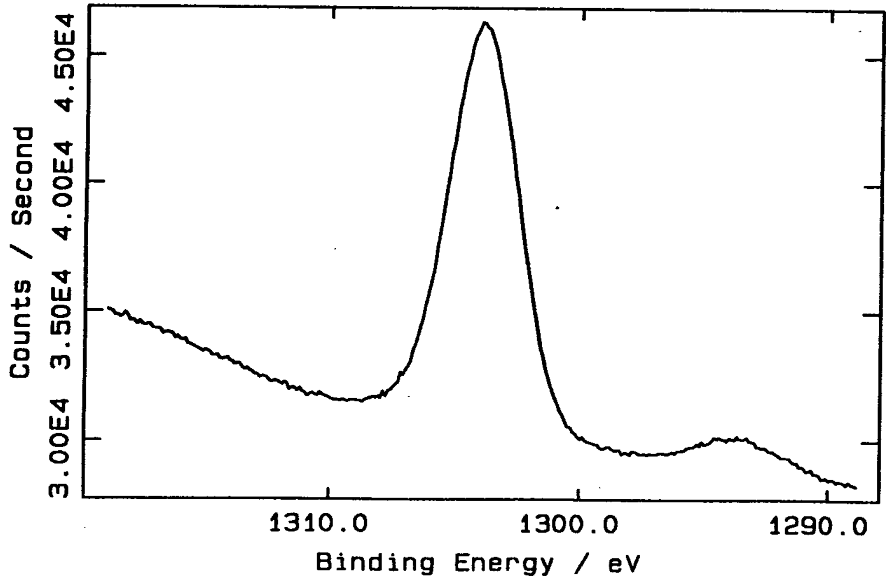
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN030.R1	Mg 1s	1303.93	54132.0000	31.78
2	ALPAN030.R2	O 1s	531.58	73612.0000	579.07
3	ALPAN030.R3	N 1s	399.38	2104.6250	32.94
4	ALPAN030.R4	C 1s	284.80	17271.0000	597.11
5	ALPAN030.R5	Si 2s	152.33	733.9276	11.87
6	ALPAN030.R5	See comments	140.13		
7	ALPAN030.R5	P 2p	133.99	708.9279	8.93
8	ALPAN030.R6	Mg 2s	88.71		
9	ALPAN030.R6	Al 2p	74.17	3018.7270	100.00

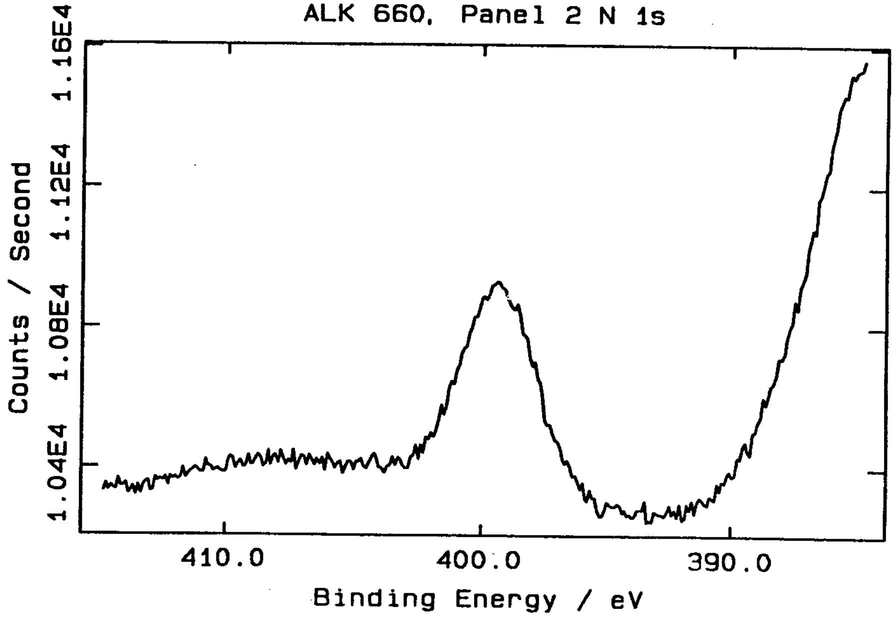
COMMENTS

1. Area of Si 2s peak estimated by curve-fitting.
2. Peak 6 may be assigned to Al 2s shakeup or to Zn 3s.

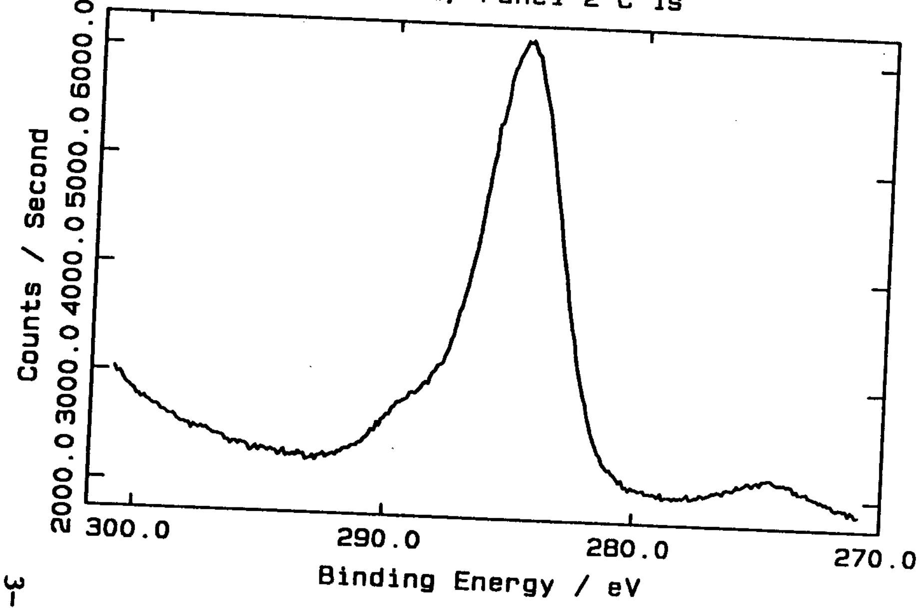

ALK 660. Panel 2 Survey


ALK 660. Panel 2 O 1s

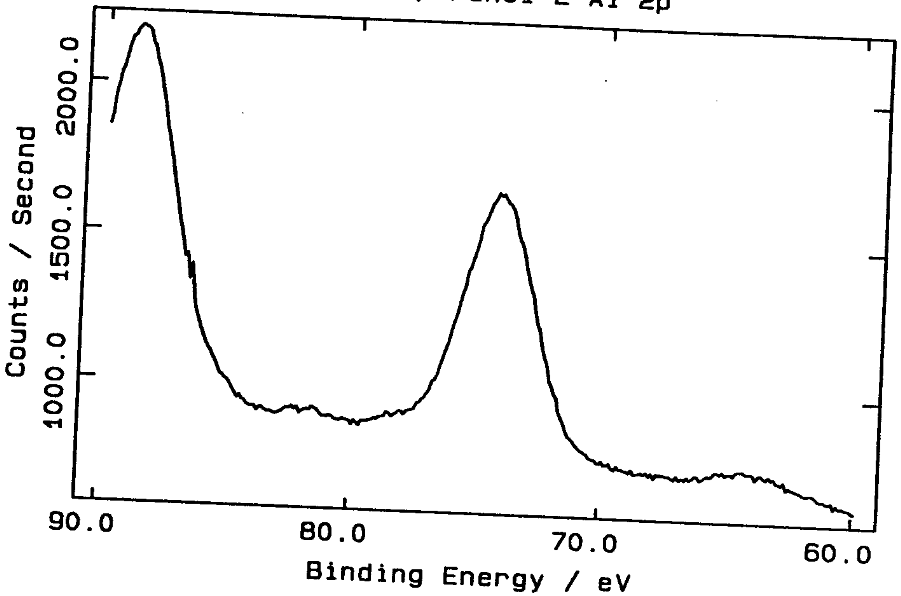

ALK 660. Panel 2 Mg 1s


ALK 660. Panel 2 N 1s

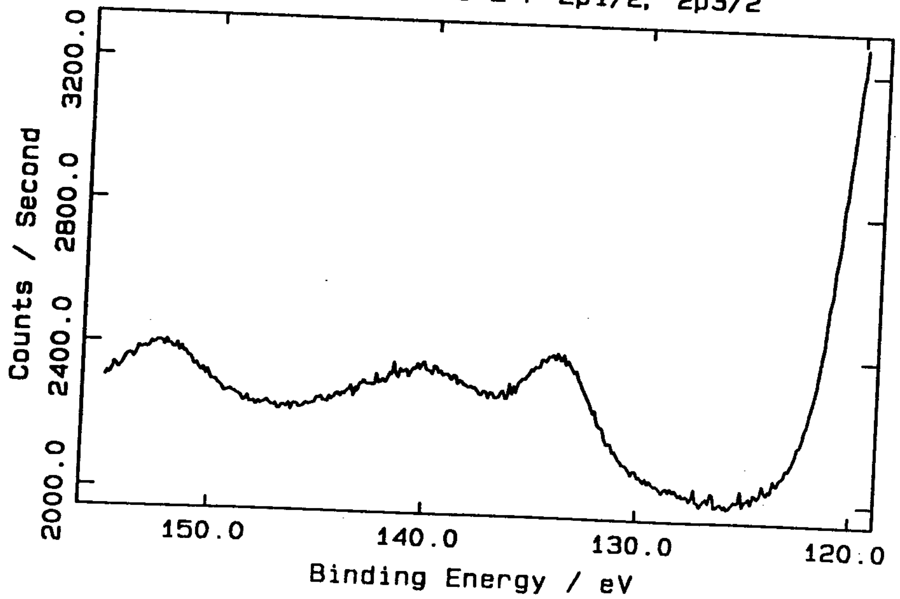
ALK 660, Panel 2 C 1s

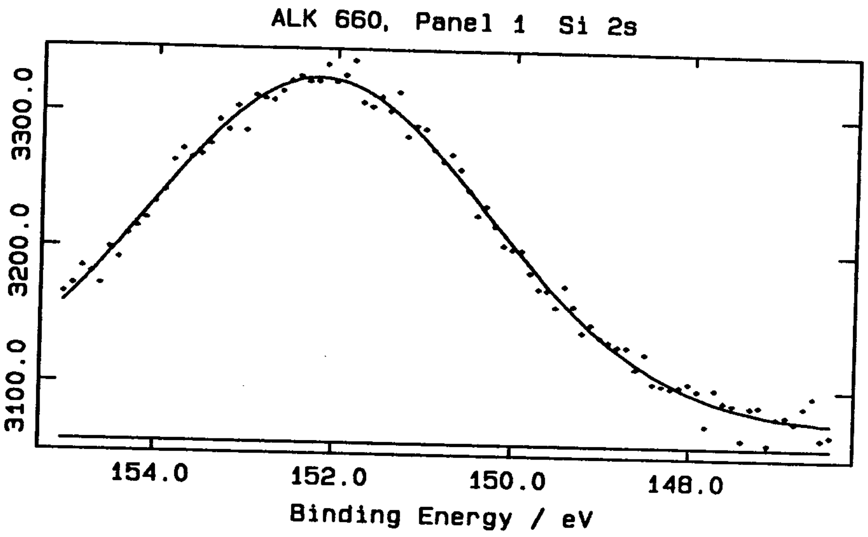


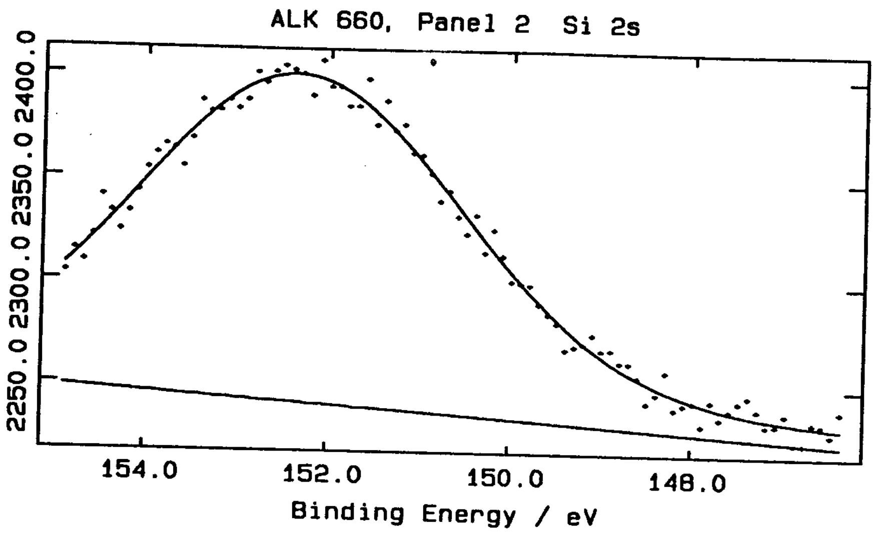
ALK 660, Panel 2 Al 2p

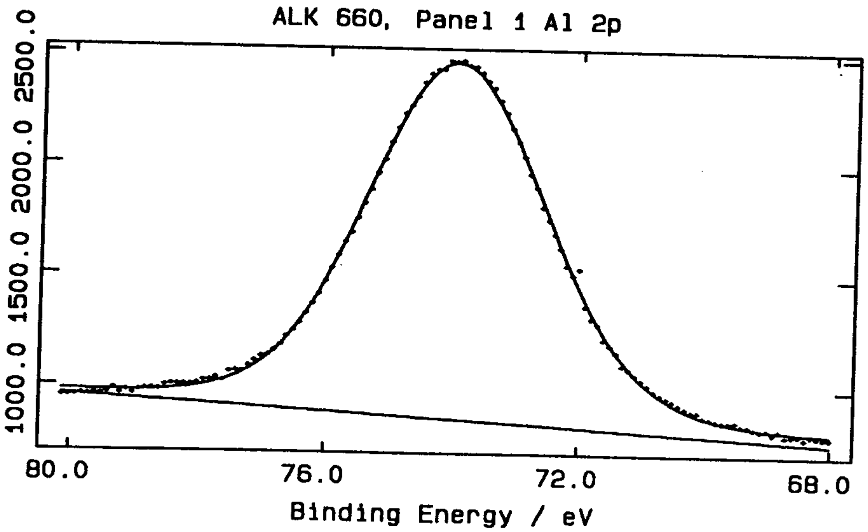


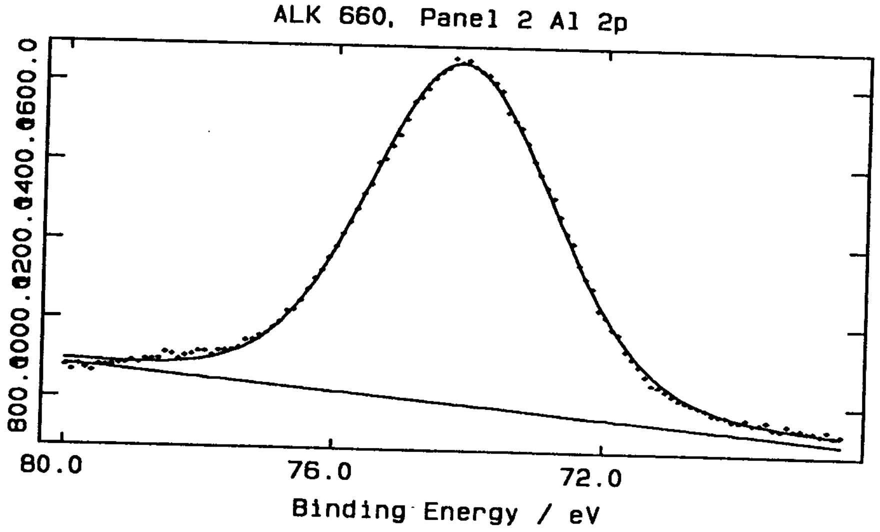
ALK 660, Panel 2 P 2p1/2, 2p3/2




ALK 660, Panel 1 Si 2s


ALK 660, Panel 2 Si 2s


ALK 660, Panel 1 Al 2p


ALK 660, Panel 2 Al 2p

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Penair HD-1 Cleaned 7075 Al Test Panel 1

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

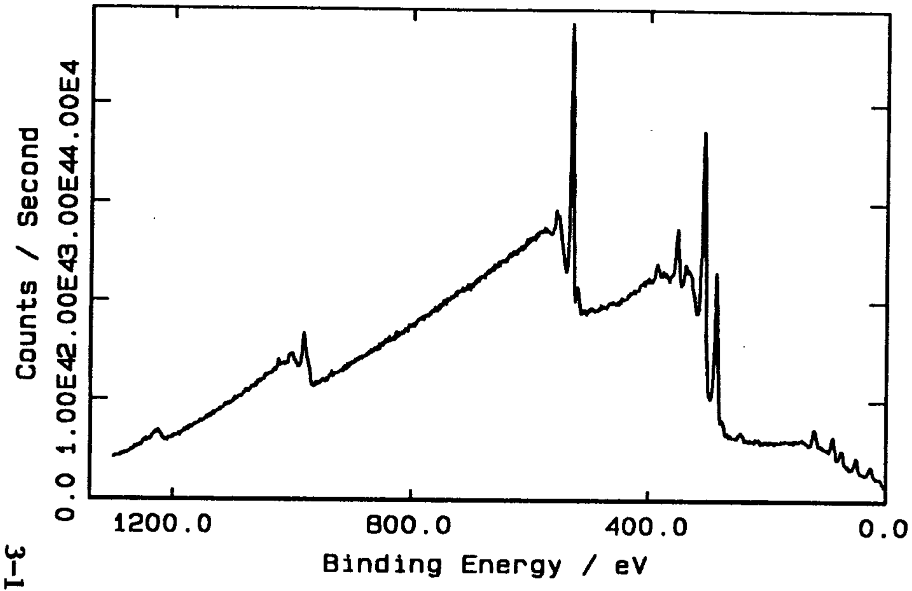
File name	Charge correction	Type	Instrument settings
ALPAN031.R1	None	Survey	RF = 3
ALPAN032	1.9863	Detail	PE = 200

SUMMARY OF ANALYSIS

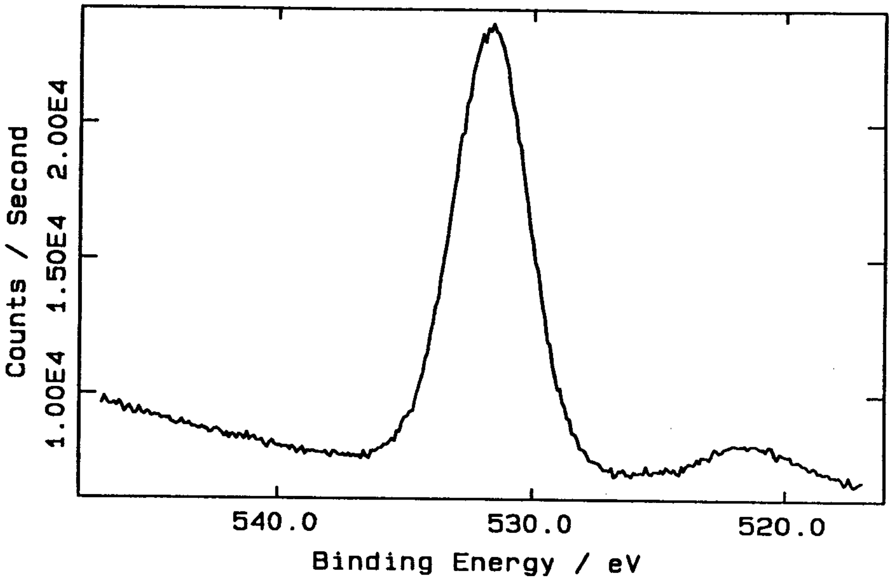
Run number: 1 Excitation: Al Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN032.R1	Mg 1s	1303.96	40302.0000	32.09
2	ALPAN032.R2	O 1s	531.71	59589.0000	635.79
3	ALPAN032.R3	C 1s	284.80	26258.0000	1231.39
4	ALPAN032.R4	Mg 2s	88.70		
5	ALPAN032.R4	Al 2p	74.29	2225.5890	100.00

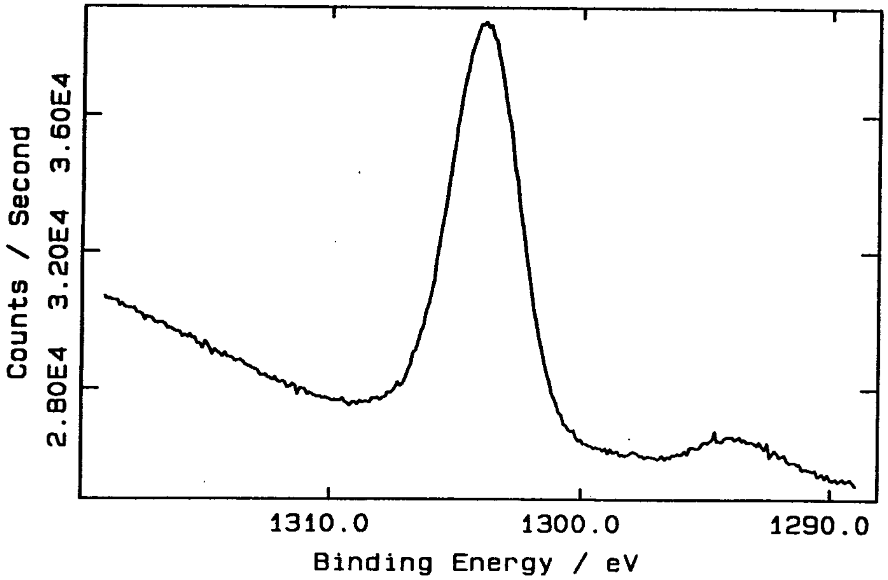
Penair HD-1, Panel 1 Survey

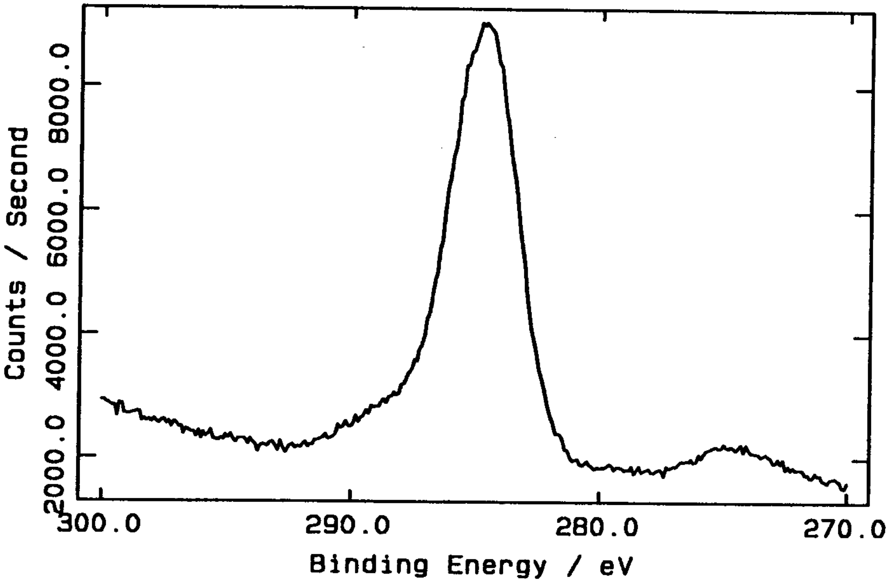


Penair HD-1, Panel 1 O 1s

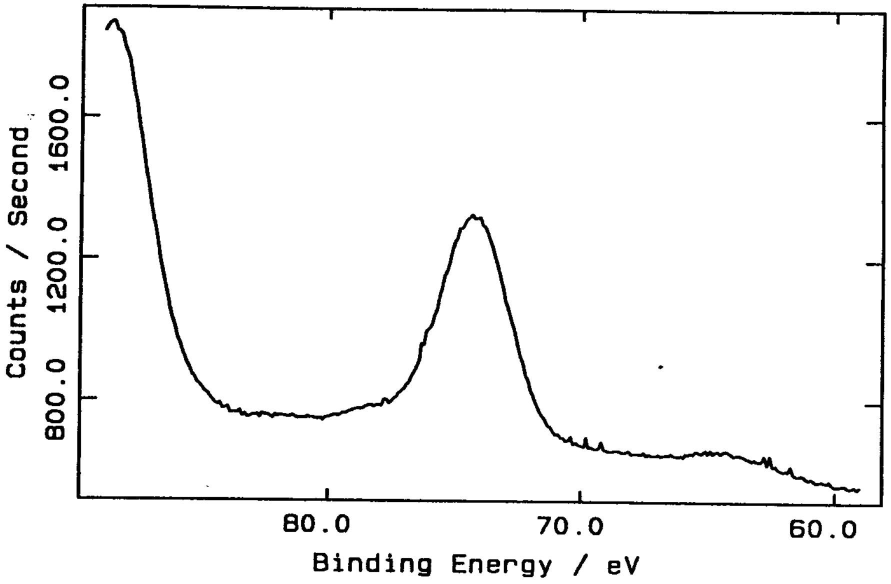


Penair HD-1, Panel 1 Mg 1s





Penair HD-1, Panel 1 C 1s



Penair HD-1, Panel 1 Al 2p

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Penair HD-1 Cleaned 7075 Al Test Panel 2

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

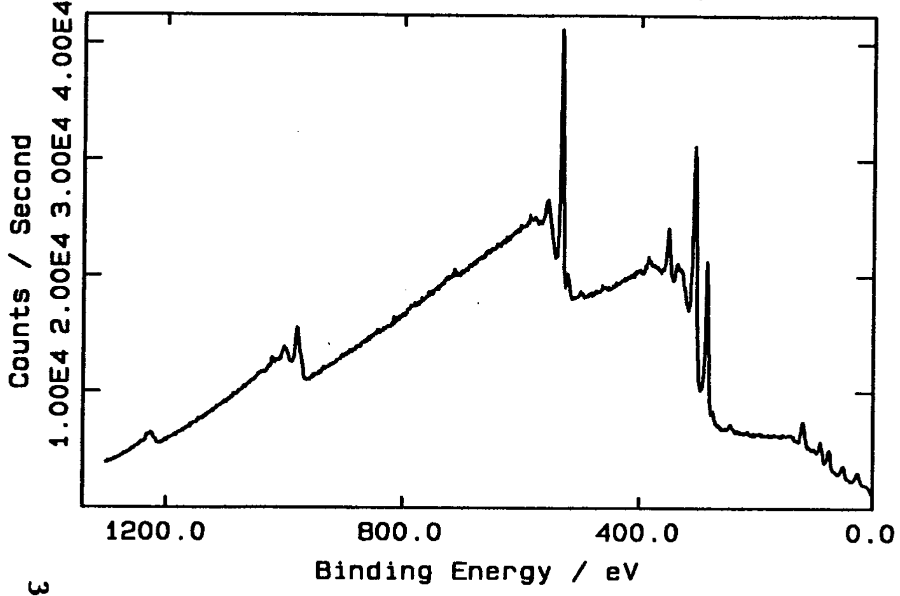
FILE SUMMARY

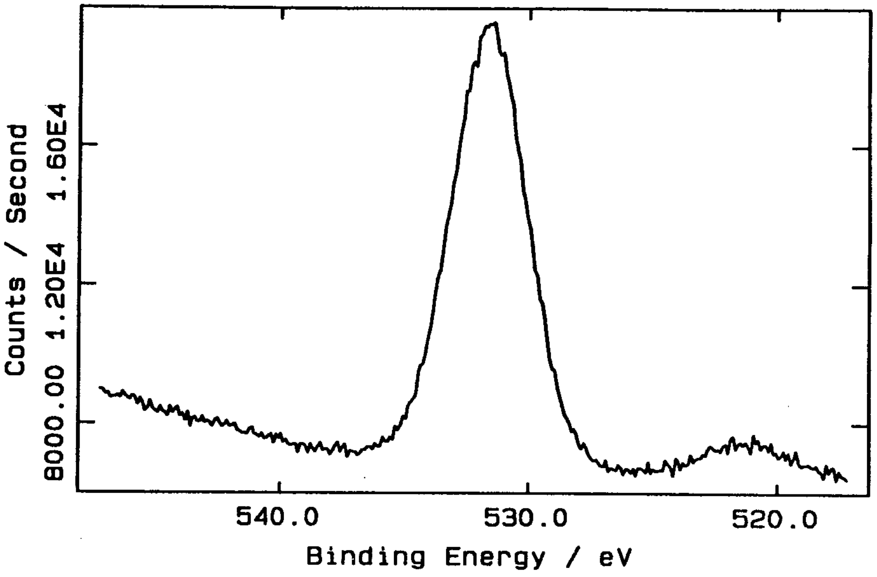
File name	Charge correction	Type	Instrument settings
ALPAN033.R1	None	Survey	RF = 3
ALPAN034	1.7536	Detail	PE = 200

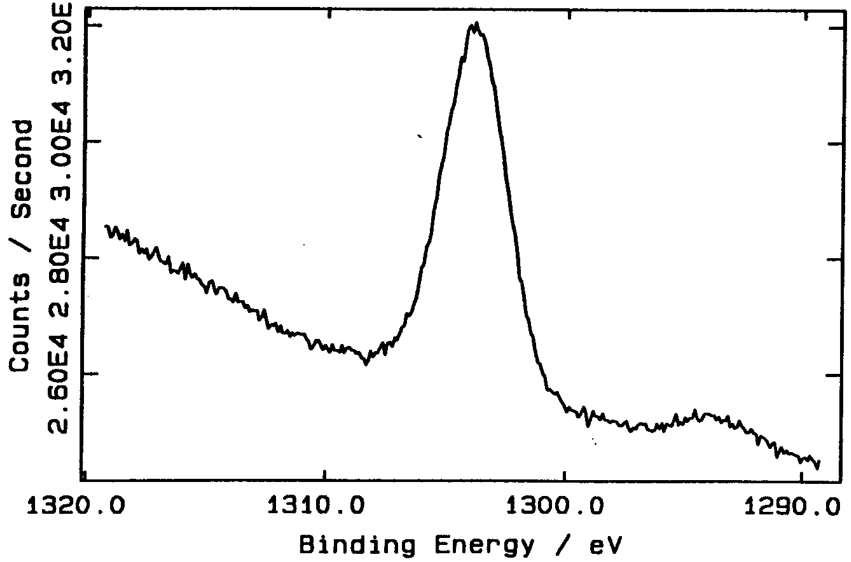
SUMMARY OF ANALYSIS

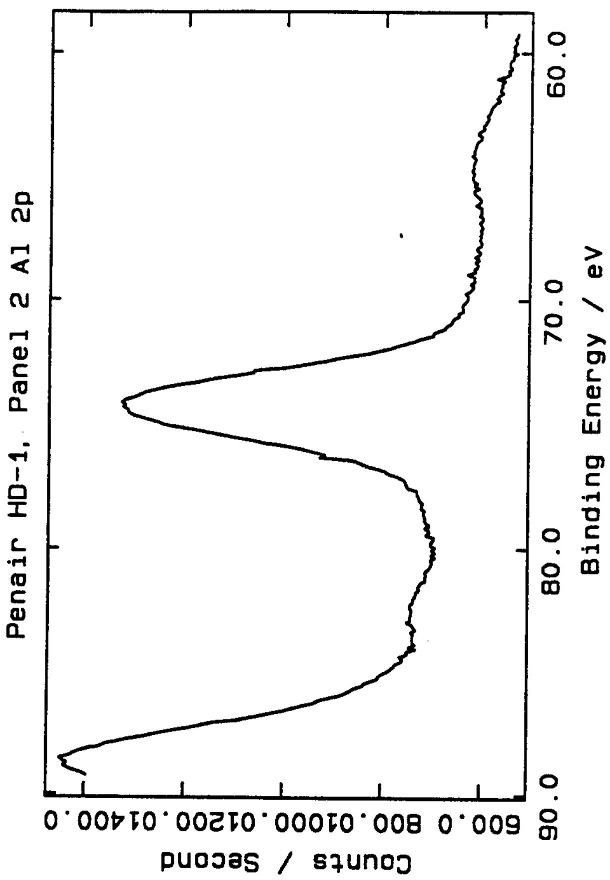
Run number: 1 Excitation: Al Pass energy: 200 eV

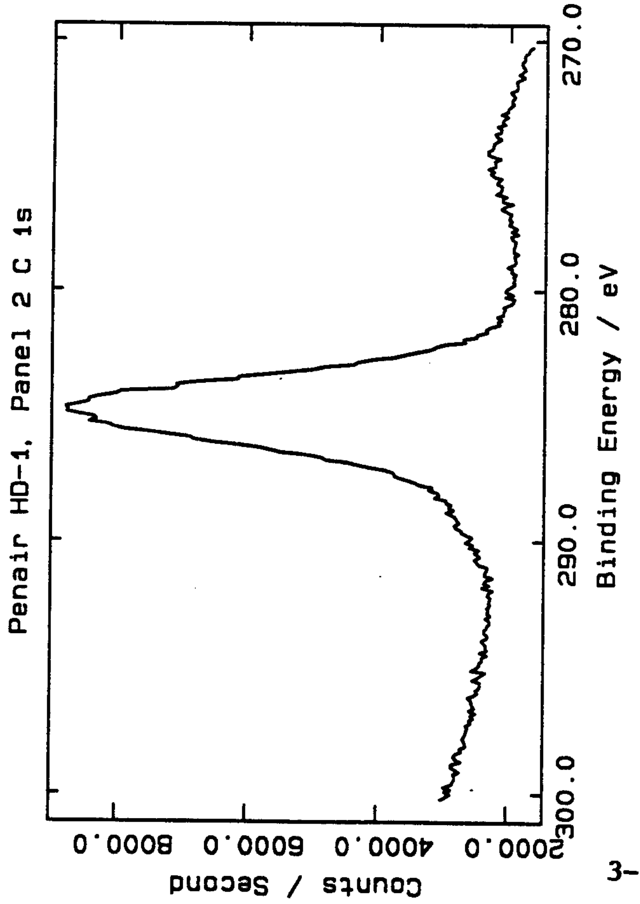
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN034.R1	Mg 1s	1303.87	20861.0000	15.61
2	ALPAN034.R2	O 1s	531.65	47387.0000	475.15
3	ALPAN034.R3	C 1s	284.80	24393.0000	1075.00
4	ALPAN034.R4	Mg 2s	88.63		
5	ALPAN034.R4	Al 2p	74.29	2368.3000	100.00


Penair HD-1, Panel 2 Survey


Penair HD-1, Panel 2 O 1s


Penair HD-1, Panel 2 Mg 1s


Penair HD-1, Panel 2 Al 2p
Counts / Second
600.0
800.0
1000.0
1200.0
1400.0
Binding Energy / eV
90.0
80.0
70.0
60.0


Penair HD-1, Panel 2 C 1s
Counts / Second
2000.0
4000.0
6000.0
8000.0
Binding Energy / eV
300.0
290.0
280.0
270.0

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Rebound 7 Cleaned 7075 Al Test Panel 1

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

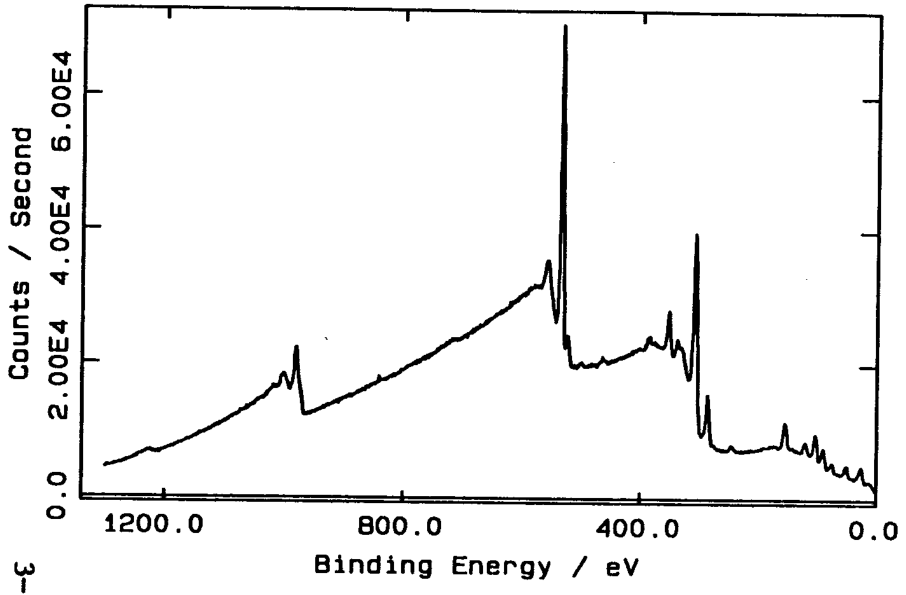
File name	Charge correction	Type	Instrument settings
ALPAN035.R1	None	Survey	RF = 3
ALPAN036	2.1810	Detail	PE = 200

SUMMARY OF ANALYSIS

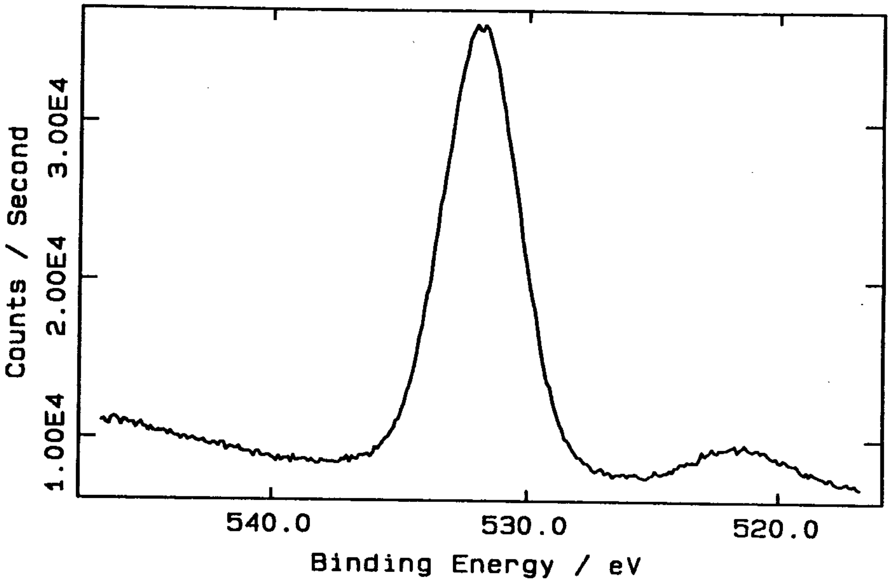
Run number: 1   Excitation: Al   Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN036.R1	Mg 1s	1304.16	44908.0000	25.00
2	ALPAN036.R2	O 1s	531.88	104780.0000	782.12
3	ALPAN036.R3	C 1s	284.80	11997.0000	393.64
4	ALPAN036.R4	Si 2p	102.42	6275.9970	122.61
5	ALPAN036.R5	Mg 2s	88.87		
6	ALPAN036.R5	Al 2p	74.32	3180.9970	100.00

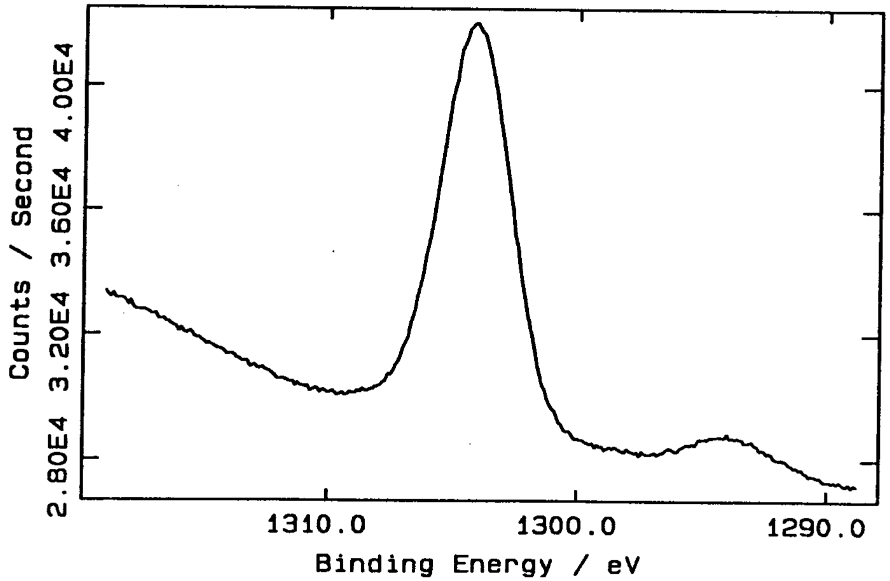
Rebound 7. Panel 1 Survey



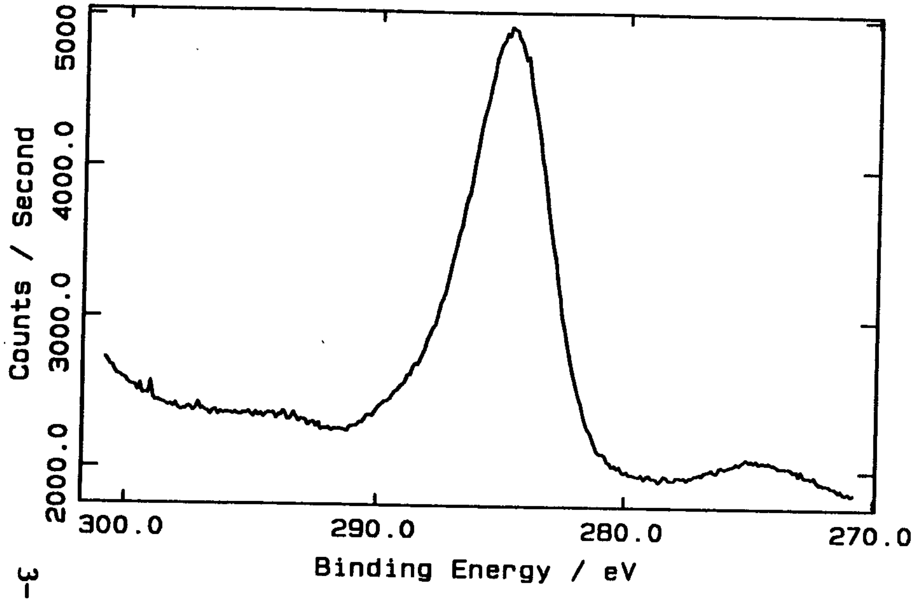
Rebound 7. Panel 1 O 1s



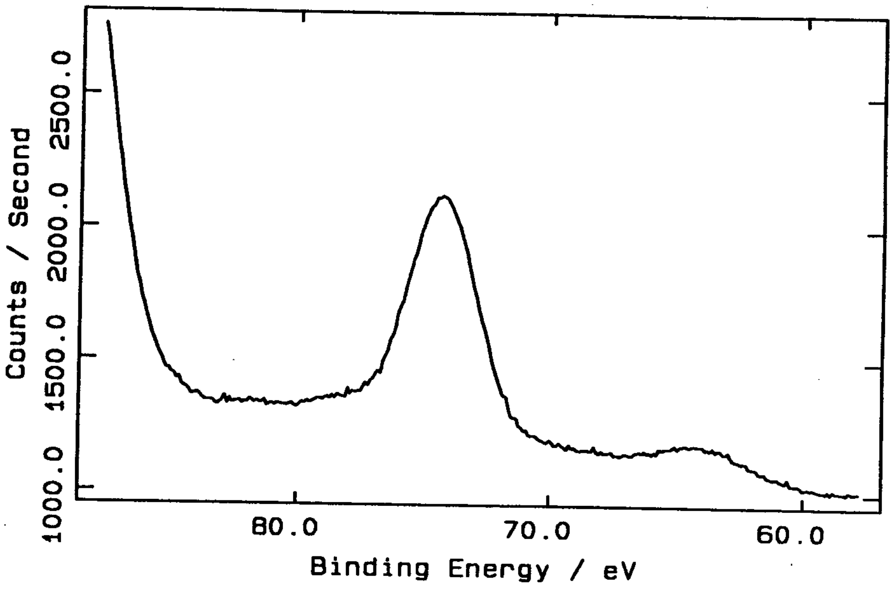
Rebound 7. Panel 1 Mg 1s



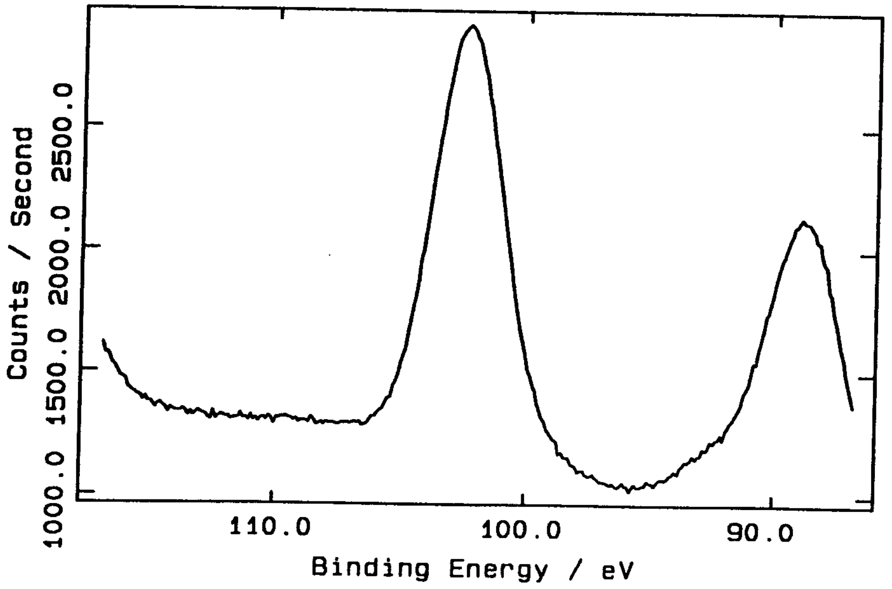
Rebound 7, Panel 1 C 1s



Rebound 7, Panel 1 Al 2p



Rebound 7, Panel 1 Si 2p



Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Rebound 7 Cleaned 7075 Al Test Panel 2

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

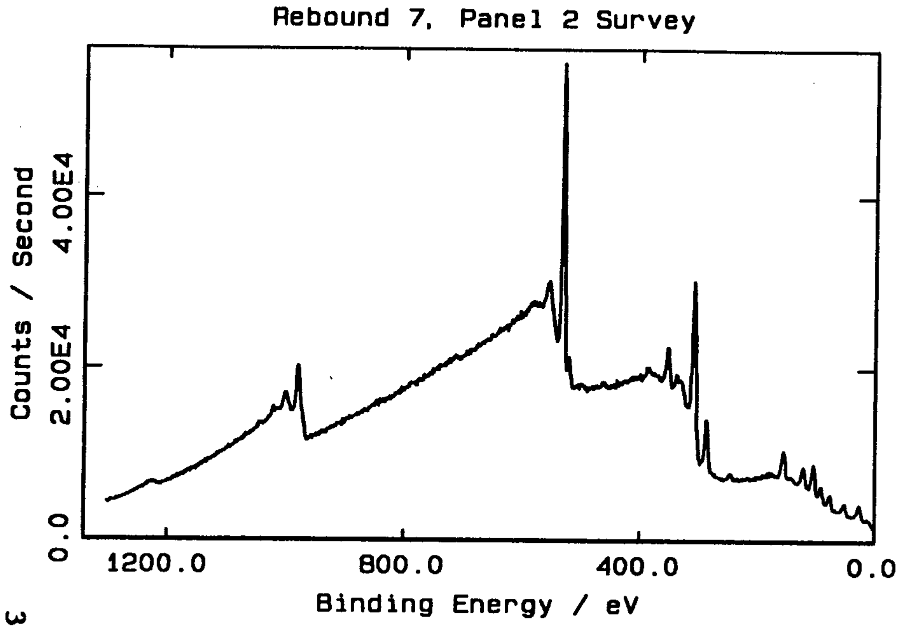
FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN037.R1	None	Survey	RF = 3
ALPAN038	1.9700	Detail	PE = 200

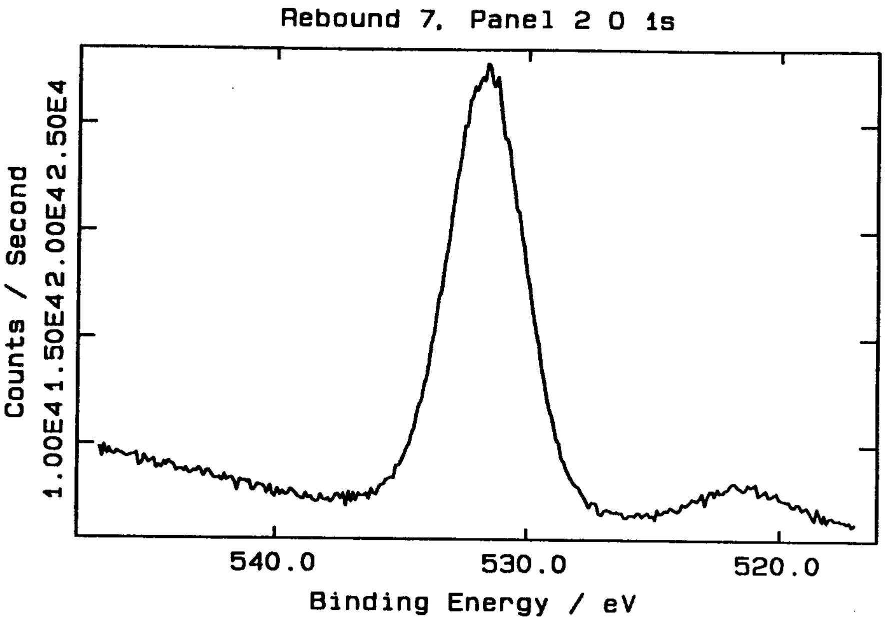
SUMMARY OF ANALYSIS

Run number: 1   Excitation: Al   Pass energy: 200 eV

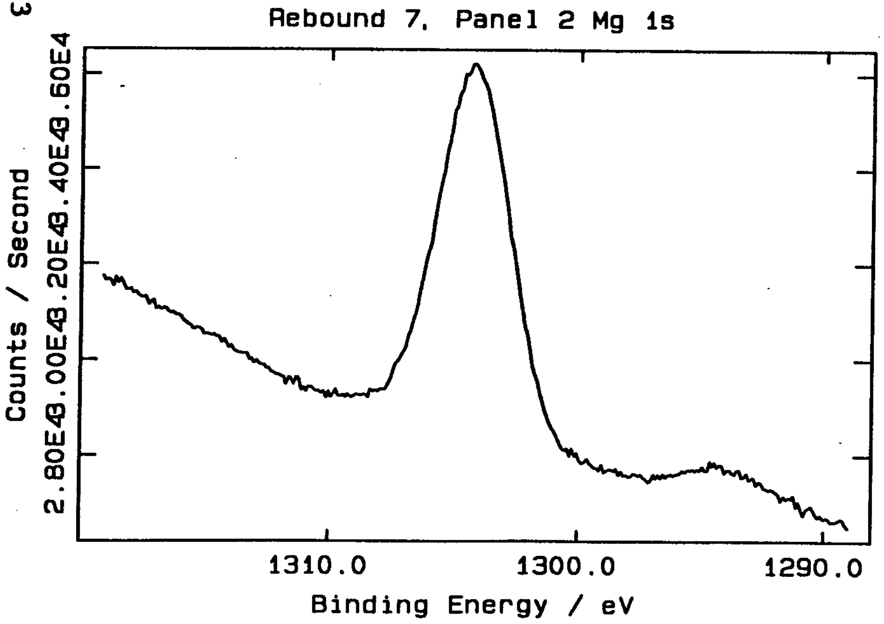
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN038.R1	Mg 1s	1304.27	27828.0000	14.01
2	ALPAN038.R2	O 1s	531.70	77900.0000	526.03
3	ALPAN038.R3	C 1s	284.80	12201.0000	362.12
4	ALPAN038.R4	Si 2p	102.44	5064.4430	89.50
5	ALPAN038.R5	Mg 2s	88.95		
6	ALPAN038.R5	Al 2p	74.26	3516.6090	100.00



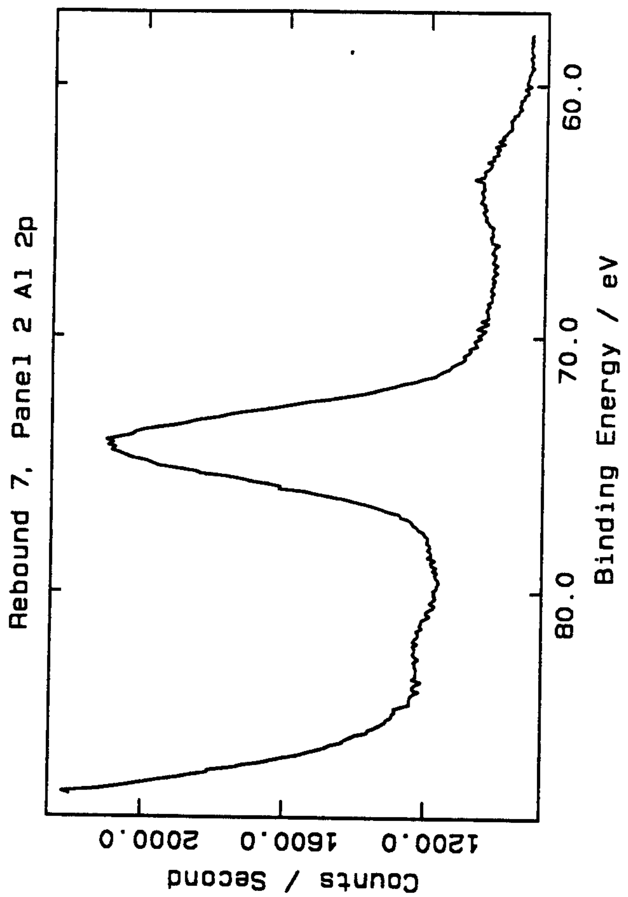
Rebound 7. Panel 2 Survey

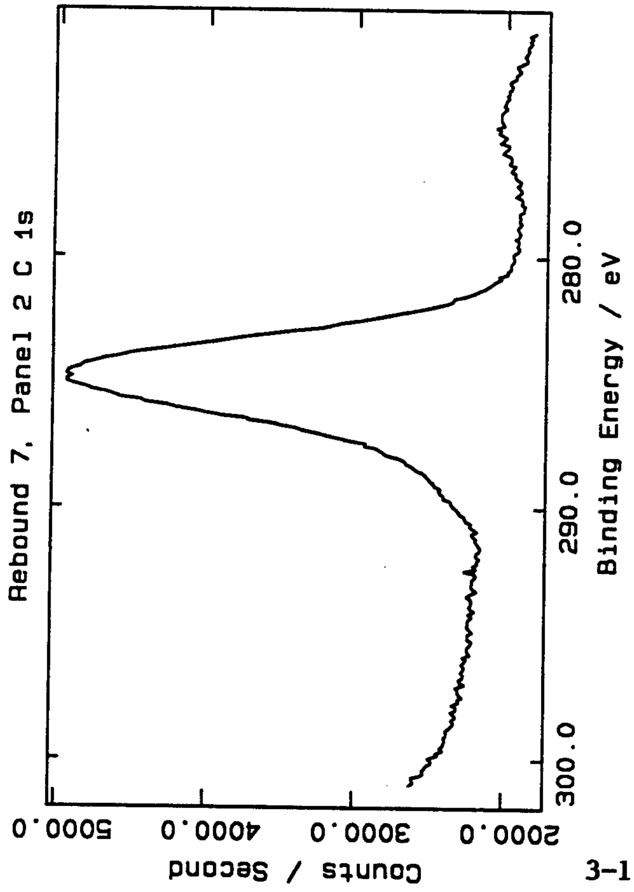


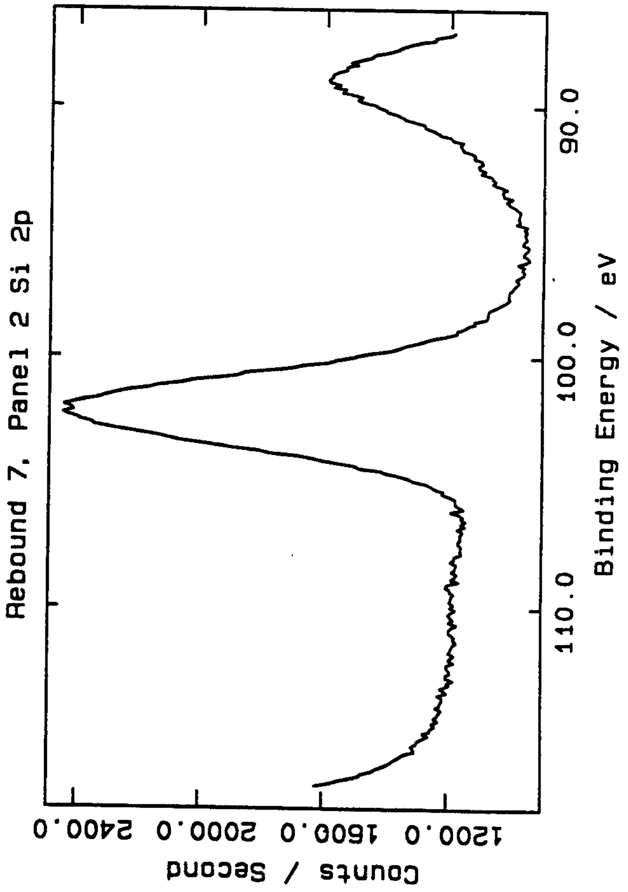
Rebound 7. Panel 2 O 1s



Rebound 7. Panel 2 Mg 1s


Rebound 7, Panel 2 Al 2p
Counts / Second
1200.0
1600.0
2000.0
Binding Energy / eV
80.0
70.0
60.0


Rebound 7, Panel 2 C 1s
Counts / Second
2000.0
3000.0
4000.0
5000.0
Binding Energy / eV
300.0
290.0
280.0


Rebound 7, Panel 2 Si 2p
Counts / Second
1200.0
1600.0
2000.0
2400.0
Binding Energy / eV
110.0
100.0
90.0

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: DOT-111/ 113 Cleaned 7075 Al Test Panel 1

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

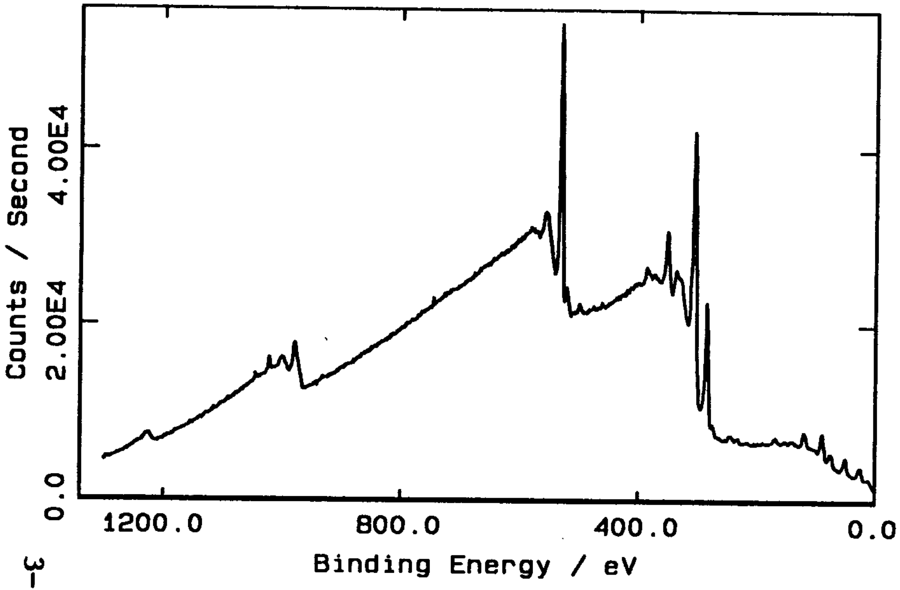
File name	Charge correction	Type	Instrument settings
ALPAN039.R1	None	Survey	RF = 3
ALPAN040	2.0678	Detail	PE = 200

SUMMARY OF ANALYSIS

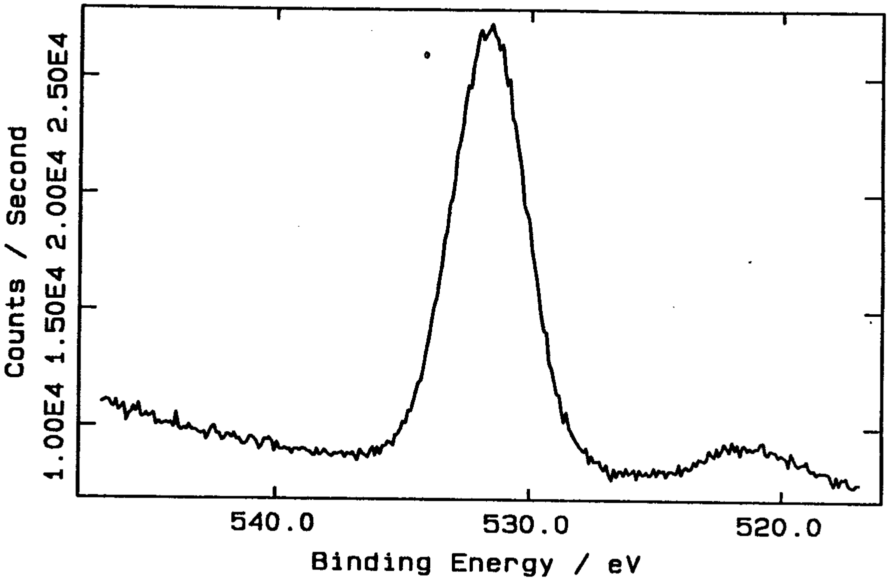
Run number: 1   Excitation: Al   Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN040.R1	Mg 1s	1303.92	47283.0000	36.05
2	ALPAN040.R2	O 1s	531.65	67563.0000	690.23
3	ALPAN040.R3	C 1s	284.80	23828.0000	1069.90
4	ALPAN040.R4	S 2p	168.25	1574.2500	17.42
5	ALPAN040.R5	Mg 2s	88.81		
6	ALPAN040.R5	Al 2p	74.29	2324.4730	100.00

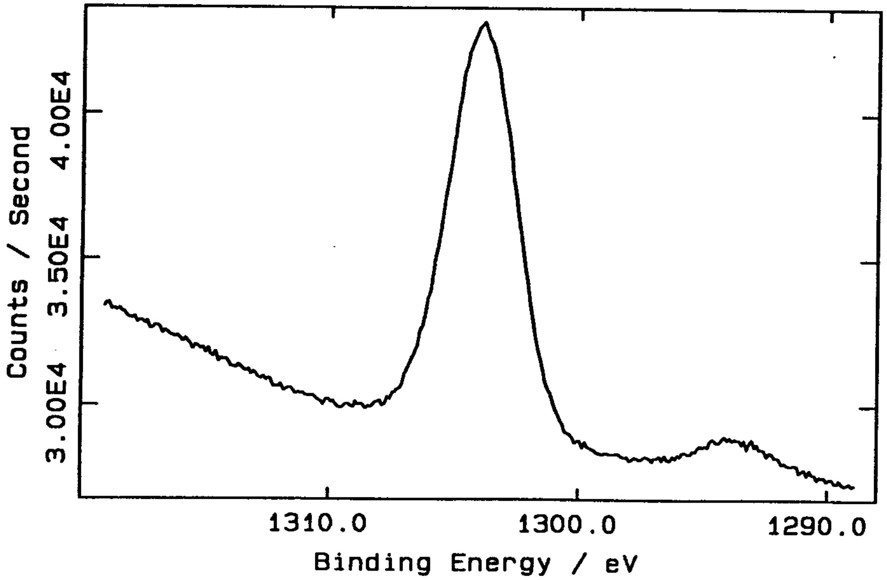
DOT- 111/ 113, Panel 1 Survey



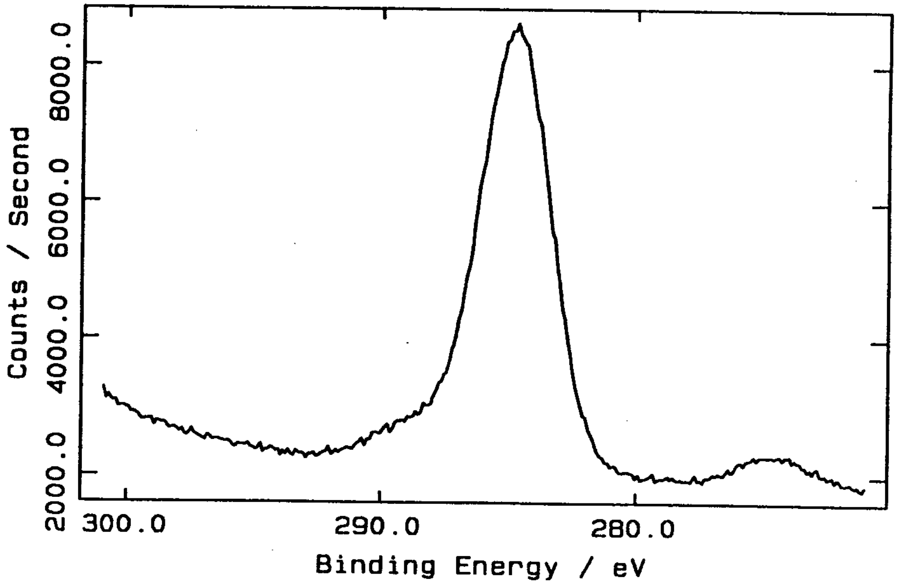
DOT- 111/ 113, Panel 1 O 1s

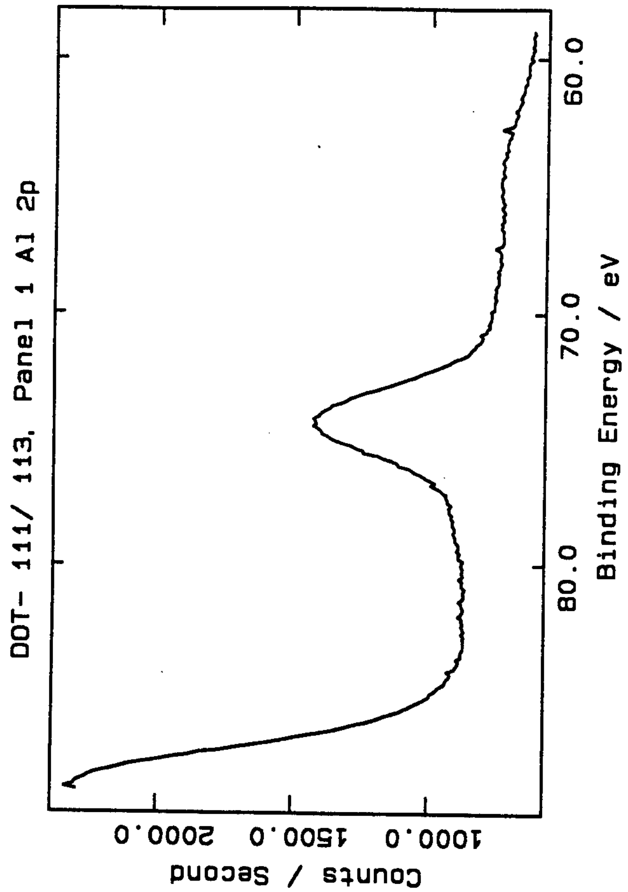


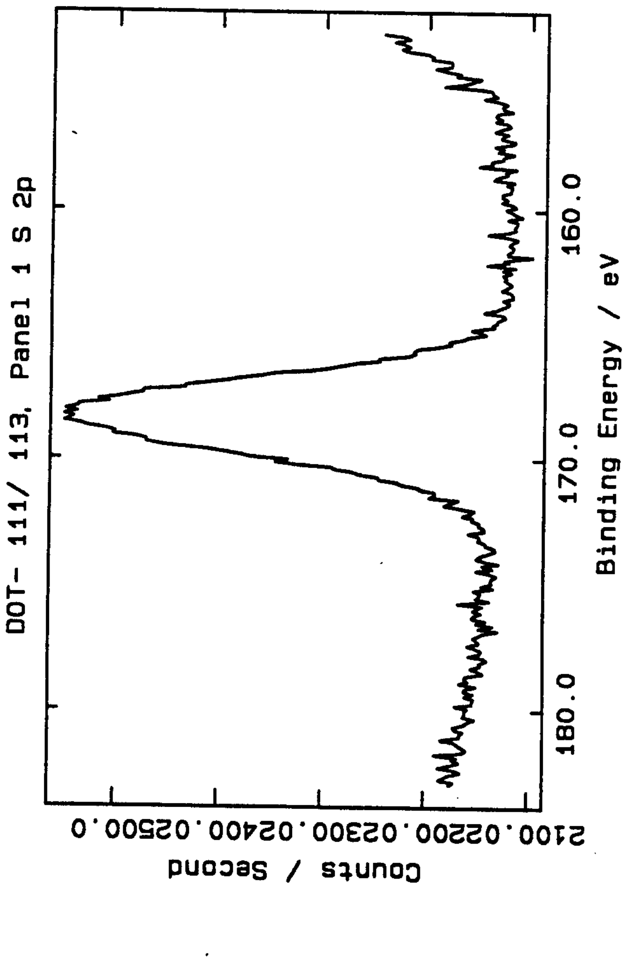
DOT- 111/ 113, Panel 1 Mg 1s



DOT- 111/ 113, Panel 1 C 1s




DOT- 111/ 113, Panel 1 Al 2p
Counts / Second
1000.0
1500.0
2000.0
Binding Energy / eV
80.0
70.0
60.0


DOT- 111/ 113, Panel 1 S 2p
Counts / Second
2100.0
2200.0
2300.0
2400.0
2500.0
Binding Energy / eV
180.0
170.0
160.0

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: DOT-111/ 113 Cleaned 7075 Al Test Panel 2

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

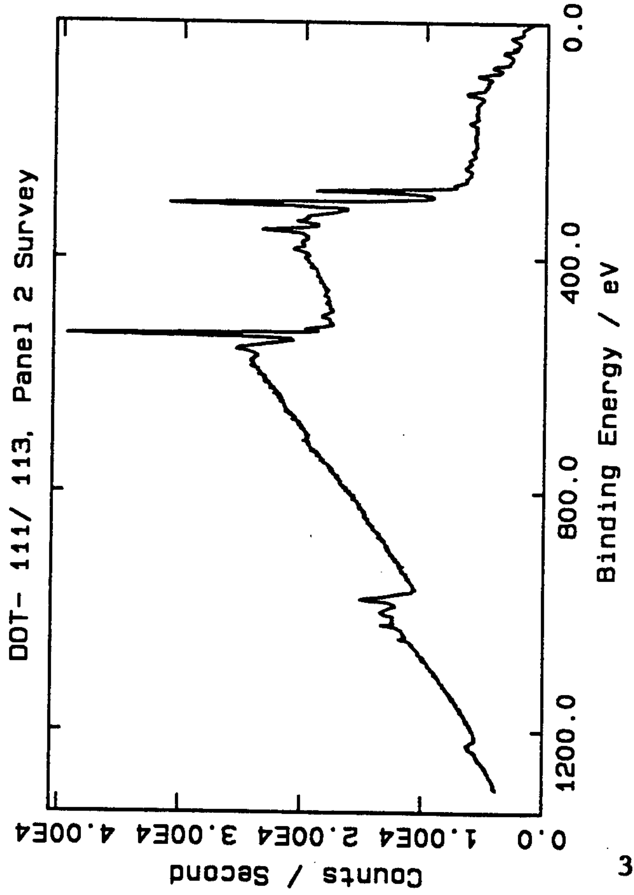
FILE SUMMARY

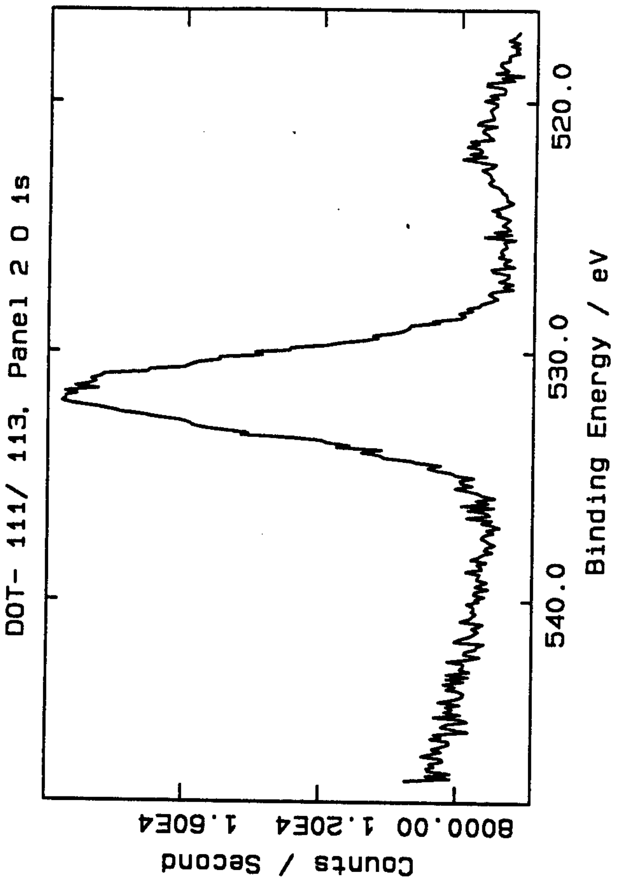
File name	Charge correction	Type	Instrument settings
ALPAN041	None	Survey	RF = 3
ALPAN042	1.7898	Detail	PE = 200

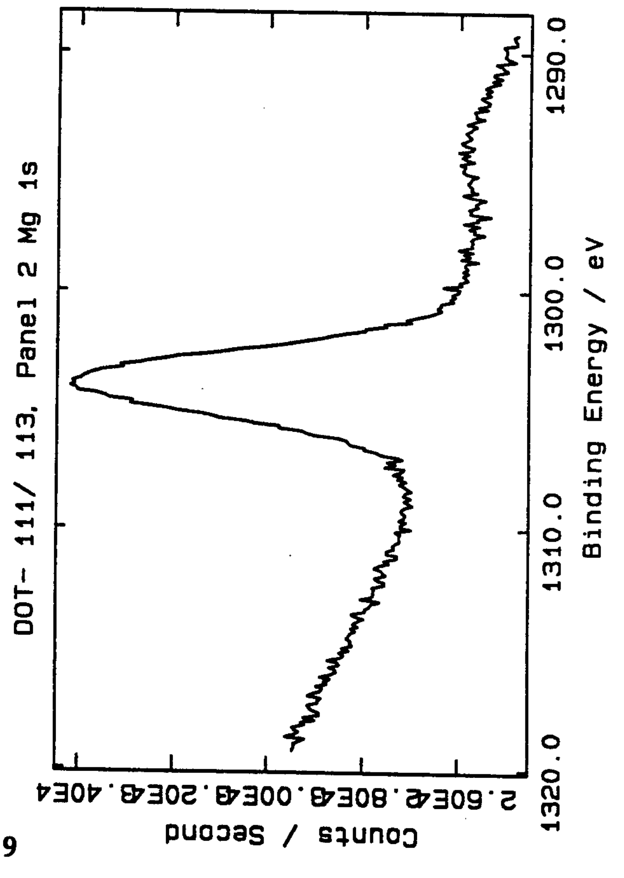
SUMMARY OF ANALYSIS

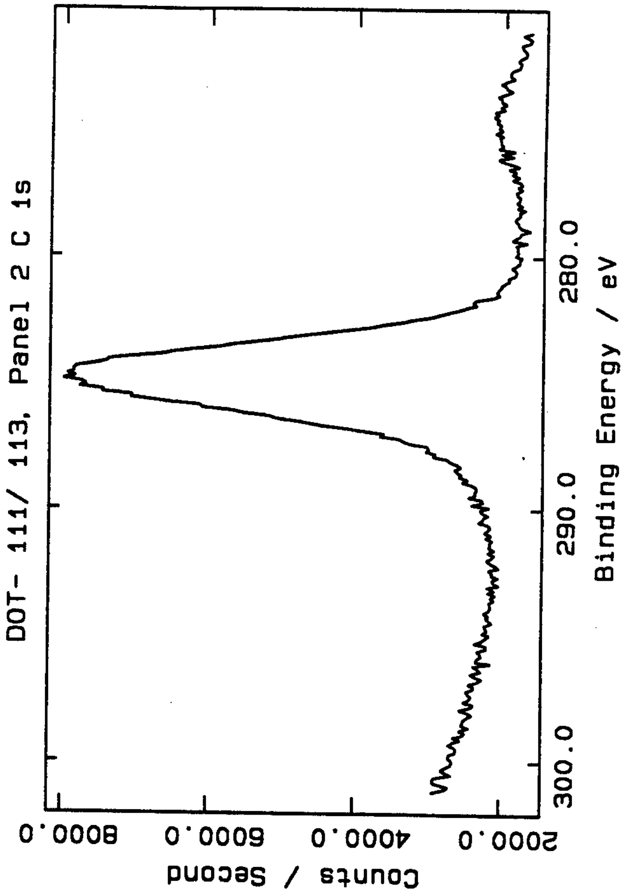
Run number: 1   Excitation: Al   Pass energy: 200 eV

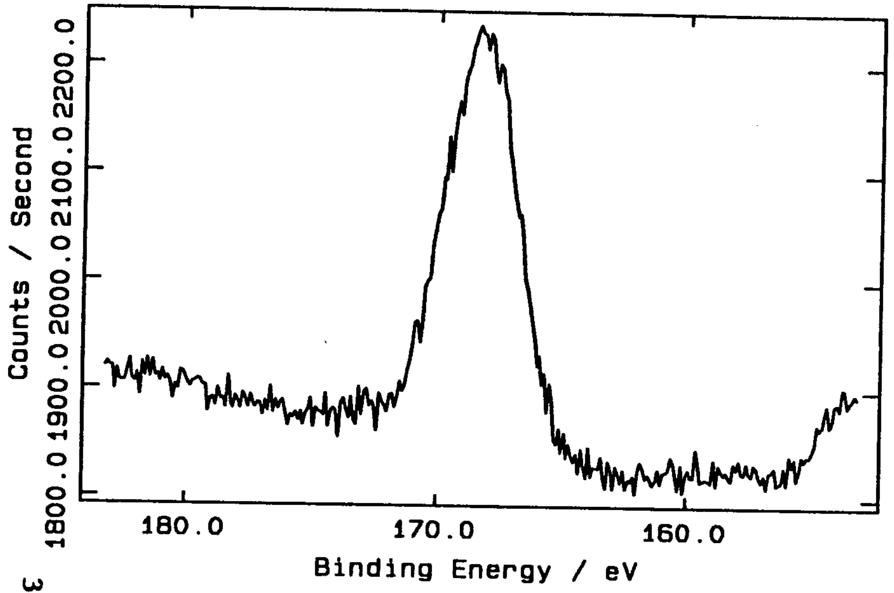
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN042.R1	Mg 1s	1303.97	26109.0000	25.13
2	ALPAN042.R2	O 1s	531.65	45729.0000	589.79
3	ALPAN042.R3	C 1s	284.80	21619.0000	1225.51
4	ALPAN042.R4	S 2p	168.27	1420.1940	19.84
5	ALPAN042.R5	Mg 2s	88.80		
6	ALPAN042.R5	Al 2p	74.36	1841.2340	100.00

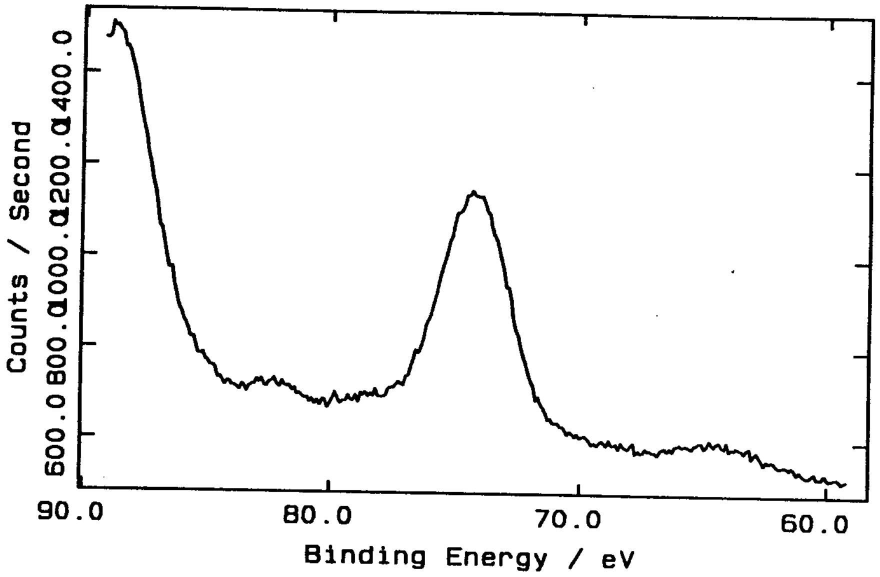

DOT- 111/ 113, Panel 2 Survey
Counts / Second
0.0
1.00E4
2.00E4
3.00E4
4.00E4
Binding Energy / eV
1200.0
800.0
400.0
0.0


DOT- 111/ 113, Panel 2 O 1s
Counts / Second
8000.00
1.20E4
1.60E4
Binding Energy / eV
540.0
530.0
520.0


DOT- 111/ 113, Panel 2 Mg 1s
Counts / Second
2.60E4
2.80E4
3.00E4
3.20E4
3.40E4
Binding Energy / eV
1320.0
1310.0
1300.0
1290.0


DOT- 111/ 113, Panel 2 C 1s
Counts / Second
2000.0
4000.0
6000.0
8000.0
Binding Energy / eV
300.0
290.0
280.0


DOT- 111/ 113, Panel 2 S 2p


DOT- 111/ 113, Panel 2 Al 2p

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Metal Aid-Dr Cleaned 7075 Al Test Panel 1, Side A

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

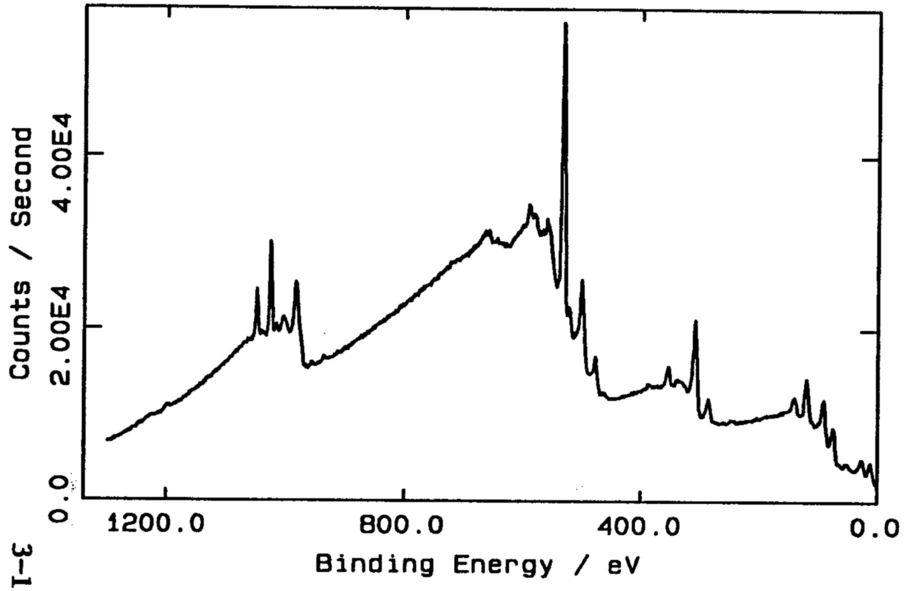
FILE SUMMARY

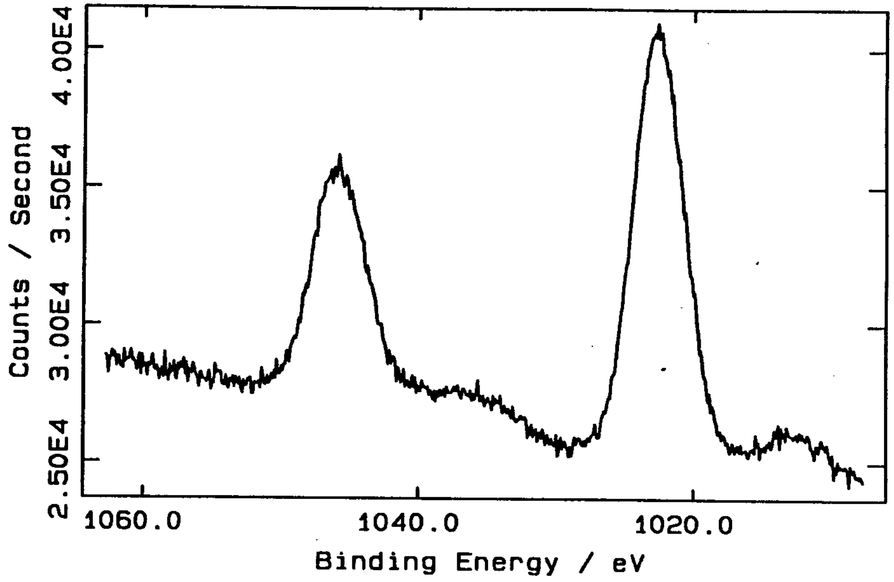
File name	Charge correction	Type	Instrument settings
ALPAN044.R1	None	Survey	RF = 3
ALPAN045	2.2299	Detail	PE = 200

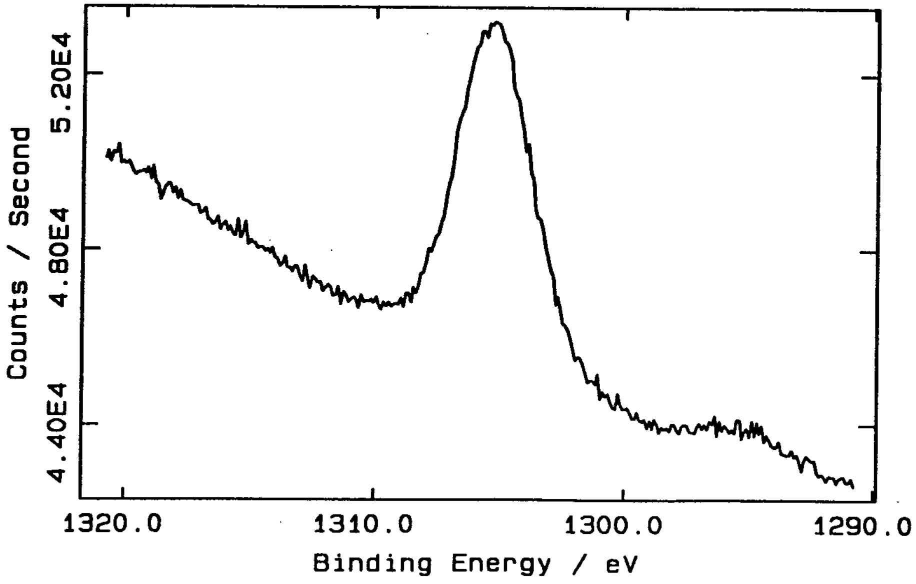
SUMMARY OF ANALYSIS

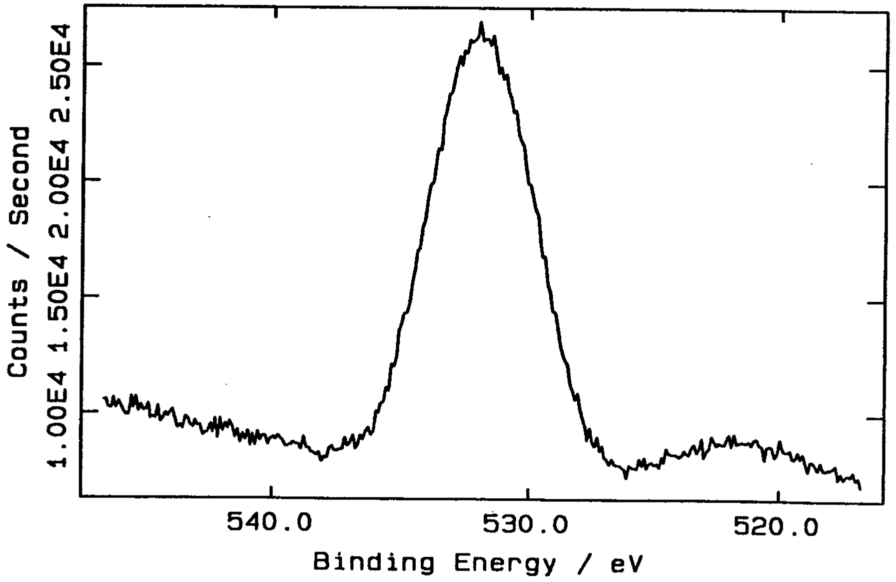
Run number: 1   Excitation: Al   Pass energy: 200 eV

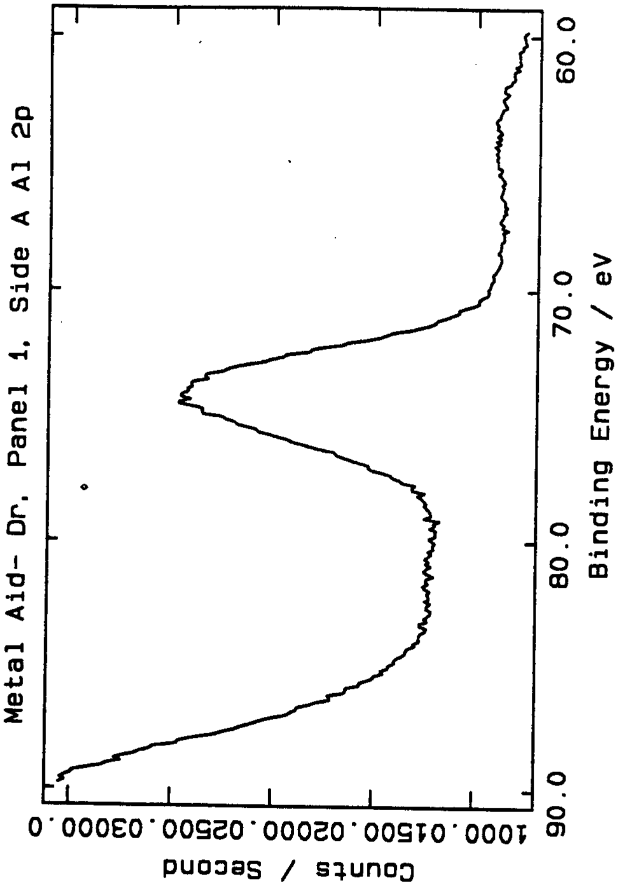
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN045.R1	Mg 1s	1305.37	29181.0000	8.49
2	ALPAN045.R2	Zn 2p$_{1/2}$	1045.86		
3	ALPAN045.R2	Zn 2p$_{3/2}$	1022.75	67710.0000	7.22
4	ALPAN045.R3	O 1s	531.98	91856.0000	359.41
5	ALPAN045.R4	C 1s	289.47		
6	ALPAN045.R4	C 1s	284.80		
7	ALPAN045.R4	C 1s		6690.1430	115.03
8	ALPAN045.R5	Al 2p	74.20	6067.8210	100.00


Metal Aid- Dr. Panel 1. Side A. Survey


Metal Aid- Dr. Panel 1. Side A Zn 2p1/2. 2p3/2


Metal Aid- Dr. Panel 1. Side A Mg 1s


Metal Aid- Dr. Panel 1. Side A O 1s


Metal Aid- Dr. Panel 1, Side A Al 2p
Counts / Second
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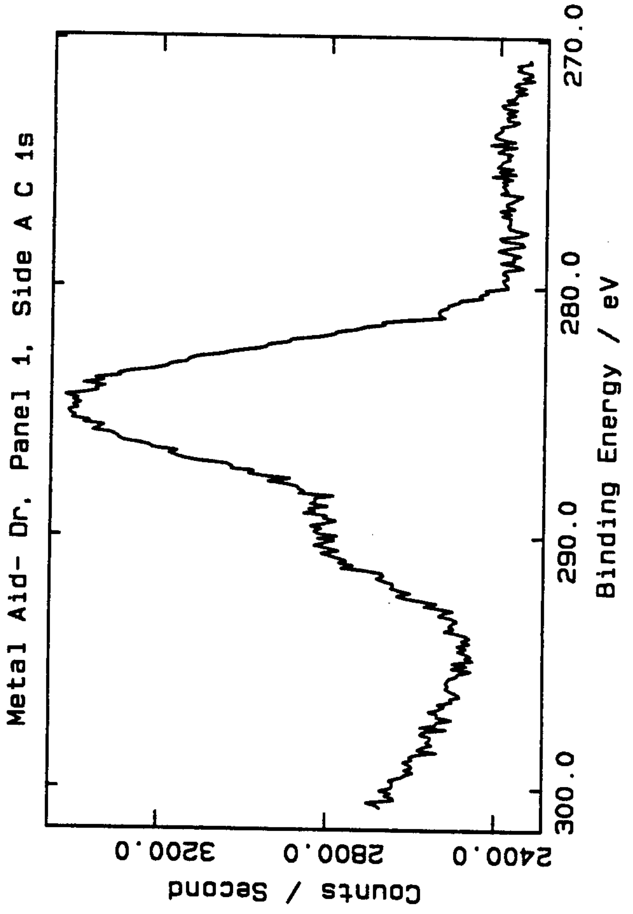
1500.0
2000.0
2500.0
3000.0
90.0
80.0
70.0
60.0
Binding Energy / eV


Metal Aid- Dr. Panel 1, Side A C 1s
Counts / Second
2400.0
2800.0
3200.0
300.0
290.0
280.0
270.0
Binding Energy / eV

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Metal Aid-Dr Cleaned 7075 Al Test Panel 1, Side B

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

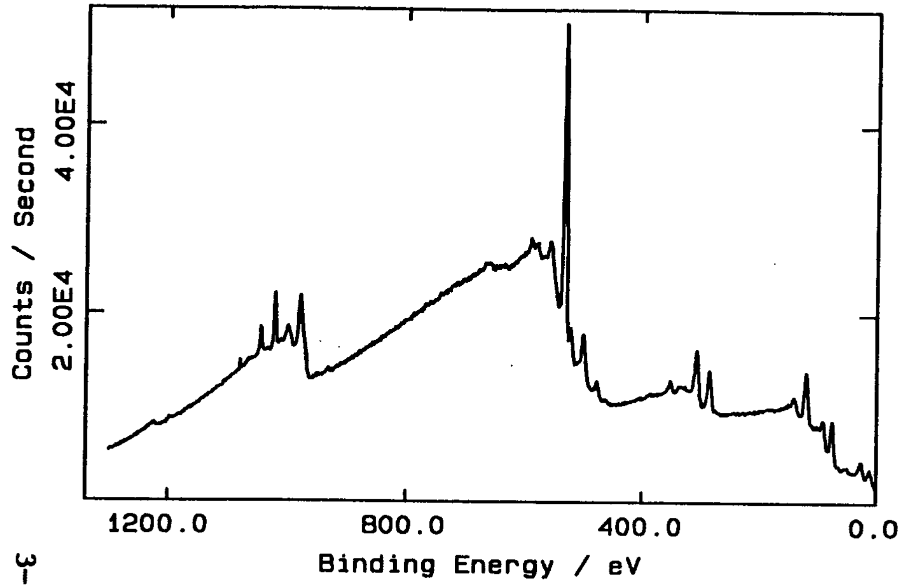
File name	Charge correction	Type	Instrument settings
ALPAN046.R1	None	Survey	RF = 3
ALPAN047	1.7558	Detail	PE = 200

SUMMARY OF ANALYSIS

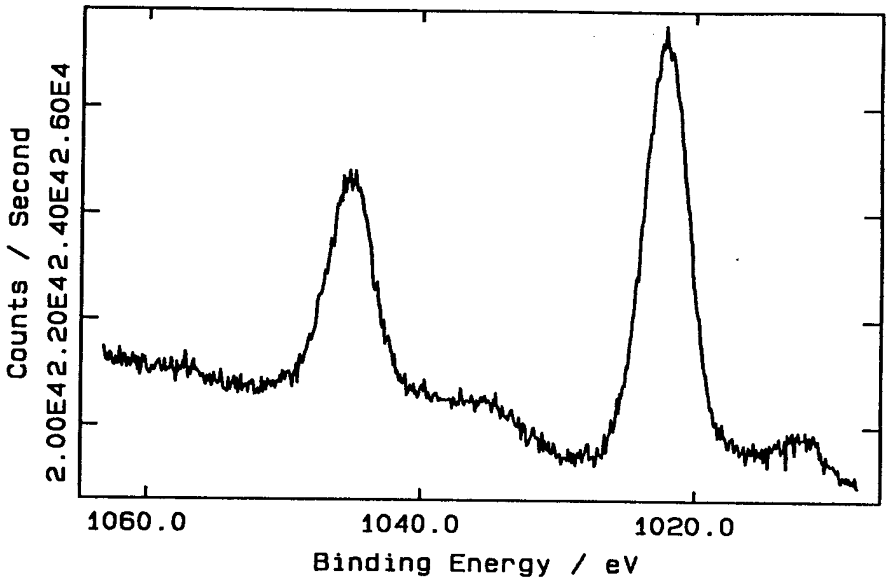
Run number: 1 Excitation: Al Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN047.R1	Mg 1s	1304.96	14390.0000	3.64
2	ALPAN047.R2	Zn 2p$_{1/2}$	1045.18		
3	ALPAN047.R2	Zn 2p$_{3/2}$	1022.11	31092.0000	2.88
4	ALPAN047.R3	O 1s	531.48	79003.0000	268.60
5	ALPAN047.R4	C 1s	289.84		
6	ALPAN047.R4	C 1s	284.80		
7	ALPAN047.R4	C 1s		8963.9930	133.89
8	ALPAN047.R5	Mg 2s	89.68		
9	ALPAN047.R5	Al 2p	74.15	6984.9450	100.00

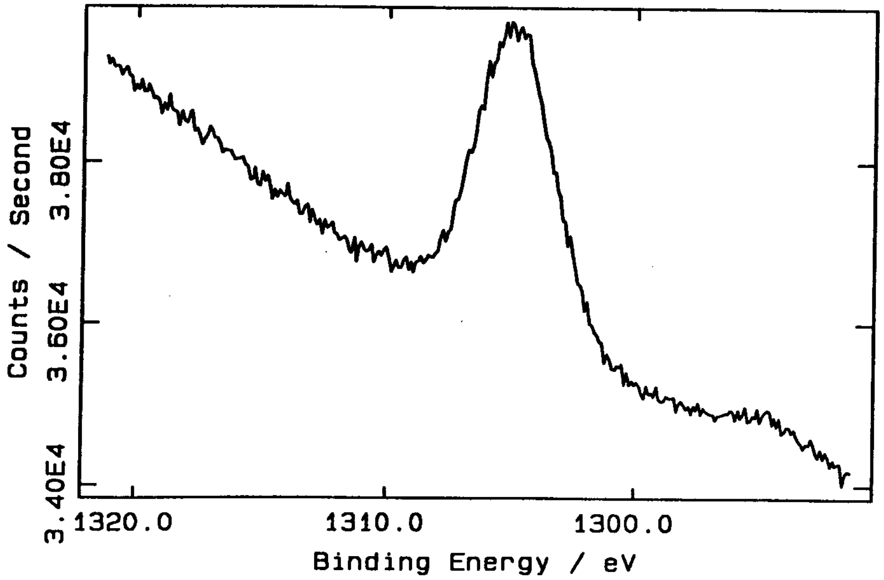
Metal Aid- Dr. Panel 1. Side B Survey



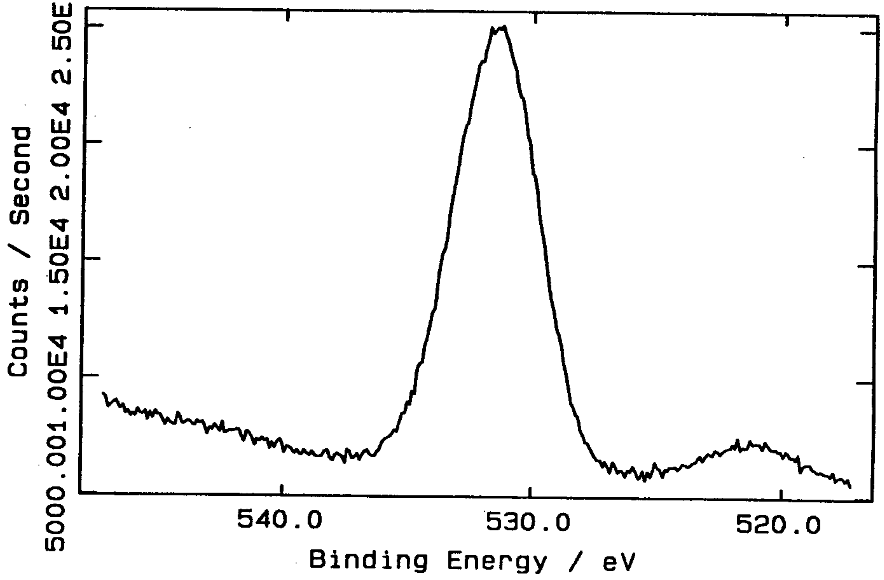
Metal Aid- Dr. Panel 1. Side B Zn 2p1/2. 2p3/2

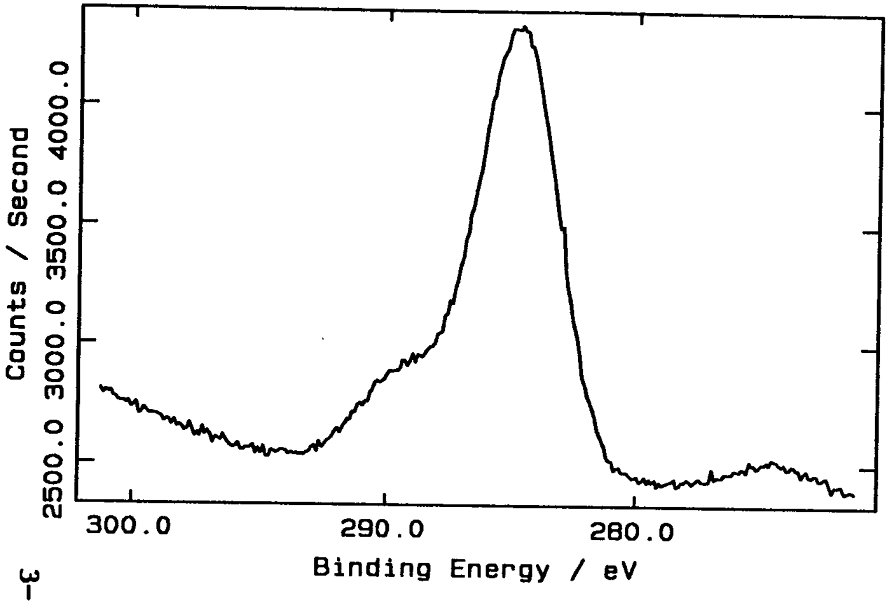


Metal Aid- Dr. Panel 1. Side B Mg 1s

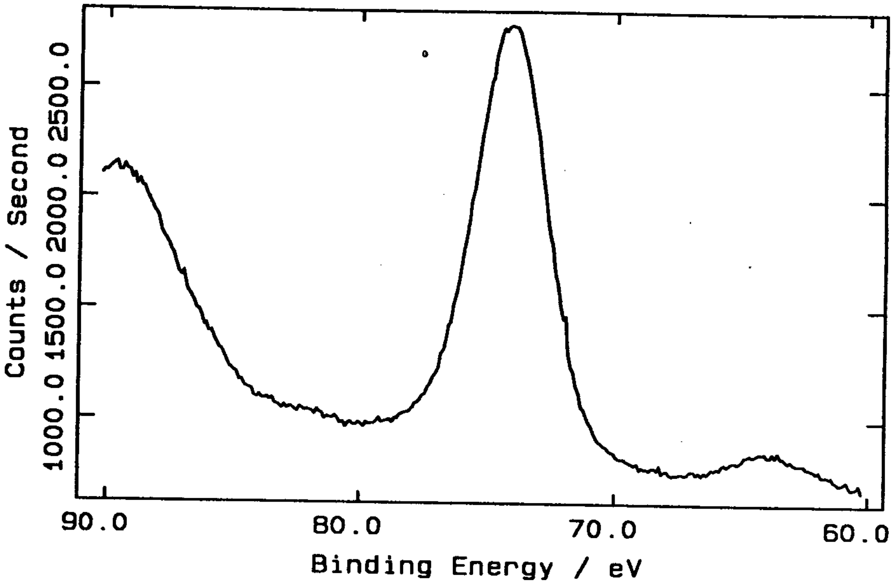


Metal Aid- Dr. Panel 1. Side B O 1s





Metal Aid- Dr, Panel 1, Side B C 1s



Metal Aid- Dr, Panel 1, Side B Al 2p

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: 1,1,1-Trichloroethane Cleaned 7075 Al, Contaminated Test Panel 1

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN051.R1	None	Survey	RF = 3
ALPAN052	2.4289	Detail	PE = 200

SUMMARY OF ANALYSIS

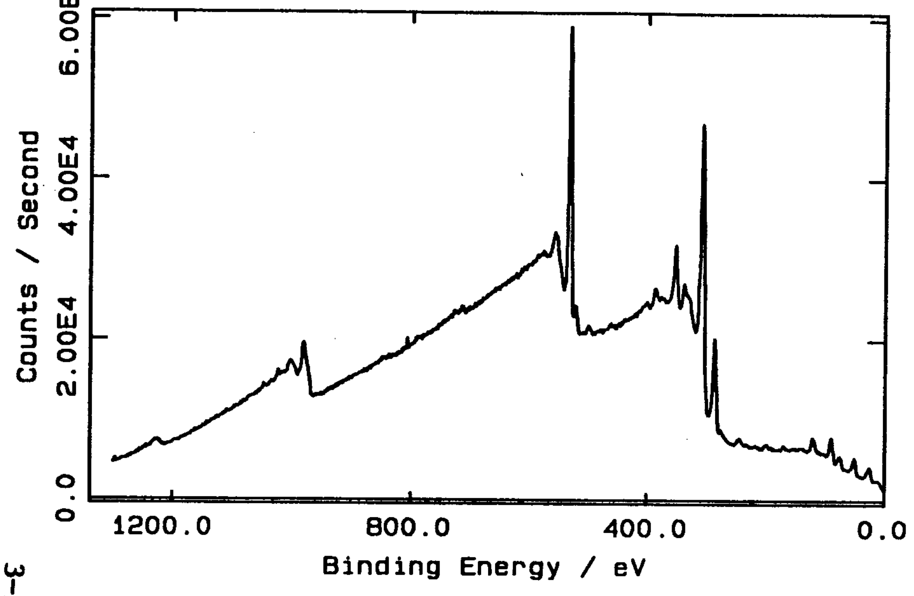
Run number: 1   Excitation: Al   Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN052.R1	Mg 1s	1303.68	68173.0000	51.70
2	ALPAN052.R2	O 1s	531.46	79441.0000	806.73
3	ALPAN052.R3	C 1s	284.80	22497.0000	1004.00
4	ALPAN052.R4	See comments	243.14		
5	ALPAN052.R4	S 2s	232.13	765.7124	9.12
6	ALPAN052.R5	Cl 2p	198.21	1710.2120	12.20
7	ALPAN052.R5	See comments	190.96		
8	ALPAN052.R6	Mg 2s	88.50		
9	ALPAN052.R6	Al 2p	74.09	2338.5110	100.00

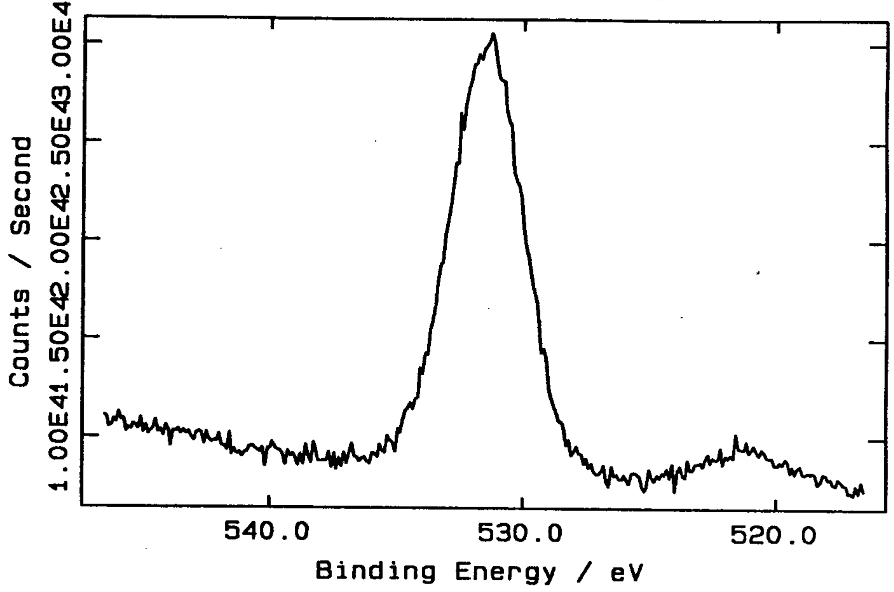
COMMENTS

1. The closest reasonable match for peak 4 is Ar 2p, possibly present due to the processing conditions for making the 7075 Al alloy.
2. Source of S is unknown. No Mo 3d doublet is observed, so MoS_2 is excluded.
3. Peak 7 is assigned to the Bremstrahlung excited Al KL_1L_1 Auger transition.

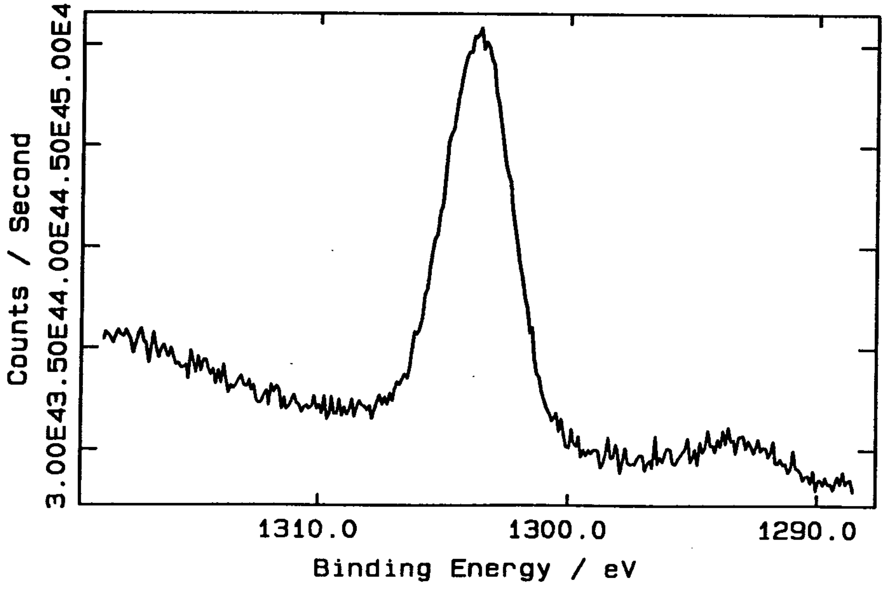
Trichlor, Panel 1 Survey



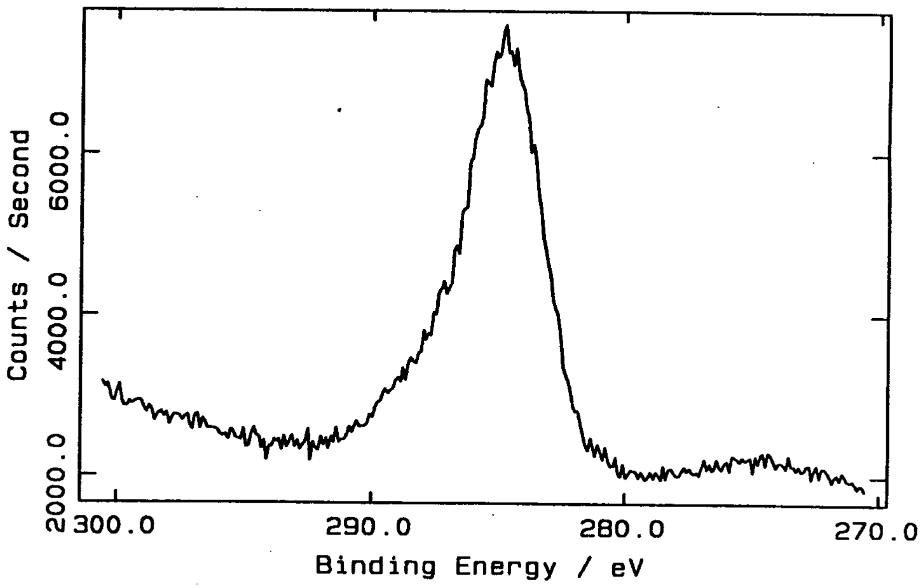
Trichlor, Panel 1 O 1s

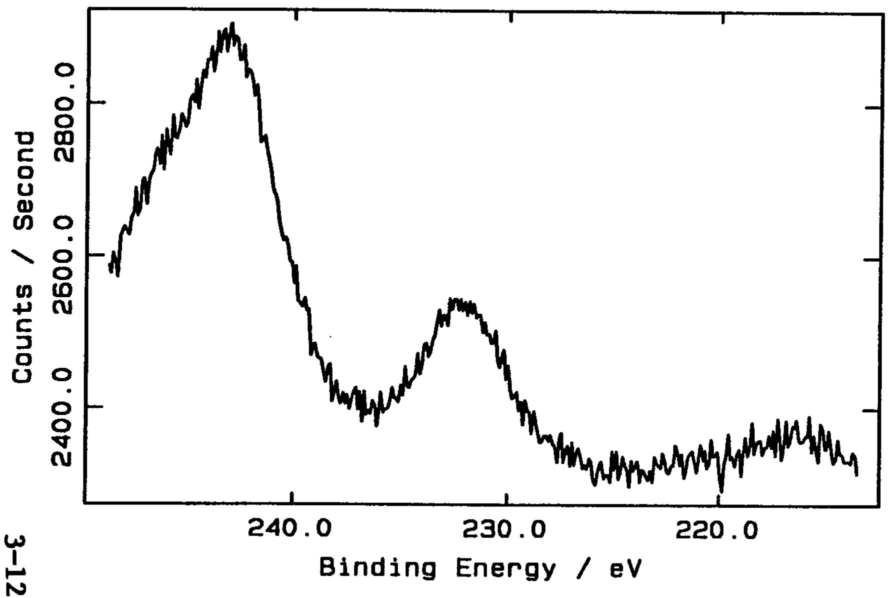


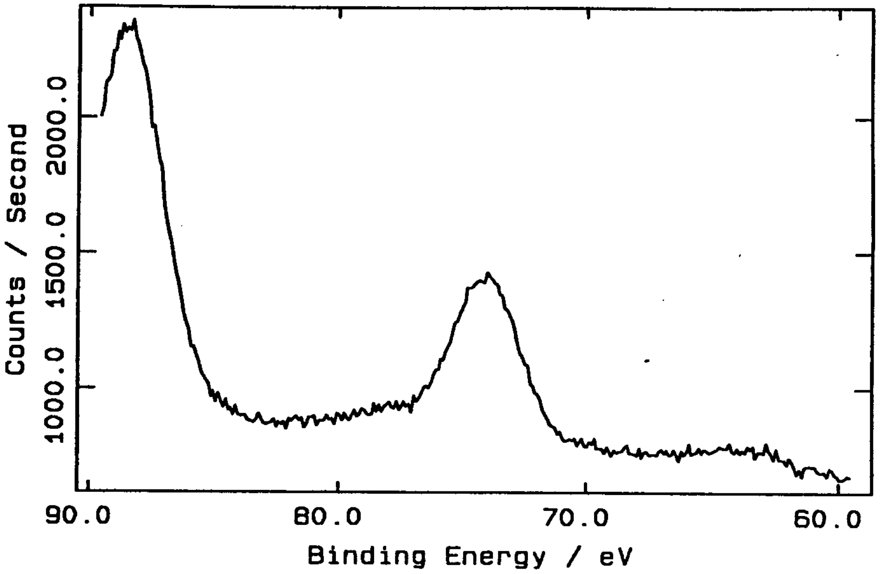
Trichlor, Panel 1 Mg 1s

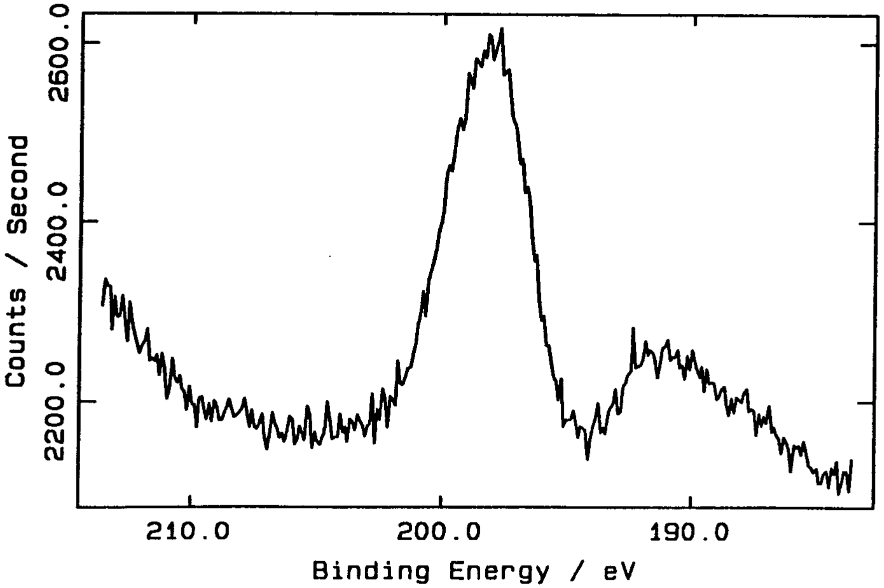


Trichlor, Panel 1 C 1s




Trichlor, Panel 1 Mo 3d3/2, 3d5/2


Trichlor, Panel 1 Al 2p


Trichlor, Panel 1 Cl 2p

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: 1,1,1-Trichloroethane Cleaned 7075 Al, Contaminated Test Panel 2

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN053.R1	None	Survey	RF = 3
ALPAN054	2.0521	Detail	PE = 200

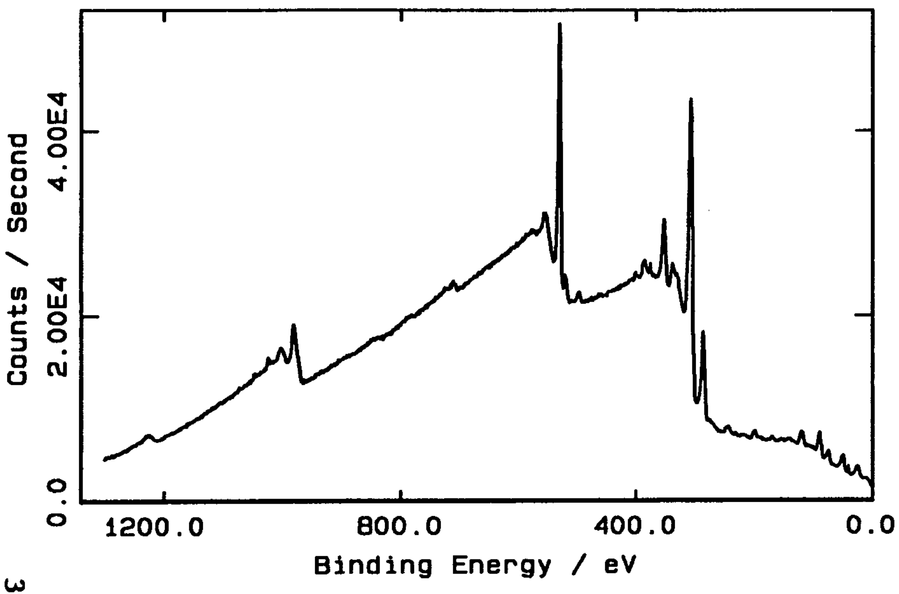
SUMMARY OF ANALYSIS

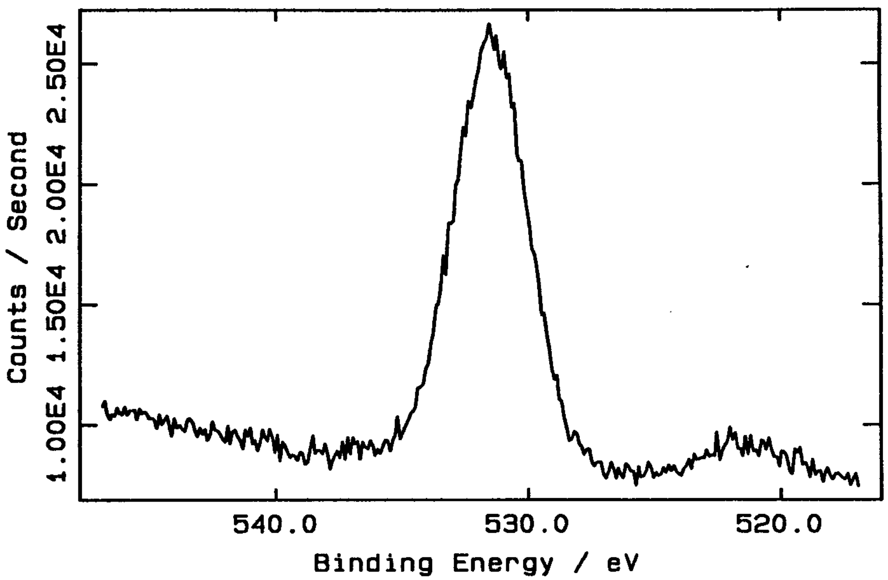
Run number: 1 Excitation: Al Pass energy: 200 eV

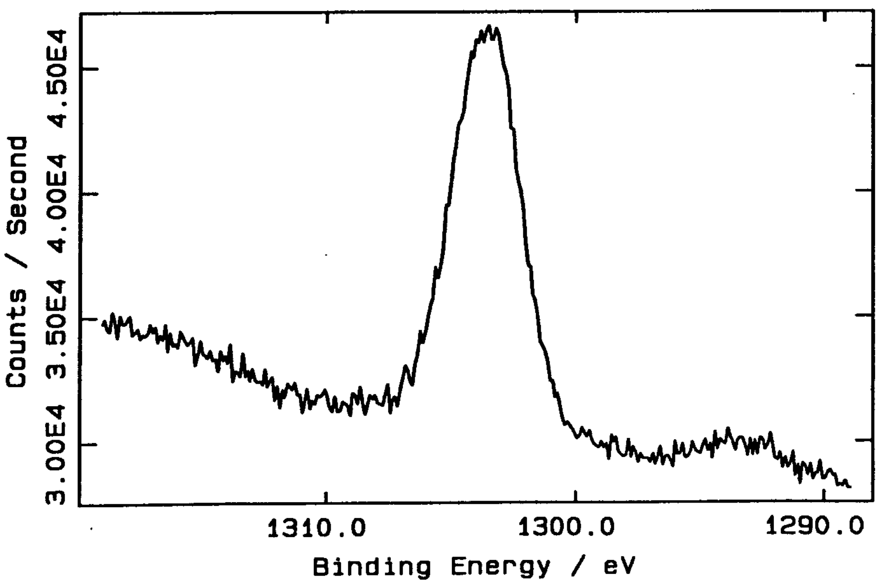
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN054.R1	Mg 1s	1303.63	55422.0000	52.35
2	ALPAN054.R2	O 1s	531.45	66198.0000	837.26
3	ALPAN054.R3	C 1s	284.80	19708.0000	1095.42
4	ALPAN054.R4	See comments	242.99		
5	ALPAN054.R4	S 2s	232.18	501.8820	7.45
6	ALPAN054.R5	Cl 2p	198.22	1929.4930	17.14
7	ALPAN054.R5	See comments	191.18		
8	ALPAN054.R6	Mg 2s	88.49		
9	ALPAN054.R6	Al 2p	74.12	1877.6450	100.00

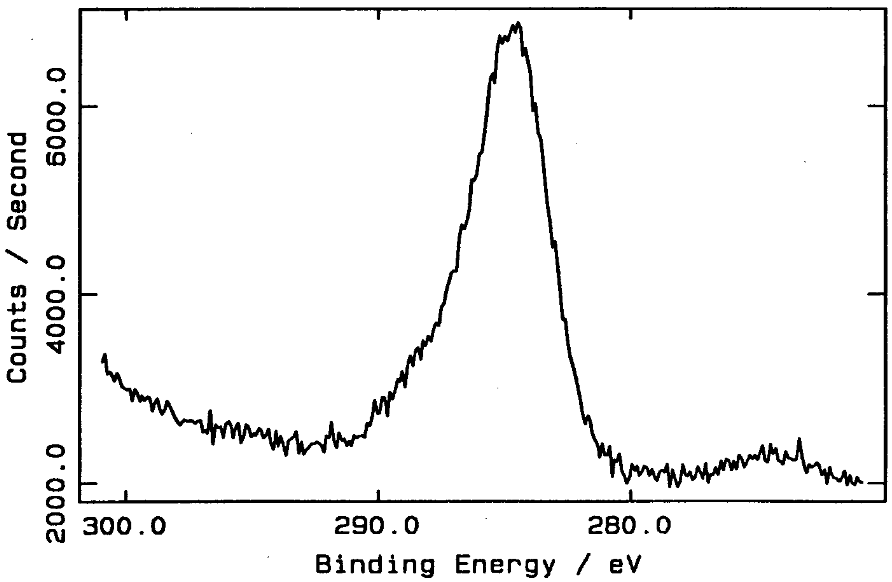
COMMENTS

1. The closest reasonable match for peak 4 is Ar 2p, possibly present due to the processing conditions for making the 7075 Al alloy.
2. Source of S is unknown. No Mo 3d doublet is observed, so MoS_2 is excluded.
3. Peak 7 is assigned to the Bremstrahlung excited Al KL_1L_1 Auger transition.

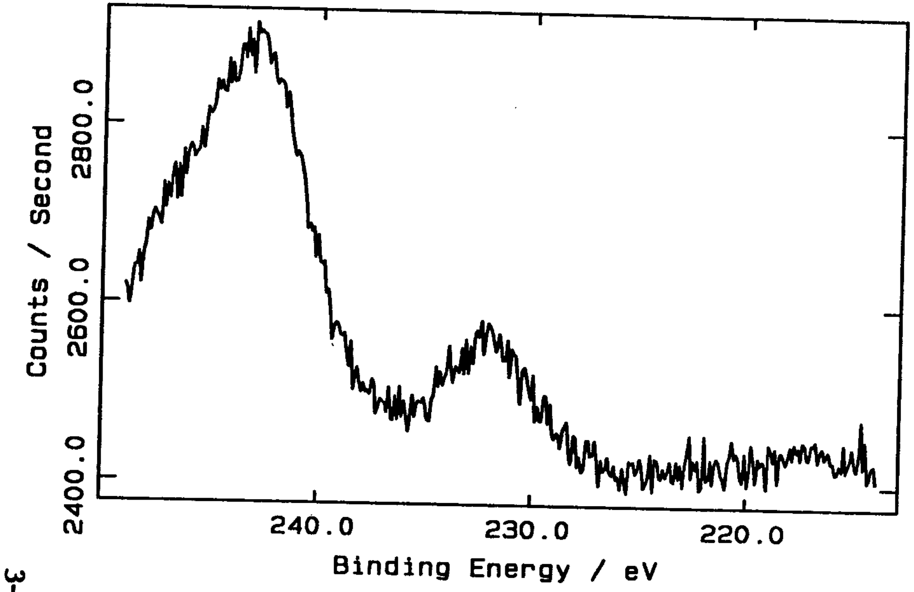

Trichlor, Panel 2 Survey


Trichlor, Panel 2 O 1s

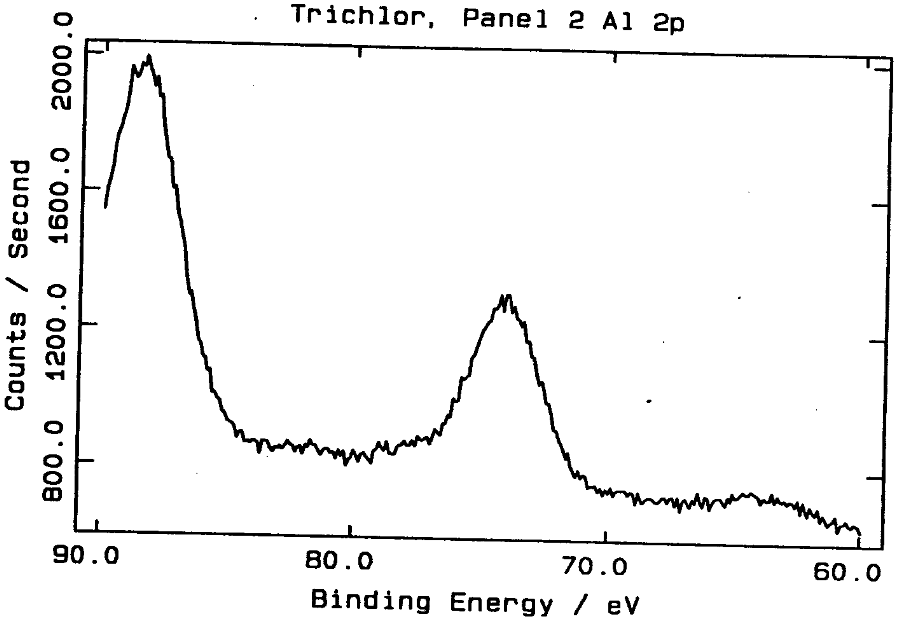

Trichlor, Panel 2 Mg 1s


Trichlor, Panel 2 C 1s

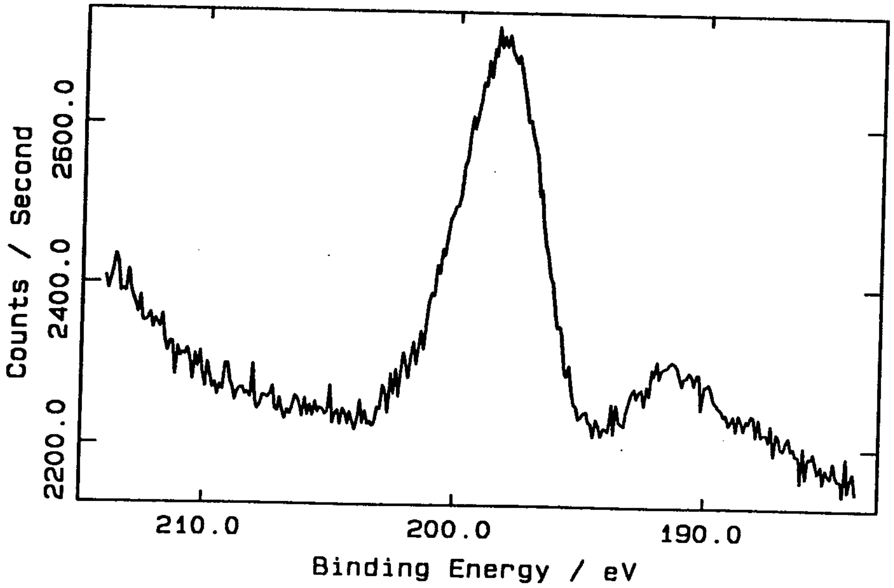
Trichlor, Panel 2 Mo 3d3/2, 3d5/2



Trichlor, Panel 2 Al 2p



Trichlor, Panel 2 Cl 2p



Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Shopmaster Cleaned 7075 Al Test Panel 1

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

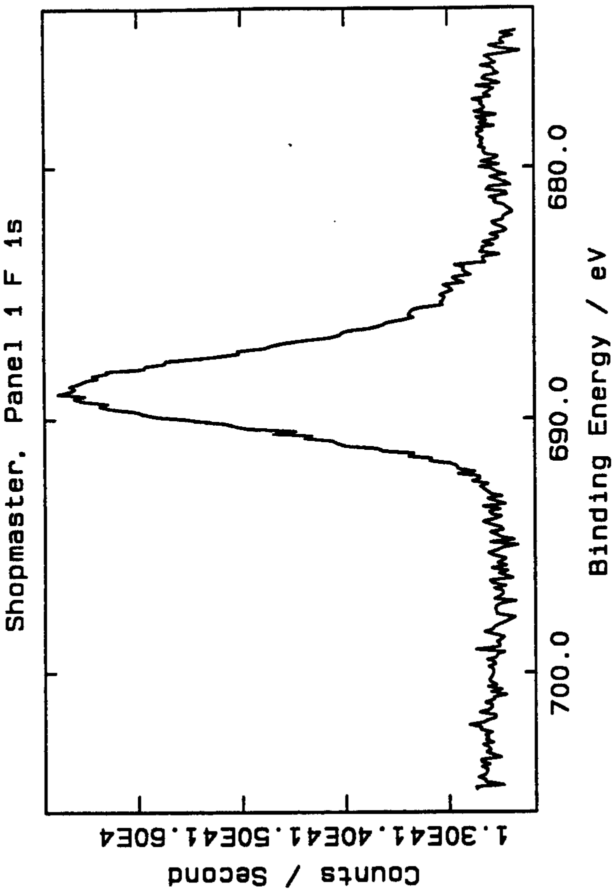
FILE SUMMARY

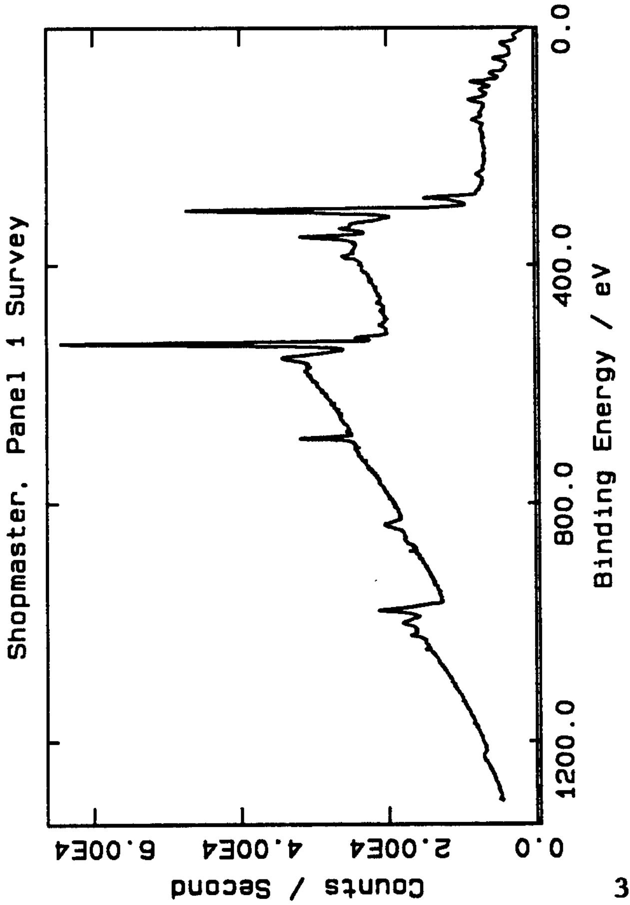
File name	Charge correction	Type	Instrument settings
ALPAN055.R1	None	Survey	RF = 3
ALPAN056	2.3209	Detail	PE = 200

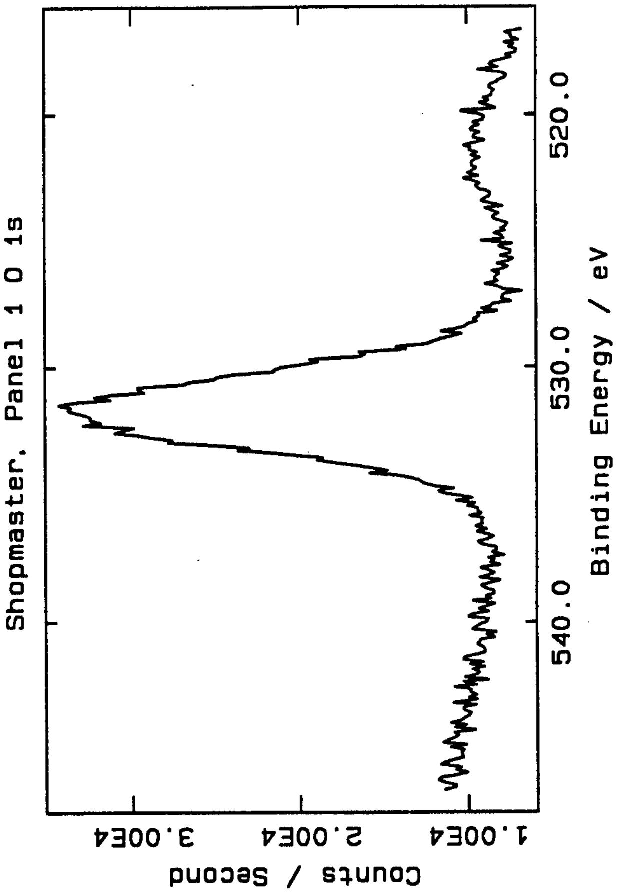
SUMMARY OF ANALYSIS

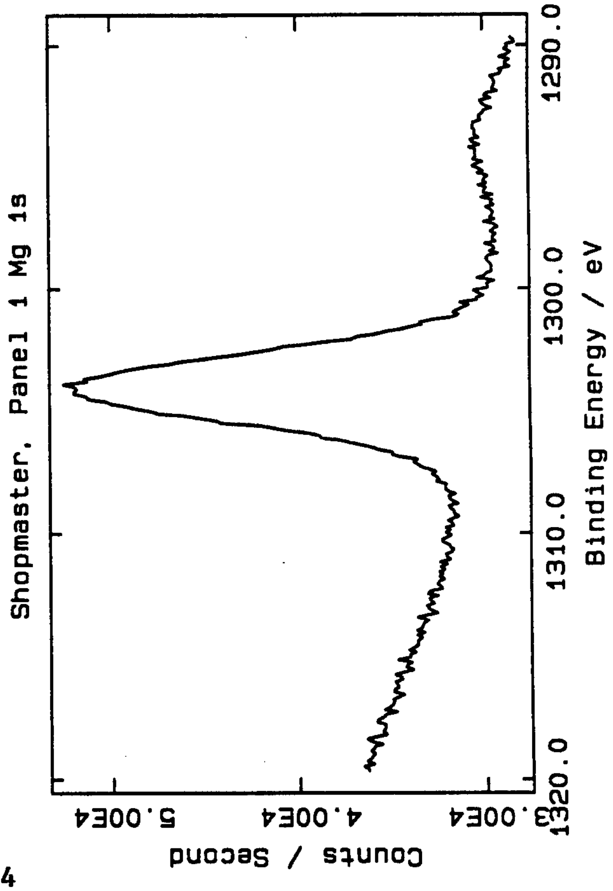
Run number: 1 Excitation: Al Pass energy: 200 eV

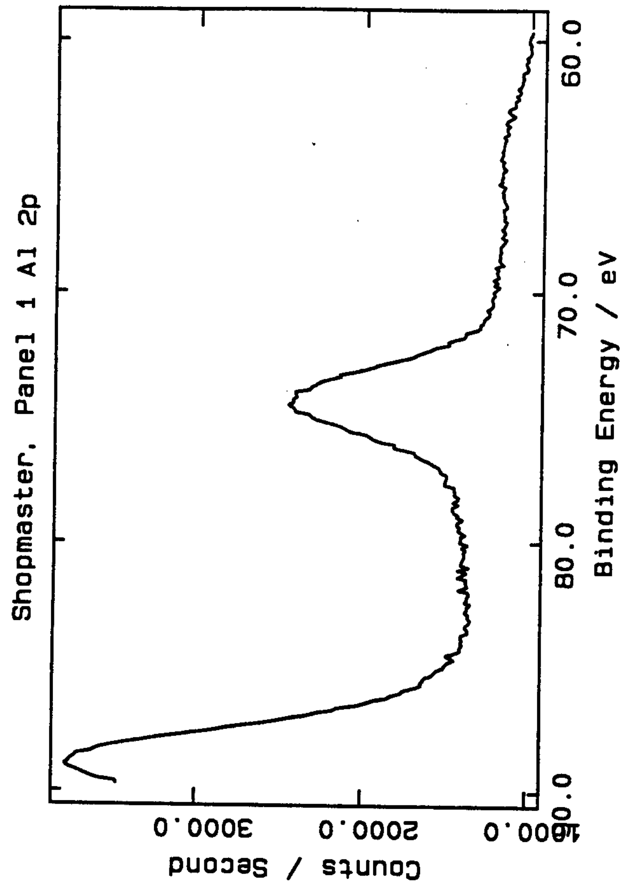
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN056.R1	Mg 1s	1304.06	73944.0000	29.50
2	ALPAN056.R2	F 1s	688.84	17348.0000	46.97
3	ALPAN056.R3	O 1s	531.77	96468.0000	515.81
4	ALPAN056.R4	C 1s	284.80	14608.0000	343.32
5	ALPAN056.R5	Si 2p	101.95	3734.8650	52.27
6	ALPAN056.R5	Mg 2s	88.86		
7	ALPAN056.R6	Mg 2s	88.86		
8	ALPAN056.R6	Al 2p	74.36	4441.0340	100.00


Shopmaster. Panel 1 F 1s
Counts / Second
1.30E4
1.40E4
1.50E4
1.60E4
Binding Energy / eV
700.0
690.0
680.0

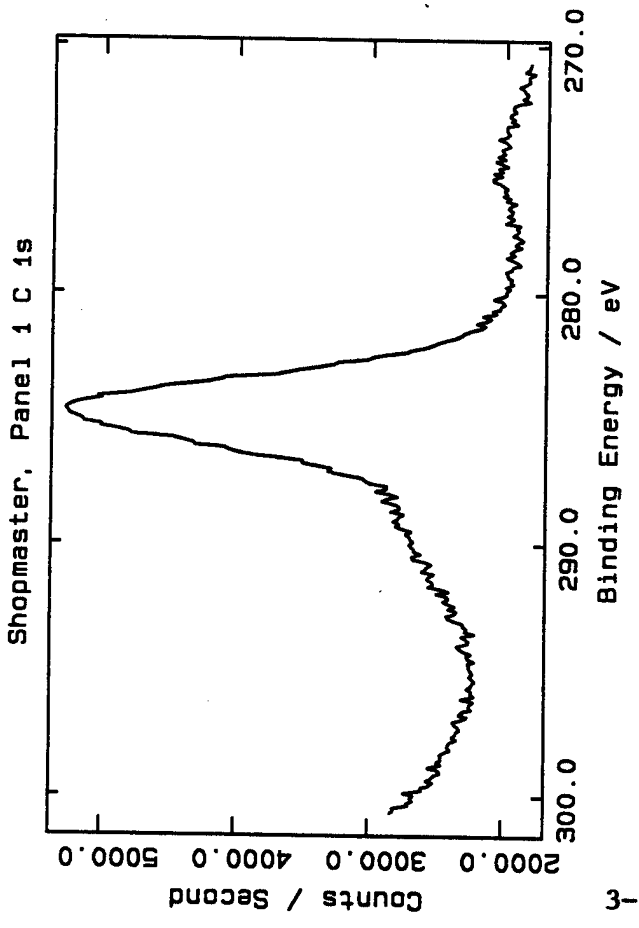

Shopmaster. Panel 1 Survey
Counts / Second
0.0
2.00E4
4.00E4
6.00E4
Binding Energy / eV
1200.0
800.0
400.0
0.0


Shopmaster. Panel 1 O 1s
Counts / Second
1.00E4
2.00E4
3.00E4
Binding Energy / eV
540.0
530.0
520.0

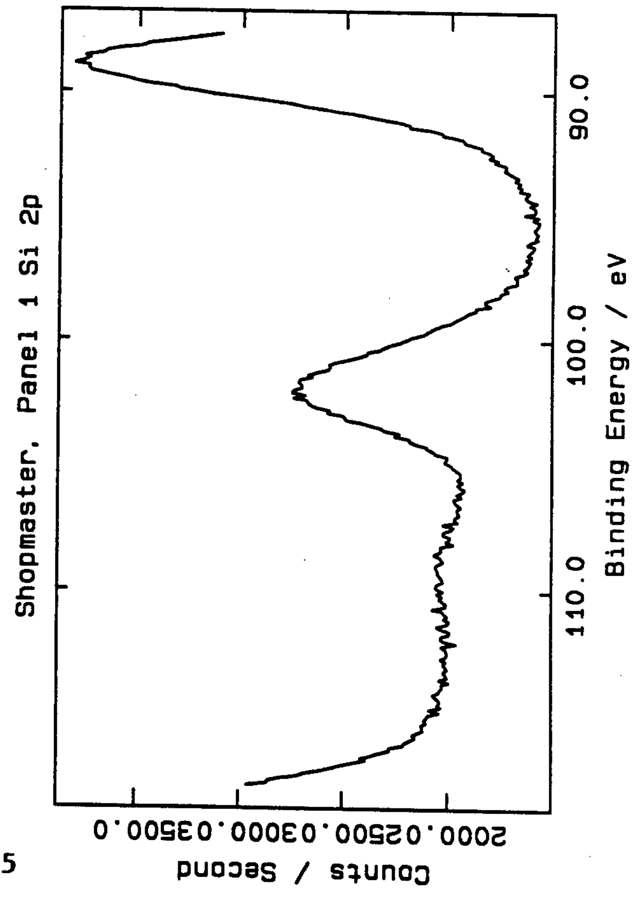

Shopmaster. Panel 1 Mg 1s
Counts / Second
3.00E4
4.00E4
5.00E4
Binding Energy / eV
1320.0
1310.0
1300.0
1290.0



Shopmaster, Panel 1 Al 2p



Shopmaster, Panel 1 C 1s



Shopmaster, Panel 1 Si 2p

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Shopmaster Cleaned 7075 Al Test Panel 2

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

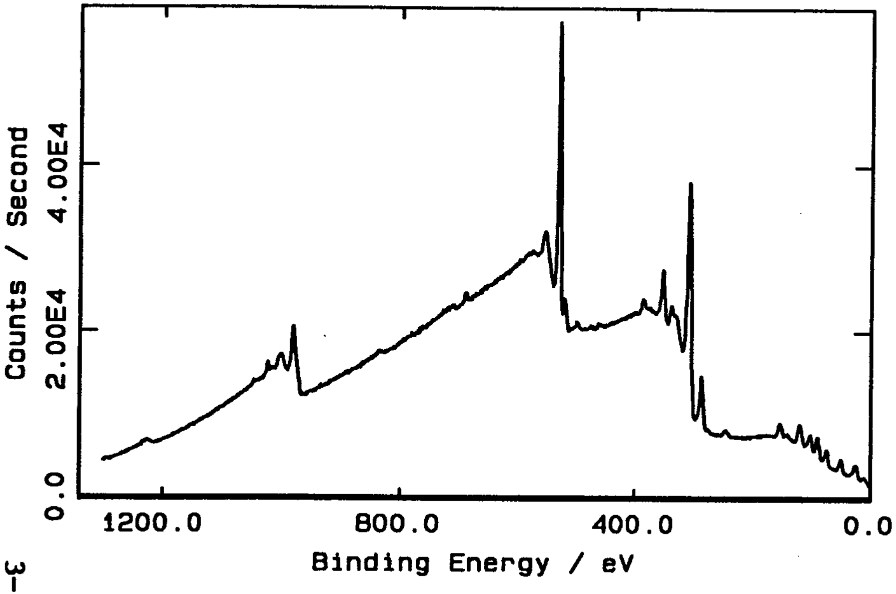
File name	Charge correction	Type	Instrument settings
ALPAN057.R1	None	Survey	RF = 3
ALPAN058	1.7128	Detail	PE = 200

SUMMARY OF ANALYSIS

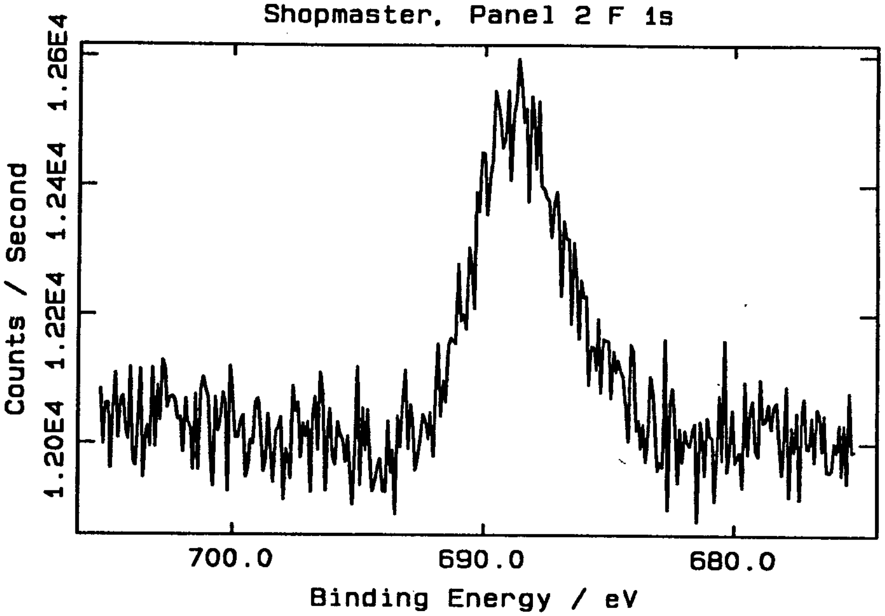
Run number: 1   Excitation: Al   Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN058.R1	Mg 1s	1304.19	51121.0000	20.13
2	ALPAN058.R2	F 1s	687.13	17144.0000	45.89
3	ALPAN058.R3	O 1s	531.69	78722.0000	415.67
4	ALPAN058.R4	C 1s	284.80	12637.0000	293.28
5	ALPAN058.R5	Si 2p	102.09	4695.6290	64.90
6	ALPAN058.R5	Mg 2s	88.98		
7	ALPAN058.R6	Mg 2s	88.98		
8	ALPAN058.R6	Al 2p	74.41	4497.4360	100.00

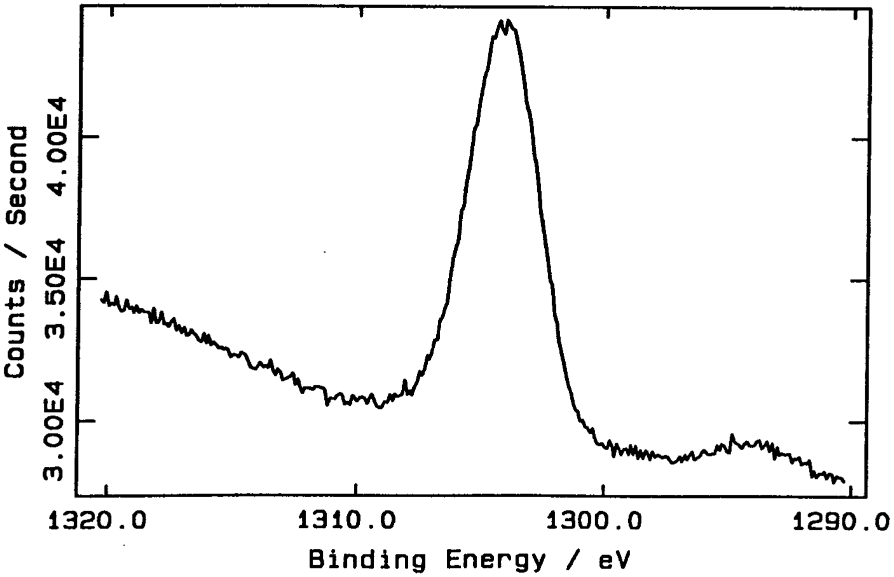
Shopmaster, Panel 2 Survey



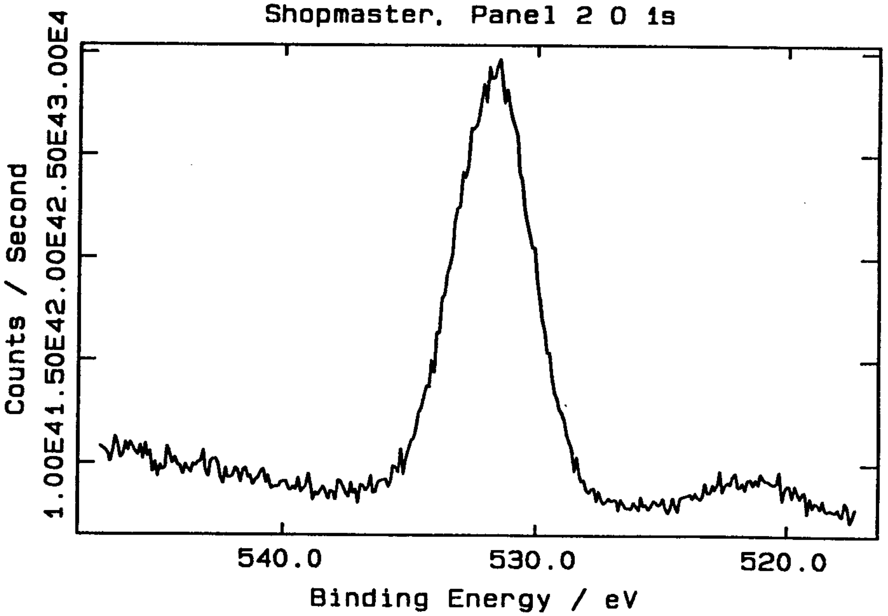
Shopmaster, Panel 2 F 1s

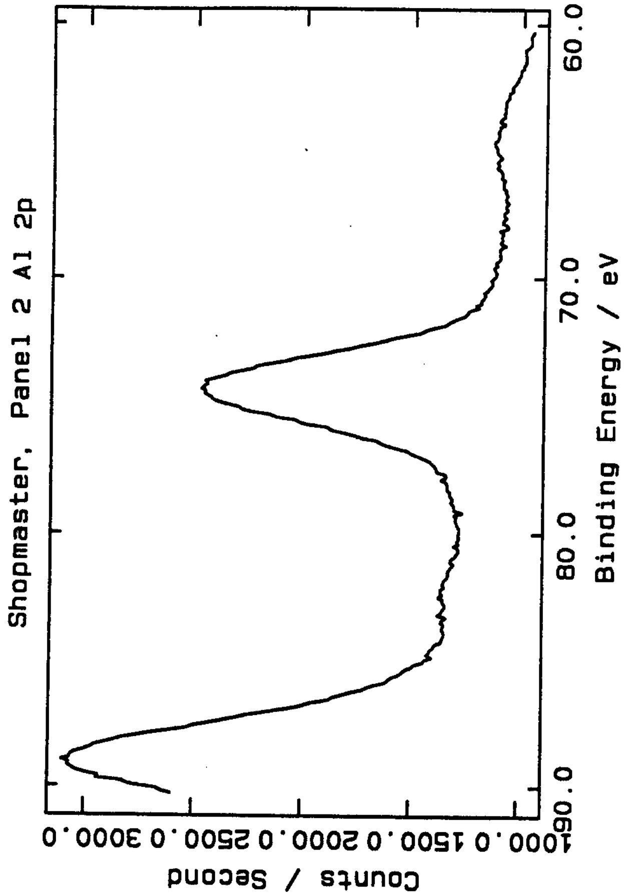


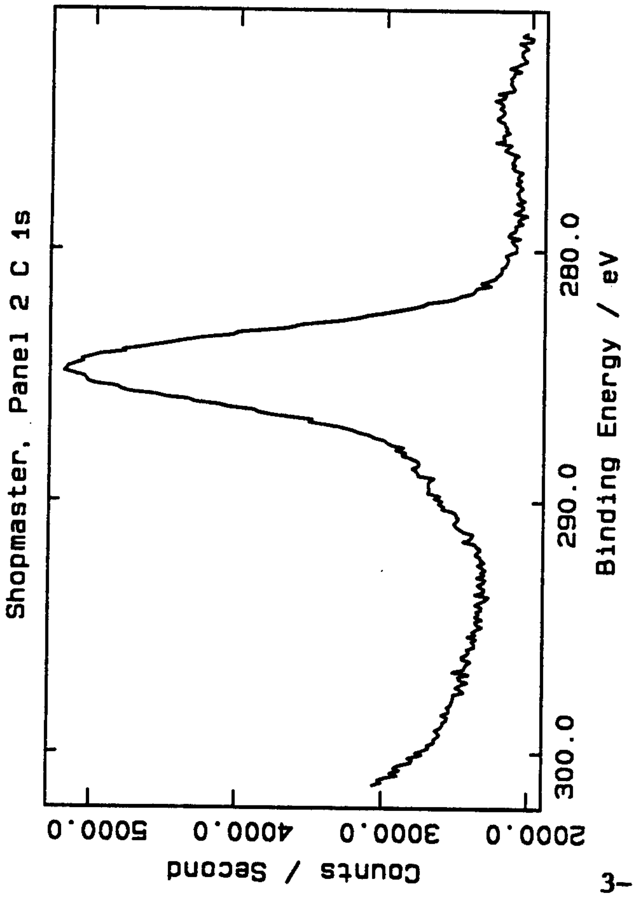
Shopmaster, Panel 2 Mg 1s

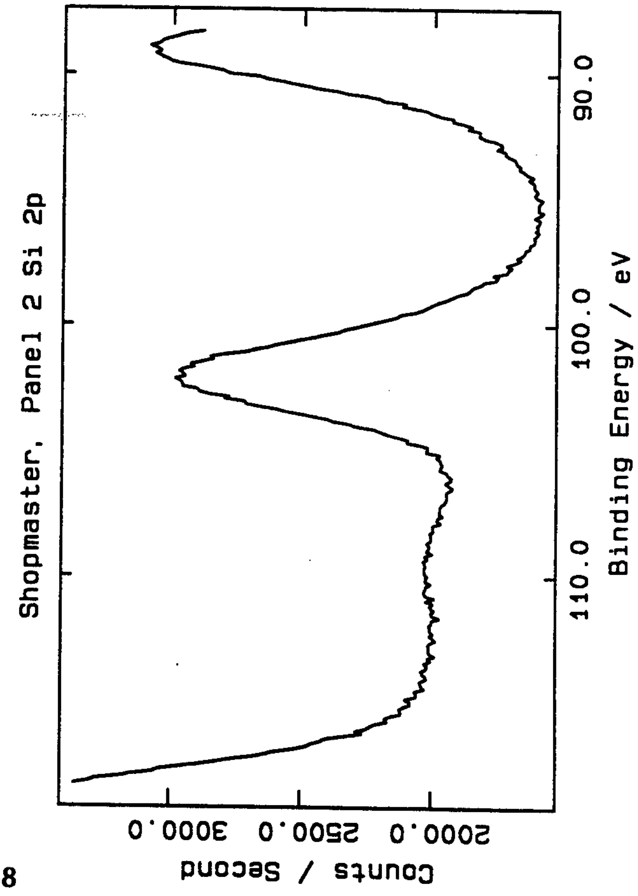


Shopmaster, Panel 2 O 1s




Shopmaster, Panel 2 Al 2p
Counts / Second
1000.0
1500.0
2000.0
2500.0
3000.0
Binding Energy / eV
90.0
80.0
70.0
60.0


Shopmaster, Panel 2 C 1s
Counts / Second
2000.0
3000.0
4000.0
5000.0
Binding Energy / eV
300.0
290.0
280.0


Shopmaster, Panel 2 Si 2p
Counts / Second
2000.0
2500.0
3000.0
Binding Energy / eV
110.0
100.0
90.0

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Aerosolv 2000 Cleaned 7075 Al Test Panel 1

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

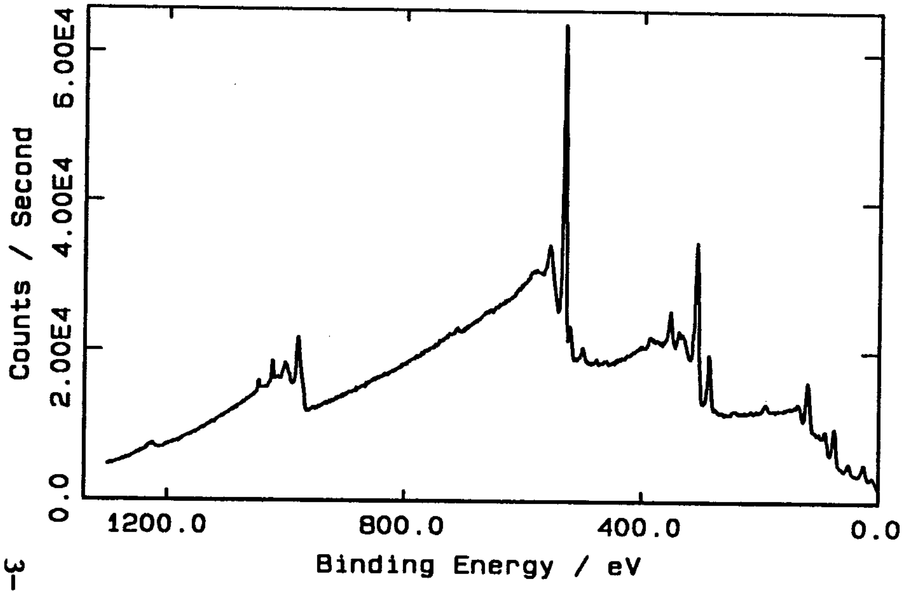
FILE SUMMARY

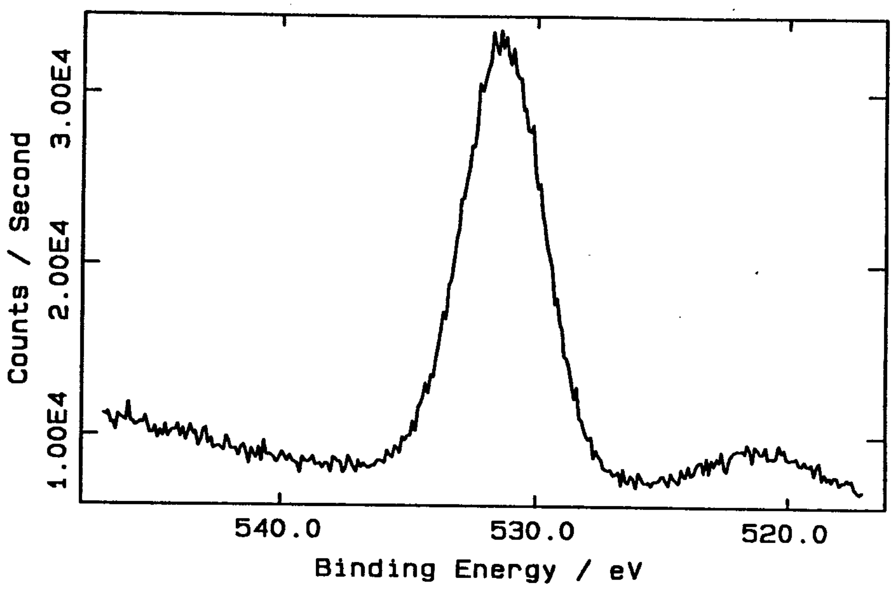
File name	Charge correction	Type	Instrument settings
ALPAN059.R1	None	Survey	RF = 3
ALPAN060	1.9469	Detail	PE = 200

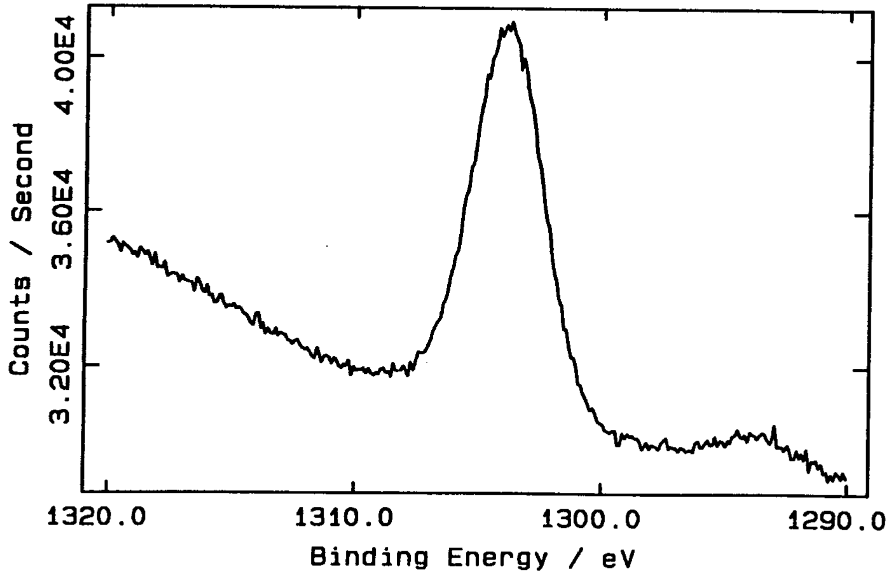
SUMMARY OF ANALYSIS

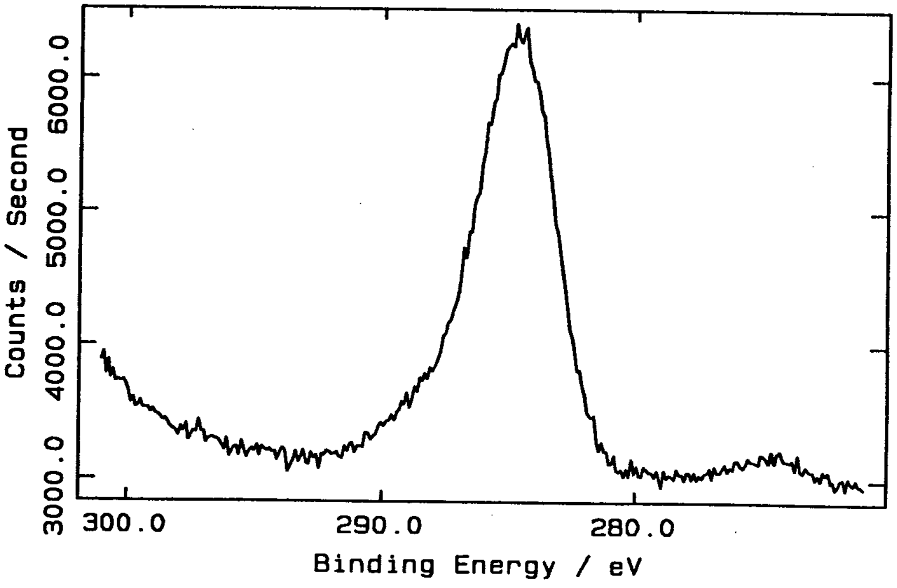
Run number: 1   Excitation: Al   Pass energy: 200 eV

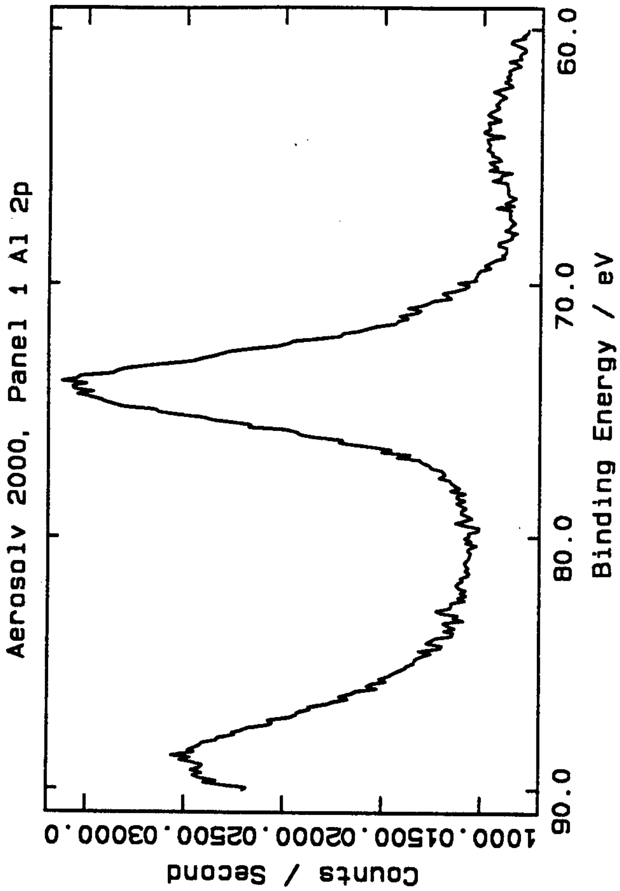
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN060.R1	Mg 1s	1303.93	36040.0000	7.84
2	ALPAN060.R2	O 1s	531.41	99920.0000	291.16
3	ALPAN060.R3	C 1s	284.80	13876.0000	177.69
4	ALPAN060.R4	P 2p	133.84	4279.2660	19.96
5	ALPAN060.R5	Mg 2s	88.88		
6	ALPAN060.R5	Al 2p	74.09	8149.8510	100.00

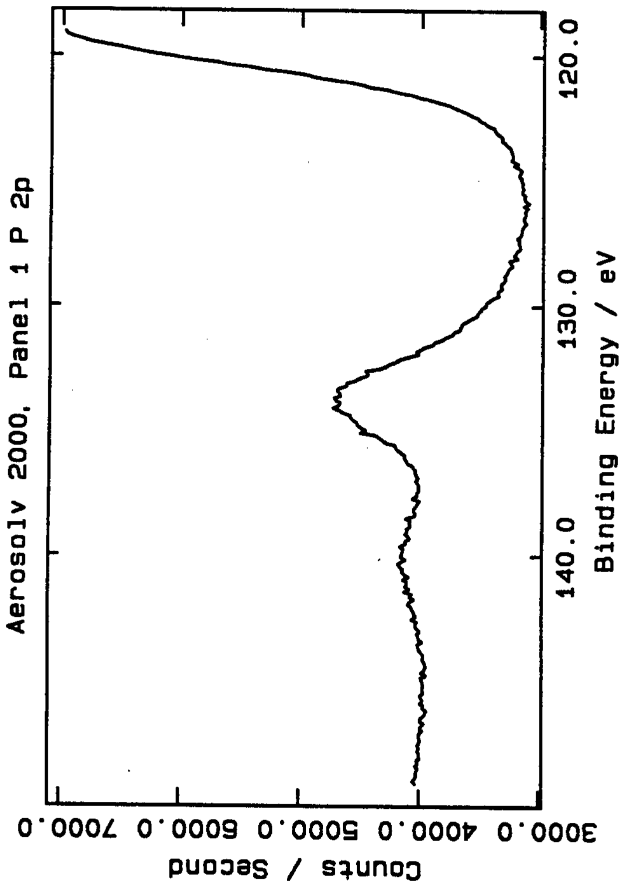

Aerosolv 2000, Panel 1 Survey


Aerosolv 2000, Panel 1 O 1s


Aerosolv 2000, Panel 1 Mg 1s


Aerosolv 2000, Panel 1 C 1s


Aerosolv 2000, Panel 1 Al 2p
Counts / Second
1000.0
1500.0
2000.0
2500.0
3000.0
Binding Energy / eV
90.0
80.0
70.0
60.0


Aerosolv 2000, Panel 1 P 2p
Counts / Second
3000.0
4000.0
5000.0
6000.0
7000.0
Binding Energy / eV
140.0
130.0
120.0

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Aerosolv 2000 Cleaned 7075 Al Test Panel 2

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

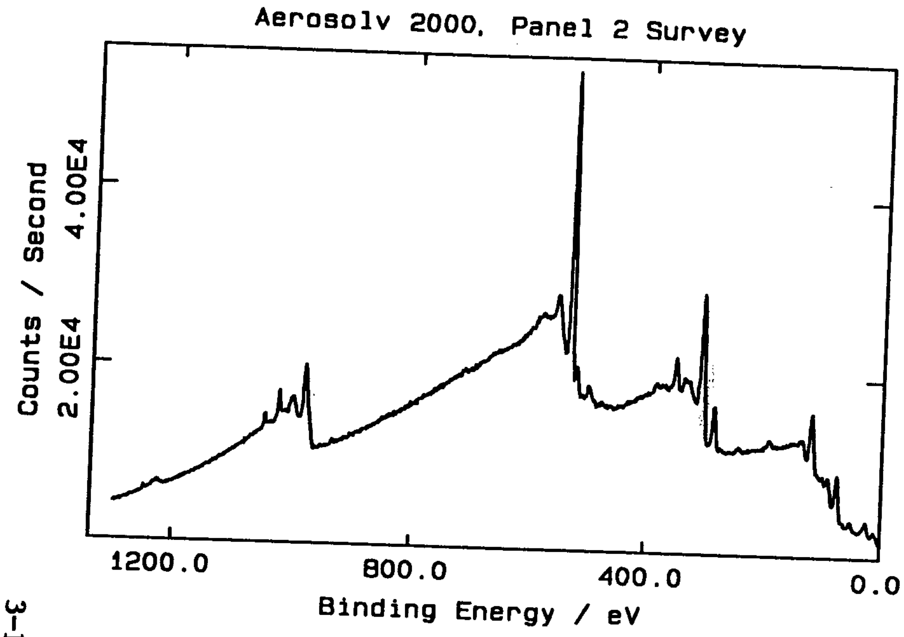
FILE SUMMARY

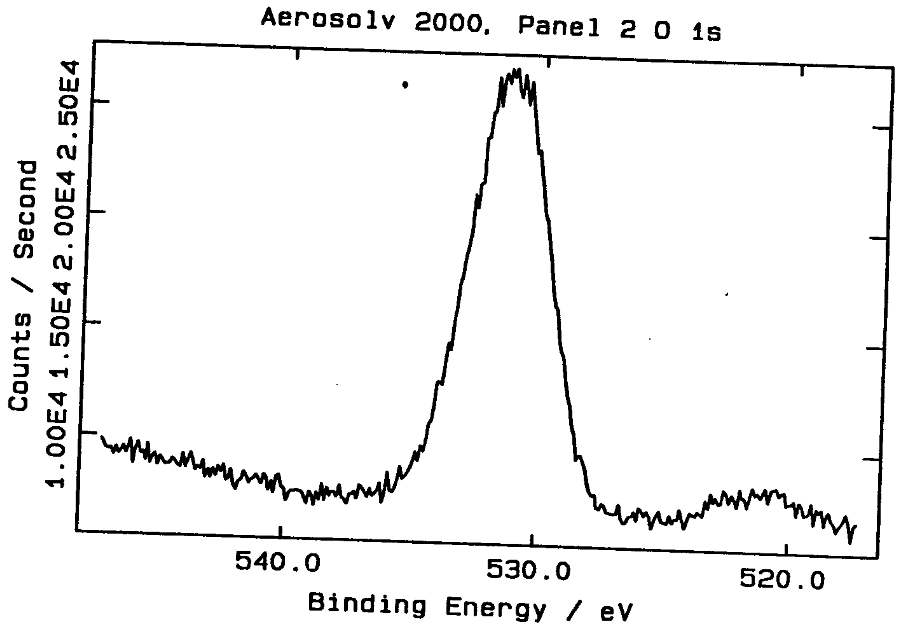
File name	Charge correction	Type	Instrument settings
ALPAN061.R1	None	Survey	RF = 3
ALPAN062	1.7414	Detail	PE = 200

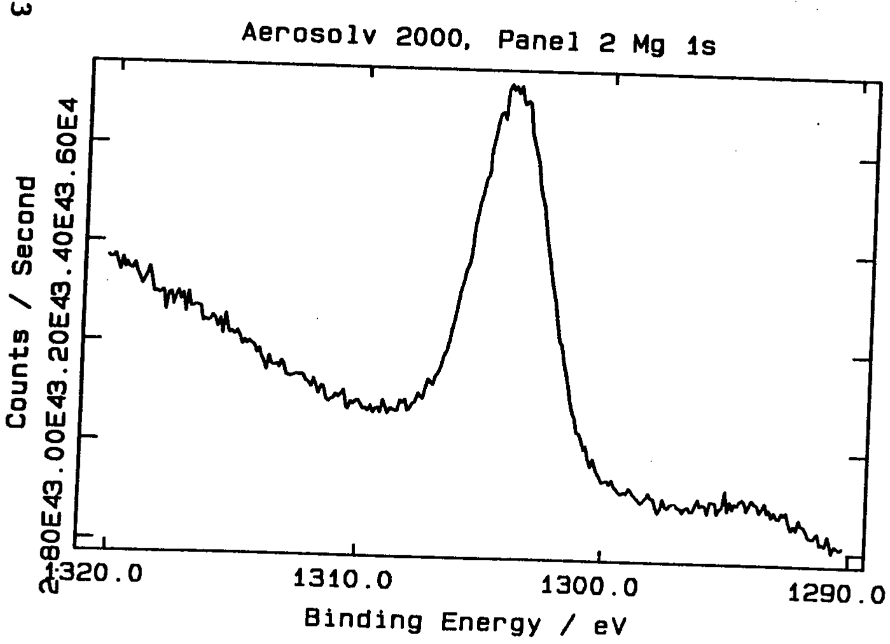
SUMMARY OF ANALYSIS

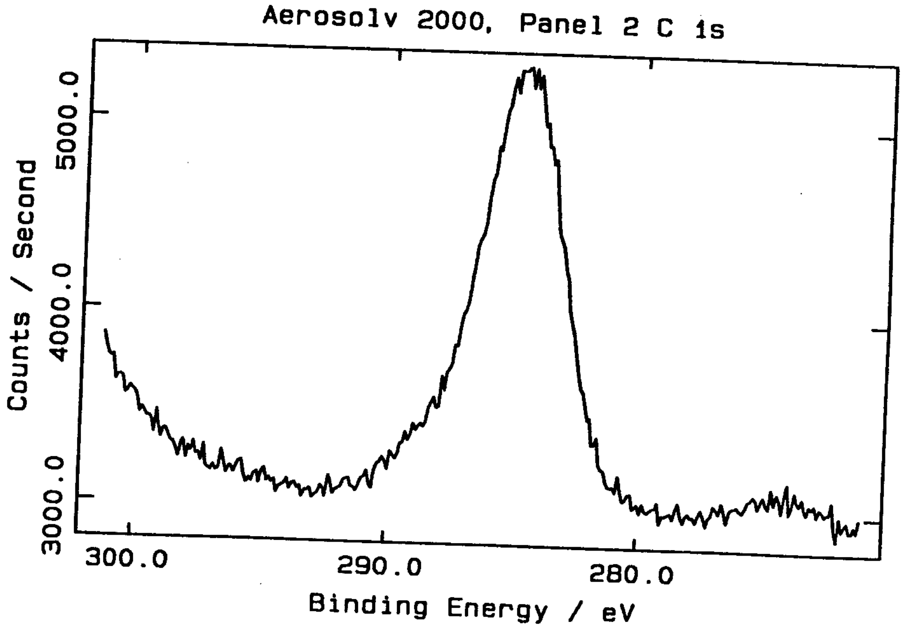
Run number: 1 Excitation: Al Pass energy: 200 eV

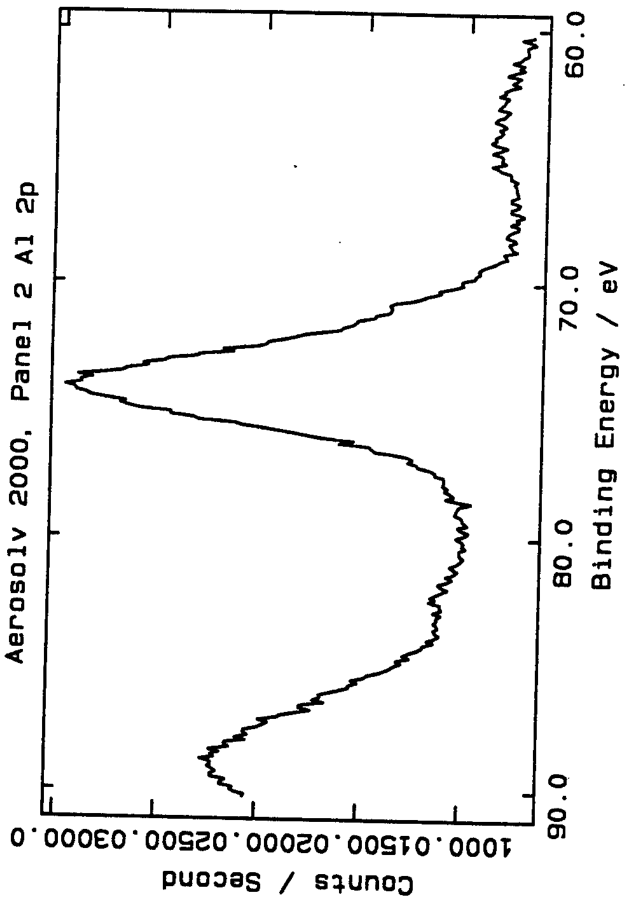
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN062.R1	Mg 1s	1304.04	27465.0000	5.89
2	ALPAN062.R2	O 1s	531.26	78483.0000	225.66
3	ALPAN062.R3	C 1s	284.80	9963.5000	125.89
4	ALPAN062.R4	P 2p	133.96	3659.5820	16.84
5	ALPAN062.R5	Mg 2s	88.97		
6	ALPAN062.R5	Al 2p	74.16	8260.2330	100.00

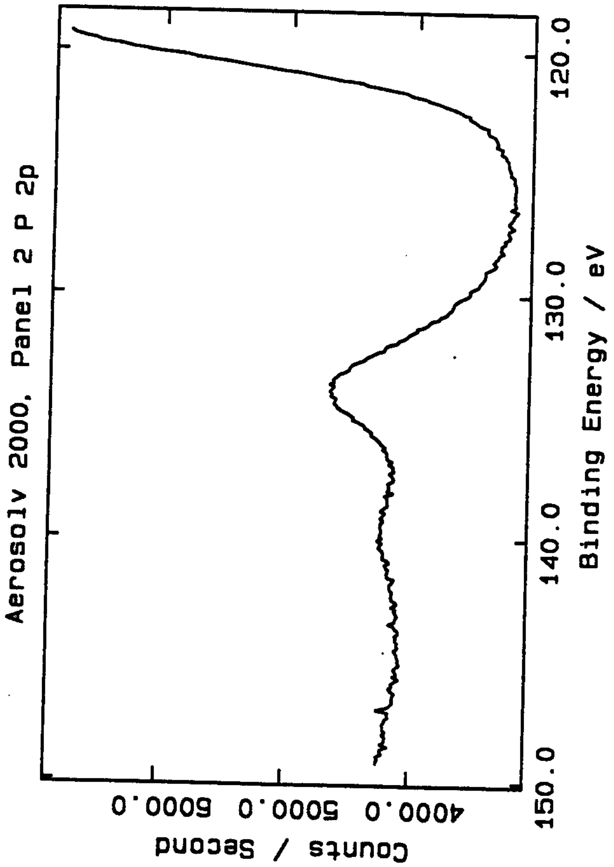

Aerosolv 2000, Panel 2 Survey


Aerosolv 2000, Panel 2 O 1s


Aerosolv 2000, Panel 2 Mg 1s


Aerosolv 2000, Panel 2 C 1s


Aerosolv 2000, Panel 2 Al 2p
Counts / Second
1000.0
1500.0
2000.0
2500.0
3000.0
90.0
80.0
70.0
60.0
Binding Energy / eV


Aerosolv 2000, Panel 2 P 2p
Counts / Second
4000.0
5000.0
6000.0
150.0
140.0
130.0
120.0
Binding Energy / eV

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Sputter Cleaned 7075 Al

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN063.R1	None	Survey	RF = 3
ALPAN064	0.9643	Detail	PE = 200

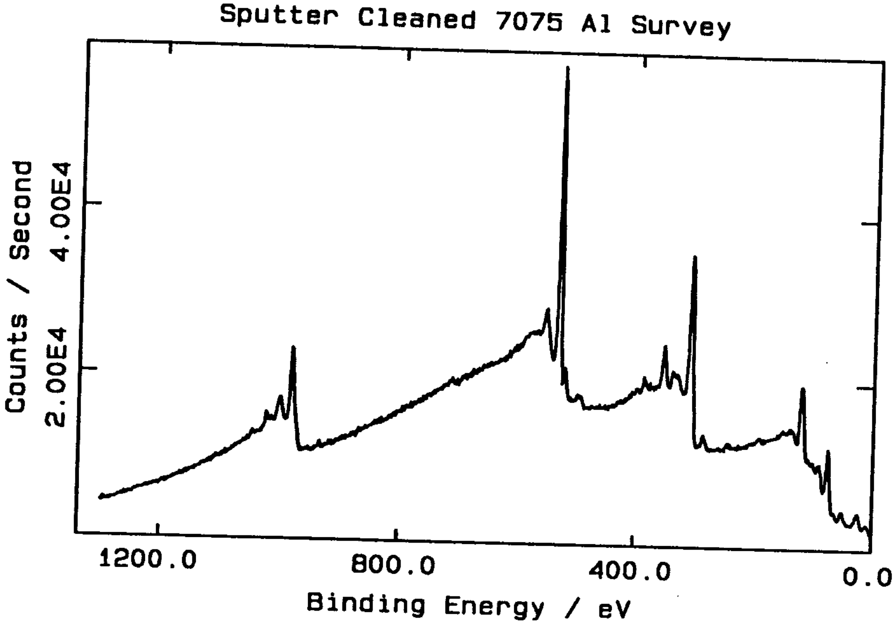
SUMMARY OF ANALYSIS

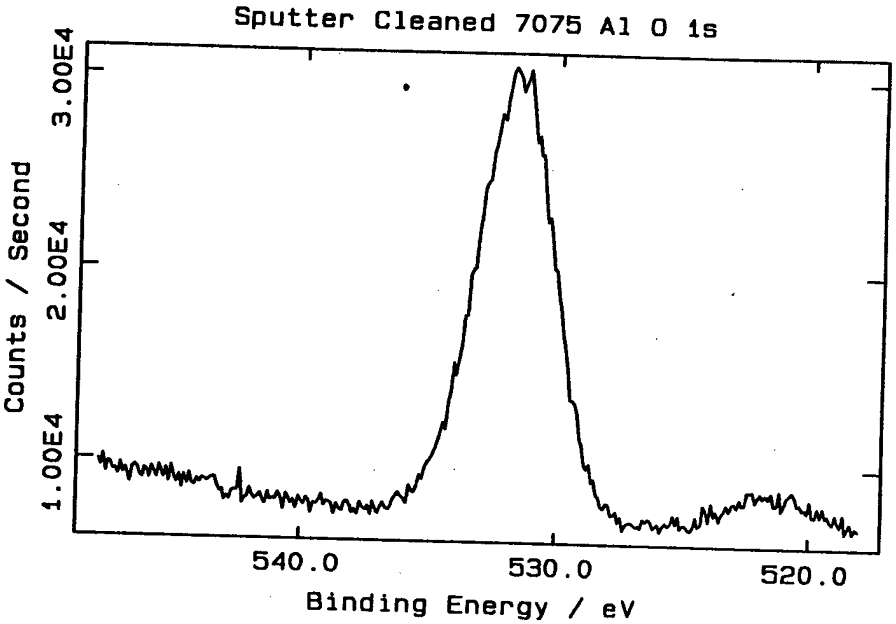
Run number: 1   Excitation: Al   Pass energy: 200 eV

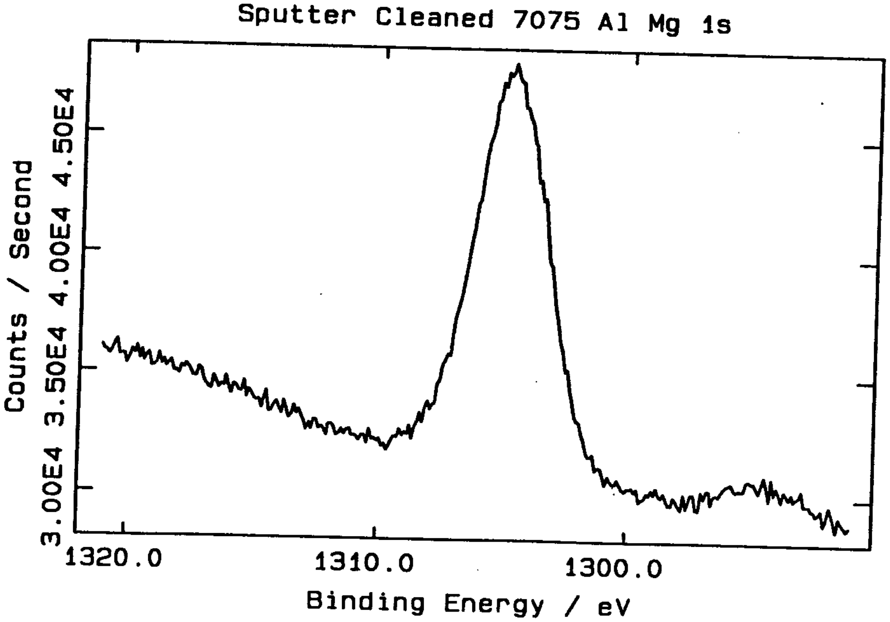
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN064.R1	Mg 1s	1304.83	60548.0000	9.36
2	ALPAN064.R2	O 1s	531.68	86914.0000	180.44
3	ALPAN064.R3	C 1s	284.80	6754.2200	61.63
4	ALPAN064.R4	See comments	134.41		
5	ALPAN064.R5	Mg 2s	89.24		
6	ALPAN064.R5	Al 2p	74.80	11440.0000	100.00

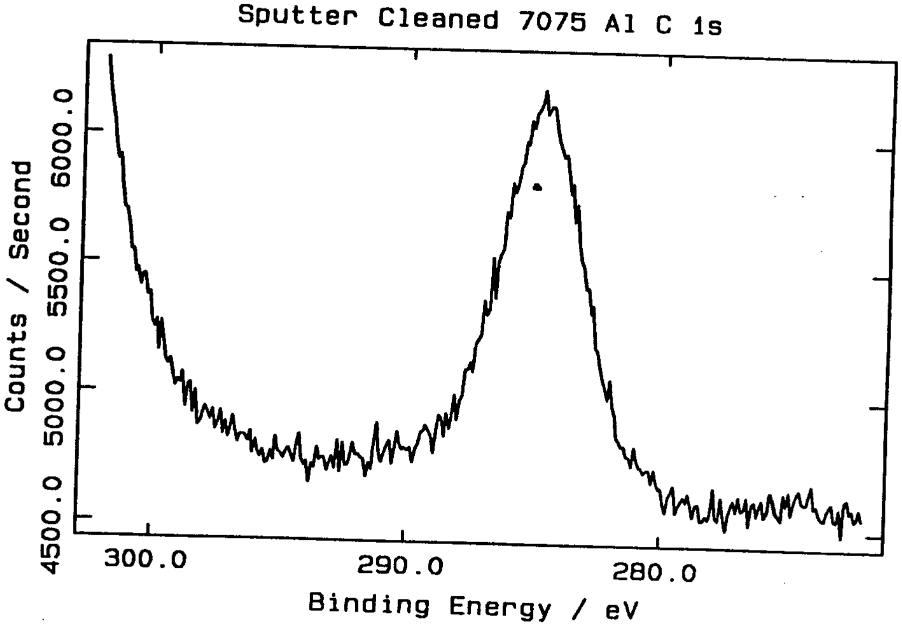
COMMENTS

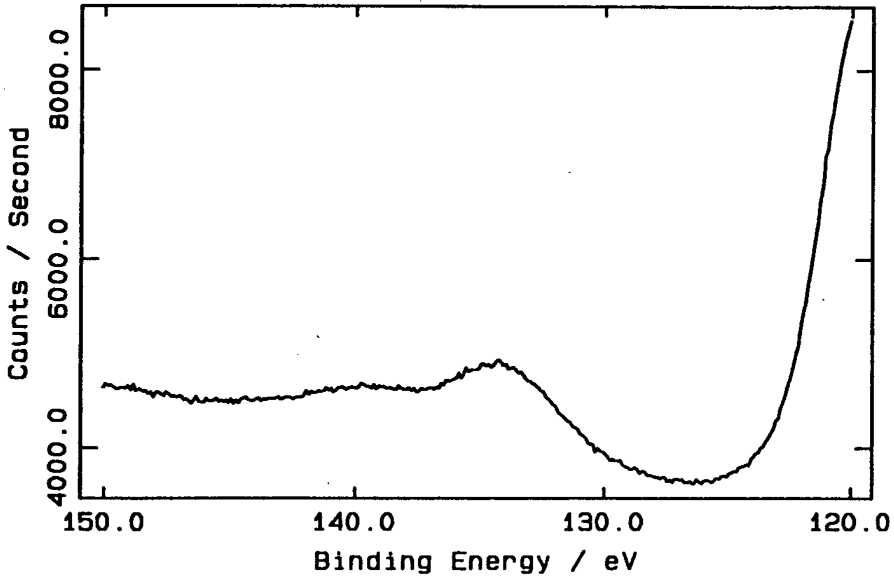
Peak 4 assigned to Al 2s shakeup. This peak appears at approximately the Same binding energy as the P 2p transition. The area of peak 4 is 2704.594.

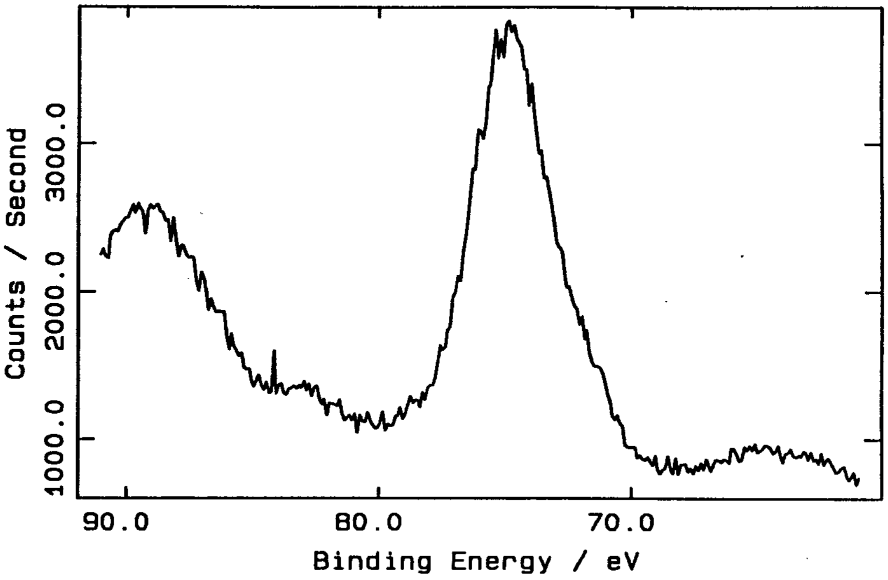

Sputter Cleaned 7075 Al Survey
Counts / Second
2.00E4
4.00E4
1200.0
800.0
400.0
0.0
Binding Energy / eV


Sputter Cleaned 7075 Al O 1s
Counts / Second
1.00E4
2.00E4
3.00E4
540.0
530.0
520.0
Binding Energy / eV


Sputter Cleaned 7075 Al Mg 1s
Counts / Second
3.00E4
3.50E4
4.00E4
4.50E4
1320.0
1310.0
1300.0
Binding Energy / eV


Sputter Cleaned 7075 Al C 1s
Counts / Second
4500.0
5000.0
5500.0
6000.0
300.0
290.0
280.0
Binding Energy / eV


Sputter Cleaned 7075 Al Al 2s Shakeup


Sputter Cleaned 7075 Al Al 2p

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Brulin 815 GD Cleaned 7075 Al Test Panel 1

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN065.R1	None	Survey	RF = 3
ALPAN066	1.7315	Detail	PE = 200

SUMMARY OF ANALYSIS

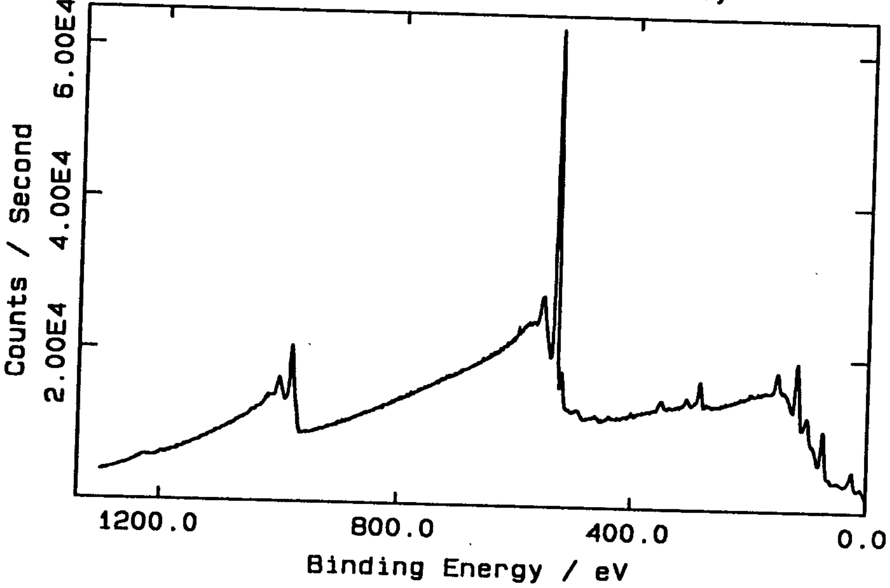
Run number: 1   Excitation: Al   Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN066.R1	Mg 1s	1305.39	3858.8020	0.66
2	ALPAN066.R2	O 1s	531.59	108020.0000	247.38
3	ALPAN066.R3	Ca 2p$_{1/2}$	351.56		
4	ALPAN066.R3	Ca 2p$_{3/2}$	348.53		
5	ALPAN066.R3	Ca 2p			
6	ALPAN066.R4	C 1s	284.80	3079.1240	1.86
7	ALPAN066.R5	Cl 2p	200.16	6154.2650	61.94
8	ALPAN066.R6	Si 2p	102.30	829.1332	1.33
9	ALPAN066.R7	Al 2p	74.45	5129.4170	30.74
10	ALPAN066.R7	Al 2p	71.20		
11	ALPAN066.R7	Al 2p		10368.0000	100.00

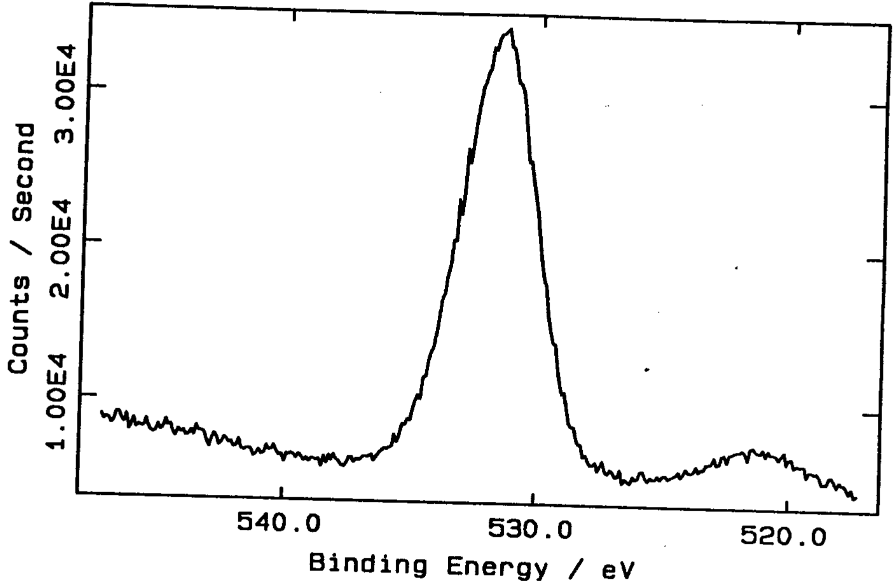
COMMENTS

Peaks 3- 5 overlap with Mg KL_1L_{23}. The Ca 2p doublet does not appear in the photoemission spectrum for test panel 2 of this set.

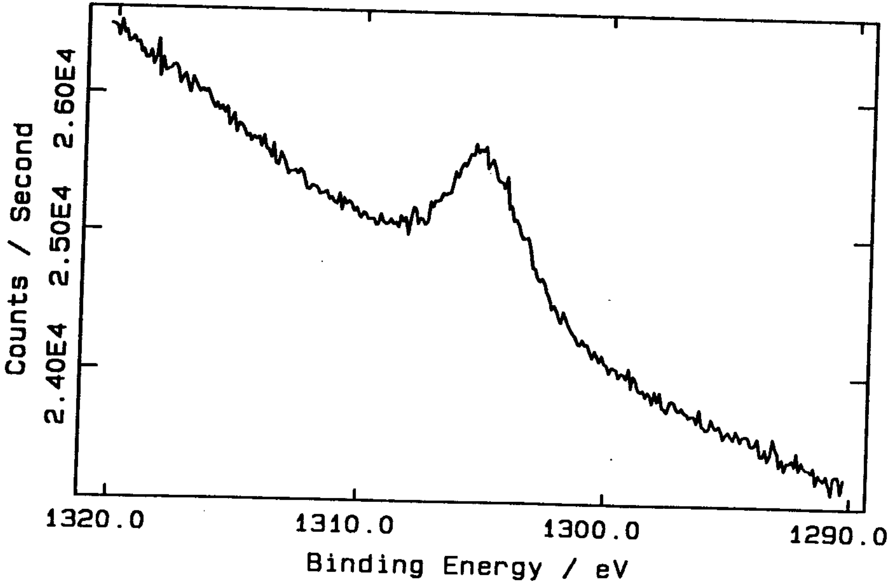
Brulin 815 GD, Panel 1 Survey



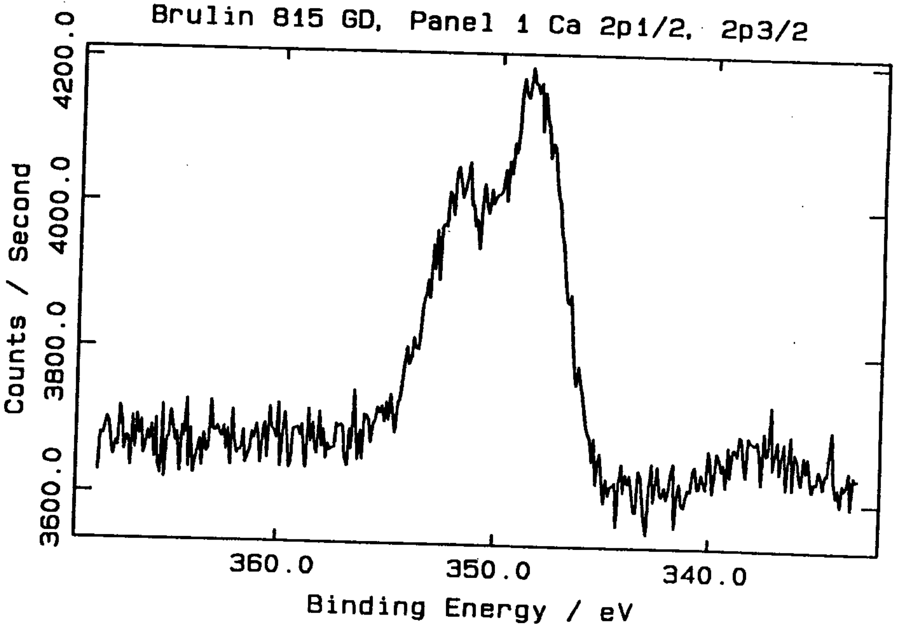
Brulin 815 GD, Panel 1 O 1s

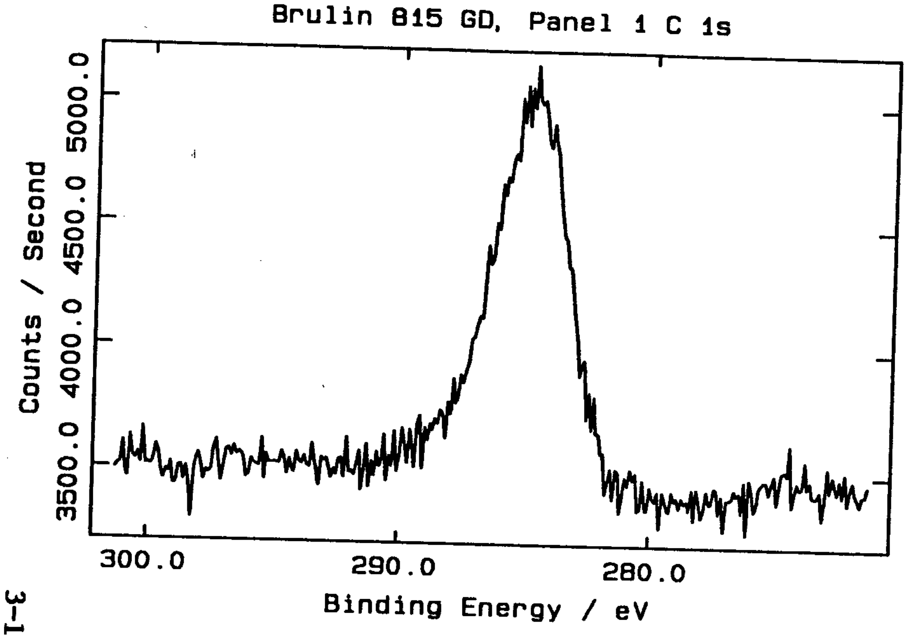


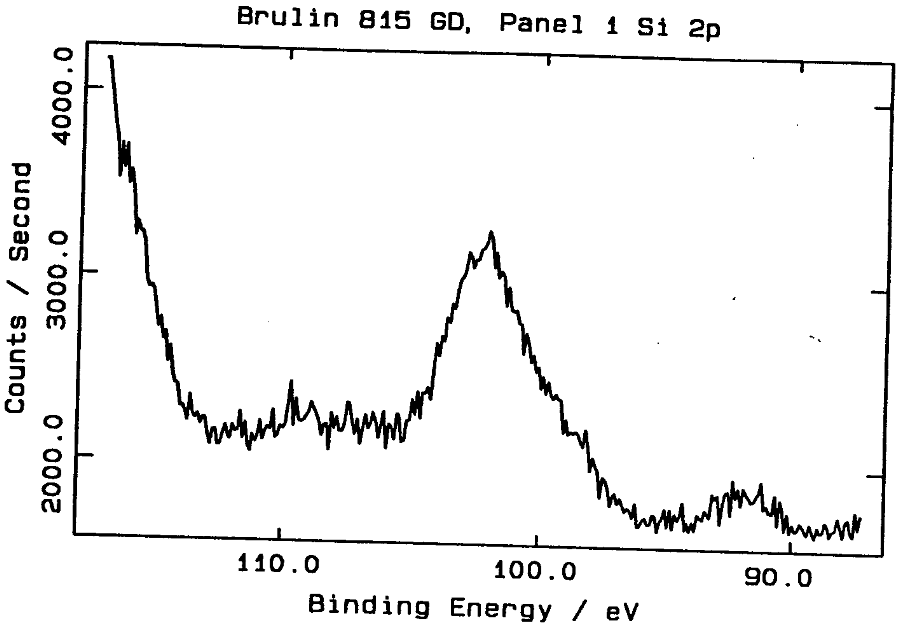
Brulin 815 GD, Panel 1 Mg 1s

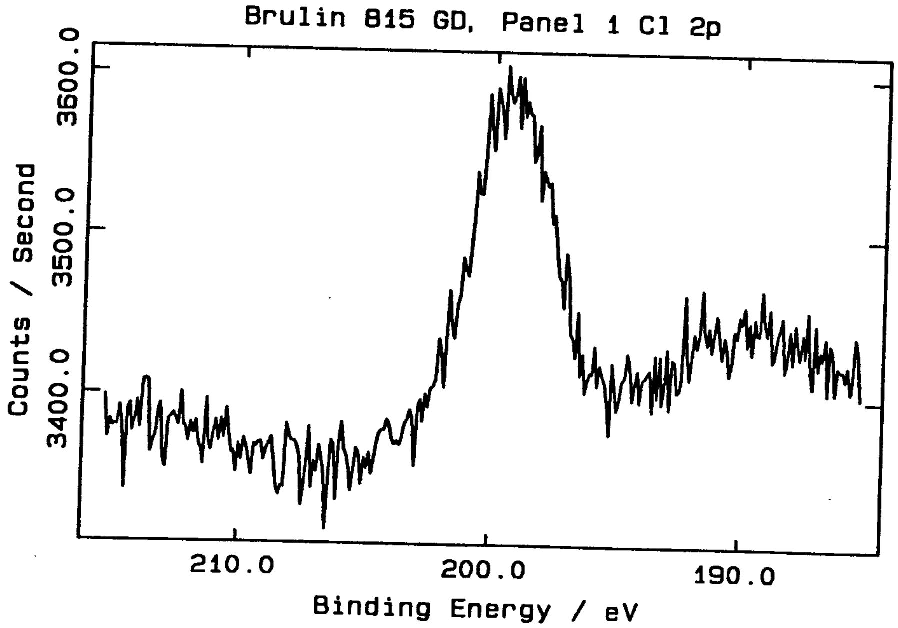


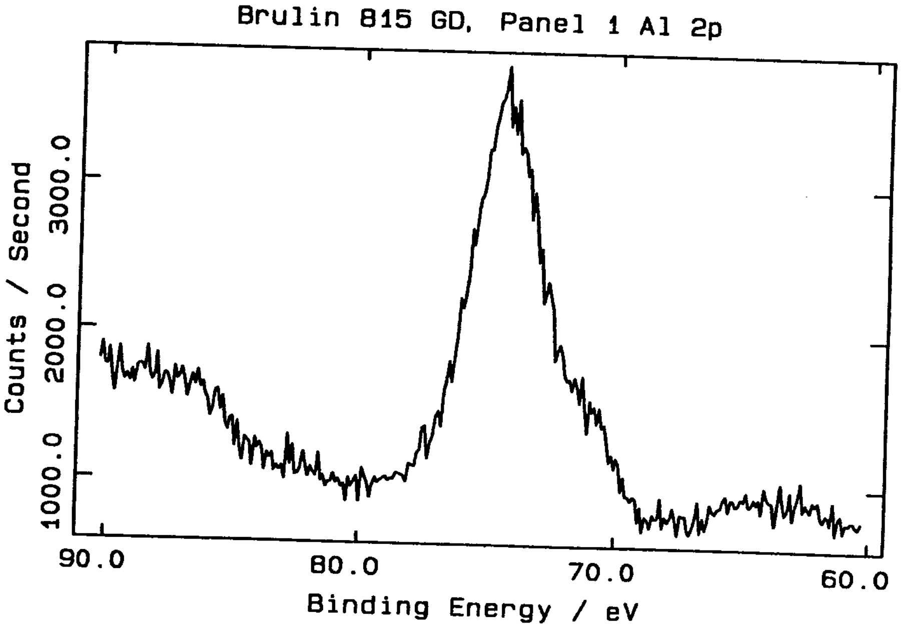
Brulin 815 GD, Panel 1 Ca 2p1/2, 2p3/2




Brulin 815 GD, Panel 1 C 1s


Brulin 815 GD, Panel 1 Si 2p


Brulin 815 GD, Panel 1 Cl 2p


Brulin 815 GD, Panel 1 Al 2p

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Brulin 815 GD Cleaned 7075 Al Test Panel 2

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN067.R1	None	Survey	RF = 3
ALPAN068	1.5232	Detail	PE = 200

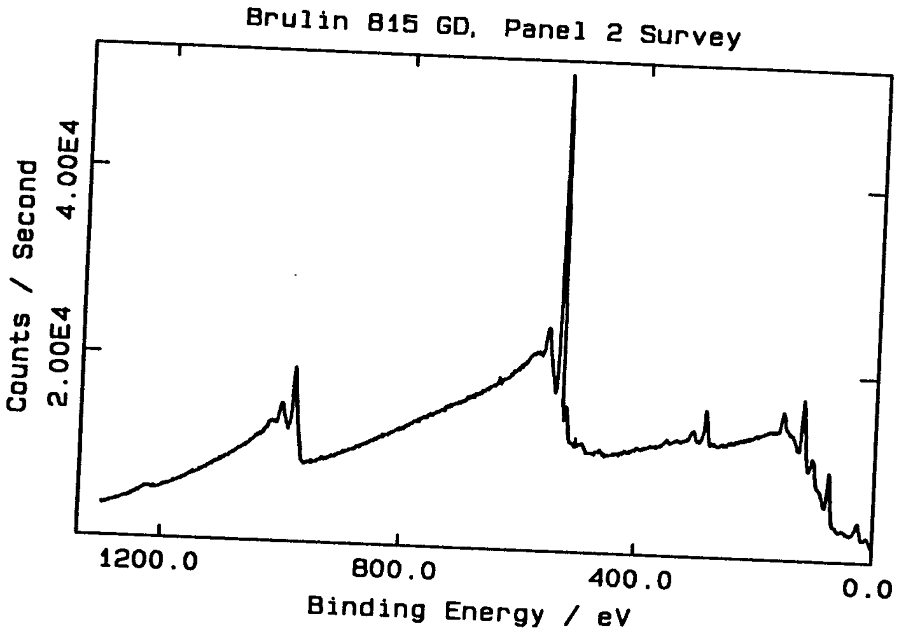
SUMMARY OF ANALYSIS

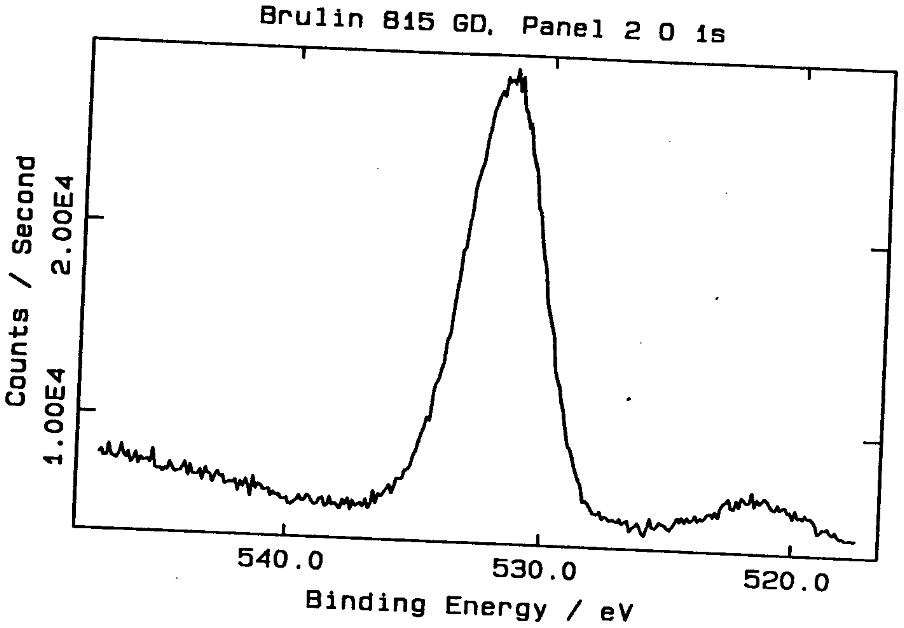
Run number: 1 Excitation: Al Pass energy: 200 eV

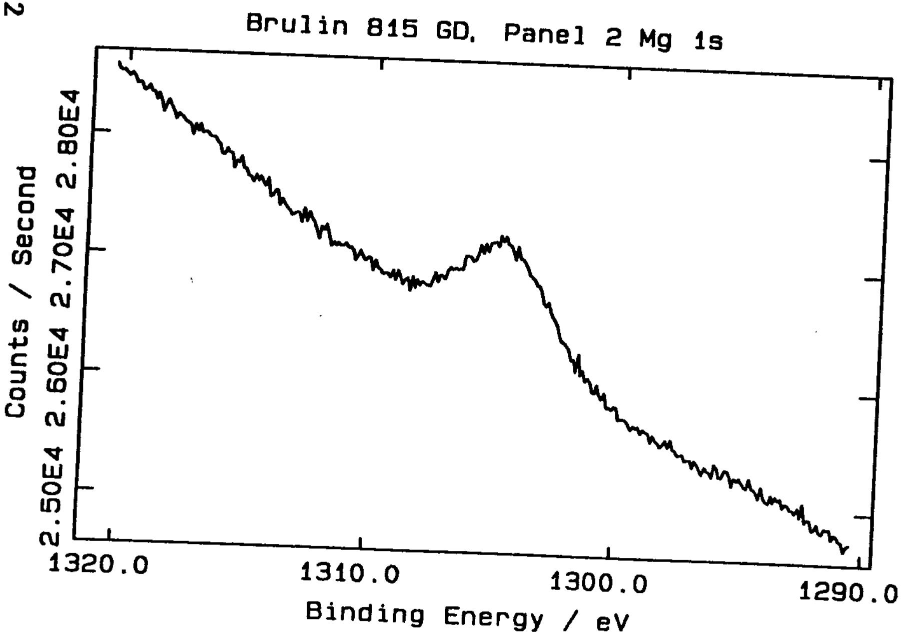
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN068.R1	Mg 1s	1304.93	3657.2520	0.71
2	ALPAN068.R2	O 1s	531.69	89111.0000	232.64
3	ALPAN068.R3	Mg KL_1L_{23}	351.56		
4	ALPAN068.R4	C 1s	284.80	7263.8160	83.35
5	ALPAN068.R5	Cl 2p	199.21	313.2660	0.57
6	ALPAN068.R6	Si 2p	102.42	4287.4980	29.29
7	ALPAN068.R7	Al 2p	74.59	9097.0290	100.00

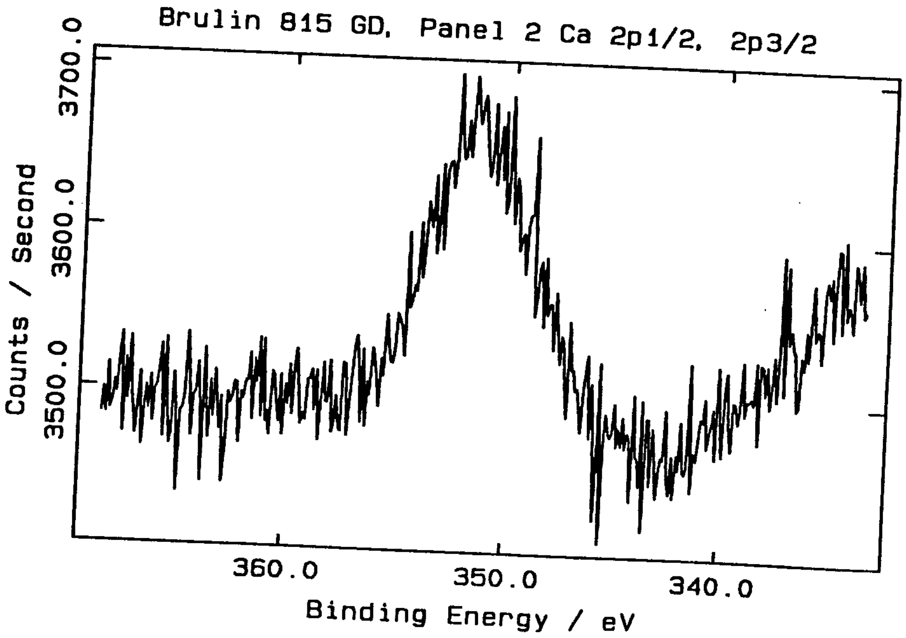
COMMENTS

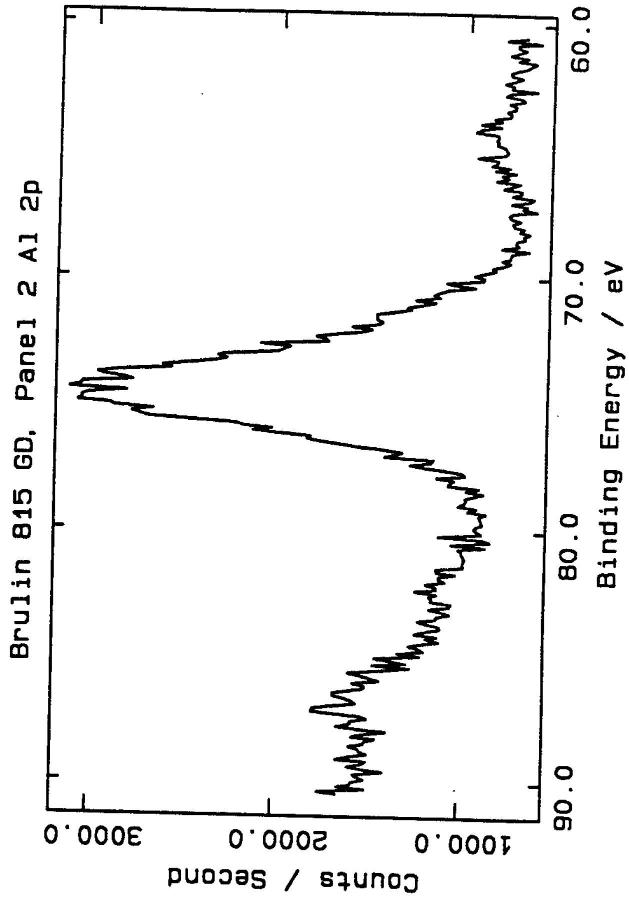
The Ca 2p doublet appears in the spectrum for test panel 1 of this set, but only the Mg KL_1L_{23} peak appears for test panel 2 (see peak 3, above).

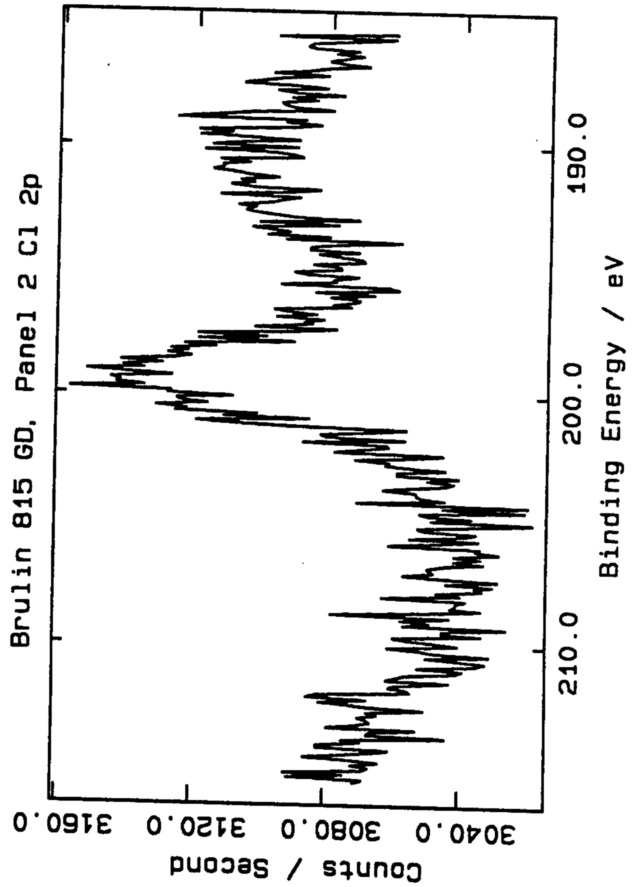

Brulin 815 GD, Panel 2 Survey

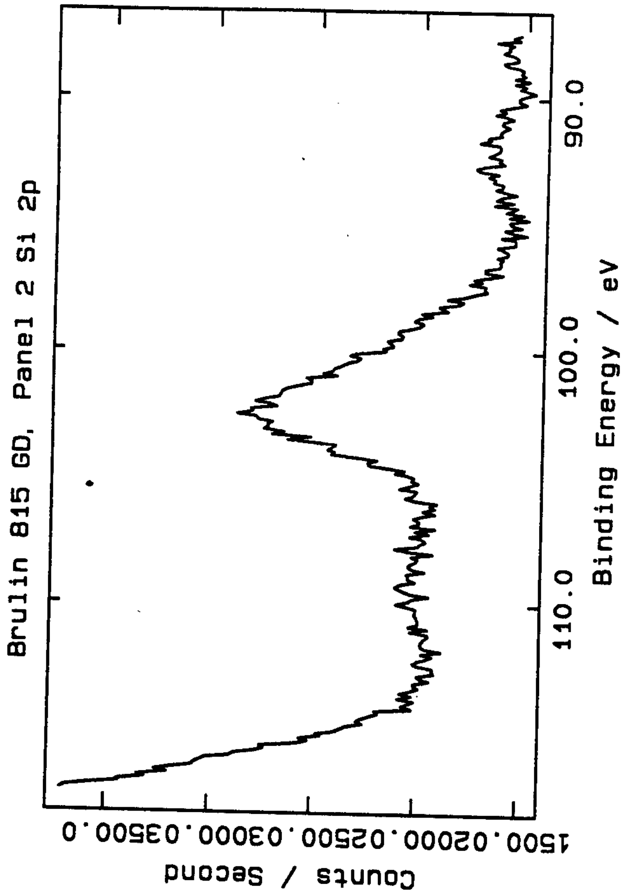

Brulin 815 GD, Panel 2 O 1s

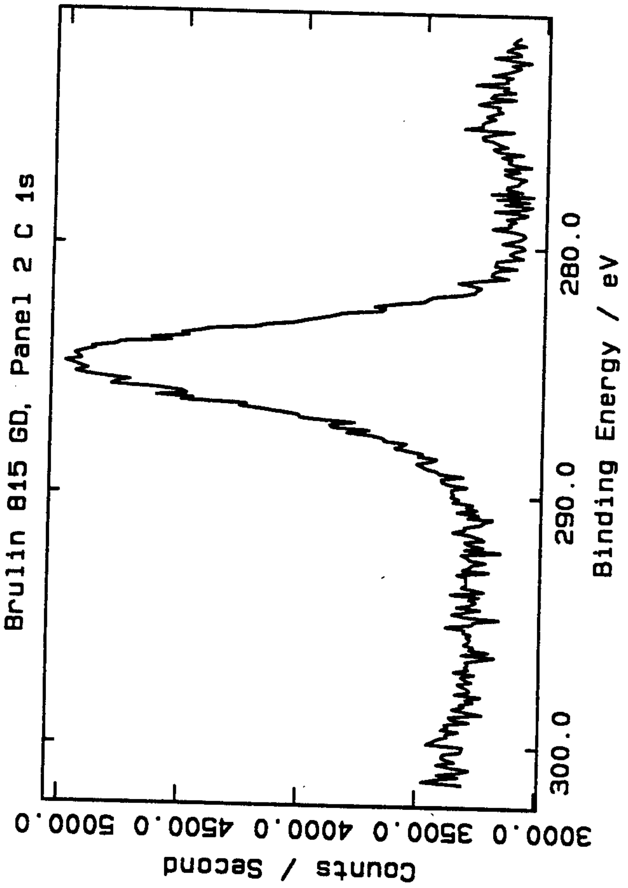

Brulin 815 GD, Panel 2 Mg 1s


Brulin 815 GD, Panel 2 Ca 2p1/2, 2p3/2


Brulin 815 GD, Panel 2 Al 2p
Binding Energy / eV
60.0
70.0
80.0
90.0
Counts / Second
1000.0
2000.0
3000.0


Brulin 815 GD, Panel 2 Cl 2p
Binding Energy / eV
190.0
200.0
210.0
Counts / Second
3040.0
3080.0
3120.0
3160.0


Brulin 815 GD, Panel 2 Si 2p
Binding Energy / eV
90.0
100.0
110.0
Counts / Second
1500.0
2000.0
2500.0
3000.0
3500.0


Brulin 815 GD, Panel 2 C 1s
Binding Energy / eV
280.0
290.0
300.0
Counts / Second
3000.0
3500.0
4000.0
4500.0
5000.0

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Power Cleaner 310 L Cleaned 7075 Al Test Panel 1

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN069.R1	None	Survey	RF = 3
ALPAN070	1.8584	Detail	PE = 200

SUMMARY OF ANALYSIS

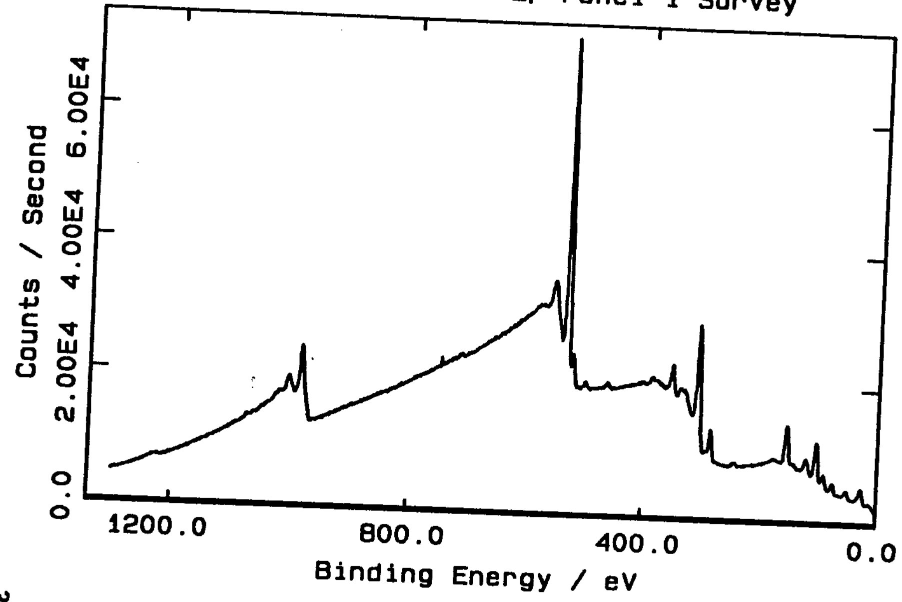
Run number: 1 Excitation: Al Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN070.R1	Mg 1s	1304.87	26832.0000	20.97
2	ALPAN070.R2	O 1s	532.00	110130.0000	1156.10
3	ALPAN070.R3	See comments	294.06		
4	ALPAN070.R3	C 1s	284.80	8489.1440	391.74
5	ALPAN070.R4	Si 2p	102.62	9609.1110	264.01
6	ALPAN070.R4	Mg 2s	89.38		
7	ALPAN070.R5	Al 2p	74.41	2261.8260	100.00

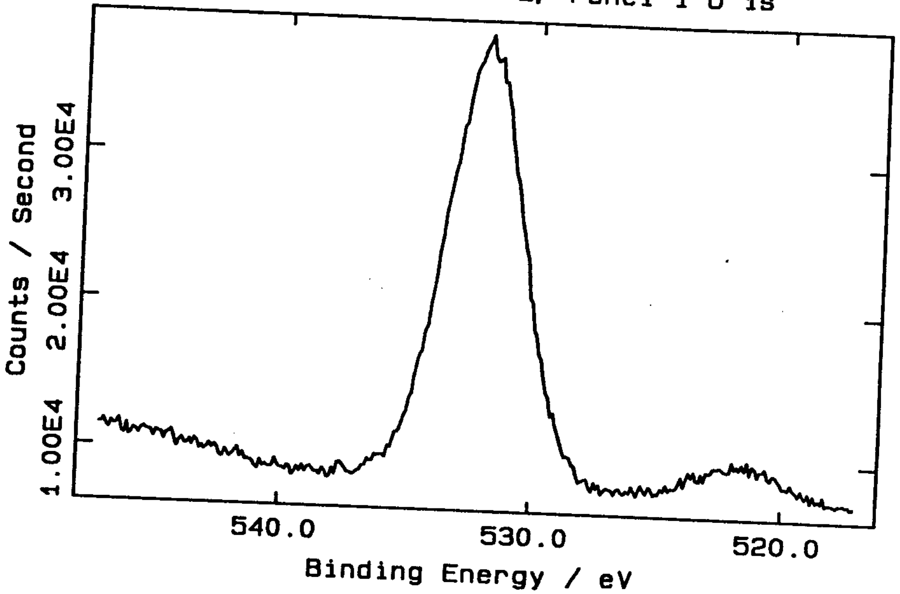
COMMENTS

Peak 3 may be due to Mg $KL_{23}V$.

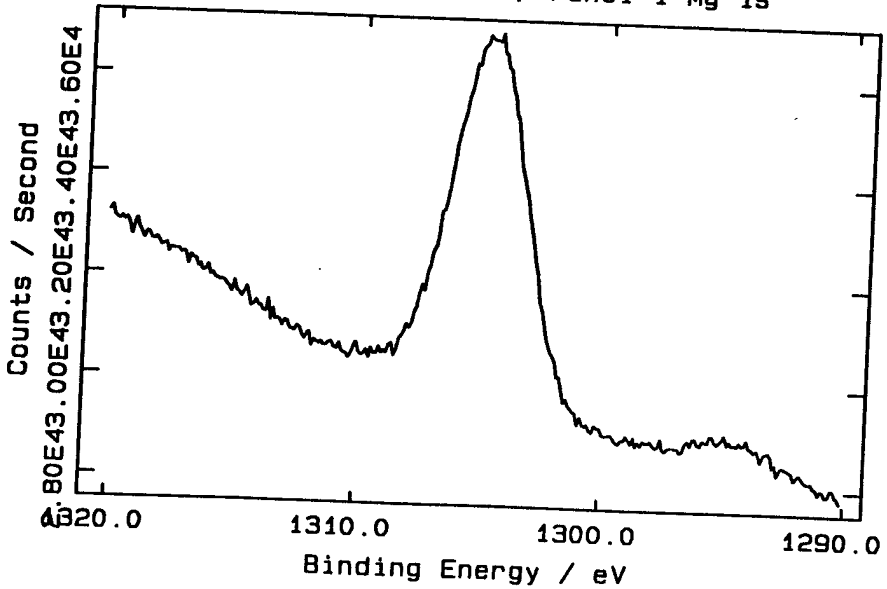
Power Cleaner 310 L. Panel 1 Survey



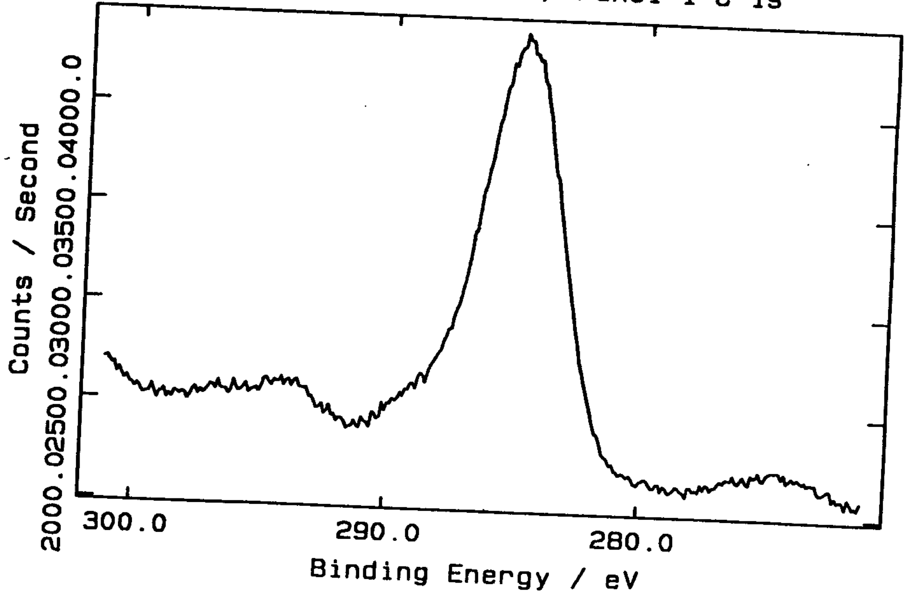
Power Cleaner 310 L. Panel 1 O 1s

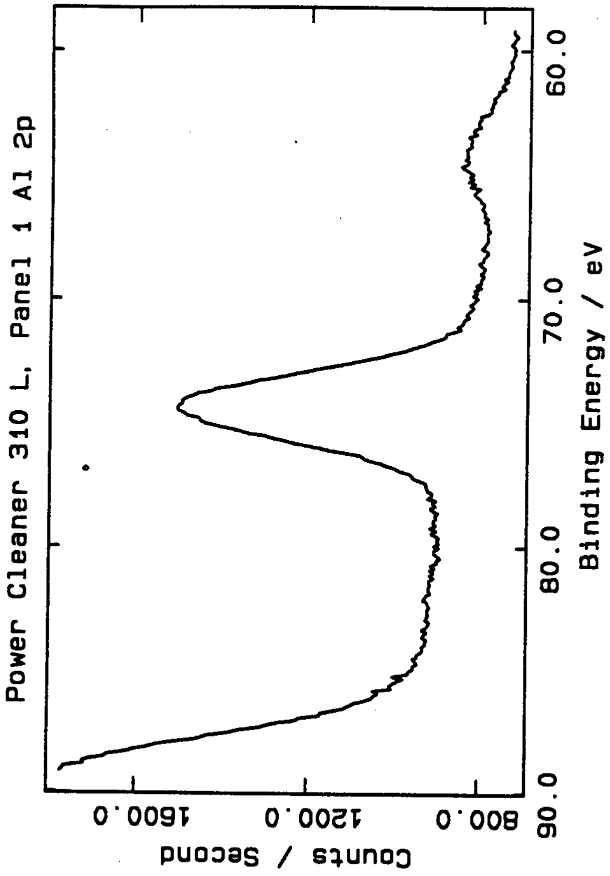


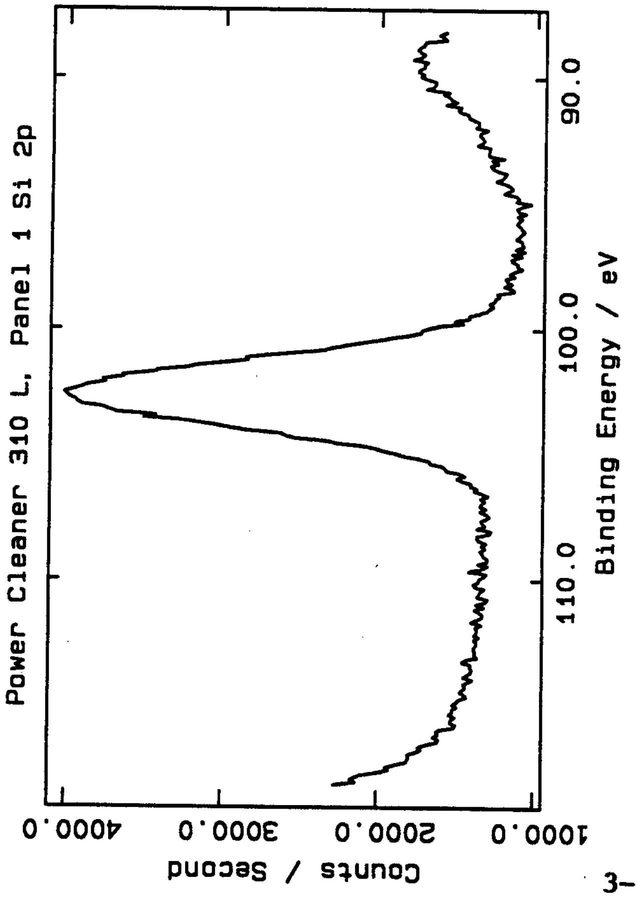
Power Cleaner 310 L. Panel 1 Mg 1s



Power Cleaner 310 L. Panel 1 C 1s




Power Cleaner 310 L, Panel 1 Al 2p
Counts / Second
800.0
1200.0
1600.0
Binding Energy / eV
90.0
80.0
70.0
60.0


Power Cleaner 310 L, Panel 1 Si 2p
Counts / Second
1000.0
2000.0
3000.0
4000.0
Binding Energy / eV
110.0
100.0
90.0

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Power Cleaner 310 L Cleaned 7075 Al Test Panel 2

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN071.R1	None	Survey	RF = 3
ALPAN072	1.7910	Detail	PE = 200

SUMMARY OF ANALYSIS

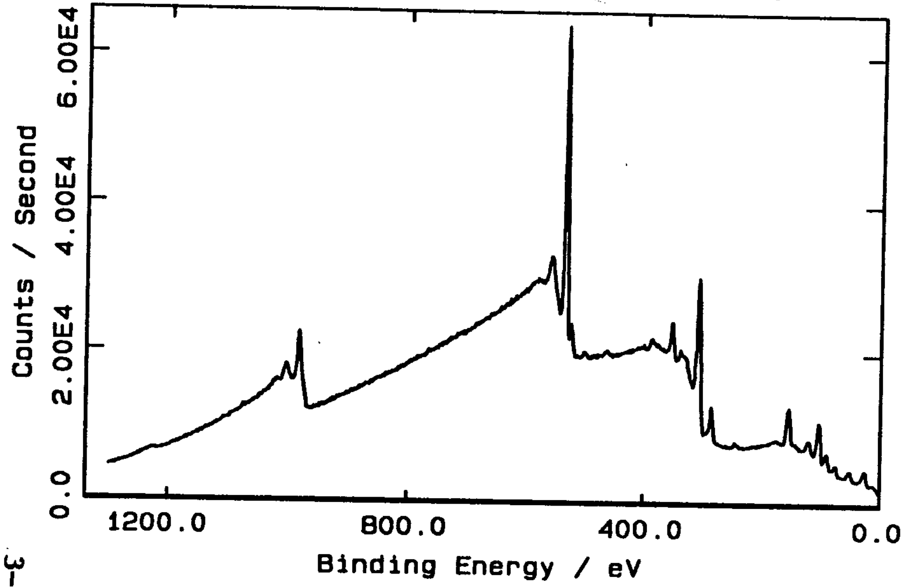
Run number: 1   Excitation: Al   Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN072.R1	Mg 1s	1304.92	22317.0000	21.95
2	ALPAN072.R2	O 1s	532.09	93318.0000	1232.79
3	ALPAN072.R3	See comments	294.13		
4	ALPAN072.R3	C 1s	284.80	8728.7060	506.92
5	ALPAN072.R4	Si 2p	102.72	8030.3750	277.66
6	ALPAN072.R4	Mg 2s	89.33		
7	ALPAN072.R5	See comments	82.22		
8	ALPAN072.R5	Al 2p	74.52	1797.3010	100.00

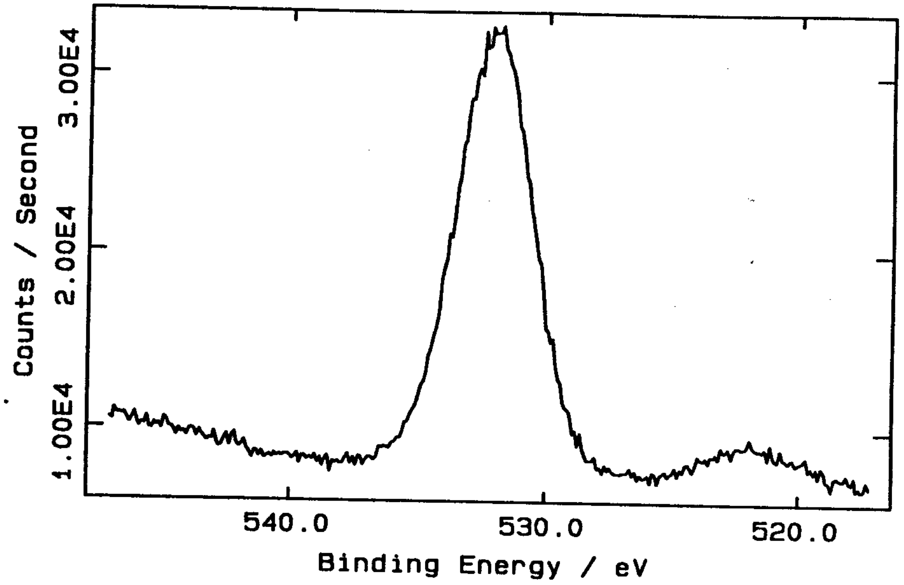
COMMENTS

Peak 3 may be due to Mg $KL_{23}V$.
Peak 7 assigned to Si 2s excited by Al K-beta radiation.

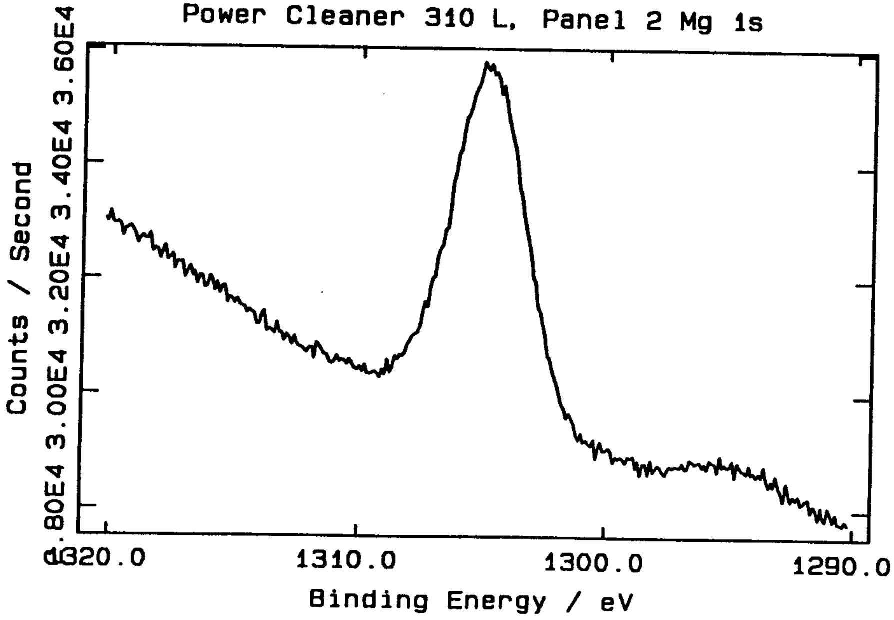
Power Cleaner 310 L, Panel 2 Survey



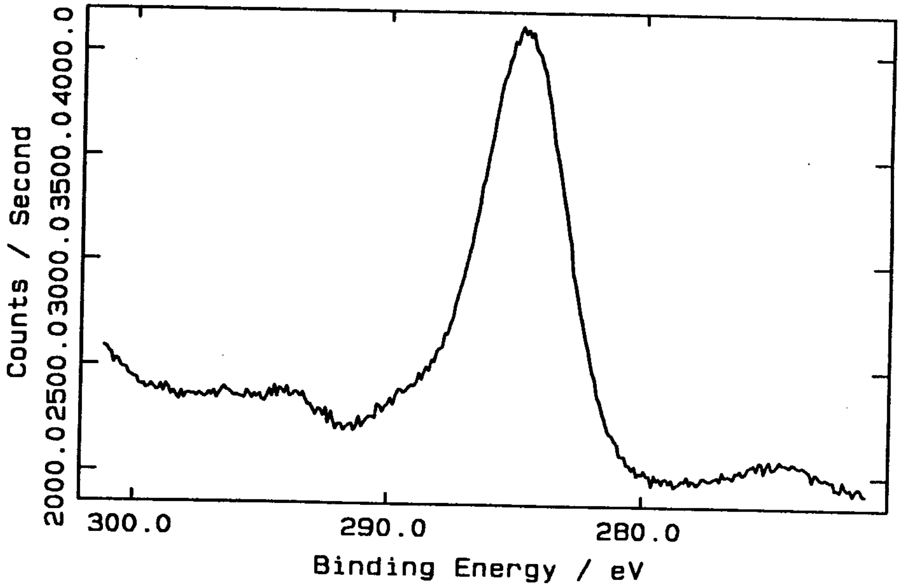
Power Cleaner 310 L, Panel 2 O 1s

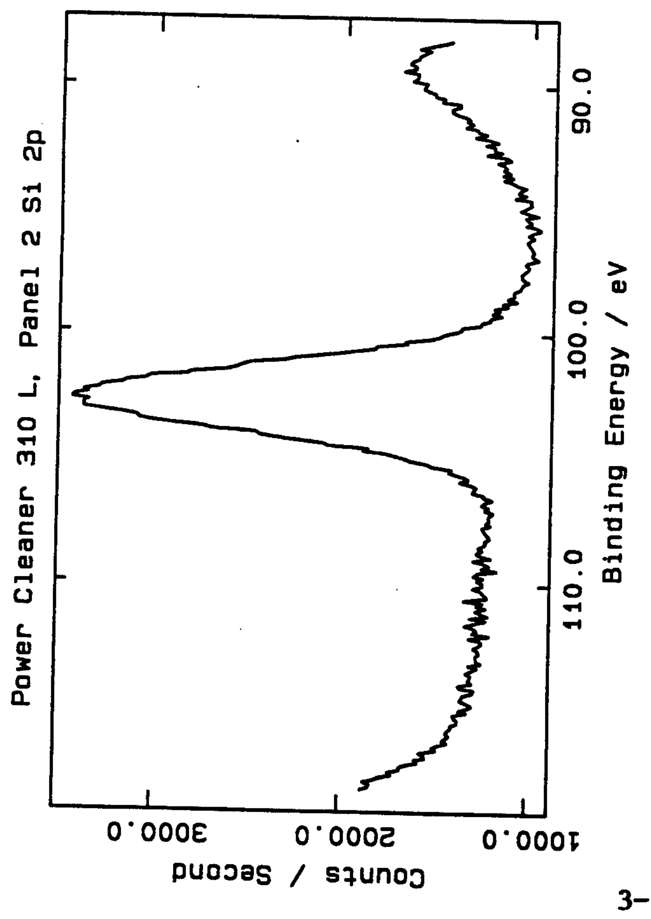


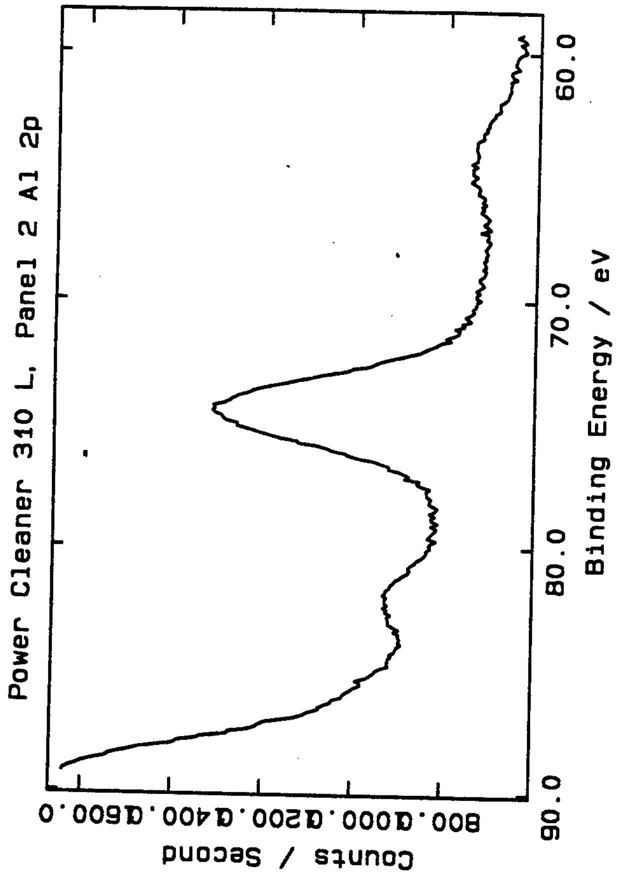
Power Cleaner 310 L, Panel 2 Mg 1s



Power Cleaner 310 L, Panel 2 C 1s




Power Cleaner 310 L, Panel 2 Si 2p
Counts / Second
1000.0
2000.0
3000.0
Binding Energy / eV
110.0
100.0
90.0


Power Cleaner 310 L, Panel 2 Al 2p
Counts / Second
800.0
1000.0
1200.0
1400.0
1600.0
Binding Energy / eV
90.0
80.0
70.0
60.0

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Jettacin Cleaned 7075 Al Test Panel 1

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

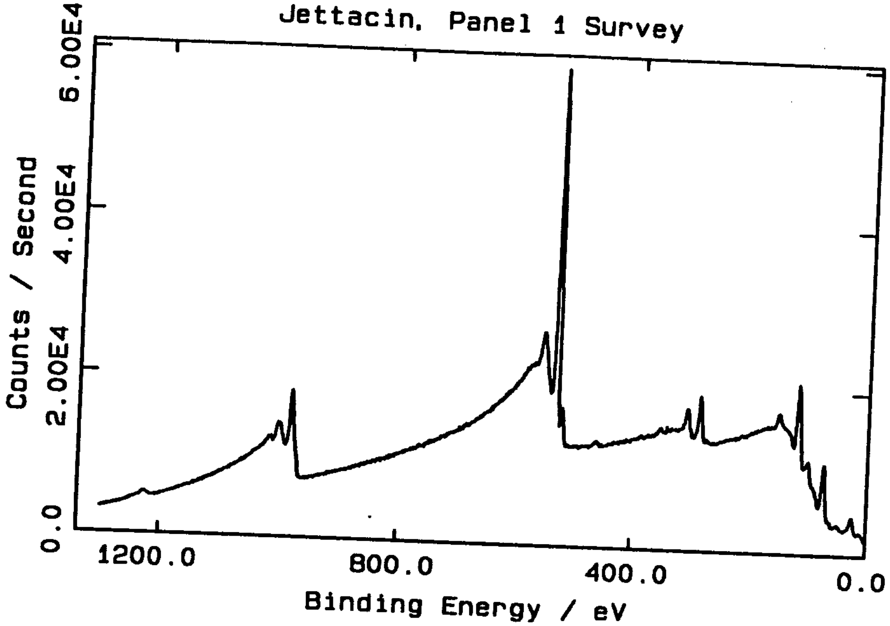
FILE SUMMARY

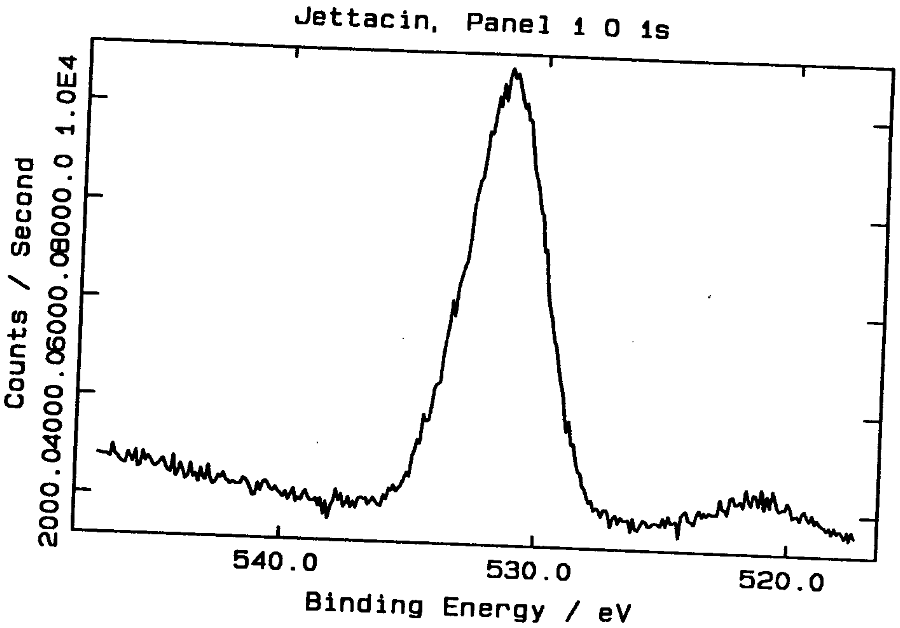
File name	Charge correction	Type	Instrument settings
ALPAN073.R1	None	Survey	RF = 3
ALPAN074	1.6955	Detail	PE = 200

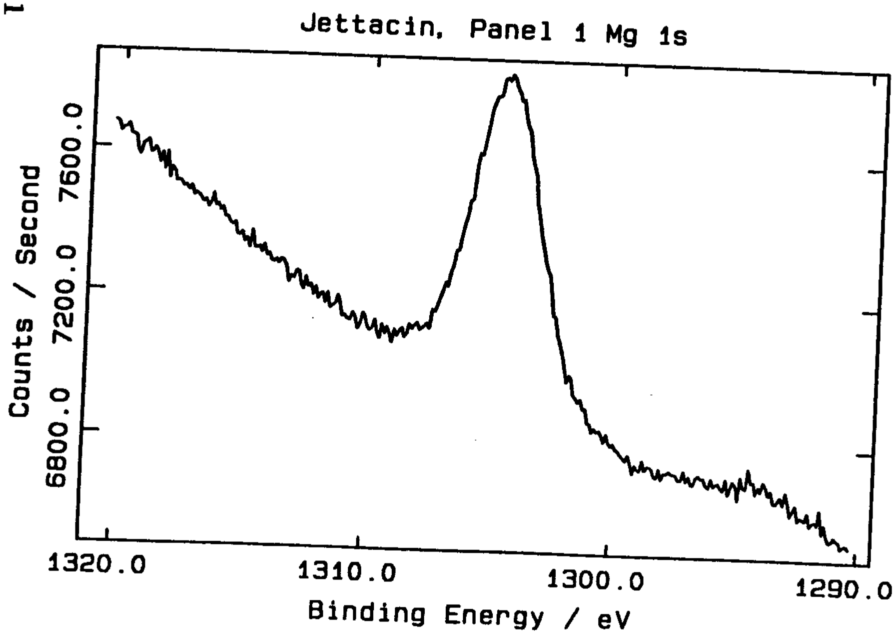
SUMMARY OF ANALYSIS

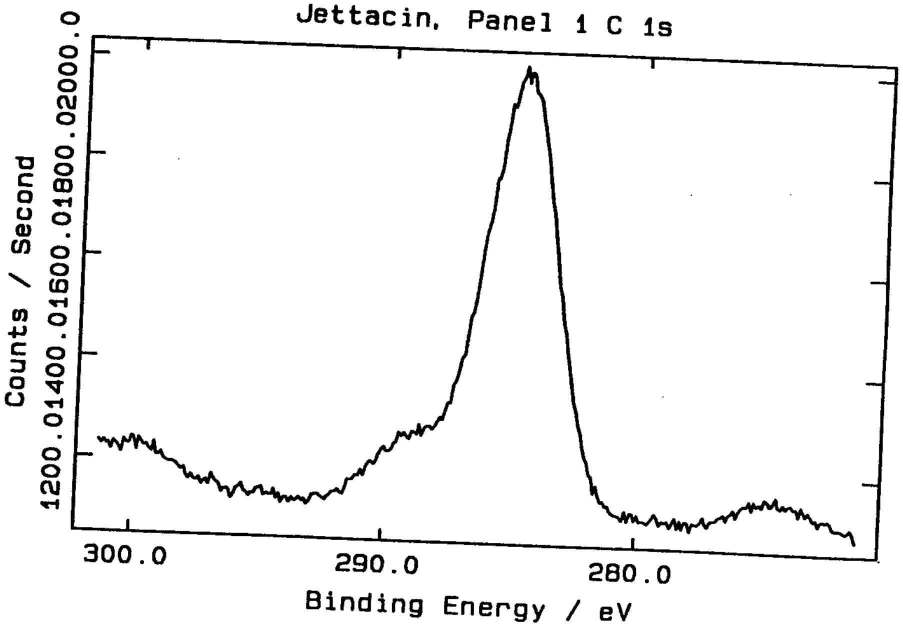
Run number: 1   Excitation: Al   Pass energy: 200 eV

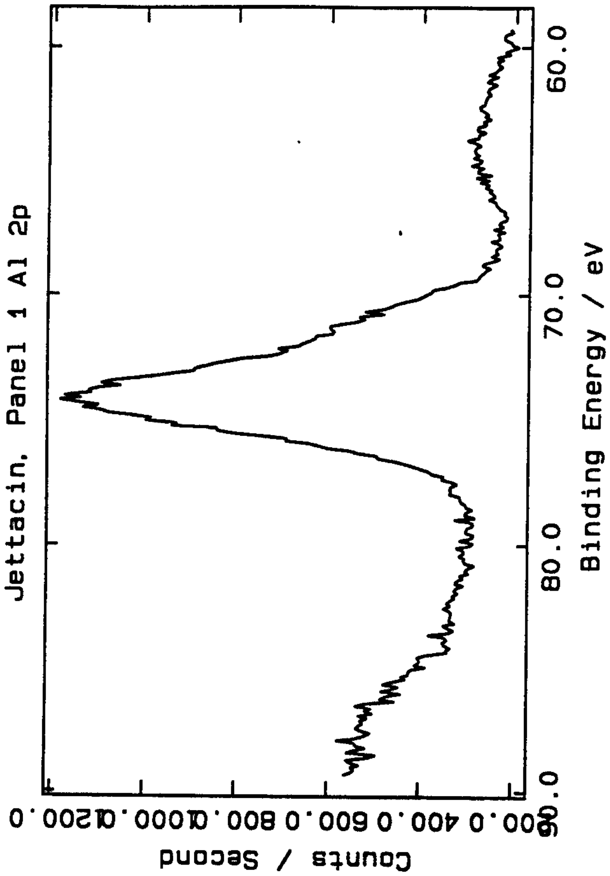
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN074.R1	Mg 1s	1304.59	3201.7910	1.57
2	ALPAN074.R2	O 1s	531.37	35165.0000	231.17
3	ALPAN074.R3	C 1s	289.13		
4	ALPAN074.R3	C 1s	284.80		
5	ALPAN074.R3	C 1s		3475.9220	100.39
6	ALPAN074.R4	Si 2p	101.54	1105.2410	19.02
7	ALPAN074.R5	Al 2p	74.22	3612.7650	100.00

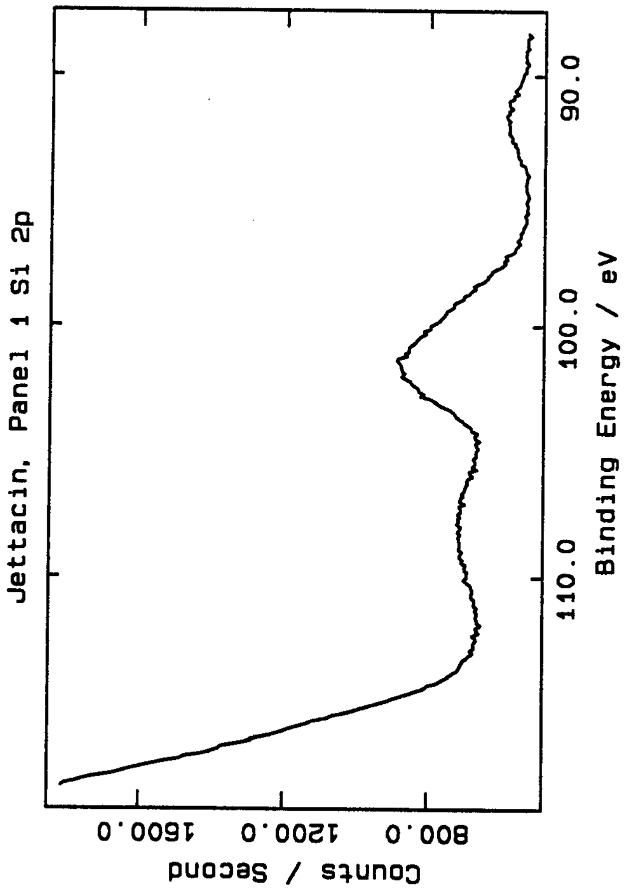

Jettacin, Panel 1 Survey


Jettacin, Panel 1 O 1s


Jettacin, Panel 1 Mg 1s


Jettacin, Panel 1 C 1s


Jettacin, Panel 1 Al 2p
Binding Energy / eV
60.0
70.0
80.0
90.0
Counts / Second
00.0
400.0
600.0
800.0
1000.0
1200.0


Jettacin, Panel 1 Si 2p
Binding Energy / eV
90.0
100.0
110.0
Counts / Second
800.0
1200.0
1600.0

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Jettacin Cleaned 7075 Al Test Panel 2

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

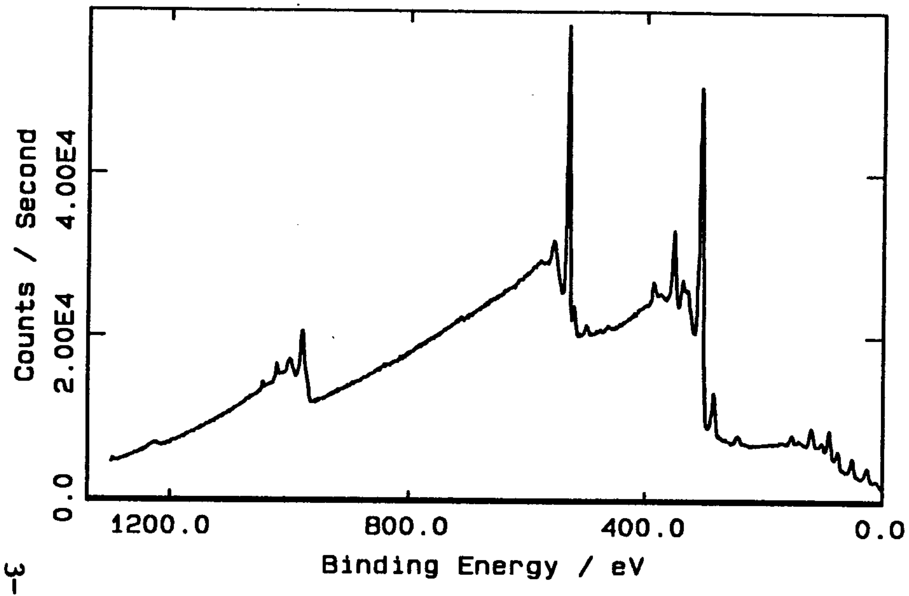
FILE SUMMARY

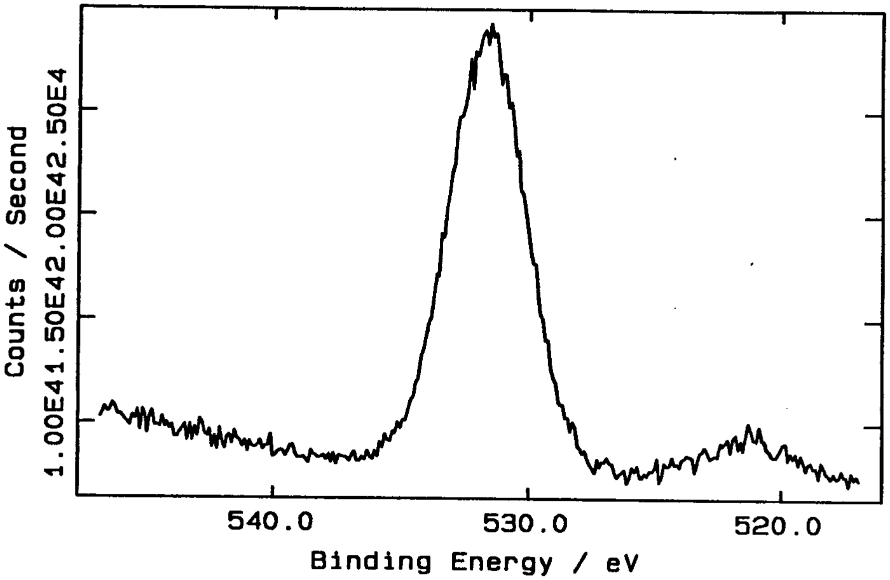
File name	Charge correction	Type	Instrument settings
ALPAN075.R1	None	Survey	RF = 3
ALPAN076	2.0777	Detail	PE = 200

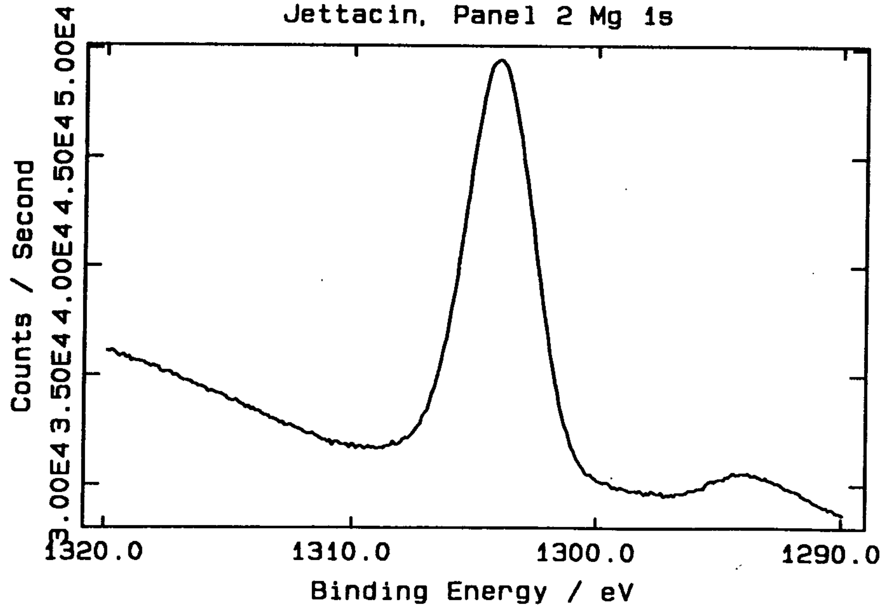
SUMMARY OF ANALYSIS

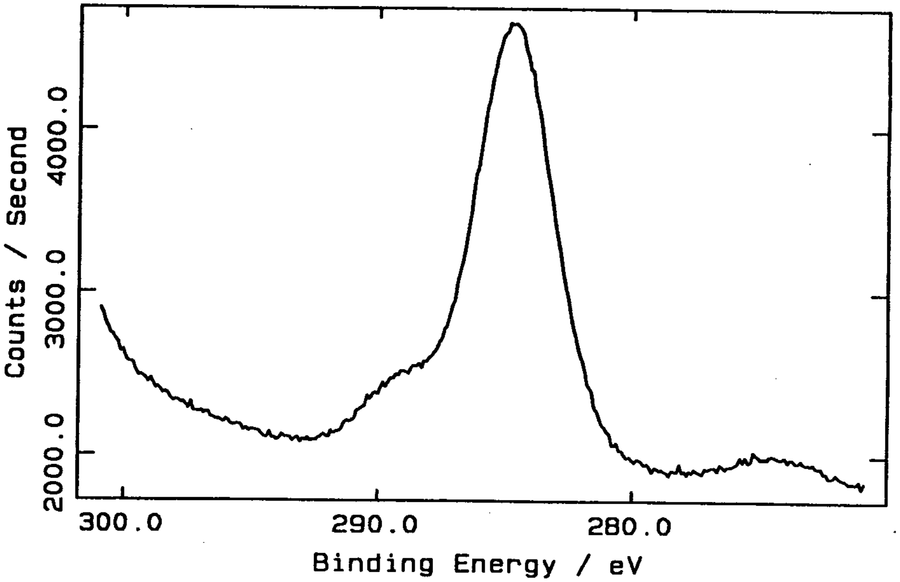
Run number: 1   Excitation: Al   Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN076.R1	Mg 1s	1304.02	64780.0000	41.20
2	ALPAN076.R2	O 1s	531.66	78929.0000	672.84
3	ALPAN076.R3	C 1s	289.30		
4	ALPAN076.R3	C 1s	284.80		
5	ALPAN076.R3	C 1s		11665.0000	436.92
6	ALPAN076.R4	Si 2p	101.68	1838.3260	41.02
7	ALPAN076.R4	Mg 2s	88.83		
8	ALPAN076.R5	Mg 2s	88.83		
9	ALPAN076.R5	Al 2p	74.27	2785.6660	100.00

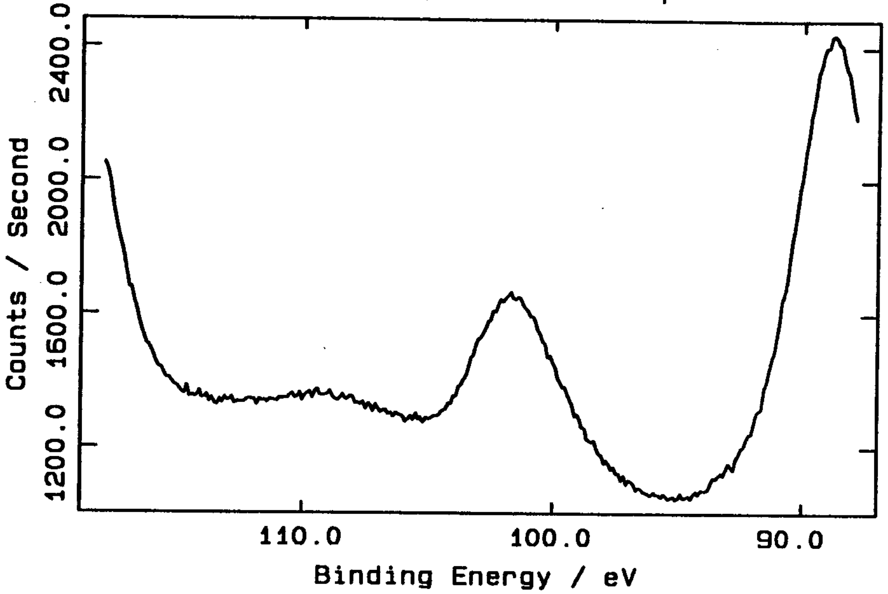

Jettacin, Panel 2 Survey


Jettacin, Panel 2 O 1s

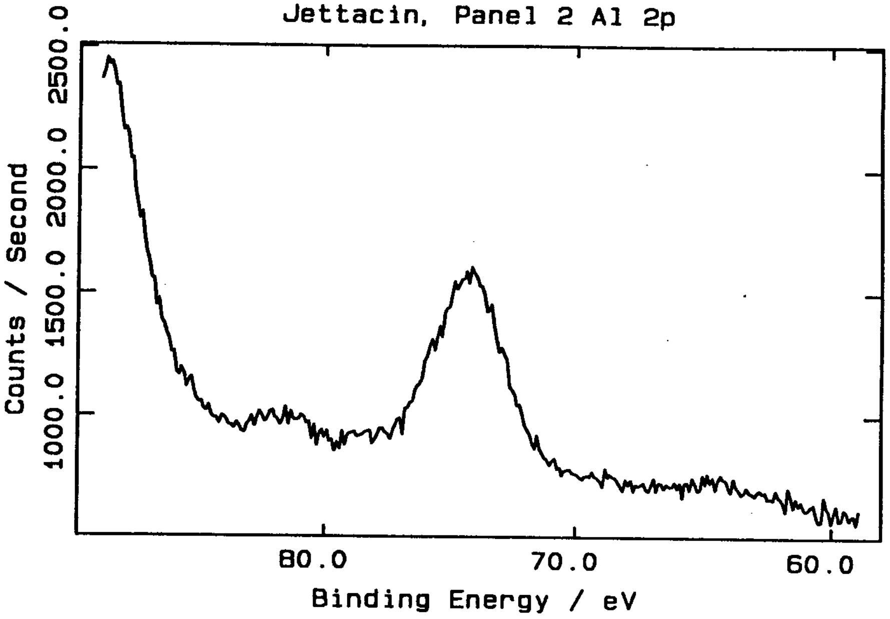

Jettacin, Panel 2 Mg 1s


Jettacin, Panel 2 C 1s

Jettacin, Panel 2 Si 2p



Jettacin, Panel 2 Al 2p



Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Cee Bee A 7 x 7 Cleaned 7075 Al Test Panel 1

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

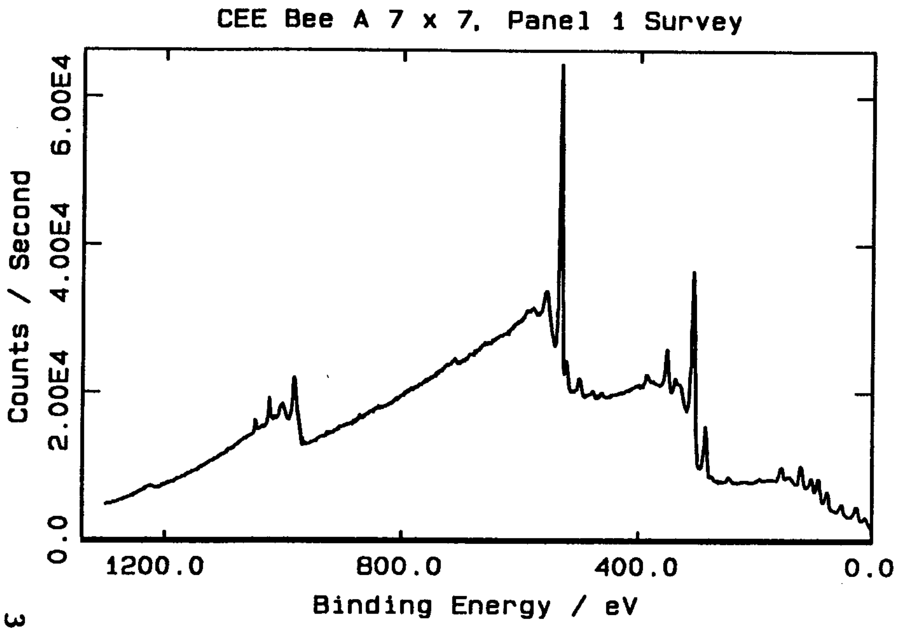
FILE SUMMARY

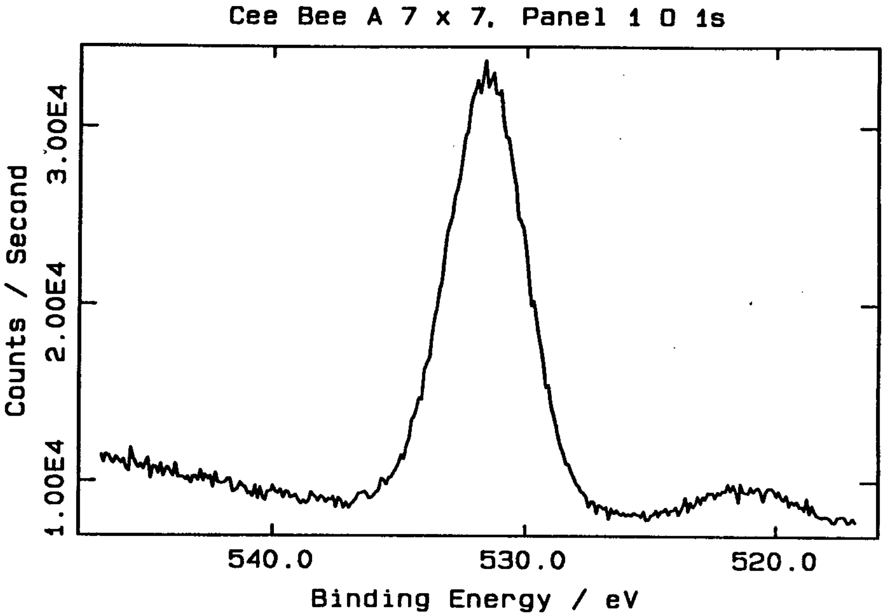
File name	Charge correction	Type	Instrument settings
ALPAN077.R1	None	Survey	RF = 3
ALPAN078	2.1082	Detail	PE = 200

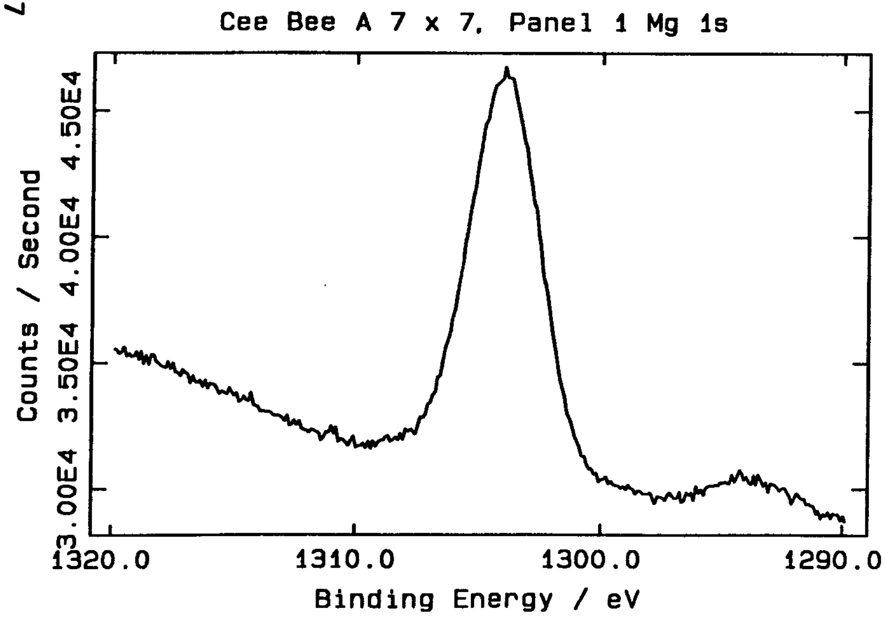
SUMMARY OF ANALYSIS

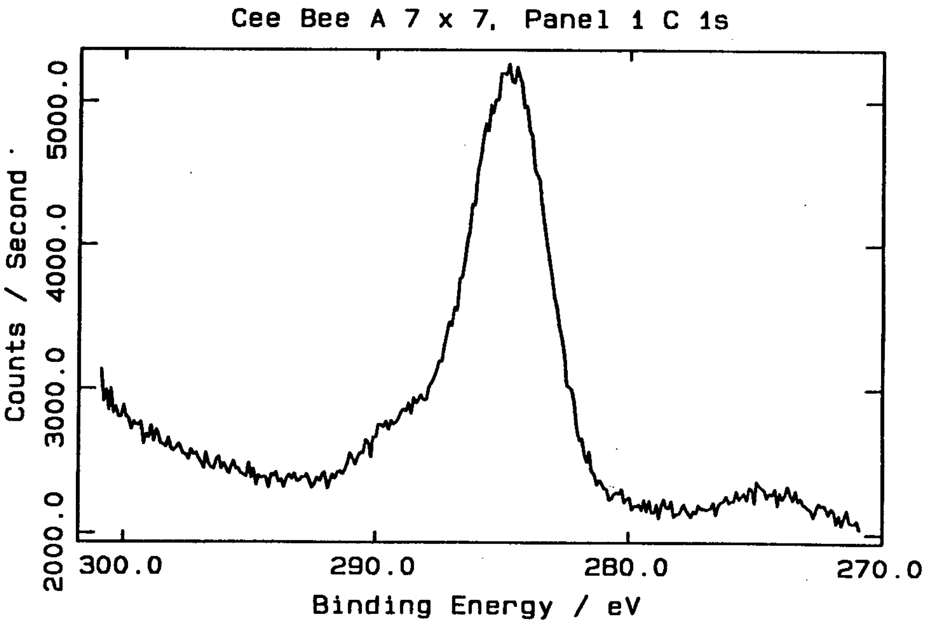
Run number: 1   Excitation: Al   Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN078.R1	Mg 1s	1304.03	77086.0000	38.30
2	ALPAN078.R2	O 1s	531.55	94716.0000	630.72
3	ALPAN078.R3	C 1s	289.54		
4	ALPAN078.R3	C 1s	284.80		
5	ALPAN078.R3	C 1s		12819.0000	375.04
6	ALPAN078.R4	Si 2s	140.30		
7	ALPAN078.R4	P 2p	134.12	682.3900	7.27
8	ALPAN078.R5	Si 2p	101.95	3270.3940	57.00
9	ALPAN078.R5	Mg 2s	88.88		
10	ALPAN078.R6	Mg 2s	88.88		
11	ALPAN078.R6	Al 2p	74.22	3566.2050	100.00

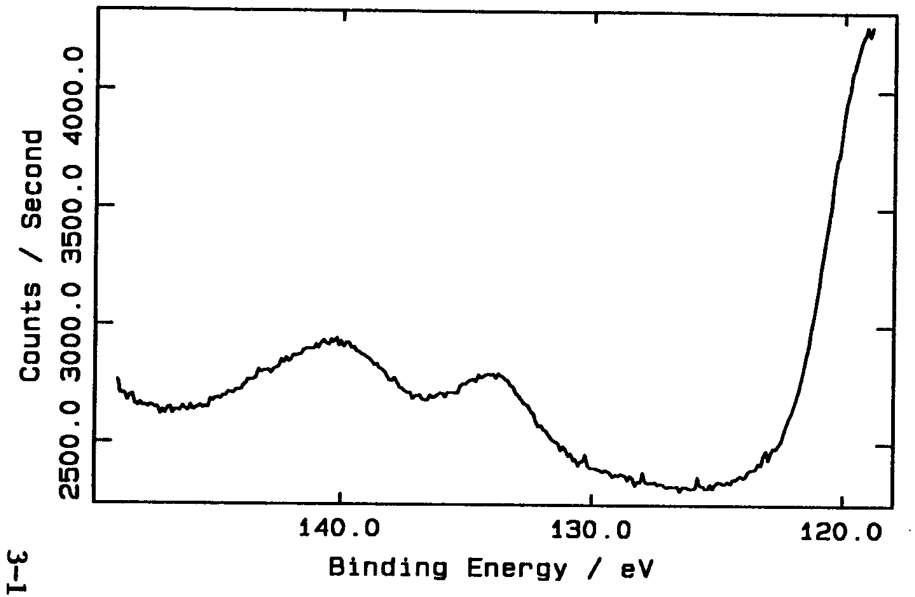

CEE Bee A 7 x 7. Panel 1 Survey
Counts / Second
0.0
2.00E4
4.00E4
6.00E4
1200.0
800.0
400.0
0.0
Binding Energy / eV


Cee Bee A 7 x 7. Panel 1 O 1s
Counts / Second
1.00E4
2.00E4
3.00E4
540.0
530.0
520.0
Binding Energy / eV

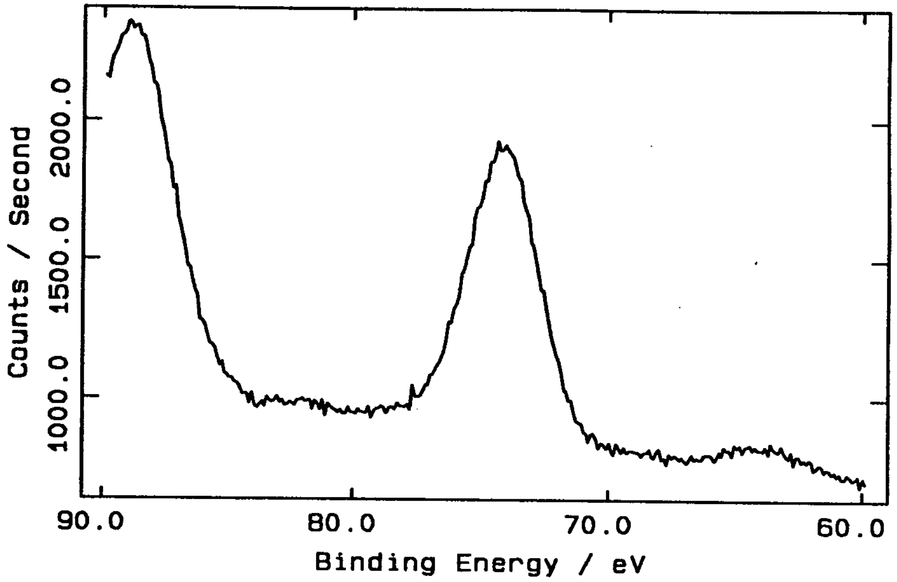

Cee Bee A 7 x 7. Panel 1 Mg 1s
Counts / Second
3.00E4
3.50E4
4.00E4
4.50E4
1320.0
1310.0
1300.0
1290.0
Binding Energy / eV


Cee Bee A 7 x 7. Panel 1 C 1s
Counts / Second
2000.0
3000.0
4000.0
5000.0
300.0
290.0
280.0
270.0
Binding Energy / eV

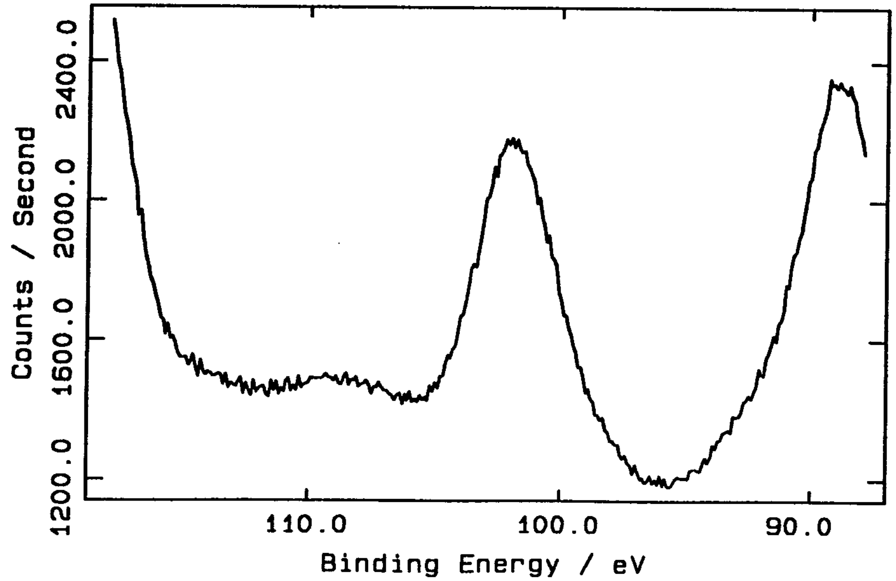
Cee Bee A 7 x 7, Panel 1 P 2p



Cee Bee A 7 x 7, Panel 1 Al 2p



Cee Bee A 7 x 7, Panel 1 Si 2p



Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Cee Bee A 7 x 7 Cleaned 7075 Al Test Panel 2

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN079.R1	None	Survey	RF = 3
ALPAN080	2.1457	Detail	PE = 200

SUMMARY OF ANALYSIS

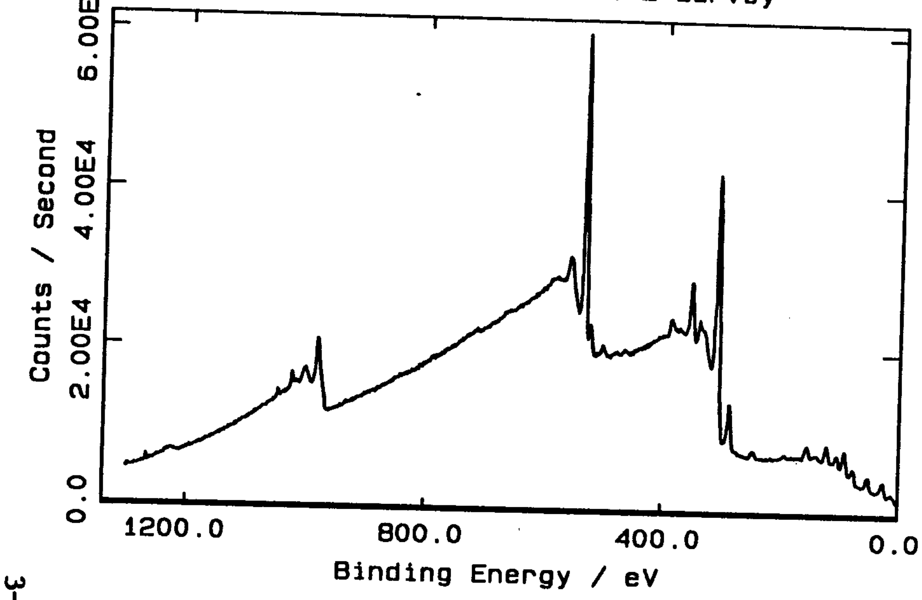
Run number: 1   Excitation: Al   Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN080.R1	Mg 1s	1304.09	63953.0000	44.26
2	ALPAN080.R2	O 1s	531.70	84737.0000	786.21
3	ALPAN080.R3	C 1s	289.53		
4	ALPAN080.R3	C 1s	284.80		
5	ALPAN080.R3	C 1s		11329.0000	461.86
6	ALPAN080.R4	Si 2s	140.55		
7	ALPAN080.R4	P 2p	134.07	1014.2240	15.06
8	ALPAN080.R5	Si 2p	102.12	2562.0610	62.22
9	ALPAN080.R5	Mg 2s	88.87		
10	ALPAN080.R6	Mg 2s	88.87		
11	ALPAN080.R6	See comments	81.80		
12	ALPAN080.R6	Al 2p	74.34	2559.3960	100.00

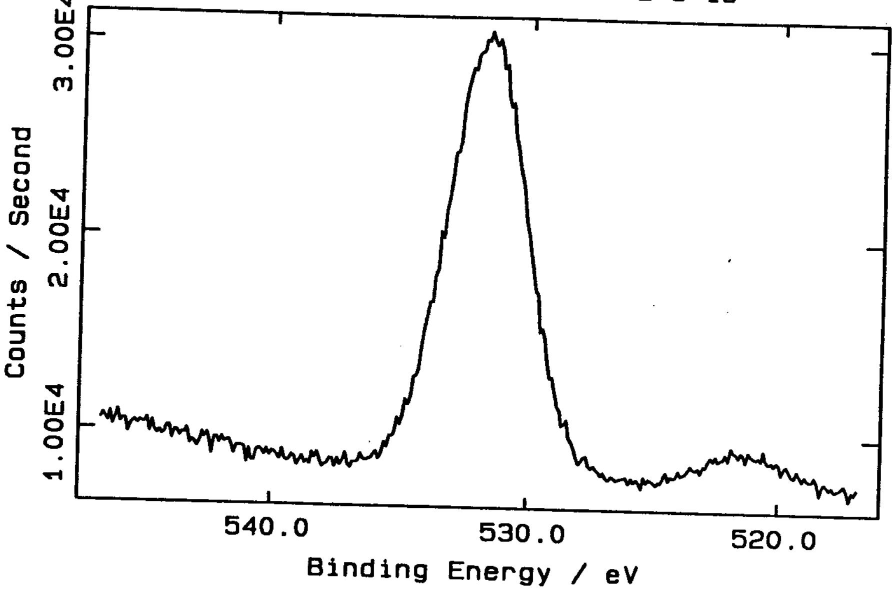
COMMENTS

Peak 11 assigned to Si 2p K-alpha$_5$ satellite.

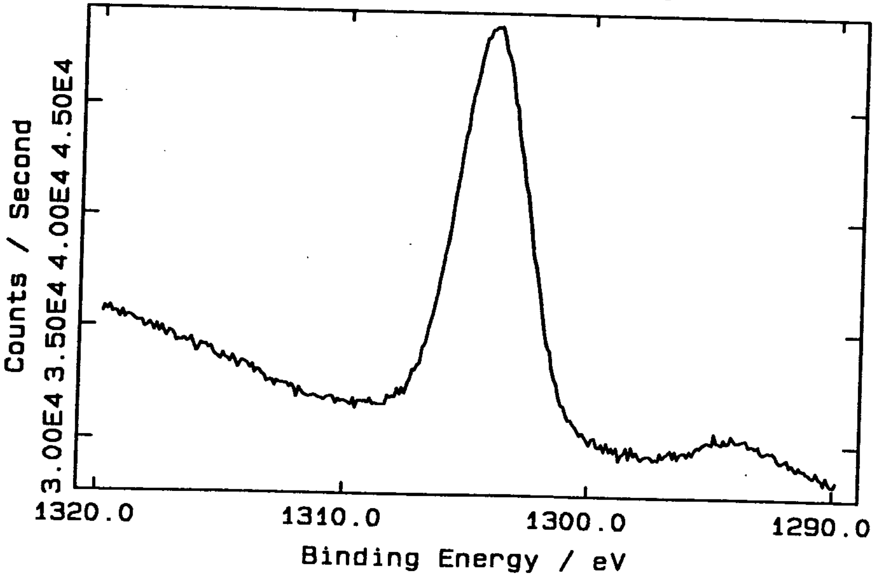
Cee Bee A 7 x 7, Panel 2 Survey



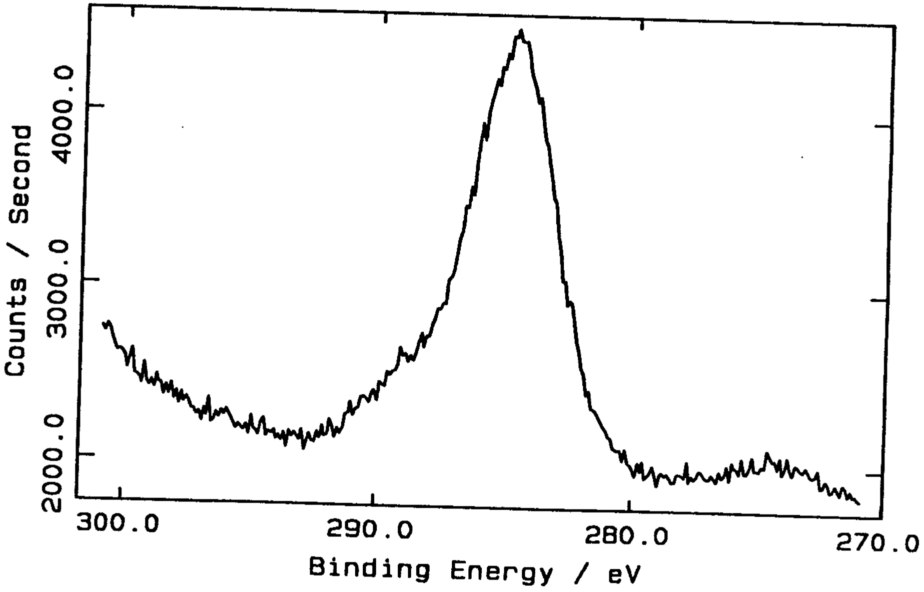
Cee Bee A 7 x 7, Panel 2 O 1s



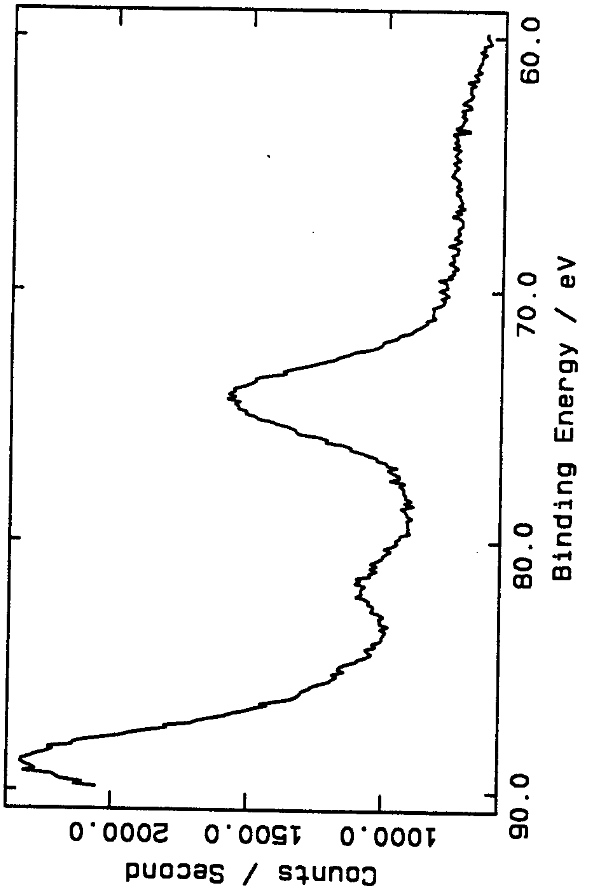
Cee Bee A 7 x 7, Panel 2 Mg 1s



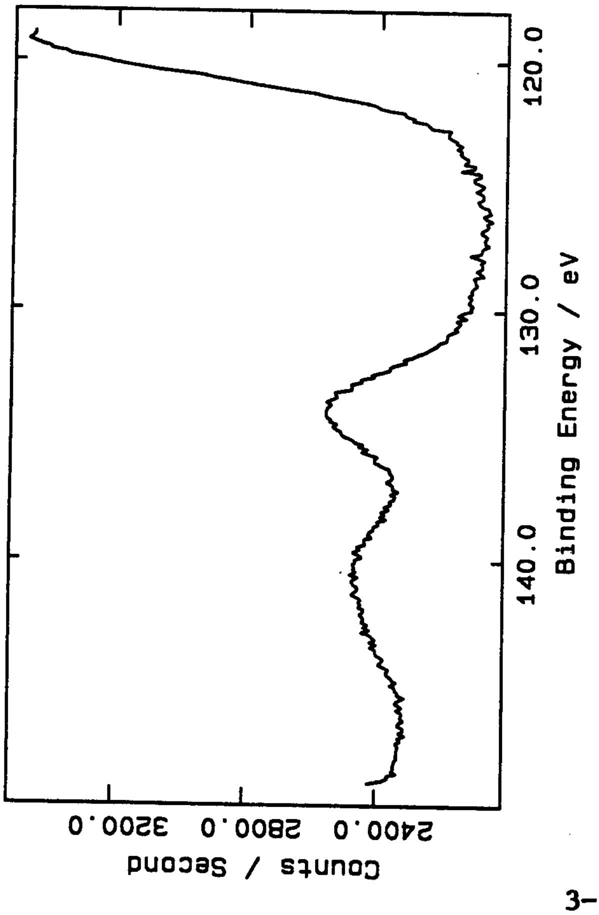
Cee Bee A 7 x 7, Panel 2 C 1s



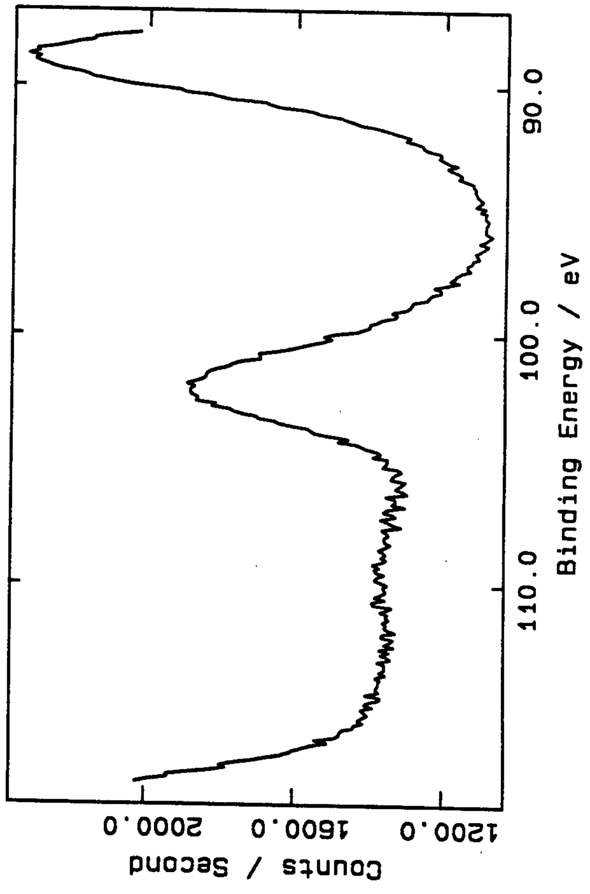
Cee Bee A 7 x 7. Panel 2 Al 2p



Cee Bee A 7 x 7. Panel 2 P 2p



Cee Bee A 7 x 7. Panel 2 Si 2p



Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Turco 4215-NC-LT Cleaned Al Test Panel 1

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

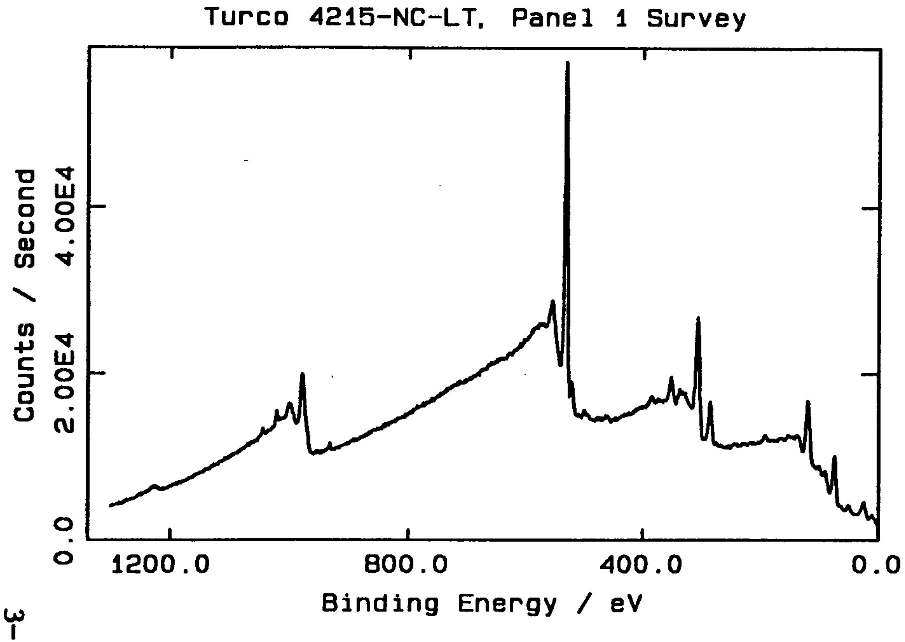
FILE SUMMARY

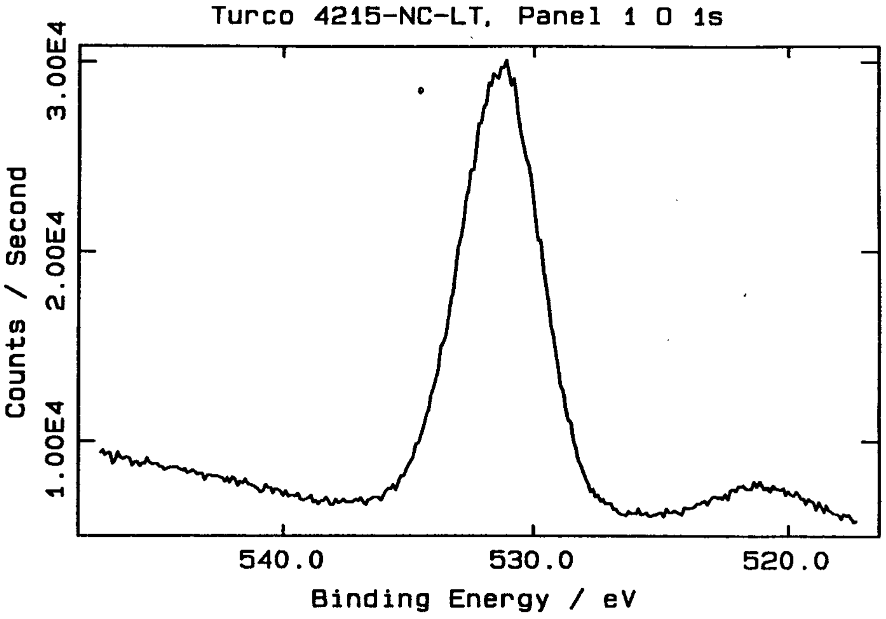
File name	Charge correction	Type	Instrument settings
ALPAN081.R1	None	Survey	RF = 3
ALPAN082	1.6879	Detail	PE = 200

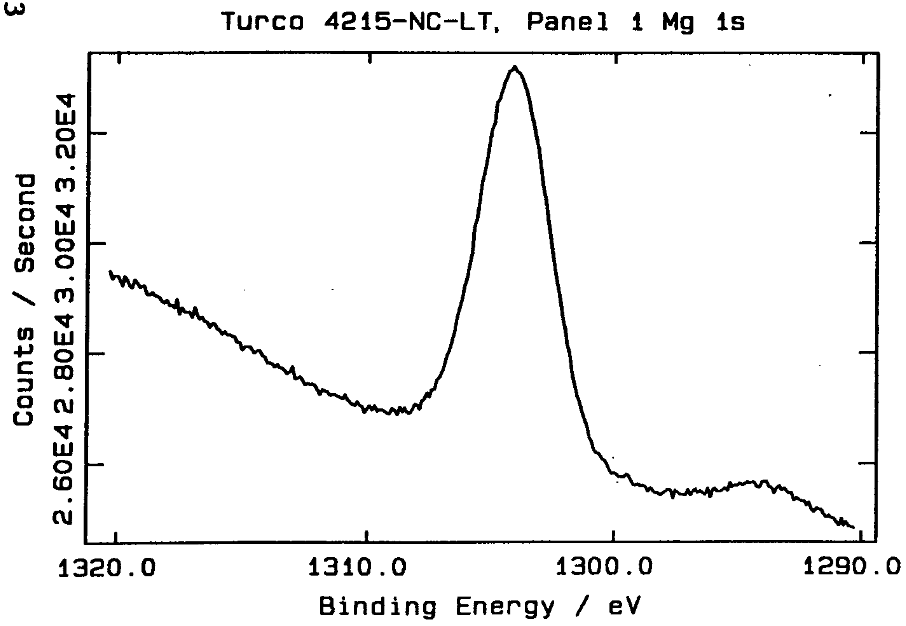
SUMMARY OF ANALYSIS

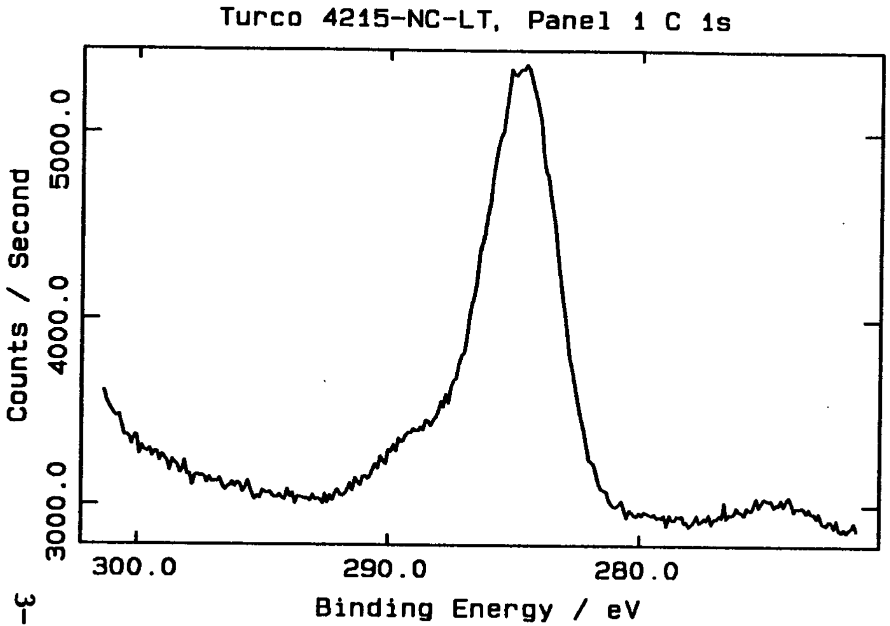
Run number: 1   Excitation: Al   Pass energy: 200 eV

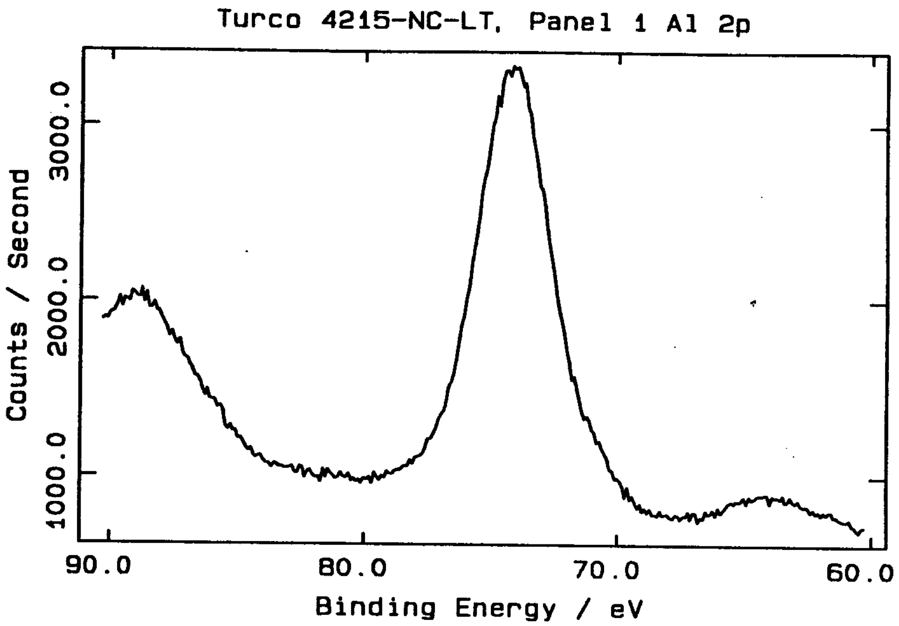
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN082.R1	Mg 1s	1304.13	25397.0000	4.71
2	ALPAN082.R2	O 1s	531.32	92798.0000	231.01
3	ALPAN082.R3	C 1s	289.22		
4	ALPAN082.R3	C 1s	284.80		
5	ALPAN082.R3	C 1s		9761.9670	106.76
6	ALPAN082.R4	Mg 2s	88.98		
7	ALPAN082.R4	Al 2p	74.21	9540.7150	100.00


Turco 4215-NC-LT, Panel 1 Survey


Turco 4215-NC-LT, Panel 1 O 1s


Turco 4215-NC-LT, Panel 1 Mg 1s


Turco 4215-NC-LT, Panel 1 C 1s


Turco 4215-NC-LT, Panel 1 Al 2p

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Turco 4215-NC-LT Cleaned Al Test Panel 2

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

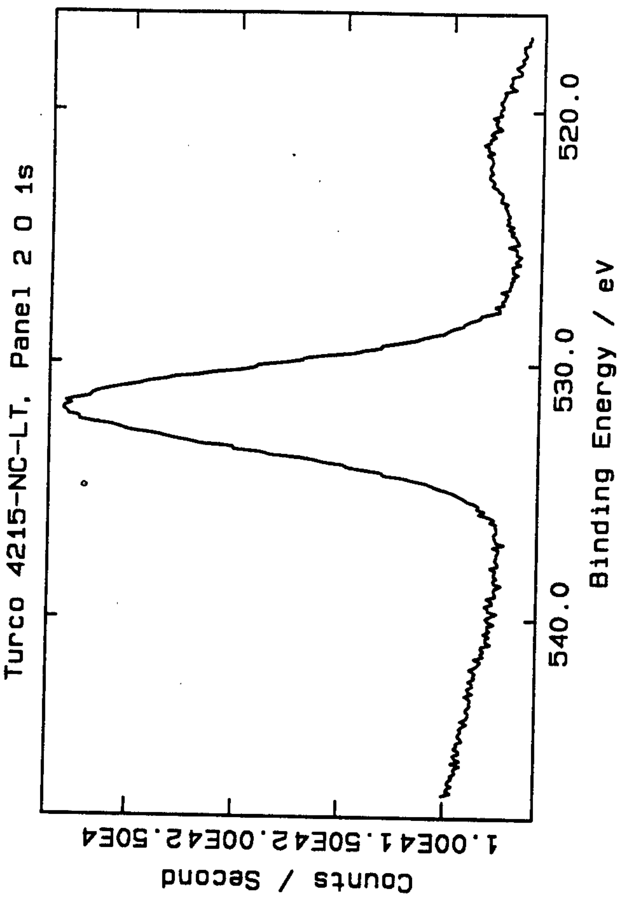
FILE SUMMARY

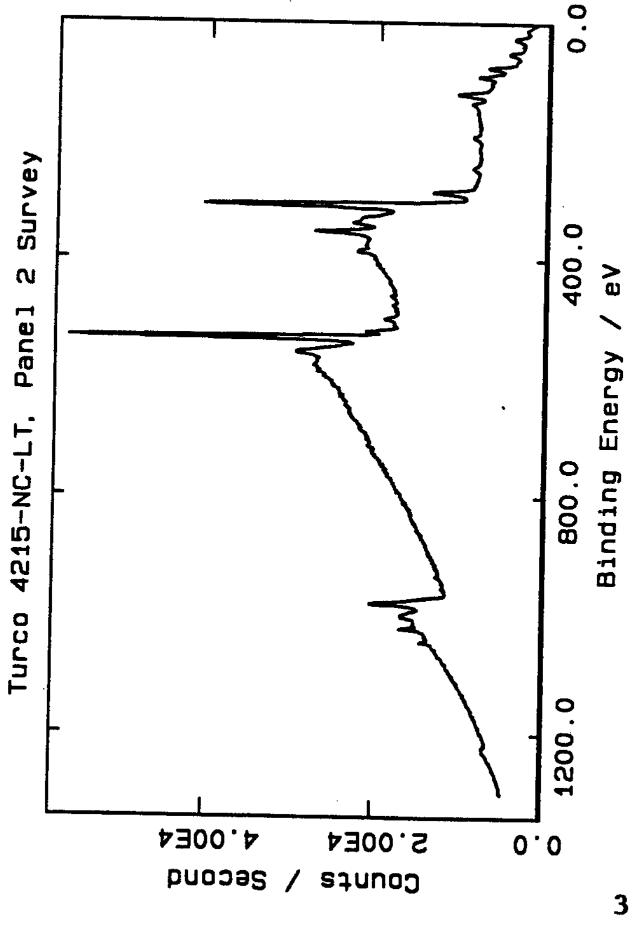
File name	Charge correction	Type	Instrument settings
ALPAN083.R1	None	Survey	RF = 3
ALPAN084	1.9555	Detail	PE = 200

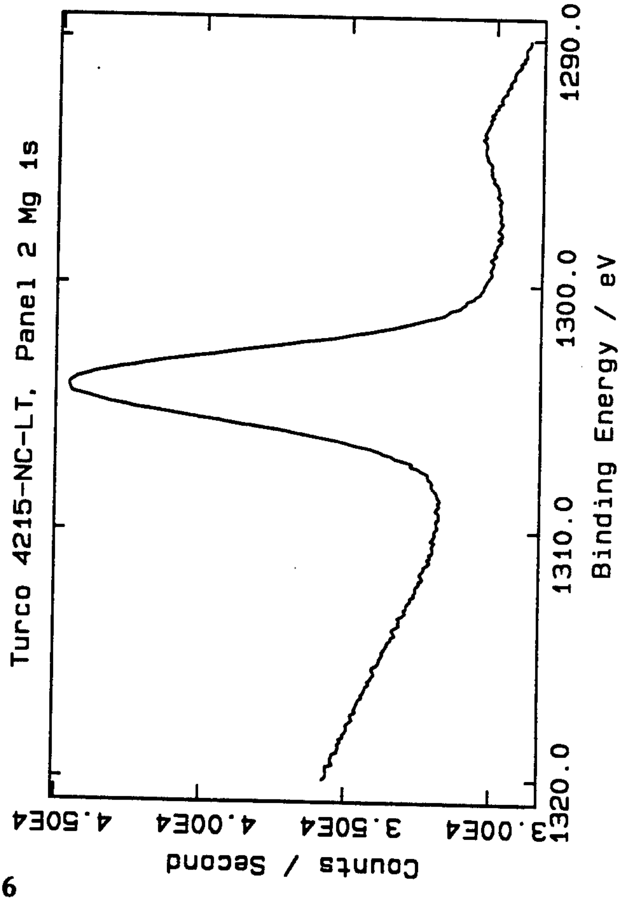
SUMMARY OF ANALYSIS

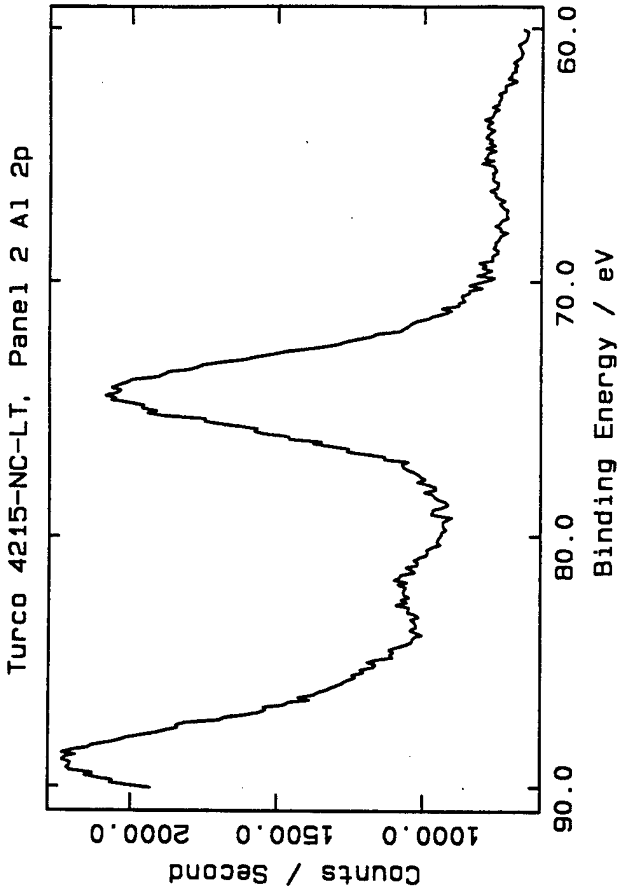
Run number: 1   Excitation: Al   Pass energy: 200 eV

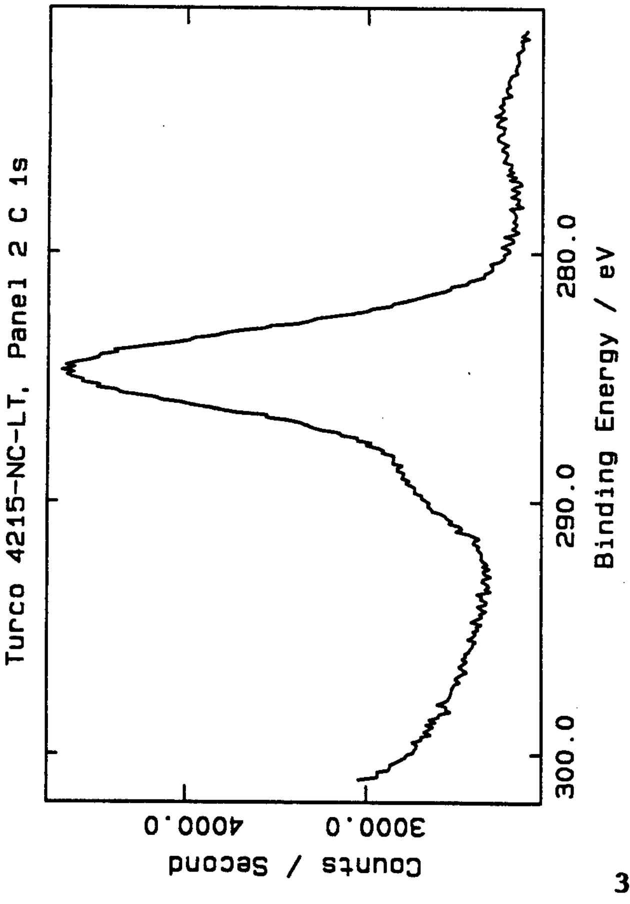
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN084.R1	Mg 1s	1304.19	48555.0000	19.03
2	ALPAN084.R2	O 1s	531.75	81744.0000	429.50
3	ALPAN084.R3	C 1s	289.26		
4	ALPAN084.R3	C 1s	284.80		
5	ALPAN084.R3	C 1s		11240.0000	259.50
6	ALPAN084.R4	Mg 2s	88.97		
7	ALPAN084.R4	Al 2p	74.39	4519.5070	100.00


Turco 4215-NC-LT, Panel 2 O 1s
Counts / Second
1.00E4
1.50E4
2.00E4
2.50E4
Binding Energy / eV
540.0
530.0
520.0


Turco 4215-NC-LT, Panel 2 Survey
Counts / Second
0.0
2.00E4
4.00E4
Binding Energy / eV
1200.0
800.0
400.0
0.0


Turco 4215-NC-LT, Panel 2 Mg 1s
Counts / Second
3.00E4
3.50E4
4.00E4
4.50E4
Binding Energy / eV
1320.0
1310.0
1300.0
1290.0


Turco 4215-NC-LT, Panel 2 Al 2p
Counts / Second
1000.0
1500.0
2000.0
Binding Energy / eV
90.0
80.0
70.0
60.0


Turco 4215-NC-LT, Panel 2 C 1s
Counts / Second
3000.0
4000.0
Binding Energy / eV
300.0
290.0
280.0

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Brulin 815 GD Cleaned 7075 Al Test Panel 3

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN085.R1	None	Survey	RF = 3
ALPAN086	1.6862	Detail	PE = 200

SUMMARY OF ANALYSIS

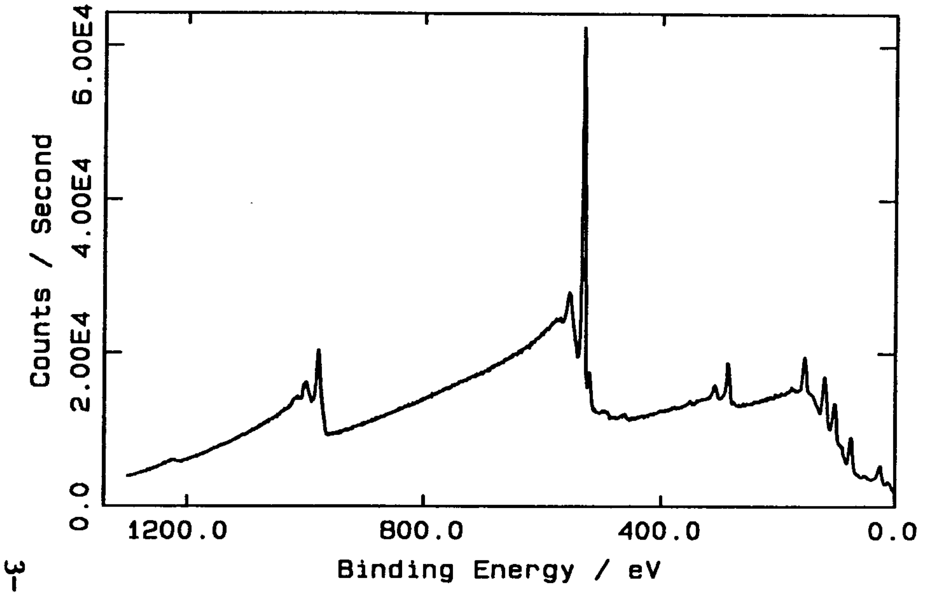
Run number: 1   Excitation: Al   Pass energy: 200 eV

Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN086.R1	Mg 1s	1305.53	5731.5660	1.27
2	ALPAN086.R2	O 1s	531.94	112700.0000	336.06
3	ALPAN086.R3	Mg KL_1L_{23}	352.29		
4	ALPAN086.R4	C 1s	284.80	8668.6000	113.63
5	ALPAN086.R5	See comments			
6	ALPAN086.R6	Si 2p	102.69	7497.0590	58.51
7	ALPAN086.R7	Al 2p	74.56	7963.2010	100.00

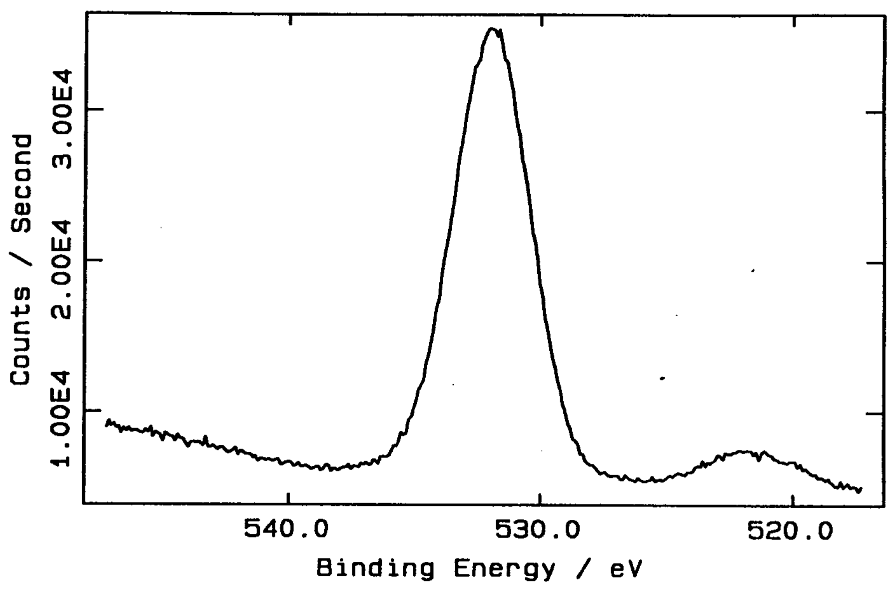
COMMENTS

1. No Ca 2p doublet signal observed (peak 3).
2. No Cl 2p peak observed (peak 5).

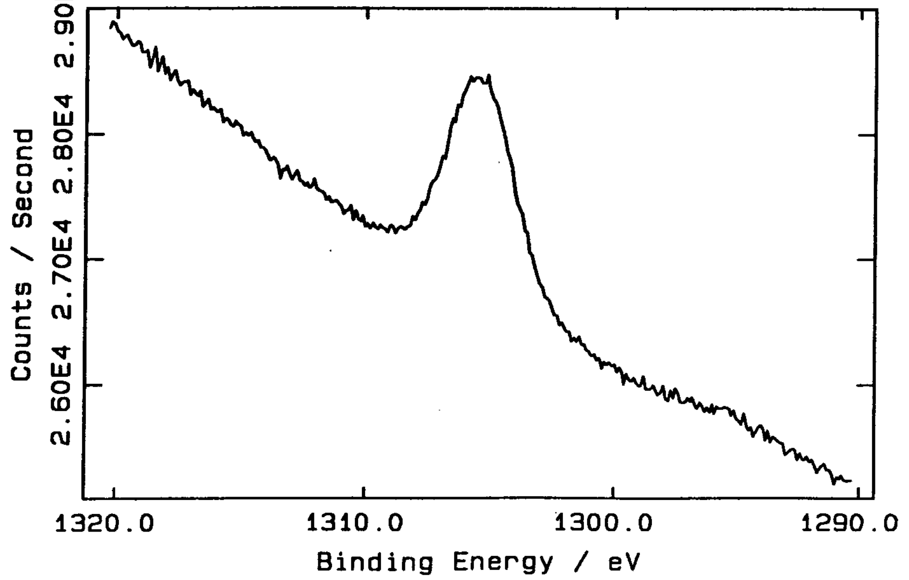
Brulin 815 GD, Panel 3 Survey



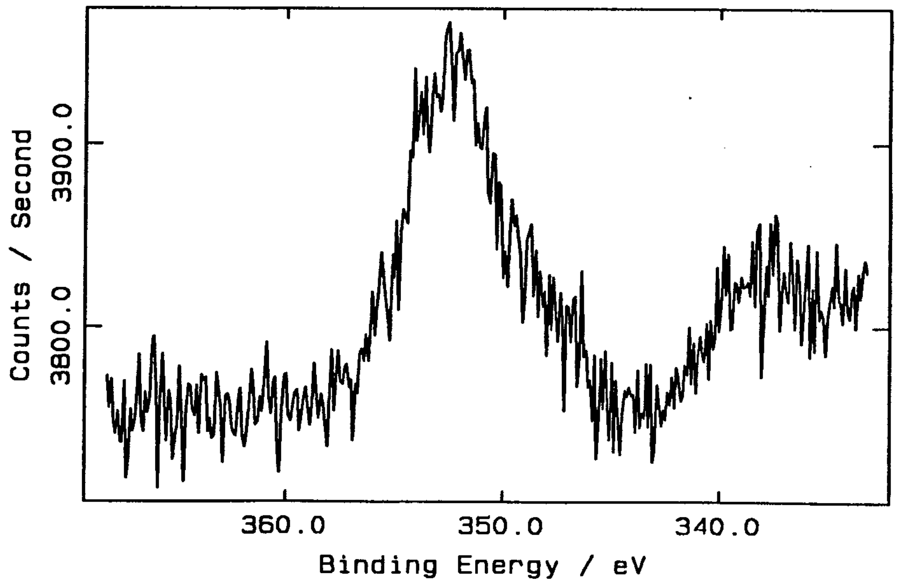
Brulin 815 GD, Panel 3 O 1s

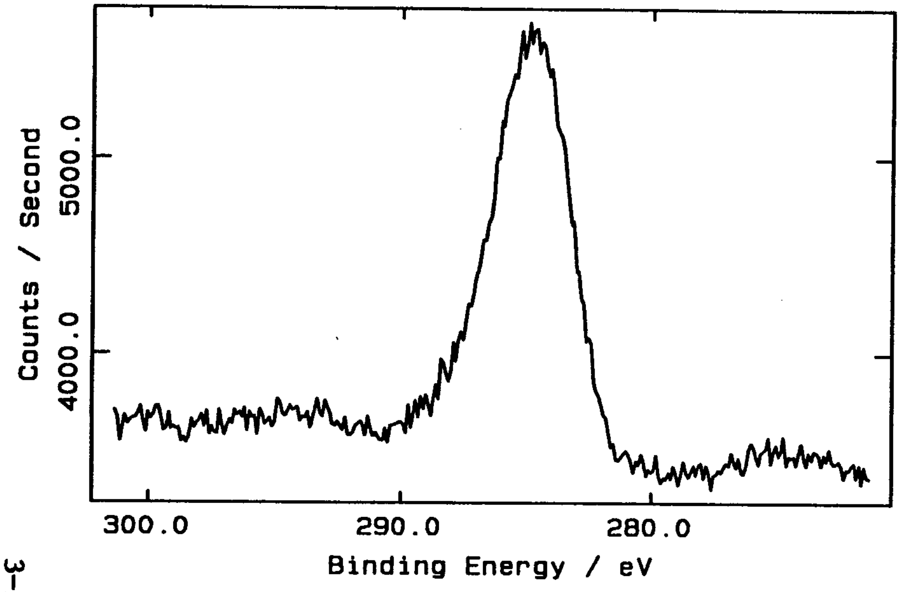


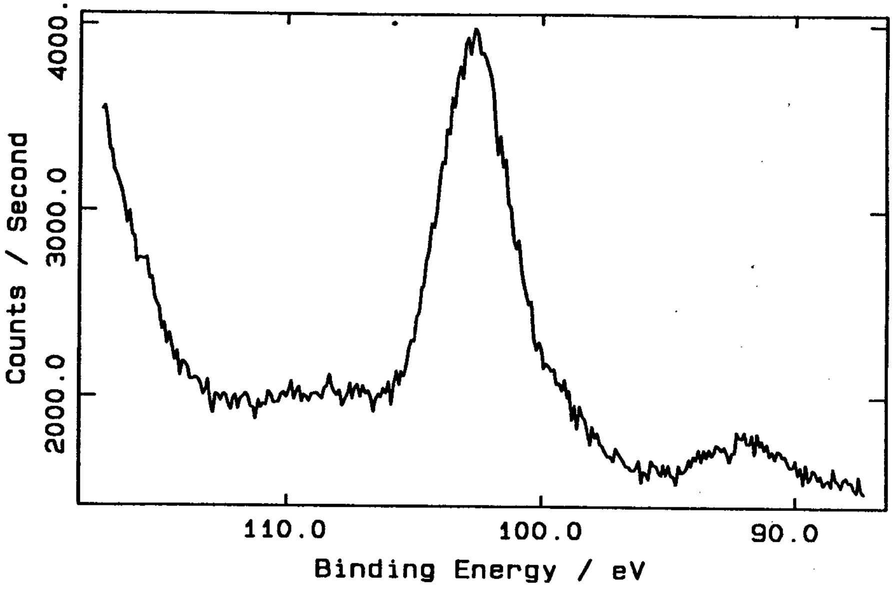
Brulin 815 GD, Panel 3 Mg 1s

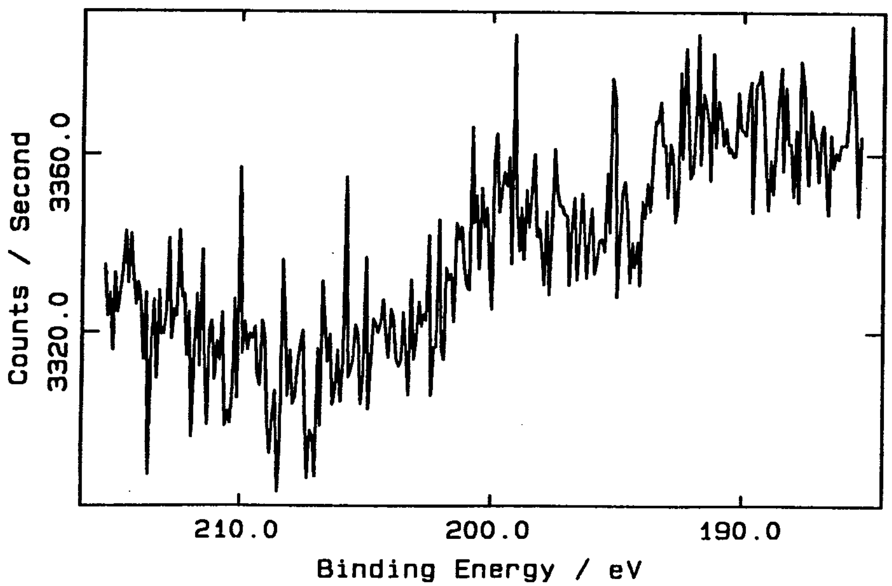


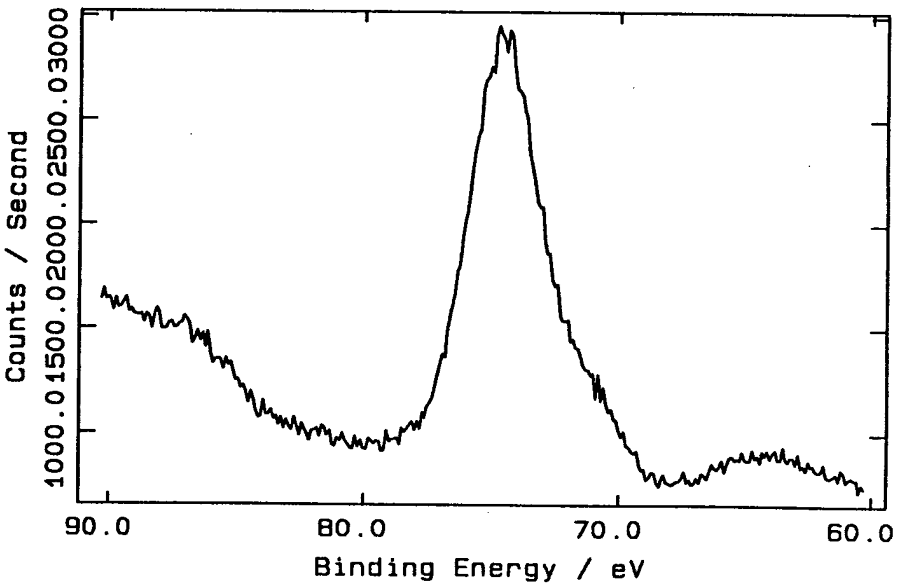
Brulin 815 GD, Panel 3 Ca 2p1/2, 2p3/2




Brulin 815 GD, Panel 3 C 1s


Brulin 815 GD, Panel 3 Si 2p


Brulin 815 GD, Panel 3 Cl 2p


Brulin 815 GD, Panel 3 Al 2p

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Brulin 815 GD Cleaned 7075 Al Test Panel 4

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
ALPAN087.R1	None	Survey	RF = 3
ALPAN088	1.4115	Detail	PE = 200

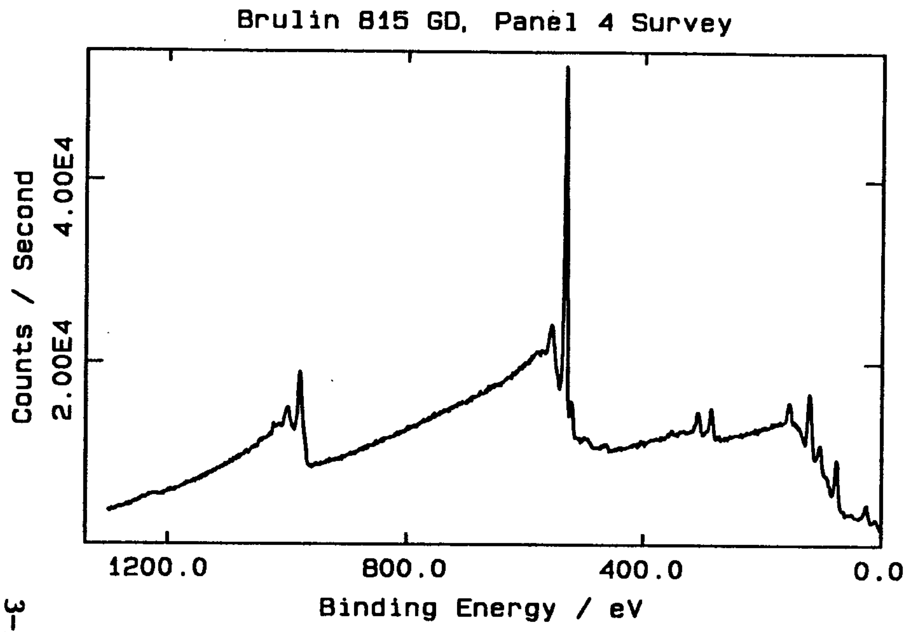
SUMMARY OF ANALYSIS

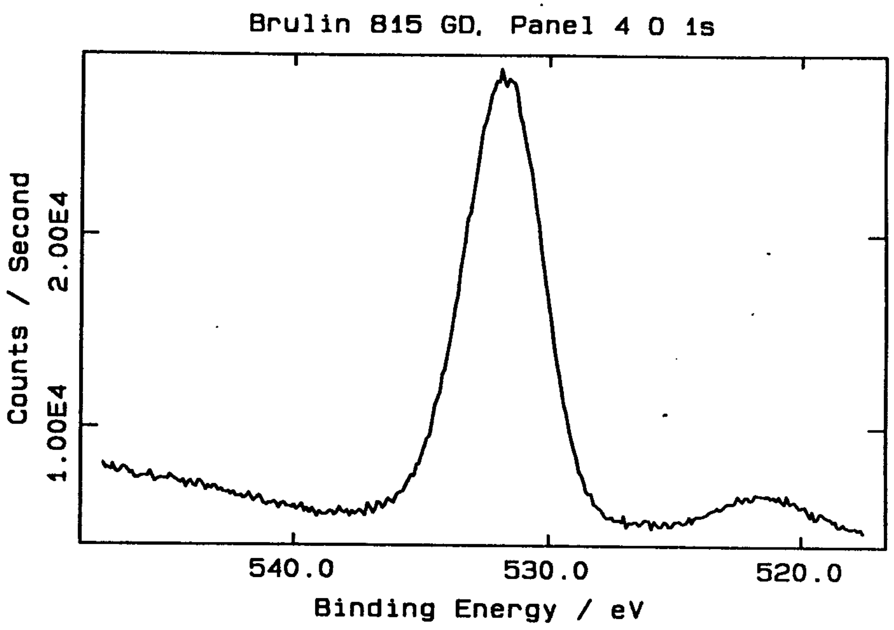
Run number: 1   Excitation: Al   Pass energy: 200 eV

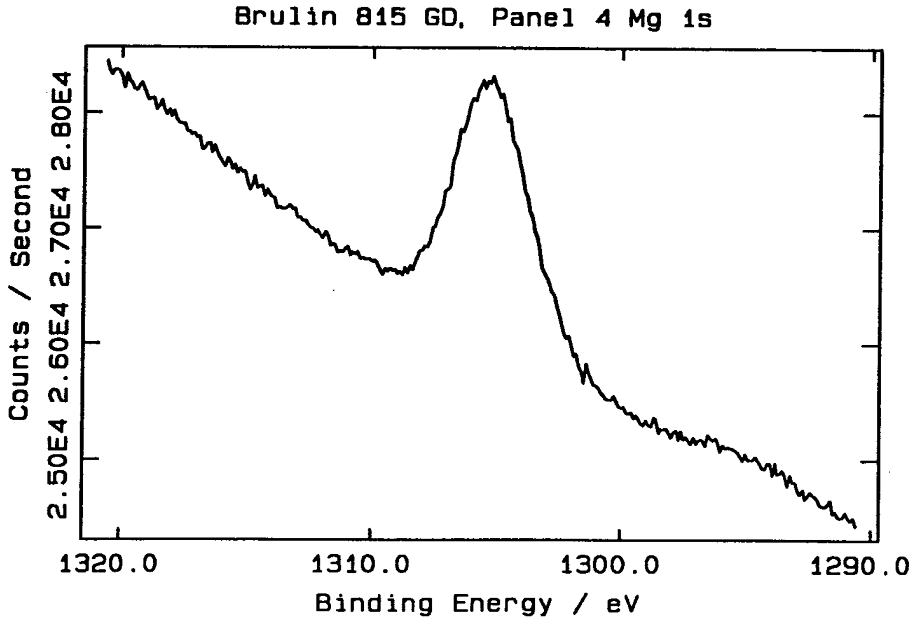
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN088.R1	Mg 1s	1305.38	8140.7510	1.65
2	ALPAN088.R2	O 1s	531.80	87615.0000	238.26
3	ALPAN088.R3	Mg KL_1L_{23}	352.22		
4	ALPAN088.R4	C 1s	284.80	6498.8450	77.68
5	ALPAN088.R5	See comments			
6	ALPAN088.R6	Si 2p	102.54	1468.6530	10.45
7	ALPAN088.R7	Al 2p	73.25	8728.7310	100.00

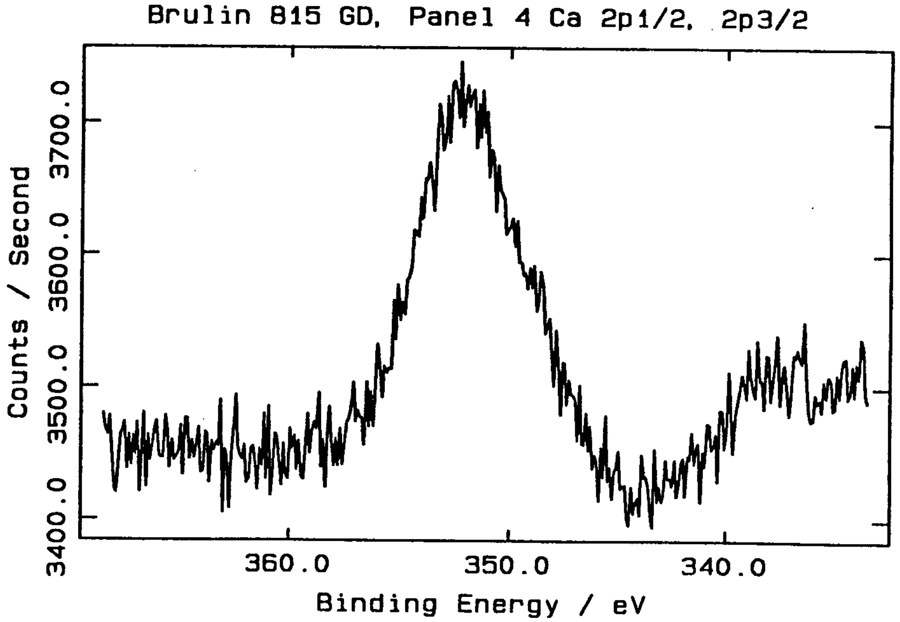
COMMENTS

1. No Ca 2p doublet signal observed (peak 3).
2. No Cl 2p peak observed (peak 5).

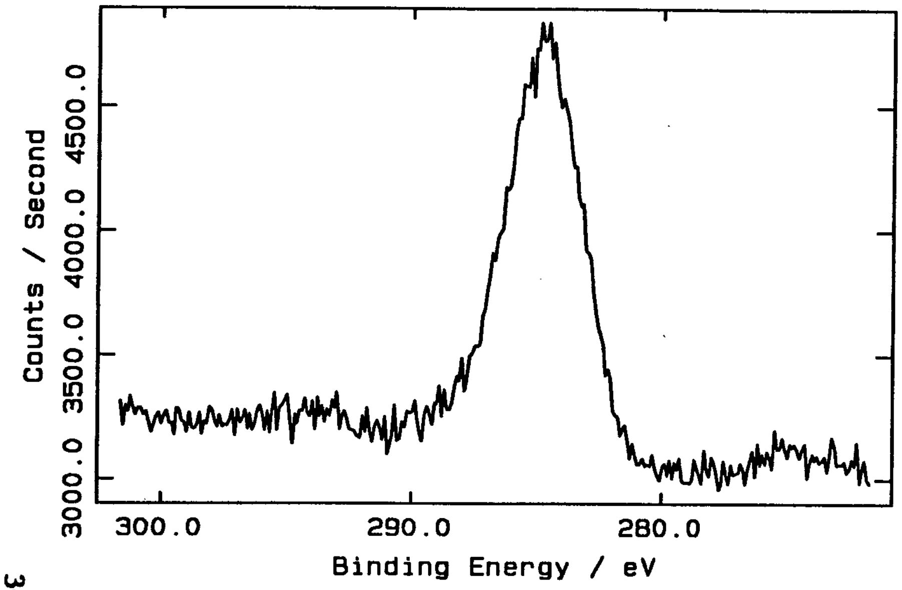

Brulin 815 GD, Panel 4 Survey


Brulin 815 GD, Panel 4 O 1s

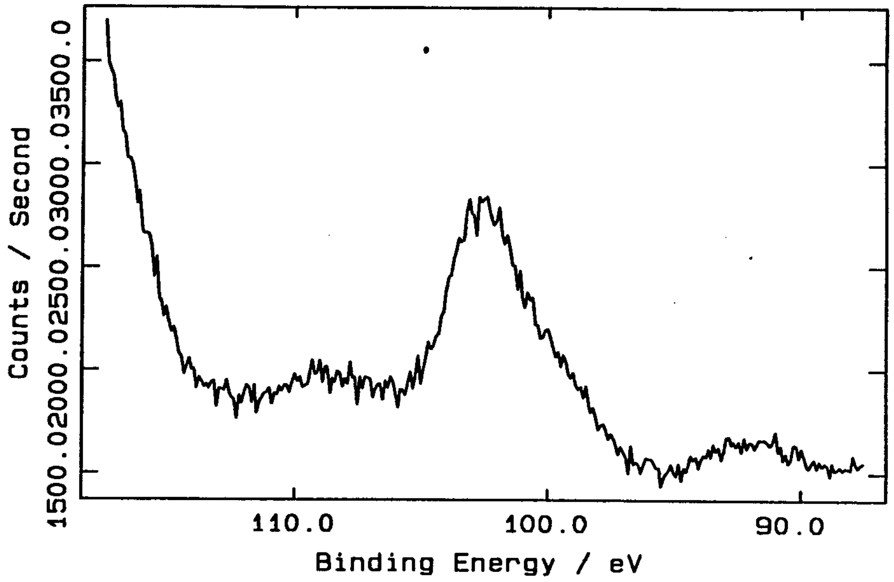

Brulin 815 GD, Panel 4 Mg 1s


Brulin 815 GD, Panel 4 Ca 2p1/2, 2p3/2

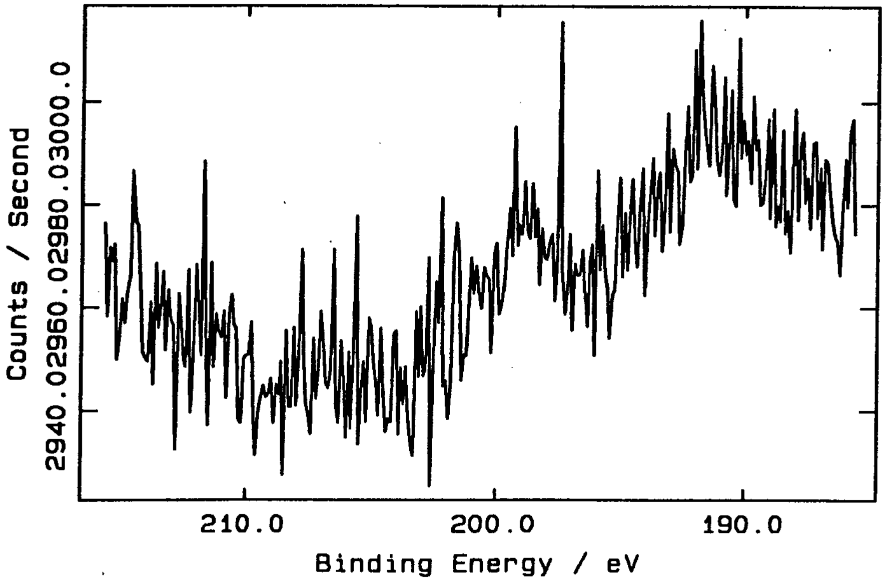
Brulin 815 GD, Panel 4 C 1s



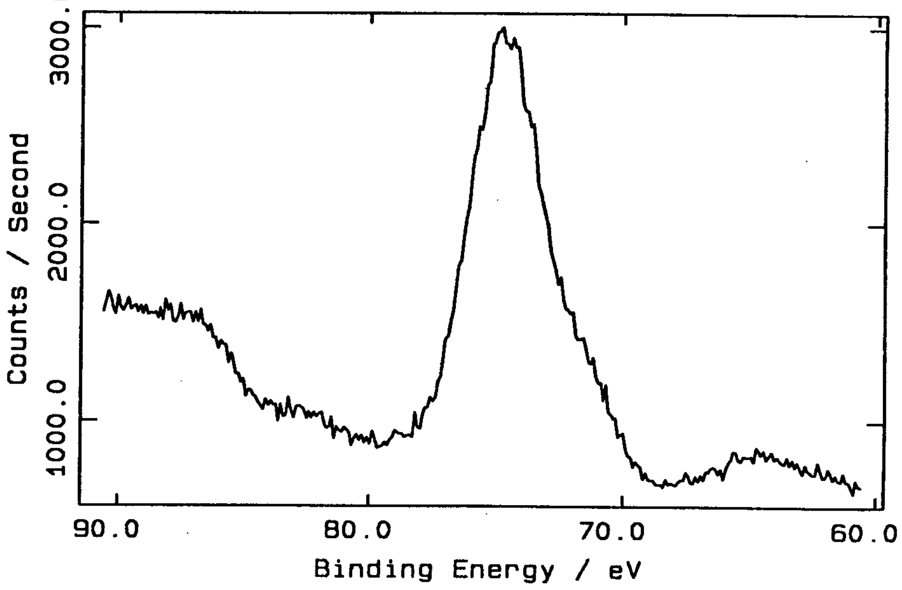
Brulin 815 GD, Panel 4 Si 2p



Brulin 815 GD, Panel 4 Cl 2p



Brulin 815 GD, Panel 4 Al 2p



Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Callasolv 120 Cleaned 7075 Al Test Panel 1

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

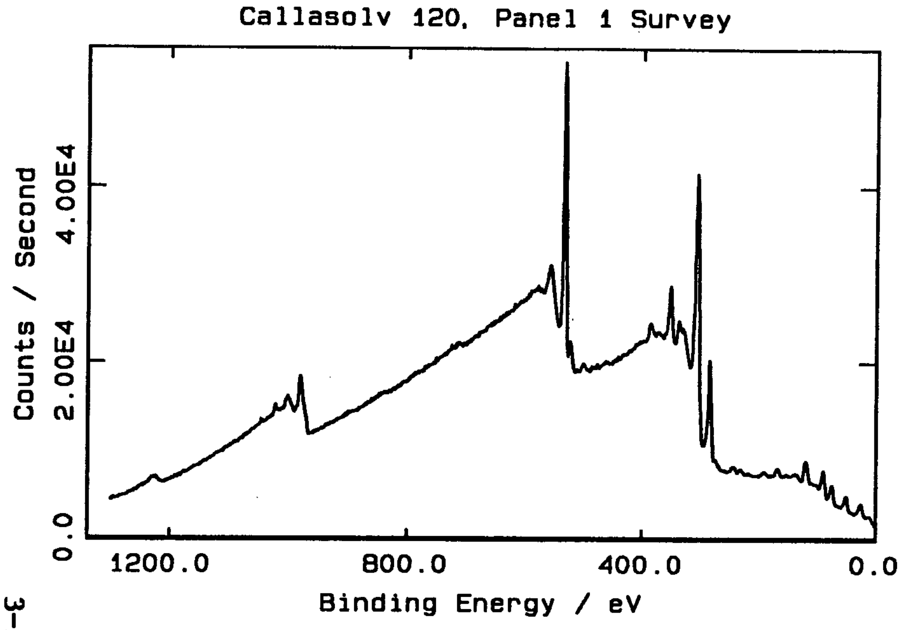
FILE SUMMARY

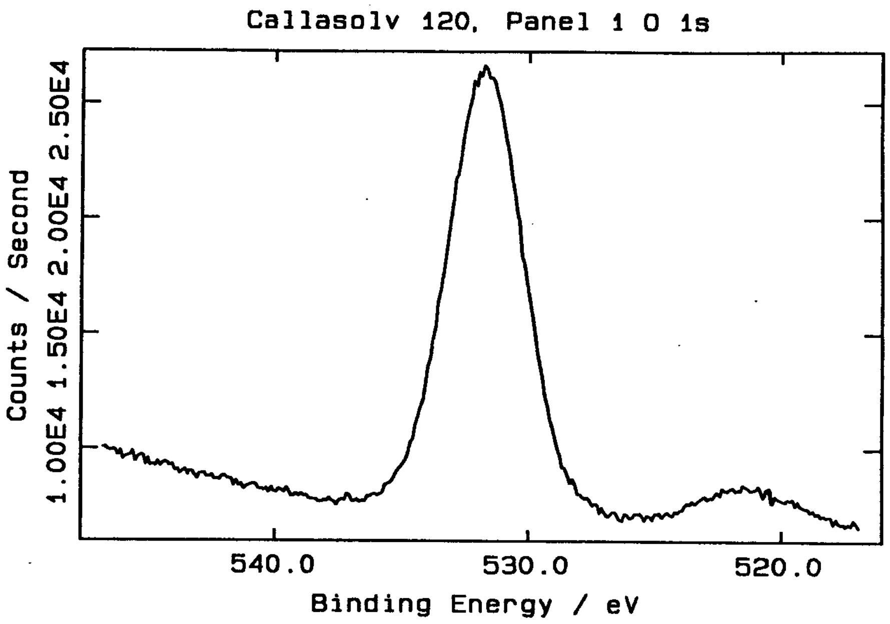
File name	Charge correction	Type	Instrument settings
ALPAN089.R1	None	Survey	RF = 3
ALPAN090	2.0437	Detail	PE = 200

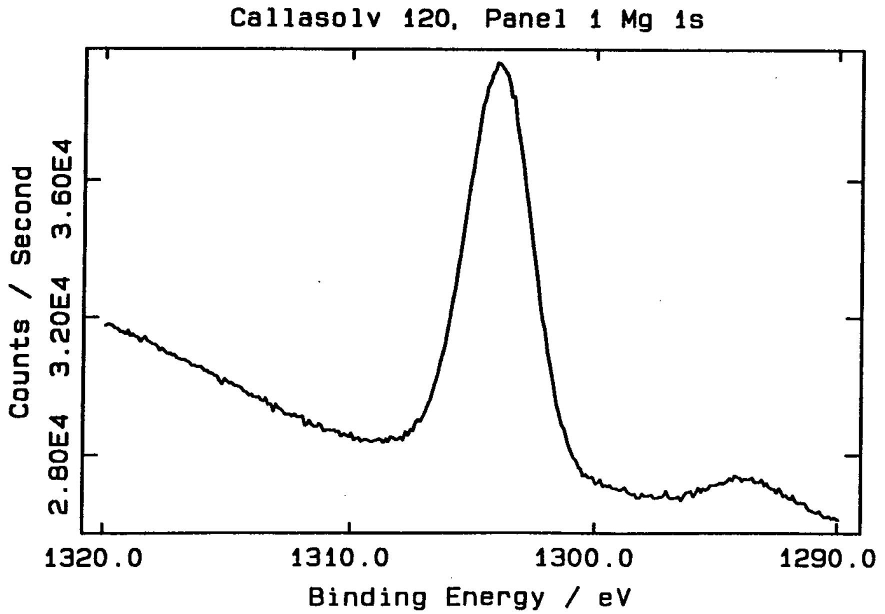
SUMMARY OF ANALYSIS

Run number: 1   Excitation: Al   Pass energy: 200 eV

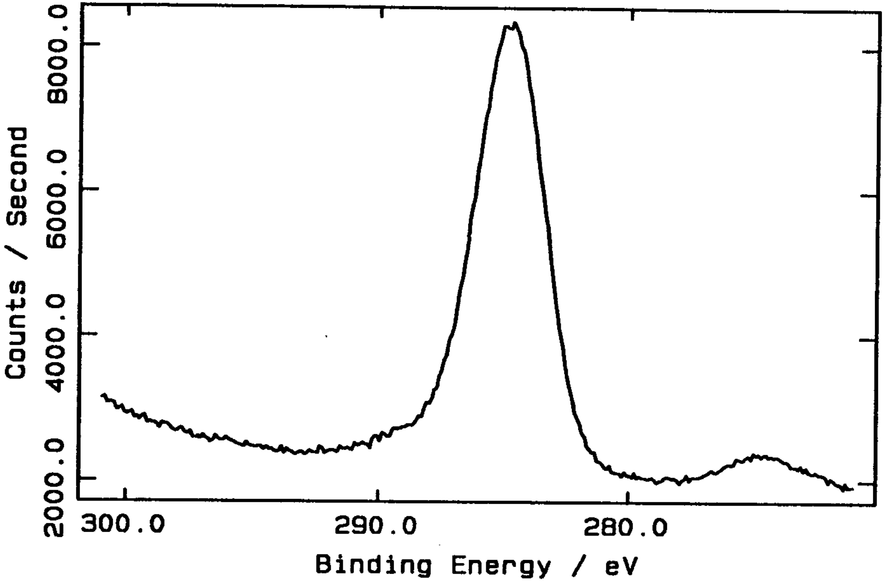
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN090.R1	Mg 1s	1303.99	39803.0000	24.58
2	ALPAN090.R2	O 1s	531.72	70527.0000	583.69
3	ALPAN090.R3	C 1s	284.80	22725.0000	826.64
4	ALPAN090.R4	Mg 2s	88.81		
5	ALPAN090.R4	Al 2p	74.37	2869.3190	100.00


Callasolv 120, Panel 1 Survey

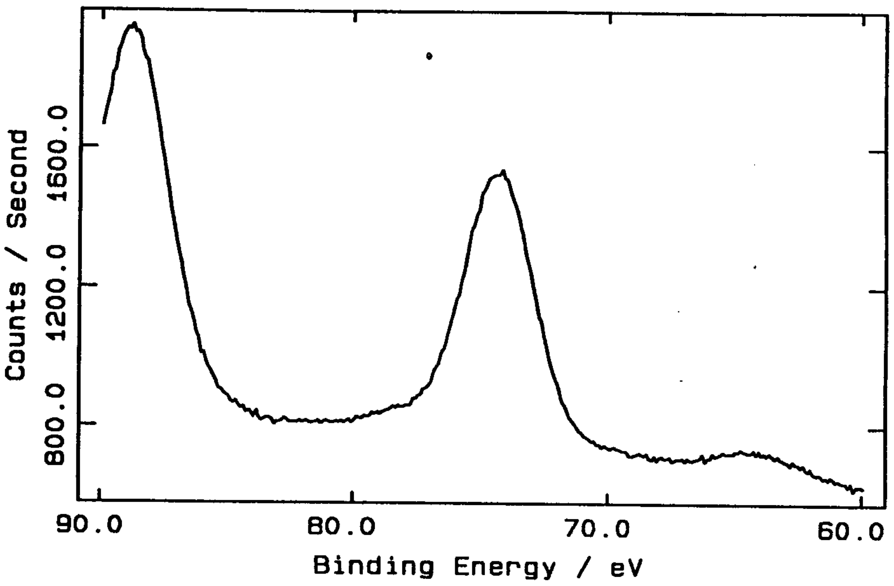

Callasolv 120, Panel 1 O 1s


Callasolv 120, Panel 1 Mg 1s

Callasolv 120, Panel 1 C 1s



Callasolv 120, Panel 1 Al 2p



Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: Callasolv 120 Cleaned 7075 Al Test Panel 2

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

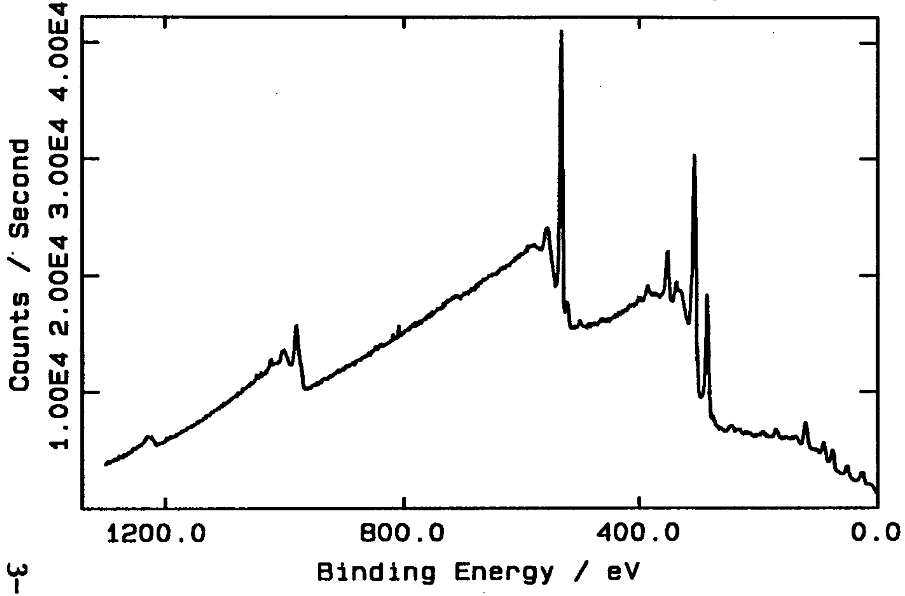
FILE SUMMARY

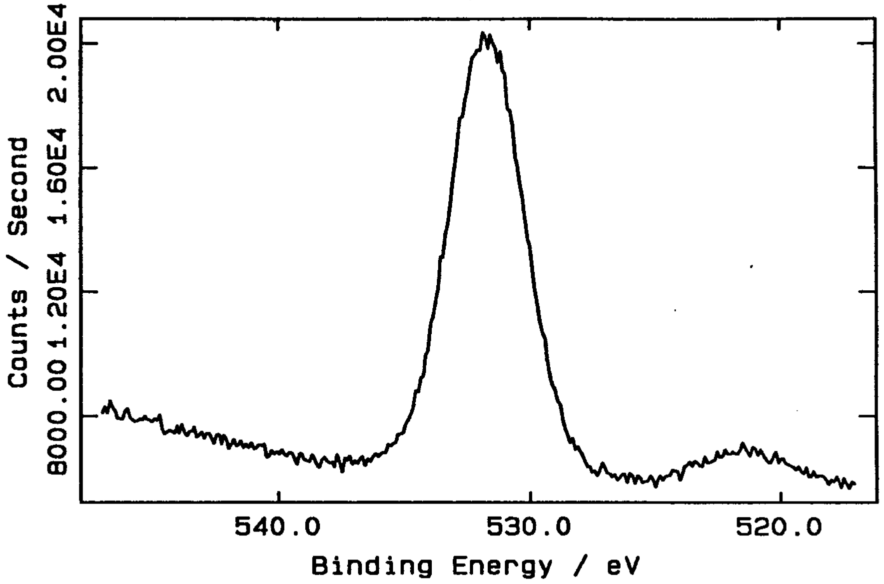
File name	Charge correction	Type	Instrument settings
ALPAN091.R1	None	Survey	RF = 3
ALPAN092	1.9070	Detail	PE = 200

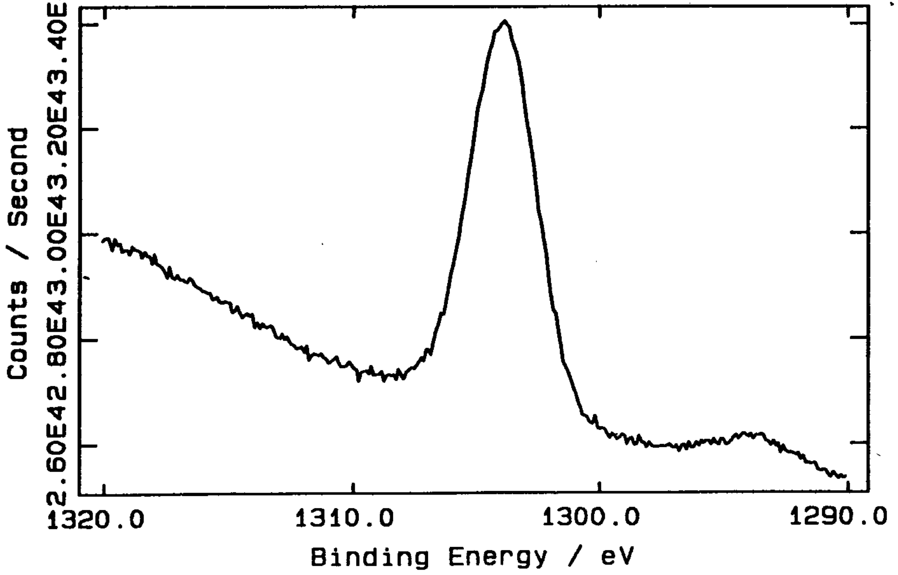
SUMMARY OF ANALYSIS

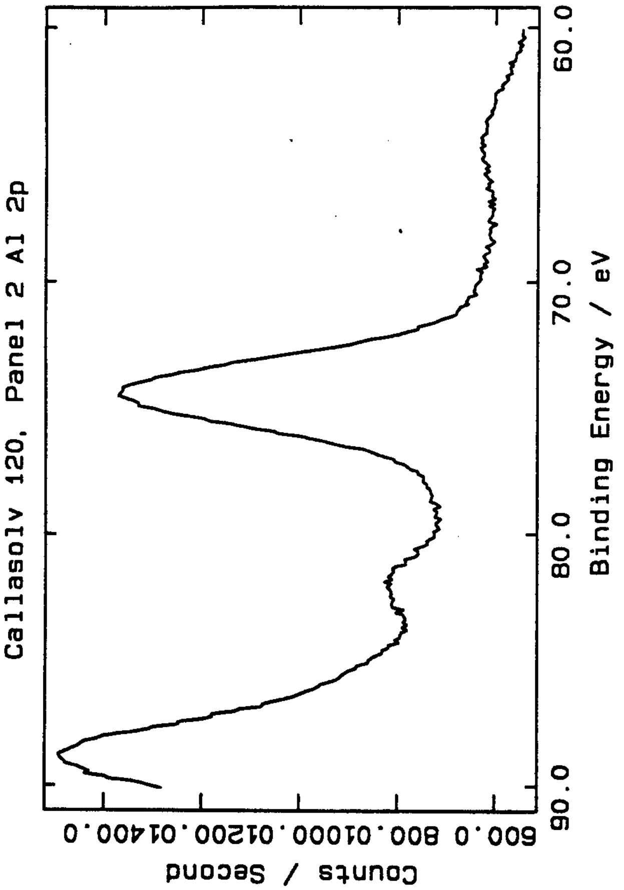
Run number: 1   Excitation: Al   Pass energy: 200 eV

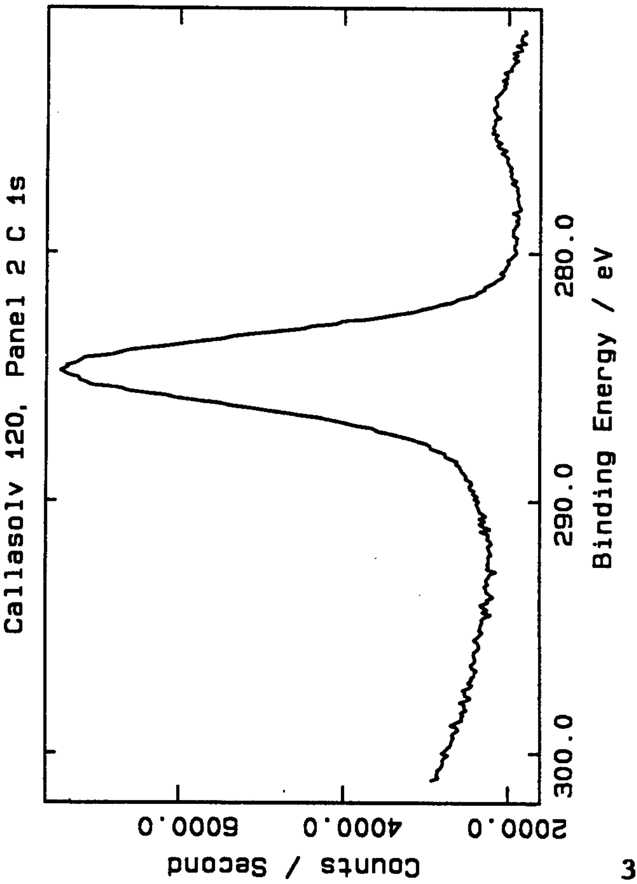
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN092.R1	Mg 1s	1303.97	24533.0000	18.13
2	ALPAN092.R2	O 1s	531.75	52930.0000	524.16
3	ALPAN092.R3	C 1s	284.80	20241.0000	881.02
4	ALPAN092.R4	Mg 2s	88.81		
5	ALPAN092.R4	Al 2p	74.43	2397.9870	100.00


Callasolv 120, Panel 2 Survey


Callasolv 120, Panel 2 O 1s


Callasolv 120, Panel 2 Mg 1s


Callasolv 120, Panel 2 Al 2p
Counts / Second
600.0
800.0
1000.0
1200.0
1400.0
Binding Energy / eV
60.0
70.0
80.0
90.0


Callasolv 120, Panel 2 C 1s
Counts / Second
2000.0
4000.0
6000.0
Binding Energy / eV
280.0
290.0
300.0

Surface analysis summary for: Scott Grendahl, Douglas Nedeau, Dr. James H. Gorrell

Sample: PARTSPREP Cleaned 7075 Al Test Panel 3

Method: XPS
Mounting: Secured with a single gold-covered screw.
Theoretical sensitivity factors used. Assigned density = 0.900 g/cm^3

FILE SUMMARY

File name	Charge correction	Type	Instrument settings
NO SURVEY	None	Survey	RF = 0
ALPAN094	2.4650	Detail	PE = 200

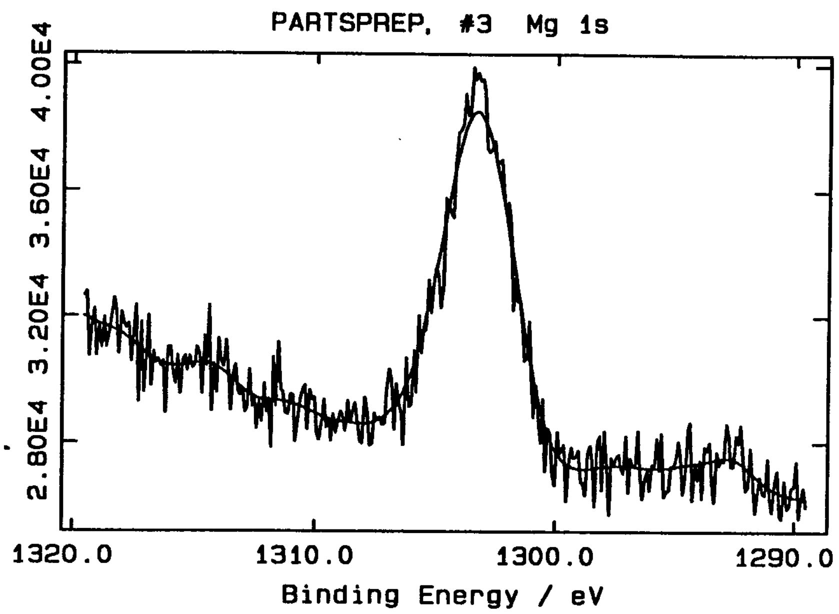
SUMMARY OF ANALYSIS

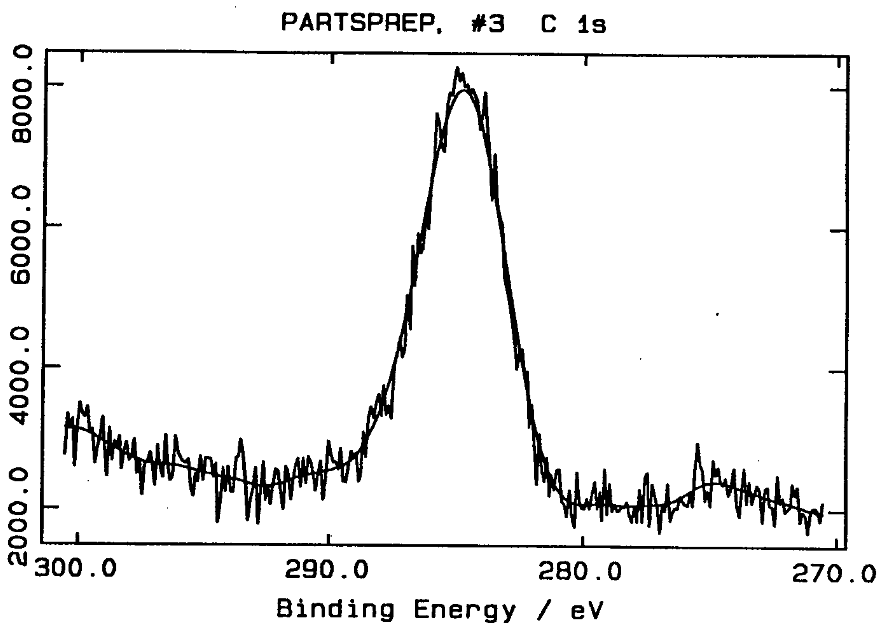
Run number: 1   Excitation: Al   Pass energy: 200 eV

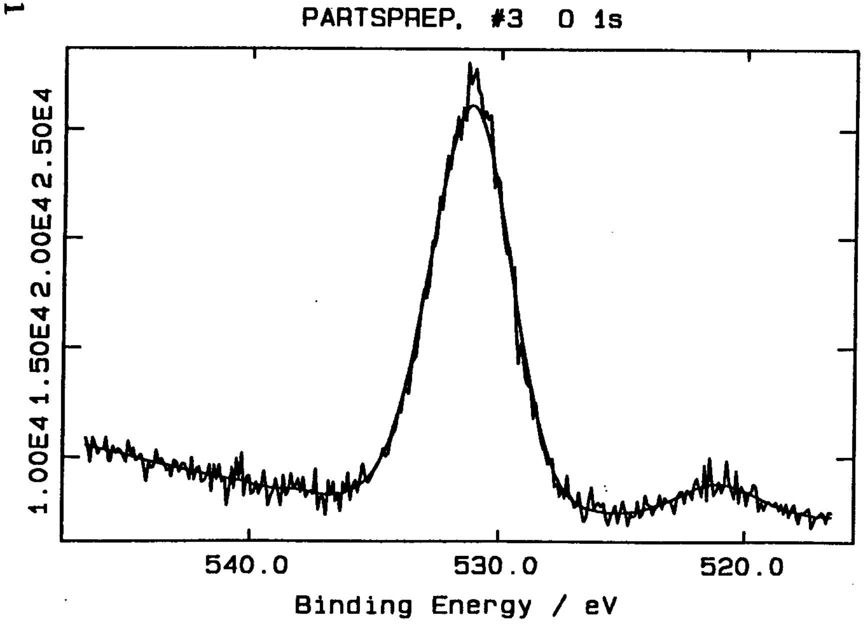
Peak Number	File name	Peak Assignment	Binding Energy (eV)	Peak Intensity	Atom Ratios
1	ALPAN094.R1	Mg 1s	1303.34	38406.0000	31.36
2	ALPAN094.R2	O 1s	531.18	72956.0000	797.26
3	ALPAN094.R3	C 1s	284.80	24489.0000	1175.91
4	ALPAN094.R4	See comments			
5	ALPAN094.R5	Mg 2s	88.13		
6	ALPAN094.R5	Al 2p	73.57	2173.0260	100.00

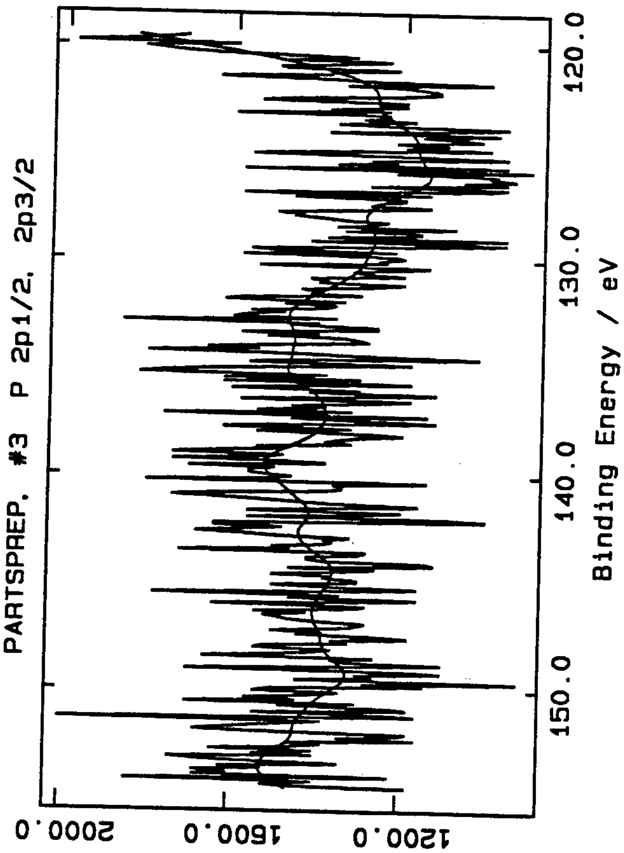
COMMENTS

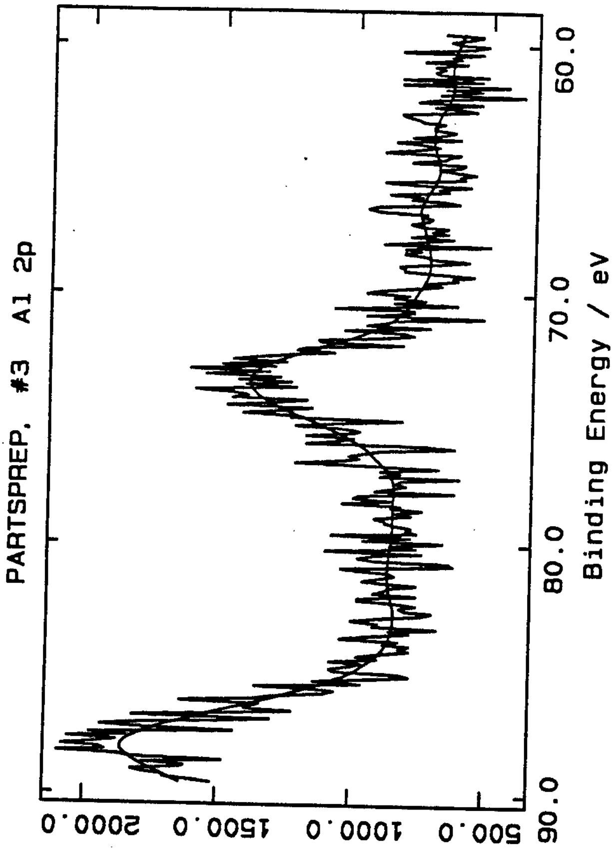
Areas (hence element concentrations) are based on smoothed data.
The signal/ noise ratio is too small to observe the P 2p doublet.


PARTSPREP, #3 Mg 1s
4.00E4
3.60E4
3.20E4
2.80E4
1320.0
1310.0
1300.0
1290.0
Binding Energy / eV


PARTSPREP, #3 C 1s
8000.0
6000.0
4000.0
2000.0
300.0
290.0
280.0
270.0
Binding Energy / eV


PARTSPREP, #3 O 1s
2.50E4
2.00E4
1.50E4
1.00E4
540.0
530.0
520.0
Binding Energy / eV


PARTSPREP. #3 P 2p1/2, 2p3/2
2000.0
1600.0
1200.0
150.0
140.0
130.0
120.0
Binding Energy / eV


PARTSPREP. #3 Al 2p
2000.0
1500.0
1000.0
500.0
90.0
80.0
70.0
60.0
Binding Energy / eV

IV. TABLE OF DATA SUMMARIZED.

The following table summarizes all of the XPS analyses that were performed on all samples. The atomic percentages were obtained by analyzing all of the raw data found in Section III.

12 July, 1995 Update

Elemental Concentrations on 7075 Al

Sample	[Al]	[Mg]	[C]	[O]	[Fe]	[Zn]
Bare Al, Panel 1	100	39	1200	750	2.6	2.0
Bare Al, Panel 2	100	45	1000	720	5.3	1.2
Contaminated, Panel 1	-	-	100	63	-	-
Contaminated, Panel 2	-	-	100	23	-	-
Sputtered Al	100	9.4	62	180	-	-

Elemental Concentrations on Cleaned 7075 Al

Sample/ Panel No.	[Al]	[Zn]	[Mg]	[C]	[O]	[N]	[P]	[S]	[Si]	[Cl]	[F]
Bare Al, #1	100	-	39	1200	750	-	-	-	-	-	-
Bare Al, #2	100	-	45	1000	720	-	-	-	-	-	-
Solvall 5234, #1	100	-	28	220	210	-	-	-	-	-	-
Solvall 5234, #2	100	-	24	760	590	-	-	-	-	-	-
PARTSPREP, #1	100	-	39	1200	820	-	15	-	-	-	-
PARTSPREP, #2	100	-	30	930	600	-	15	-	-	-	-
ALK 660, #1	100	-	15	290	360	18	6.5	-	11	-	-
ALK 660, #2	100	-	32	600	580	33	8.9	-	12	-	-
Penair HD-1, #1	100	-	32	1200	640	-	-	-	-	-	-
Penair HD-1, #2	100	-	16	1100	480	-	-	-	-	-	-
Rebound 7, #1	100	-	25	390	780	-	-	-	120	-	-
Rebound 7, #2	100	-	14	360	530	-	-	-	90	-	-
DOT-111/ 113, #1	100	-	36	1100	690	-	-	17	-	-	-
DOT-111/ 113, #2	100	-	25	1200	590	-	-	20	-	-	-
Metal Aid- Dr, #1A	100	7.2	8.5	110	360	-	-	-	-	-	-
Metal Aid- Dr, #1B	100	2.9	3.6	130	270	-	-	-	-	-	-
Trichlor, #1	100	-	52	1000	810	-	-	9.1	-	12	-
Trichlor, #2	100	-	52	1100	840	-	-	7.4	-	17	-
Shopmaster, #1	100	-	30	340	520	-	-	-	52	-	47
Shopmaster, #2	100	-	20	290	420	-	-	-	65	-	46
Aerosolv 2000, #1	100	-	7.8	180	290	-	20	-	-	-	-
Aerosolv 2000, #2	100	-	5.9	130	230	-	17	-	-	-	-
Brulin 815 GD, #1	100	-	0.66	62	250	-	-	-	31	1.3	-
Brulin 815 GD, #2	100	-	0.71	83	230	-	-	-	29	0.57	-
PowerCleaner 310L, #1	100	-	21	390	1200	-	-	-	260	-	-
PowerCleaner 310L, #2	100	-	22	510	1200	-	-	-	280	-	-
Jettacin, #1	100	-	1.6	100	230	-	-	-	19	-	-
Jettacin, #2	100	-	41	440	670	-	-	-	41	-	-
Cee Bee A 7 x 7, #1	100	-	38	380	630	-	-	-	57	-	-
Cee Bee A 7 x 7, #2	100	-	44	460	790	-	-	-	62	-	-
Turco 4215-NC-LT, #1	100	-	4.7	110	230	-	-	-	-	-	-
Turco 4215-NC-LT, #2	100	-	19	260	430	-	-	-	-	-	-
Brulin 815 GD, #3	100	-	1.3	110	340	-	-	-	59	-	-
Brulin 815 GD, #4	100	-	1.7	78	240	-	-	-	10	-	-
Callasolv 120, #1	100	-	25	830	580	-	-	-	-	-	-
Callasolv 120, #2	100	-	18	880	520	-	-	-	-	-	-
PARTSPREP, #3	100	-	31	1200	800	-	-	-	-	-	-

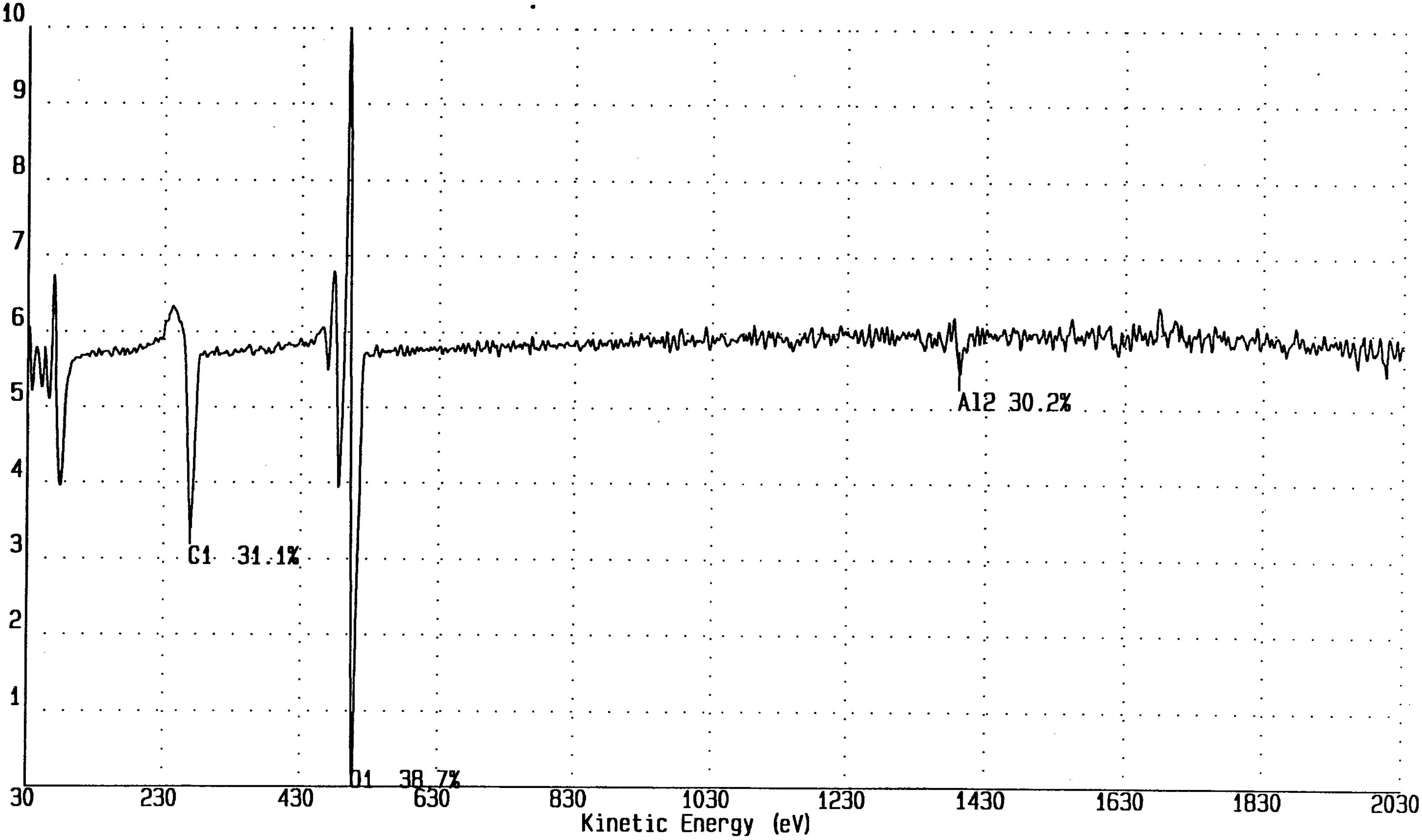
Note: Test results below the blank line are for test panels with 'face up' orientation during analysis.

V. Scanning Auger Data.

In order to confirm some of the XPS data, svanning Auger spectroscopy experiments were performed. The following spectra are specific Auger runs on samples that had also been anlyzed by XPS methods. Similar agreement was found for these different analyses. It shoudl be kept in mind that the two techniques analyze different areas although the depth of analysis is roughly the same.

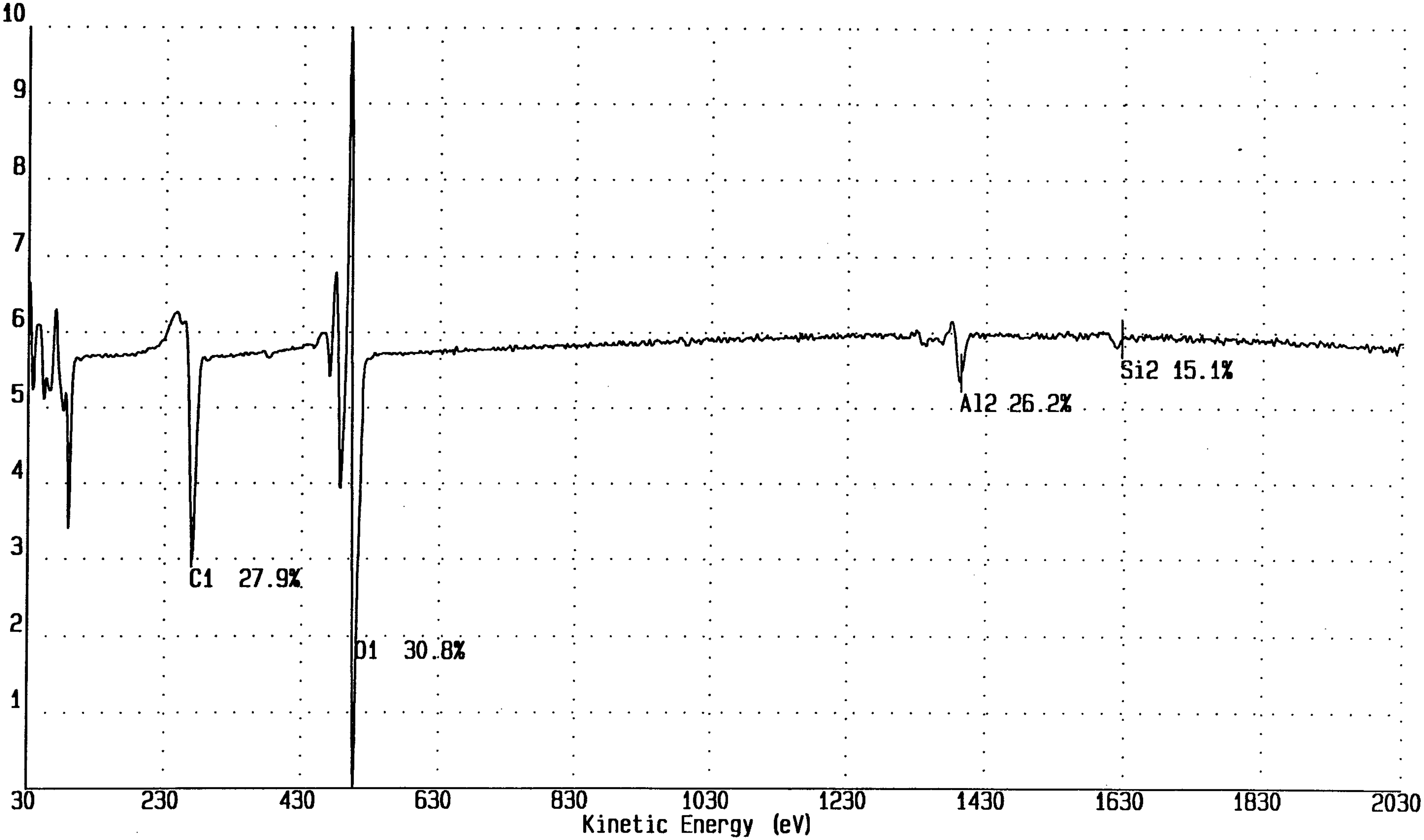
Brulin 815 GD, Spot 2, 12 sweeps
File: B:\CLEANAL\ALPANA02.SUR
Date: Sat Jul 08 06:54:08 1995

Res.: 1.0 eV Time/Step: 100 mS Sweeps: 12 Beam V: 3.00 KV
Min: -1539 cps Max: 1331 cps



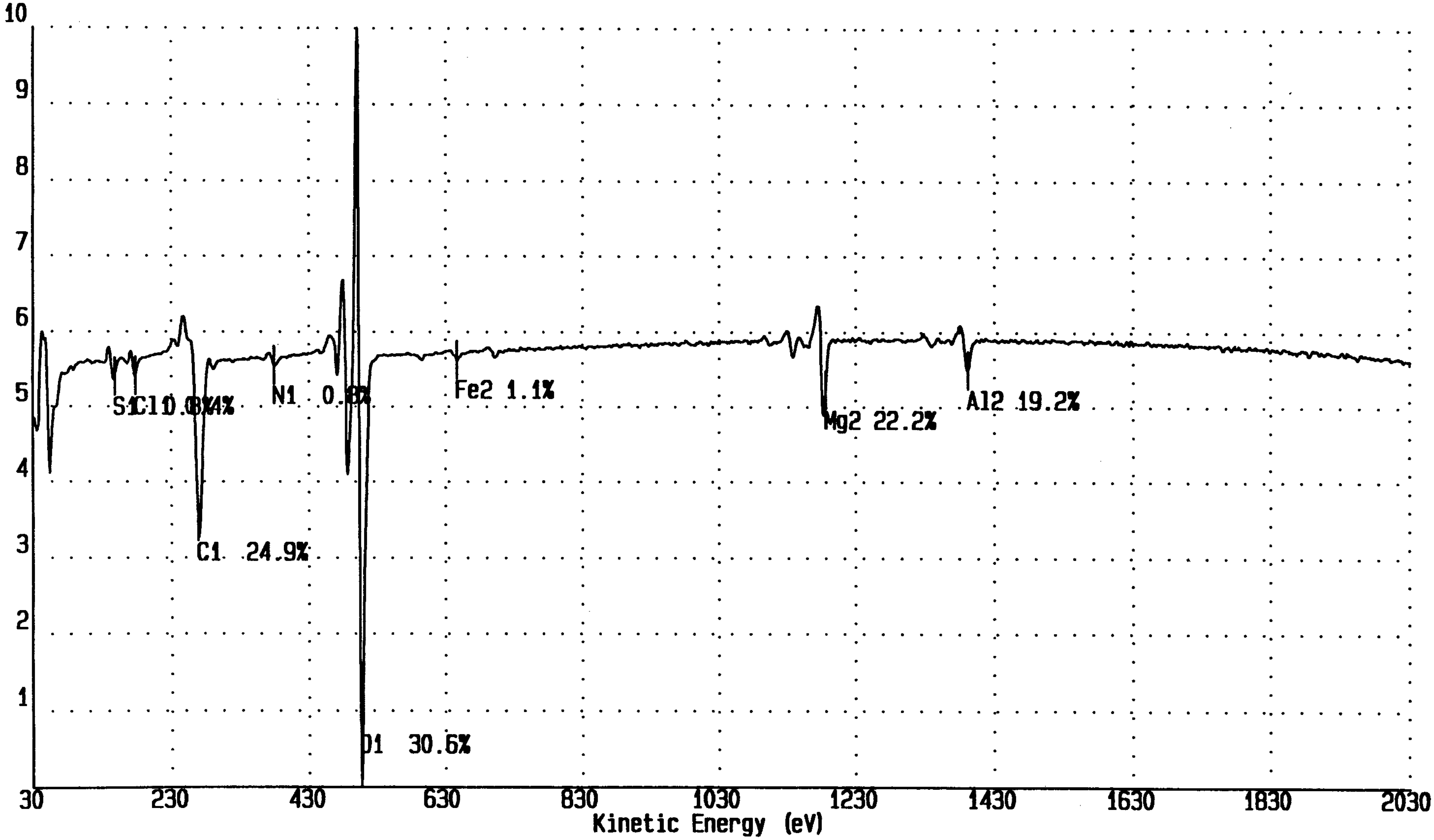
Brulin 815 GD, Spot 1, 240 sweeps
File: B:\CLEANAL\ALPANA01.SUR
Date: Sat Jul 08 06:04:05 1995

Res.: 1.0 eV Time/Step: 100 mS Sweeps: 240 Beam V: 3.00 KV
Min: -659 cps Max: 583 cps



Bare 7075 Al: Trichlor Cleaned
File: C:\AESDATA\ALPANA03.SUR
Date: Tue Jul 11 07:07:23 1995

Res.: 1.0 eV Time/Step: 100 mS Sweeps: 274 Beam V: 3.00 KV
Min: -1220 cps Max: 1090 cps



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Summary Data Sheet For Adhesive Bonding Replacement Cleaners

#	Alternate Cleaner Name	Manufacturer	Class according to CAST	Residue Rinsibility	Water Break Free Test	Biodegradability	Unacceptable Materials	EPA Hazardous Index	pH Value	Flash Point °F	Cold Stability	Volatility	Hard Water Stability	Cleaning Efficiency Test	Heat Stability	Auger Ranking	XPS Ranking	Total Immersion Corrosion	Effects on Unpainted Surfaces	Sandwich Corrosion	Stress Corrosion Cracking	Hydrogen Embrittlement	Comments
*	**Trichloroethane**		**5**		**p**		**x**	**x**	**6-7**	**n**		**f**				**10**	**10**						
1	Callasolve 120	Zip Chem Prod.	2	p*	p	p	x	x	9.6	127	p	p		92.30%	p	1	8						* slight discoloration
2	Aerosolve 2000	Aerocote	2	p	p	p	p	p	6.1	142	p	p	176	86.67%	f	2	1	Materials					
4	Parts Prep	Ecolink	2	p	p	p	p	p	9.9	193	p	p	57	94.94%	p	4	9	Compatability					
6	ShopMaster	Buckeye Int	2	p	p	p	p	p	13	n	p	p	200	94.52%	p	6	3	Section					Passes per mfg. testing also
7	Solvall 5234	Working Solutions	2	p*	p	p	p	p	12.5	204	p	p	0.47	92.52%	p	7	4						* slight discoloration
8	Alk -660	Eldorado Chem	1	p	p	p	p	p	9.3	n	p	f	12.5	90.02%	p	8	5						MIL 87937 A QPL product
3	Quaker 624GD	Quaker	2	f*	p	f	x	x	12.3	n	p	p		96.52%	p	3	-						*Residue is silicates, implications of which are not known
5	Quaker 697UT	Quaker	2	f*	p	f	x	x	12.7	n	p	p		93.69%	p	5	-						*Residue is silicates, implications of which are not known
9	Power Cleaner 310L	West Pentone	2	p	p	p	p	p	10.5	n	p	p		96.88%		9	-						Replaces EPA 2000 a Mil I 25135 QPL product
10	Cee-Bee Cleaner A 7x7	McGean-Rohco	2	p	p		x	x	12.4	n	p	p	18	96.15%		11	6						
11	Penair HD-1	West Pentone	2	p	p	p	p	p	10.3	125	p	p	200	96.34%	p	12	11						Replaces EPA 2000 a Mil I 25135 QPL, Mil 87937B
12	Turco 4215-NCLT	Turco Prod.	2	p	p	p	x	x	10	n	p	p	0.25	95.98%	f	13	2						
13	Jettacin	Dubois Mfg.	2	p*	p		p	p	11.2	n	p	p	5.1	98.00%	f	14	7						* slight discoloration
14	Alu-Kleen	Heat Bath	1	p*	p		x	x	10.1	n	p	p		98.03%	p	15	-						* slight discoloration
15	Brulin 815 GD	Brulin	1	p	p		p	p	11.9	n	p	p	0.22	94.75%	f	16	-						
16	DOT 111/113	Delta Omega	1	p	p	p	p	p	10.1	n	p	p	102	96.44%	p	17	12						MIL 87937 A QPL product
17	Bioact 40	Petroferm	1	p	p	p	p	p	6.2	214	p	p	0.15	91.35%	p	18	-						
18	Metal Aid DR	PCT tech	1	p	p	p	p	p	12.6	n	p	p	13	117.00%	f	19	-						Mil 87937 A QPL Product - Panel corroded-117%
19	Aeroclean DN30	Aerocote	1	f	p	p	p	p	11.4	n	p												
20	Blend 300	Ecolink	2	f	p	p	x	x	7	200	p												
21	Natural Blue	Loctite	3	f	p	p	x	x	10.6	n	p												
22	ReBound 7	XXCEL Tech	2	p	f	p	p	p	10.3	n	p			Testing Discontinued									
23	ReBound 4	XXCEL Tech	2	f	f	p	p	p	12.1	n	p			On These Cleaners									
24	Soluclean 5131	Working Solutions	2	f	p				12.5	n	f			Due To Failure In Some Aspect									
25	Turco Spray Ease	Turco Prod.	1	f	f		x	x	10.5	n	p												
26	UniKleen # 129 3	Heat Bath	1	p*	f		x	x	12.0	n	f												* slight discoloration
27	UniKleen #14 B	Heat Bath	1	f	f		x	x	10.5	n	p												
28	Bioact 50	Petroferm	1	p	f		p	p	7	214	p												
29	Magnaflux 1-2-3	Magnaflux	2	f	p	p	x	x	7	200	p												
30	Super Bee Cleaner 212	McGean-Rohco	1	f	p				10.5	n	p												
31	Penair HD-4	West Pentone	2	p	p			p	9	n	p												

Summary Data Sheet For Non-Destructive Inspection Replacement Cleaners

Code #	Alternate Cleaner Nam	Manufacturer	Preference according to CAST	Unacceptable Materials	EPA Hazardous Index	pH Value	Flash Point °F	Volatility	**Total Immersion Corrosion**	**Effects on Unpainted Surfaces**	**Sandwich Corrosion**	**Stress Corrosion Cracking**	**Hydrogen Embrittlement**	Comments
	Trichloroethane		**5**	**x**	**x**	**6-7**	**n**	**100**						
*	Isopropyl alcohol		2	p	x	n\a	53	100						
1	PD-680		4	p	x	n\a		100		Materials				
2	Citrex	Inland Tech	3	p	p	n\a	144	100		Compatability				
3	Spotcheck SKC-HF	Magnaflux	3	x	x	n\a	120	100		Section				MIL-I-25135 QPL
4	Desoclean 45	Courtnauld Aero	4	x	x	n\a	46	100						
5	Teksol EP	Inland Tech	4	p	p	n\a	112	100						
6	Bioact 113	Petroferm	4	p	p	n\a	112	100						
7	Axarel 56	Petroferm	3	p	x	n\a	205	100						
8	TPC Solvent	West Pentone	3	p	p	n\a	130	100						
9	Dynasolv-108	Dynamold	4	p	p	n\a	115	100						
10	Electron NDE	Ecolink	3	p	p	n\a	147	100						
11	D-Greeze 500	Solvent Kleen Inc	3	p	p	n\a	142	100	Testing Discontinued On These Cleaners Due To Failure In Some Aspect					
12	EP 921	Inland Tech	3		p	n\a	146	100						
13	Kustom	Certified Labs	3			n\a		100						
14	PF 01	P-T Tech.	3	p	p	n\a	144	100						
15	PF 145HP	P-T Tech.	3	p	p	n\a	145	100						
16	Pre-solv	LPS	3	p	p	n\a		100						
17	Electro 140	LPS	3	p	p	n\a		100						
18	Super 140	LPS	3	x	x	n\a		100						
19	Super Chem Trust	Madison Bionics	3	p	p	n\a	143	100						
20	Vortex	Ecolink	3	p	p	n\a	119	100						
21	X-Caliber	Inland Tech	3	p	p	n\a		100						
22	Loctite 70/70	Loctite	3	x	p	n\a	130	100						
23	Spotcheck-SKC-S	Magnaflux	4	x	x	n\a	50	100						
24	Pensolv L805	West Pentone	3	p	p	n\a	105	100						
25	Pensolv L945	West Pentone	3	p	p	n\a	145	100						

Section 4:

Materials Compatibility Investigation

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The top six candidates for cleaning prior to adhesive bonding were subjected to materials compatibility testing. The cleaners were Callosolve 120, Aerosolve 2000, Parts Prep, Shop Master, Solvall 5234, and ALK-660, acquired from the listing and analysis detailed in the previous section. The top 11 candidates for cleaning prior to NDI were also subjected to materials compatibility testing. They included isopropyl alcohol, P-D-680, Citrex, Spotcheck SKC-HF, Desoclean 45, Teksol EP, Bioact 113, Axarel 56, TPC Solvent, Dynasolv 108, and Electron NDE. Although it was not expected that these compliant solvent cleaners would be extremely corrosive or embrittling, the testing was carried out on the side of caution.

Materials Compatibility

The testing performed included total immersion corrosion, effects on unpainted surfaces, sandwich corrosion, stress corrosion cracking, and hydrogen embrittlement testing. A listing of the specifications called out in performing these tests is as follows:

Total Immersion Corrosion	ASTM-F-483
Effects On Unpainted Surfaces	ASTM-F-485
Sandwich Corrosion	ASTM-F-1110
Stress Corrosion Cracking	ASTM-G-30, ASTM-G-38, ASTM-G-39, ASTM-G-41, ASTM-G-44, ASTM-G-47, ASTM-G-103, ASTM-G-123 ASTM-F-945, ARP 1795A
Hydrogen Embrittlement	ASTM-F-519.

All tests were performed on the six materials (AM-355, PH 13-8 steel, maraging C-250 steel, aluminum 7075-T6, titanium 6Al-4V, and cadmium-plated 4340) except the hydrogen embrittlement testing, which was performed only on cadmium-plated 4340 according to the governing specification.

All of the testing was performed precisely following the specification guidelines except for the stress corrosion testing and the addition of the other materials investigated under this program. Several of the materials were not included in the aforementioned specifications and therefore did not have requirements to follow. However, extrapolated tests were developed based upon these specifications. The standards for stress corrosion testing of titanium and aluminum alloys, ASTM-F-945, ASTM-G-44, and ASTM-G-47, were extremely helpful in this regard. U-type bend specimens were fabricated from the appropriate material. These specimens were then subjected to a sodium chloride environment for varying time intervals coupled with furnace heat treatments to inflict a stress corrosive condition. The processes were then modified until stress corrosion cracking was evident on a regular basis (i.e., when all specimens subjected to a stress corrosive medium and baking treatment experienced cracking). The process was then altered by replacing the sodium chloride solution with concentrated solutions of the test alternatives. The specimens would then be subjected to similar exposure and heat treatment cycles. The specific procedures for each material are described as follows for each individual material.

Titanium:
- U-bend specimens of the appropriate dimensions were fabricated per ASTM-F-945.
- Three specimens were left untreated to establish validity of the sheet material.
- Six specimens were dipped in the sodium chloride solution, allowed to dry, and then put in a furnace at 900 ±20° F for 8 hrs.
- Three specimens were dipped in each of the test solutions, allowed to dry, and then put in a furnace at 900 ±20° F for 8 hrs.
- The specimens were evaluated both by both optical microscopy and metallurgically.

PH 13-8:
- U-bend specimens of the appropriate dimensions were fabricated per ASTM-F-945.
- Three specimens were left untreated to establish validity of the sheet material.
- Six specimens were dipped in the sodium chloride solution, allowed to dry, and then put in a furnace at 825 ±20° F for 120 hrs.
- Three specimens were dipped in each of the test solutions, allowed to dry, and then put in a furnace at 825 ±20° F for 120 hrs.
- The specimens were evaluated both by both optical microscopy and metallurgically.

C-250:
- U-bend specimens of the appropriate dimensions were fabricated per ASTM-F-945.
- Three specimens were left untreated to establish validity of the sheet material.
- Six specimens were dipped in the sodium chloride solution, allowed to dry, and then put in a furnace at 750 ±20° F for 168 hrs.
- Three specimens were dipped in each of the test solutions, allowed to dry, and then put in a furnace at 750 ±20° F for 168 hrs.
- The specimens were evaluated both by both optical microscopy and metallurgically.

AM-355:
- U-bend specimens of the appropriate dimensions were fabricated per ASTM-F-945.
- Three specimens were left untreated to establish validity of the sheet material.
- Six specimens were dipped in the sodium chloride solution, allowed to dry, and then put in a furnace at 825 ±20° F for 92 hrs.
- Three specimens were dipped in each of the test solutions, allowed to dry, and then put in a furnace at 825 ±20° F for 92 hrs.
- The specimens were evaluated both by both optical microscopy and metallurgically.

NOTE: AM-355 specimens were not visibly affected by stress corrosion cracking. ARL-MD could not get the material to stress corrosion crack even by varying the schedule probably due to the thickness of the sheet material (14 mils).

4340:
- U-bend specimens of the appropriate dimensions were fabricated per ASTM-F-945.
- Three specimens were left untreated to establish validity of the sheet material.
- Six specimens were dipped in the sodium chloride solution allowed to dry and then put in a furnace at 825 ±20° F for 168 hrs.
- Three specimens were dipped in each of the test solutions, allowed to dry, and then put in a furnace at 825 ±20° F for 168 hrs.
- The specimens were evaluated both by both optical microscopy and metallurgically.

Aluminum 7075-T6:
- U-bend specimens of the appropriate dimensions were fabricated per ASTM-F-945.
- Three specimens were left untreated to establish validity of the sheet material.
- Six specimens were dipped in the sodium chloride solution, allowed to dry, and then put in a furnace at 350 ±20° F for 104 hrs.
- Three specimens were dipped in each of the test solutions, allowed to dry, and then put in a furnace at 350 ±20° F for 104 hrs.
- The specimens were evaluated both by both optical microscopy and metallurgically.

Results

The results of the materials compatibility testing performed by ARL-MD outlined previously can be found on the following pages. A discussion of these results can be found immediately thereafter.

Total Corrosion

Titanium

		Initial Weight of Titanium	24 hours of Immersion Titanium		168 hours of Immersion of Titanium	
Cleaners		Weight (mg)	Weight (mg)		Weight (mg)	
	Conc.	Ave. weight/cm2	Ave. weight/cm2	Ave. Loss (mg/cm2/24hr)	Ave. weight/cm2	Ave. Loss (mg/cm2/168hr)
DS-108		121.8	121.8	0.0044	121.8	0.0000
Electron NDE		123.0	123.0	0.0007	123.0	0.0000
Iso Propyl		124.1	124.1	0.0022	124.1	0.0110
P-D 680		122.9	122.9	0.0000	122.9	0.0132
Citrex		122.0	122.0	0.0125	122.0	0.0353
Desoclean 45		116.4	116.4	0.0000	116.4	0.0103
Magnuflux SKC-HF		122.3	122.3	0.0000	122.3	0.0007
BioAct 113		122.1	122.1	0.0000	122.1	0.0088
Teksol EP		123.2	123.1	0.0118	123.1	0.0169
Axarel 56		121.6	121.6	0.0088	121.6	0.0051
Tpc solvent		122.6	122.6	0.0000	122.6	0.0191
Aerosolve 2000	100%	119.6	119.6	0.0037	119.6	0.0000
	10%	122.7	122.7	0.0015	122.6	0.0103
Alk-660	100%	121.3	121.3	0.0051	121.3	0.0198
	10%	121.7	121.7	0.0066	121.7	0.0213
Callasolve 120	100%	119.4	119.4	0.0051	119.4	0.0287
	10%	122.3	122.3	0.0000	122.2	0.0206
Parts Prep	100%	121.0	121.0	0.0000	121.0	0.0081
	10%	121.0	121.0	0.0037	121.0	0.0213
ShopMaster	100%	122.6	122.6	0.0000	122.6	0.0132
	10%	122.4	122.4	0.0015	122.4	0.0140
Solvall 5234	100%	121.9	121.9	0.0029	121.9	0.0162
	10%	123.5	123.5	0.0022	123.4	0.0081

						Initial Weight of Titanium					24 hours of Immersion Titanium						168 hours of Immersion of Titanium	
Cleaners	Conc.	Spec. No.				Ave. weight/cm2	Spec. No.				Weight (mg)	Ave. Loss (mg/cm 2/24hr)	Spec. No.				Ave. weight/cm2	Ave. Loss (mg/cm 2/168hr
			A	B	C			A	B	C				A	B	C		
Aerosolve 2000	100%	2	5616.7	5542.0	5117.7	119.6	2	5616.7	5541.7	5117.5	119.6	0.0037	2	5616.4	5541.9	5118.1	119.6	0.0000
	10%	3	5591.4	5619.0	5480.3	122.7	3	5591.3	5619.0	5480.2	122.7	0.0015	3	5590.8	5618.7	5479.8	122.6	0.0103
Alk-660	100%	4	5608.4	5406.5	5495.8	121.3	4	5608.0	5406.3	5495.7	121.3	0.0051	4	5607.2	5405.3	5495.5	121.3	0.0198
	10%	5	5461.4	5529.2	5568.1	121.7	5	5461.4	5528.8	5567.6	121.7	0.0066	5	5460.9	5528.1	5566.8	121.7	0.0213
Callasolve 120	100%	6	5596.8	5679.9	4976.5	119.4	6	5596.6	5679.6	4976.3	119.4	0.0051	6	5595.0	5679.0	4975.3	119.4	0.0287
	10%	7	5562.3	5498.6	5576.9	122.3	7	5562.3	5498.6	5576.9	122.3	0.0000	7	5560.9	5497.5	5576.6	122.2	0.0206
Parts Prep	100%	8	5490.5	5512.1	5462.9	121.0	8	5490.5	5512.0	5463.0	121.0	0.0000	8	5490.0	5512.0	5462.4	121.0	0.0081
	10%	9	5356.6	5467.7	5638.7	121.0	9	5356.6	5467.3	5638.6	121.0	0.0037	9	5356.2	5466.3	5637.6	121.0	0.0213
ShopMaster	100%	10	5526.2	5622.2	5539.1	122.6	10	5526.5	5622.0	5539.0	122.6	0.0000	10	5526.1	5621.6	5538.0	122.6	0.0132
	10%	11	5577.3	5520.5	5555.7	122.4	11	5577.3	5520.5	5555.5	122.4	0.0015	11	5576.6	5520.2	5554.8	122.4	0.0140
Solvall 5234	100%	12	5472.1	5575.2	5541.3	121.9	12	5471.9	5575.1	5541.2	121.9	0.0029	12	5471.4	5574.4	5540.6	121.9	0.0162
	10%	13	5609.1	5614.3	5576.3	123.5	13	5608.7	5614.5	5576.2	123.5	0.0022	13	5608.6	5614.4	5575.6	123.4	0.0081
Axarel 56		14	5498.5	5510.5	5544.8	121.6	14	5497.9	5510.3	5544.4	121.6	0.0088	14	5497.4	5511.3	5544.4	121.6	0.0051
BioAct 113		15	5551.7	5579.2	5489.3	122.1	15	5552	5579	5489.2	122.1	0.0000	15	5551.2	5578.9	5488.9	122.1	0.0088
Citrex		16	5550.1	5462.4	5590.5	122.0	16	5550	5461.7	5589.6	122.0	0.0125	16	5549.4	5459.7	5589.1	122.0	0.0353
Desoclean 45		17	5406.0	5558.4	4880.1	116.4	17	5406	5558.4	4880.1	116.4	0.0000	17	5405.1	5558.6	4879.4	116.4	0.0103
Iso Propyl		18	5665.4	5621.9	5602	124.1	18	5665	5621.8	5602.2	124.1	0.0022	18	5664.8	5621.4	5601.6	124.1	0.0110
Magnuflux SKC-HF		19	5522.3	5568.3	5558.1	122.3	19	5522.3	5568.3	5558.1	122.3	0.0000	19	5522.4	5567.9	5558.3	122.3	0.0007
P-D 680		20	5575.0	5558.8	5593.8	122.9	20	5575.1	5558.8	5593.7	122.9	0.0000	20	5574.3	5558.6	5592.9	122.9	0.0132
Teksol EP		21	5614.2	5610.8	5534.4	123.2	21	5613.5	5610.4	5533.9	123.1	0.0118	21	5613.9	5609.9	5533.3	123.1	0.0169
Tpc solvent		22	5590.5	5536.0	5562.6	122.6	22	5590.3	5536.3	5562.5	122.6	0.0000	22	5589.4	5534.9	5562.2	122.6	0.0191
DS-108		24	5521.8	5451.7	5602.1	121.8	24	5521.7	5451.3	5602.0	121.8	0.0044	24	5521.5	5451.6	5602.6	121.8	0.0000
Electron NDE		25	5565.3	5591.2	5582.3	123.0	25	5565.3	5590.9	5582.5	123.0	0.0007	25	5565.6	5590.8	5582.4	123.0	0.0000

Total Corrosion

Aluminum

		Initial Weight of Aluminum	24 hours of Immersion of Aluminum		168 hours of Immersion of Aluminum	
Cleaners		Weight (mg)	Weight (mg)		Weight (mg)	
	Conc.	Ave. weight/cm2	Ave. weight/cm2	Ave. Loss (mg/cm2/24hr)	Ave. weight/cm2	Ave. Loss (mg/cm2/168hr)
DS-108		534.9	534.9	0.0000	534.9	0.0000
Electron NDE		523.4	523.4	0.0000	523.4	0.0000
Iso Propyl		543.3	543.2	0.0459	543.2	0.0853
P-D 680		538.8	538.8	0.0459	538.7	0.0689
Citrex		547.5	547.4	0.0558	547.4	0.1083
Desoclean 45		549.5	549.4	0.0755	549.5	0.0525
Magnuflux SKC-HF		524.8	524.7	0.0787	524.7	0.1017
BioAct 113		548.5	548.5	0.0558	548.5	0.0328
Teksol EP		535.7	535.7	0.0164	535.6	0.0722
Axarel 56		532.4	532.3	0.0853	532.3	0.0787
Tpc solvent		543.7	543.6	0.0722	543.7	0.0492
Aerosolve 2000	100%	528.1	528.1	0.0066	528.1	0.0000
	10%	549.6	549.6	0.0000	549.6	0.0066
Alk-660	100%	539.8	539.8	0.0033	539.8	0.0033
	10%	541.8	541.8	0.0000	541.8	0.0000
Callasolve 120	100%	531.8	531.8	0.0000	531.8	0.0000
	10%	542.5	542.5	0.0000	542.5	0.0033
Parts Prep	100%	539.6	539.6	0.0066	539.6	0.0098
	10%	518.8	518.8	0.0000	518.8	0.0066
ShopMaster	100%	535.6	535.5	0.0066	535.6	-0.0033
	10%	543.6	543.6	0.0098	543.6	0.0066
Solvall 5234	100%	531.2	531.2	0.0033	531.2	0.0131
	10%	540.7	540.7	0.0066	540.7	0.0098

						Initial Weight of Aluminum					24 hours of Immersion of Aluminum						168 hours of Immersion of Aluminum	
Cleaners	Conc.	Spec. No.				Ave. weight/cm2	Spec. No.				Weight (mg)	Ave. Loss (mg/cm 2/24hr)	Spec. No.				Ave. weight/cm2	Ave. Loss (mg/cm 2/168hr
			A	B	C			A	B	C				A	B	C		
Aerosolve 2000	100%	2	5580.8	5032.4	5484.3	528.1	2	5580.5	5032.3	5484.5	528.1	0.0066	2	5580.7	5032.4	5484.4	528.1	0.0000
	10%	3	5588.2	5628.8	5534.8	549.6	3	5588.2	5628.8	5534.8	549.6	0.0000	3	5588.1	5628.4	5535.1	549.6	0.0066
Alk-660	100%	4	5406.4	5693.4	5353.8	539.8	4	5406.5	5693.5	5353.5	539.8	0.0033	4	5406.5	5693.5	5353.5	539.8	0.0033
	10%	5	5572.7	5346.5	5595.5	541.8	5	5572.5	5346.6	5595.6	541.8	0.0000	5	5572.5	5346.4	5595.8	541.8	0.0000
Callasolve 120	100%	6	5360.2	5361.7	5487.0	531.8	6	5360.2	5361.7	5487.0	531.8	0.0000	6	5360.0	5361.8	5487.1	531.8	0.0000
	10%	7	5653.7	5463.3	5419.6	542.5	7	5653.7	5463.5	5419.4	542.5	0.0000	7	5653.7	5463.2	5419.6	542.5	0.0033
Parts Prep	100%	8	5427.5	5584.5	5435.5	539.6	8	5427.5	5584.3	5435.5	539.6	0.0066	8	5427.3	5584.2	5435.7	539.6	0.0098
	10%	9	4779.5	5344.0	5690.8	518.8	9	4779.7	5344.1	5690.5	518.8	0.0000	9	4779.3	5344.5	5690.3	518.8	0.0066
ShopMaster	100%	10	5589.9	5339.6	5394.1	535.6	10	5589.3	5339.9	5394.2	535.5	0.0066	10	5590.1	5339.6	5394.0	535.6	-0.0033
	10%	11	5567.8	5426.6	5574.9	543.6	11	5567.7	5426.5	5574.8	543.6	0.0098	11	5568.0	5426.1	5575.0	543.6	0.0066
Solvall 5234	100%	12	5386.3	5435.2	5369.2	531.2	12	5386.1	5435.3	5369.2	531.2	0.0033	12	5386.0	5435.1	5369.2	531.2	0.0131
	10%	13	5670.1	5412.5	5397.8	540.7	13	5670.1	5412.2	5397.9	540.7	0.0066	13	5670.1	5412.0	5398.0	540.7	0.0098
Axarel 56		14	5403.0	5421.5	5401.9	532.4	14	5402	5420.8	5401	532.3	0.0853	14	5402	5421	5401	532.3	0.0787
BioAct 113		15	5397.2	5658.5	5663.6	548.5	15	5396.7	5658	5662.9	548.5	0.0558	15	5397.2	5658.1	5663	548.5	0.0328
Citrex		16	5414.3	5622.6	5650.2	547.5	16	5413.5	5622.2	5649.7	547.4	0.0558	16	5412.4	5621.7	5649.7	547.4	0.1083
Desoclean 45		17	5500.7	5634.0	5614.7	549.5	17	5499.3	5633.1	5614.7	549.4	0.0755	17	5499.9	5633.2	5614.7	549.5	0.0525
Iso Propyl		18	5603.8	5562.4	5392.2	543.3	18	5603.5	5561.7	5391.8	543.2	0.0459	18	5602.8	5561.7	5391.3	543.2	0.0853
Magnuflux SKC-HF		19	5407.1	5352.8	5236.1	524.8	19	5406.2	5352.1	5235.3	524.7	0.0787	19	5406	5351.9	5235	524.7	0.1017
P-D 680		20	5600.8	5416.8	5405.1	538.8	20	5600	5416.3	5405	538.8	0.0459	20	5599.4	5416.3	5404.9	538.7	0.0689
Teksol EP		21	5281.0	5411.5	5635	535.7	21	5281.1	5411	5634.9	535.7	0.0164	21	5280.8	5410	5634.5	535.6	0.0722
Tpc solvent		22	5645.6	5406.9	5520	543.7	22	5644.7	5406.1	5519.5	543.6	0.0722	22	5645	5406.7	5519.3	543.7	0.0492
DS-108		24	5382.5	5593.4	5326.7	534.9	24	5382.2	5593.5	5326.9	534.9	0.0000	24	5382.0	5593.5	5327.1	534.9	0.0000
Electron NDE		25	5041.5	5586.0	5326.7	523.4	25	5041.5	5586.0	5326.7	523.4	0.0000	25	5041.1	5586.0	5327.1	523.4	0.0000

Total Corrosion

AM-355

		Initial Weight of AM-355	24 hours of Immersion AM-355		168 hours of Immersion of AM-355	
Cleaners		Weight (mg)	Weight (mg)		Weight (mg)	
	Conc.	Ave. weight/cm2	Ave. weight/cm2	Ave. Loss (mg/cm2/24hr)	Ave. weight/cm2	Ave. Loss (mg/cm2/168hr)
DS-108		280.6	280.6	-0.0258	280.6	0.0078
Electron NDE		274.5	274.5	0.0078	274.5	0.0181
Iso Propyl		285.1	285.1	0.0000	285.1	0.0233
P-D 680		277.9	277.9	-0.0207	277.9	-0.0181
Citrex		268.9	268.9	0.0103	268.9	-0.0155
Desoclean 45		282.1	282.1	0.0103	282.1	0.0155
Magnuflux SKC-HF (Spotcheck)		279.8	279.9	-0.0543	279.8	-0.0207
BioAct 113		277.5	277.6	-0.0284	277.5	-0.0078
Teksol EP		290.2	290.2	-0.0052	290.2	-0.0233
Axarel 56		272.3	272.4	-0.0129	272.3	0.0310
Tpc solvent		268.2	268.2	0.0233	268.2	-0.0026
Aerosolve 2000	100%	274.4	274.4	0.0310	274.4	0.0465
	10%	270.6	270.6	-0.0103	270.5	0.0155
Alk-660	100%	260.9	260.9	-0.0026	260.9	0.0078
	10%	274.6	274.6	-0.0465	274.6	-0.0052
Callasolve 120	100%	268.6	268.6	-0.0181	268.6	-0.0233
	10%	280.4	280.4	-0.0362	280.4	0.0078
Parts Prep	100%	285.7	285.7	-0.0052	285.7	0.0207
	10%	272.9	272.9	-0.0284	272.9	-0.0233
ShopMaster	100%	274.0	273.9	0.0155	273.9	0.0310
	10%	277.9	277.9	0.0103	277.9	0.0026
Solvall 5234	100%	275.7	275.7	-0.0155	275.7	0.0000
	10%	279.8	279.8	-0.0026	279.8	0.0103

						Initial Weight of AM-355					24 hours of Immersion AM-355						168 hours of Immersion of AM-355	
Cleaners	Conc.	Spec. No.				Ave. weight/cm2	Spec. No.				Weight (mg)	Ave. Loss (mg/cm 2/24hr)	Spec. No.				Ave. weight/cm2	Ave. Loss (mg/cm 2/168hr
			A	B	C			A	B	C				A	B	C		
Aerosolve 2000	100%	2	3573.9	3428.5	3617.0	274.4	2	3573.5	3428.1	3616.6	274.4	0.0310	2	3573.3	3428.1	3616.2	274.4	0.0465
	10%	3	3429.1	3444.3	3596.9	270.6	3	3429.5	3444.8	3596.4	270.6	-0.0103	3	3429.0	3444.2	3596.5	270.5	0.0155
Alk-660	100%	4	3517.1	3334.5	3244.1	260.9	4	3517.1	3334.4	3244.3	260.9	-0.0026	4	3517.1	3334.0	3244.3	260.9	0.0078
	10%	5	3538.7	3622.6	3465.1	274.6	5	3538.7	3622.9	3466.6	274.6	-0.0465	5	3538.5	3622.6	3465.5	274.6	-0.0052
Callasolve 120	100%	6	3414.4	3437.6	3543.1	268.6	6	3414.5	3437.7	3543.6	268.6	-0.0181	6	3414.2	3437.2	3543.4	268.6	0.0078
	10%	7	3659.5	3619.6	3571.2	280.4	7	3660.0	3620.1	3571.6	280.4	-0.0362	7	3659.1	3619.6	3571.3	280.4	0.0078
Parts Prep	100%	8	3760.2	3591.1	3704.8	285.7	8	3760.4	3591.0	3704.9	285.7	-0.0052	8	3759.9	3590.6	3704.8	285.7	0.0207
	10%	9	3459.0	3629.5	3472.0	272.9	9	3458.9	3630.1	3472.6	272.9	-0.0284	9	3458.8	3629.6	3472.3	272.9	-0.0052
ShopMaster	100%	10	3300.2	3570.3	3731.6	274.0	10	3299.9	3570.2	3731.4	273.9	0.0155	10	3299.8	3570.3	3730.8	273.9	0.0310
	10%	11	3639.9	3436.1	3680.6	277.9	11	3640.2	3435.8	3680.2	277.9	0.0103	11	3640.4	3435.6	3680.5	277.9	0.0026
Solvall 5234	100%	12	3487.6	3614.3	3566.4	275.7	12	3487.4	3614.7	3566.8	275.7	-0.0155	12	3487.6	3614.3	3566.4	275.7	0.0000
	10%	13	3577.8	3493.4	3757.4	279.8	13	3577.8	3493.4	3757.5	279.8	-0.0026	13	3577.9	3493.4	3756.9	279.8	0.0103
Axarel 56		14	3436.1	3565.7	3537.7	272.3	14	3436.5	3565.6	3537.9	272.4	-0.0129	14	3436.0	3564.9	3537.4	272.3	0.0310
BioAct 113		15	3617.5	3453.2	3669.6	277.5	15	3617.8	3453.5	3670.1	277.6	-0.0284	15	3617.4	3453.4	3669.8	277.5	-0.0078
Citrex		16	3737.9	3249.6	3418.5	268.9	16	3738.0	3249.8	3417.8	268.9	0.0103	16	3738.0	3249.5	3418.6	268.9	-0.0026
Desoclean 45		17	3683.4	3566.9	3665.8	282.1	17	3683.2	3566.9	3665.6	282.1	0.0103	17	3683.2	3566.8	3665.5	282.1	0.0155
Iso Propyl		18	3688.5	3649.6	3696.1	285.1	18	3687.5	3650.1	3696.6	285.1	0.0000	18	3687.1	3649.7	3696.5	285.1	0.0233
Magnuflux SKC-HF Spot Check		19	3674.6	3582.0	3572.7	279.8	19	3675.1	3583.0	3573.3	279.9	-0.0543	19	3629.8	3582.2	3558.9	278.3	1.5090
P-D 680		20	3680.6	3551.5	3522.3	277.9	20	3681.0	3551.8	3522.4	277.9	-0.0207	20	3680.0	3550.8	3522.3	277.9	0.0336
Teksol EP		21	3676.6	3709.2	3844.5	290.2	21	3676.6	3709.2	3844.7	290.2	-0.0052	21	3676.8	3709.2	3844.5	290.2	-0.0052
Tpc solvent		22	3494.3	3448.4	3436.3	268.2	22	3493.6	3448.0	3436.5	268.2	0.0233	22	3494.0	3448.1	3437.0	268.2	-0.0026
DS-108		24	3616.6	3650.4	3591.6	280.6	24	3617.4	3650.5	3591.7	280.6	-0.0258	24	3616.6	3650.3	3591.4	280.6	0.0078
Electron NDE		25	3625.7	3574.9	3424.4	274.5	25	3625.6	3574.6	3424.5	274.5	0.0078	25	3625.6	3574.5	3424.2	274.5	0.0181

Total Corrosion

PH 13-8

		Initial Weight of Ph 13-8	24 hours of Immersion PH 13-8		168 hours of Immersion of PH 13 8	
Cleaners		Weight (mg)	Weight (mg)		Weight (mg)	
	Conc.	Ave. weight/cm2	Ave. weight/cm2	Ave. Loss (mg/cm2/24hr)	Ave. weight/cm2	Ave. Loss (mg/cm2/168hr)
DS-108		565.4	565.3	0.0248	565.3	0.0189
Electron NDE		586.2	586.2	0.0118	586.2	0.0130
Iso Propyl		572.1	572.0	0.0118	572.0	0.0130
P-D 680		564.4	564.4	-0.0059	564.4	-0.0024
Citrex		562.3	562.3	0.0130	562.3	0.0118
Desoclean 45		569.1	569.1	-0.0059	569.1	0.0118
Magnuflux SKC-HF		578.0	578.0	0.0106	578.0	0.0106
BioAct 113		568.0	568.0	0.0177	568.0	0.0177
Teksol EP		565.2	565.2	0.0177	565.2	0.0118
Axarel 56		563.0	562.9	0.0189	562.9	0.0166
Tpc solvent		585.6	585.6	0.0059	585.5	0.0118
Aerosolve 2000	100%	572.1	572.1	0.0083	572.1	0.0012
	10%	581.7	581.7	0.0130	581.7	0.0118
Alk-660	100%	575.2	575.2	0.0130	575.1	0.0213
	10%	576.0	576.0	0.0035	576.0	-0.0035
Callasolve 120	100%	576.4	576.4	0.0142	576.4	0.0095
	10%	594.6	594.6	0.0095	594.6	0.0118
Parts Prep	100%	568.1	568.1	0.0154	568.1	0.0213
	10%	561.8	561.8	0.0118	561.8	0.0201
ShopMaster	100%	572.1	572.1	0.0142	572.1	0.0154
	10%	569.2	569.2	0.0083	569.2	0.0142
Solvall 5234	100%	576.9	576.9	0.0142	576.9	0.0118
	10%	567.2	567.2	0.0071	567.2	0.0461

						Initial Weight of PH 13-8					24 hours of Immersion of PH13-8						168 hours of Immersion of PH 13-8	
Cleaners	Conc.	Spec. No.				Ave. weight/cm2	Spec. No.				Weight (mg)	Ave. Loss (mg/cm 2/24hr)	Spec. No.				Ave. weight/cm2	Ave. Loss (mg/cm 2/168hr
			A	B	C			A	B	C				A	B	C		
Aerosolve 2000	100%	2	16360.1	16242.6	15755	572.1	2	16360	16242	15755	572.1	0.0083	2	16360	16242	15755	572.1	0.0012
	10%	3	16541.0	16228.4	16398	581.7	3	16541	16228	16398	581.7	0.0130	3	16541	16228	16398	581.7	0.0118
Alk-660	100%	4	16383.5	16141.2	16090	575.2	4	16383	16141	16090	575.2	0.0130	4	16383	16140	16090	575.1	0.0213
	10%	5	16425.0	16185.9	16075	576.0	5	16425	16186	16075	576.0	0.0035	5	16425	16186	16076	576.0	-0.0035
Callasolve 120	100%	6	16736.9	15678.1	16303	576.4	6	16736	15678	16303	576.4	0.0142	6	16736	15678	16303	576.4	0.0095
	10%	7	17015.1	16900.6	16344	594.6	7	17015	16900	16344	594.6	0.0095	7	17015	16900	16344	594.6	0.0118
Parts Prep	100%	8	15820.1	16149.2	16048	568.1	8	15820	16149	16047	568.1	0.0154	8	15820	16149	16047	568.1	0.0213
	10%	9	15932.3	15732.4	15818	561.8	9	15932	15732	15817	561.8	0.0118	9	15932	15732	15817	561.8	0.0201
ShopMaster	100%	10	15993.8	15927.9	16432	572.1	10	15993	15927	16432	572.1	0.0142	10	15993	15928	16432	572.1	0.0154
	10%	11	15994.6	16187.7	15927	569.2	11	15994	16188	15927	569.2	0.0083	11	15994	16188	15927	569.2	0.0142
Solvall 5234	100%	12	15783.0	16166.9	16810	576.9	12	15782	16167	16810	576.9	0.0142	12	15782	16167	16810	576.9	0.0118
	10%	13	15809.1	16196.5	15937	567.2	13	15809	16197	15936	567.2	0.0071	13	15808	16195	15935	567.2	0.0461
Axarel 56		14	15719.9	16232.2	15630	563.0	14	15719	16232	15630	562.9	0.0189	14	15719	16232	15630	562.9	0.0166
BioAct 113		15	15922.4	16041.0	16048	568.0	15	15922	16041	16047	568.0	0.0177	15	15922	16041	16047	568.0	0.0177
Citrex		16	15980.4	15663.1	15885	562.3	16	15980	15663	15884	562.3	0.0130	16	15980	15663	15884	562.3	0.0118
Desoclean 45		17	15779.3	16437.0	15888	569.1	17	15779	16437	15888	569.1	-0.0059	17	15779	16437	15887	569.1	0.0118
Iso Propyl		18	15616.9	15913.4	16821	572.1	18	15616	15913	16821	572.0	0.0118	18	15616	15913	16821	572.0	0.0130
Magnuflux SKC-HF		19	17321.5	15574.2	15957	578.0	19	17321	15574	15956	578.0	0.0106	19	17321	15574	15956	578.0	0:0106
P-D 680		20	15868.1	15672.6	16161	564.4	20	15868	15673	16162	564.4	-0.0059	20	15868	15673	16162	564.4	-0.0024
Teksol EP		21	15909.3	15877.8	15987	565.2	21	15909	15877	15987	565.2	0.0177	21	15909	15877	15987	565.2	0.0118
Tpc solvent		22	16280.0	16942.9	16270	585.6	22	16280	16943	16269	585.6	0.0059	22	16280	16943	16269	585.5	0.0118
DS-108		24	15918.6	15917.9	15949	565.4	24	15918	15917	15948	565.3	0.0248	24	15918	15918	15948	565.3	0.0189
Electron NDE		25	16516.8	16461.7	16568	586.2	25	16517	16461	16568	586.2	0.0118	25	16517	16461	16568	586.2	0.0130

Total Corrosion

C-250

		Initial Weight of C-250	24 hours of Immersion C-250		168 hours of Immersion of C-250	
Cleaners		Weight (mg)	Weight (mg)		Weight (mg)	
	Conc.	Ave. weight/cm2	Ave. weight/cm2	Ave. Loss (mg/cm2/24hr)	Ave. weight/cm2	Ave. Loss (mg/cm2/168hr)
DS-108		641.4	641.4	0.0106	641.3	0.0189
Electron NDE		618.9	618.8	0.0106	618.8	0.0059
Iso Propyl		617.5	617.5	0.0165	617.5	0.0024
P-D 680		609.9	609.9	-0.0142	609.9	0.0083
Citrex		620.5	620.5	-0.0012	620.5	0.0094
Desoclean 45		604.7	604.6	0.0519	604.5	0.1735
Magnuflux SKC-HF		621.3	621.3	0.0118	621.3	0.0106
BioAct 113		610.6	610.6	0.0153	610.6	0.0000
Teksol EP		623.6	623.6	-0.0024	623.6	-0.0012
Axarel 56		633.9	633.9	0.0047	633.9	0.0035
Tpc solvent		634.4	634.4	0.0106	634.4	0.0142
Aerosolve 2000	100%	622.6	622.5	0.0861	622.6	0.0035
	10%	625.3	625.2	0.0271	625.2	0.0507
Alk-660	100%	629.3	629.3	0.0224	629.3	0.0094
	10%	622.9	622.9	0.0024	622.9	0.0201
Callasolve 120	100%	618.3	618.3	0.0083	618.3	0.0071
	10%	630.6	630.6	0.0130	630.6	0.0059
Parts Prep	100%	610.8	610.8	0.0000	610.8	0.0047
	10%	619.8	619.8	0.0024	619.7	0.0814
ShopMaster	100%	623.8	623.8	0.0012	623.8	-0.0035
	10%	620.1	620.1	-0.0012	620.1	0.0307
Solvall 5234	100%	620.4	620.4	0.0094	620.4	0.0189
	10%	612.0	611.9	0.0507	611.7	0.2466

						Initial Weight of C-250					24 hours of Immersion of C-250						168 hours of Immersion of C-250	
Cleaners	Conc.	Spec. No.				Ave. weight/cm2	Spec. No.				Weight (mg)	Ave. Loss (mg/cm 2/24hr)	Spec. No.				Ave. weight/cm2	Ave. Loss (mg/cm 2/168hr
			A	B	C			A	B	C				A	B	C		
Aerosolve 2000	100%	2	18596.9	16828.1	17333.6	622.6	2	18595.2	16825.4	17330.7	622.5	0.0861	2	18599.5	16829.1	17329.7	622.6	0.0035
	10%	3	17582.5	17465.9	17938.6	625.3	3	17581.6	17465.4	17937.7	625.2	0.0271	3	17581.3	17464.5	17936.9	625.2	0.0507
Alk-660	100%	4	18021.8	17847.8	17459.6	629.3	4	18020.6	17847.4	17459.3	629.3	0.0224	4	18020.7	17847.7	17460.0	629.3	0.0094
	10%	5	16924.3	17780.6	18084.9	622.9	5	16924.3	17780.5	18084.8	622.9	0.0024	5	16923.6	17779.9	18084.6	622.9	0.0201
Callasolve 120	100%	6	17413.5	18352.1	16634.2	618.3	6	17413.4	18351.8	16633.9	618.3	0.0083	6	17413.5	18351.8	16633.9	618.3	0.0071
	10%	7	17594.4	17245.7	18600.4	630.6	7	17593.8	17245.3	18600.3	630.6	0.0130	7	17594.3	17245.7	18600.0	630.6	0.0059
Parts Prep	100%	8	17151.5	17042.2	17564.5	610.8	8	17151.2	17042.4	17564.6	610.8	0.0000	8	17151.1	17042.0	17564.7	610.8	0.0047
	10%	9	17636.4	17676.9	17209.7	619.8	9	17636.3	17676.7	17209.8	619.8	0.0024	9	17633.9	17674.1	17208.1	619.7	0.0814
ShopMaster	100%	10	18187.8	17689.0	16990.5	623.8	10	18187.6	17689.0	16990.6	623.8	0.0012	10	18188.2	17688.8	16990.6	623.8	-0.0035
	10%	11	17297.0	18027.2	17225.5	620.1	11	17297.6	18027.0	17225.2	620.1	-0.0012	11	17295.7	18025.4	17226.0	620.1	0.0307
Solvall 5234	100%	12	17609.1	17469.8	17498.1	620.4	12	17608.9	17469.4	17497.9	620.4	0.0094	12	17608.7	17469.2	17497.5	620.4	0.0189
	10%	13	16589.6	17347.9	17925.7	612.0	13	16588.6	17347.1	17923.2	611.9	0.0507	13	16583.6	17343.1	17915.6	611.7	0.2466
Axarel 56		14	18259.9	18360.6	17096	633.9	14	18260	18360	17096	633.9	0.0047	14	18260	18361	17096	633.9	0.0035
BioAct 113		15	17351.4	17130.1	17266	610.6	15	17351	17130	17265	610.6	0.0153	15	17351	17130	17266	610.6	0.0000
Citrex		16	17620.8	17625.0	17339	620.5	16	17621	17625	17339	620.5	-0.0012	16	17621	17625	17338	620.5	0.0094
Desoclean 45		17	18278.5	17005.6	15958	604.7	17	18277	17004	15956	604.6	0.0519	17	18274	17001	15952	604.5	0.1735
Iso Propyl		18	17038.4	17027.7	18261	617.5	18	17038	17028	18260	617.5	0.0165	18	17038	17028	18260	617.5	0.0024
Magnuflux SKC-HF		19	17119.0	17684.9	17850	621.3	19	17119	17684	17849	621.3	0.0118	19	17118	17685	17849	621.3	0.0106
P-D 680		20	17387.9	17352.1	16948	609.9	20	17389	17352	16948	609.9	-0.0142	20	17388	17352	16948	609.9	0.0083
Teksol EP		21	17451.9	17544.9	17852	623.6	21	17452	17546	17852	623.6	-0.0024	21	17452	17546	17851	623.6	-0:0012
Tpc solvent		22	17841.7	18106.4	17811	634.4	22	17842	18106	17810	634.4	0.0106	22	17841	18107	17810	634.4	0.0142
DS-108		24	17805.2	17702.1	18845.0	641.4	24	17805.2	17701.5	18844.7	641.4	0.0106	24	17805.0	17701.6	18844.1	641.3	0.0189
Electron NDE		25	17265.6	18110.2	17068.5	618.9	25	17265.7	18110.2	17067.5	618.8	0.0106	25	17265.8	18109.8	17068.2	618.8	0.0059

Total Corrosion

4340 Steel

		Initial Weight of 4340	24 hours of Immersion 4340		168 hours of Immersion of 4340	
Cleaners		Weight (mg)	Weight (mg)		Weight (mg)	
	Conc.	Ave. weight/cm2	Ave. weight/cm2	Ave. Loss (mg/cm2/24hr)	Ave. weight/cm2	Ave. Loss (mg/cm2/168hr)
DS-108		585.3	585.3	0.0012	585.3	0.0106
Electron NDE		592.3	592.3	0.0260	592.2	0.0543
Iso Propyl		622.8	622.8	0.0212	622.8	0.0212
P-D 680		567.1	567.1	0.0142	567.0	0.0661
Citrex		592.4	592.4	0.0024	592.4	0.0024
Desoclean 45		601.9	601.9	0.0165	601.9	0.0177
Magnuflux SKC-HF		553.0	553.0	0.0142	553.0	0.0484
BioAct 113		578.2	578.2	0.0118	578.2	0.0083
Teksol EP		588.8	588.8	0.0189	588.8	0.0496
Axarel 56		597.1	597.1	0.0236	597.1	0.0142
Tpc solvent		577.5	577.4	0.0212	577.4	0.0496
Aerosolve 2000	100%	586.5	586.6	-0.0850	586.3	0.1758
	10%	589.8	589.8	0.0425	589.7	0.0826
Alk-660	100%	590.5	590.5	0.0012	590.5	0.0153
	10%	588.2	588.2	0.0106	588.2	0.0083
Callasolve 120	100%	571.3	571.3	0.0106	571.3	0.0142
	10%	591.0	591.0	0.0012	591.0	0.0118
Parts Prep	100%	594.3	594.2	0.0142	594.2	0.0059
	10%	606.9	606.8	0.0696	606.7	0.2301
ShopMaster	100%	581.1	581.1	-0.0035	581.1	-0.0012
	10%	599.7	599.7	0.0083	599.7	0.0071
Solvall 5234	100%	604.0	604.0	0.0094	604.0	0.0130
	10%	606.1	606.0	0.0649	605.8	0.3056

						Initial Weight of 4340 Steel					24 hours of Immersion of 4340 Steel						168 hours of Immersion of 4340 Steel	
Cleaners	Conc.	Spec. No.				Ave. weight/cm2	Spec. No.				Weight (mg)	Ave. Loss (mg/cm 2/24hr)	Spec. No.				Ave. weight/cm2	Ave. Loss (mg/cm 2/168hr
			A	B	C			A	B	C				A	B	C		
Aerosolve 2000	100%	2	16109.8	16981.1	16610	586.5	2	16112.8	16982.9	16612.5	586.6	-0.0850	2	16103.2	16977.0	16605.9	586.3	0.1758
	10%	3	16048.4	16683.2	17253	589.8	3	16047.4	16682.0	17251.2	589.8	0.0425	3	16046.9	16680.0	17250.3	589.7	0.0826
Alk-660	100%	4	16626.3	17213.9	16201	590.5	4	16626.3	17213.9	16201.1	590.5	0.0012	4	16626.3	17212.6	16201.2	590.5	0.0153
	10%	5	16510.3	16694.1	16646	588.2	5	16510.1	16694.1	16644.9	588.2	0.0106	5	16509.7	16693.5	16646.1	588.2	0.0083
Callasolve 120	100%	6	14877.0	17018.5	16522	571.3	6	14876.6	17018.3	16521.9	571.3	0.0106	6	14876.6	17018.4	16521.5	571.3	0.0142
	10%	7	16721.5	17013.6	16350	591.0	7	16721.9	17013.2	16349.4	591.0	0.0012	7	16721.2	17013.2	16349.2	591.0	0.0118
Parts Prep	100%	8	17134.6	16842.0	16383	594.3	8	17133.8	16841.7	16382.7	594.2	0.0142	8	17134.5	16841.7	16382.7	594.2	0.0059
	10%	9	17078.9	16931.3	17421	606.9	9	17077.1	16929.4	17418.5	606.8	0.0696	9	17074.1	16923.7	17413.6	606.7	0.2301
ShopMaster	100%	10	16676.4	15639.6	16929	581.1	10	16676.4	15639.5	16928.9	581.1	-0.0035	10	16676.4	15639.3	16928.9	581.1	-0.0012
	10%	11	17041.1	16633.6	17144	599.7	11	17040.9	16633.1	17143.7	599.7	0.0083	11	17041.6	16633.8	17142.4	599.7	0.0071
Solvall 5234	100%	12	16934.5	17261.4	16990	604.0	12	16934.1	17260.9	16990.5	604.0	0.0094	12	16934.1	17260.7	16990.4	604.0	0.0130
	10%	13	17708.1	17410.5	16243	606.1	13	17706.6	17408.7	16240.3	606.0	0.0649	13	17701.3	17402.3	16231.6	605.8	0.3056
Axarel 56		14	16447.0	17161.9	16993.9	597.1	14	16446.5	17160.8	16993.5	597.1	0.0236	14	16446.6	17161.2	16993.8	597.1	0.0142
BioAct 113		15	15691.7	16896.3	16411.3	578.2	15	15691.8	16895.9	16410.6	578.2	0.0118	15	15691.9	16896.1	16410.6	578.2	0.0083
Citrex		16	17293.3	16452.9	16455.2	592.4	16	17293.7	16452.6	16454.9	592.4	0.0024	16	17293.3	16452.7	16455.2	592.4	0.0024
Desoclean 45		17	17621.8	16893.4	16491.6	601.9	17	17621.5	16892.8	16491.1	601.9	0.0165	17	17621.3	16892.5	16491.5	601.9	0.0177
Iso Propyl		18	17937.5	16645.6	18198.8	622.8	18	17936.6	16645.2	18198.3	622.8	0.0212	18	17936.5	16645.1	18198.5	622.8	0.0212
Magnuflux SKC-HF		19	16897.0	13458.6	16512.1	553.0	19	16896.6	13458.2	16511.7	553.0	0.0142	19	16895.2	13457.4	16511.0	553.0	0.0484
P-D 680		20	16340.6	15857.6	15857.5	567.1	20	16340.2	15856.9	15857.4	567.1	0.0142	20	16337.8	15855.4	15856.9	567.0	0.0661
Teksol EP		21	17236.4	16676.9	15986.6	588.8	21	17235.4	16676.8	15986.1	588.8	0.0189	21	17232.9	16676.1	15986.7	588.8	0.0496
Tpc solvent		22	14841.4	16865.2	17230.0	577.5	22	14841.0	16864.5	17229.3	577.4	0.0212	22	14839.5	16864.1	17228.8	577.4	0.0496
DS-108		24	16493.0	16787.4	16322.4	585.3	24	16492.5	16787.2	16323.0	585.3	0.0012	24	16492.2	16787.2	16322.5	585.3	0.0106
Electron NDE		25	17166.5	15686.1	17341.5	592.3	25	17165.3	15685.8	17340.8	592.3	0.0260	25	17164.2	15685.1	17340.2	592.2	0.0543

Un-Painted Surfaces

Titanium

	Conc.	Initial Appearance of Titanium	3-5 Minutes of Immersion of Titanium	After Oven (30 min) Cycle And Rinsing	After 30 Min Drying Time
Cleaners					
DS-108	full	normal	no visible change	no visible change	no visible change
Electron NDE	full	normal	no visible change	no visible change	no visible change
Iso Propyl	full	normal	no visible change	no visible change	no visible change
P-D 680	full	normal	no visible change	no visible change	no visible change
Citrex	full	normal	no visible change	no visible change	no visible change
Desoclean 45	full	normal	no visible change	no visible change	no visible change
Magnuflux SKC-HF	full	normal	no visible change	no visible change	no visible change
BioAct 113	full	normal	no visible change	no visible change	no visible change
Teksol EP	full	normal	no visible change	no visible change	no visible change
Axarel 56	full	normal	no visible change	no visible change	no visible change
Tpc solvent	full	normal	no visible change	no visible change	no visible change
Aerosolve 2000	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Alk-660	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Callasolve 120	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Parts Prep	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
ShopMaster	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Solvall 5234	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change

Un-Painted Surfaces

Aluminum

	Conc.	Initial Appearance of Aluminum	3-5 Minutes of Immersion of Aluminum	After Oven (30 min) Cycle And Rinsing	After 30 Min Drying Time
Cleaners					
DS-108	full	normal	no visible change	no visible change	no visible change
Electron NDE	full	normal	no visible change	no visible change	no visible change
Iso Propyl	full	normal	no visible change	no visible change	no visible change
P-D 680	full	normal	no visible change	no visible change	no visible change
Citrex	full	normal	no visible change	no visible change	no visible change
Desoclean 45	full	normal	no visible change	no visible change	no visible change
Magnuflux SKC-HF	full	normal	no visible change	no visible change	no visible change
BioAct 113	full	normal	no visible change	no visible change	no visible change
Teksol EP	full	normal	no visible change	no visible change	no visible change
Axarel 56	full	normal	no visible change	no visible change	no visible change
Tpc solvent	full	normal	no visible change	no visible change	no visible change
Aerosolve 2000	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Alk-660	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Callasolve 120	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Parts Prep	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
ShopMaster	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Solvall 5234	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change

Un-Painted Surfaces

AM-355

	Conc.	Initial Appearance of AM-355	3-5 Minutes of Immersion of AM-355	After Oven (30 min) Cycle And Rinsing	After 30 Min Drying Time
Cleaners					
DS-108	full	normal	no visible change	no visible change	no visible change
Electron NDE	full	normal	no visible change	no visible change	no visible change
Iso Propyl	full	normal	no visible change	no visible change	no visible change
P-D 680	full	normal	no visible change	no visible change	no visible change
Citrex	full	normal	no visible change	no visible change	no visible change
Desoclean 45	full	normal	no visible change	no visible change	no visible change
Magnuflux SKC-HF	full	normal	no visible change	no visible change	no visible change
BioAct 113	full	normal	no visible change	no visible change	no visible change
Teksol EP	full	normal	no visible change	no visible change	no visible change
Axarel 56	full	normal	no visible change	no visible change	no visible change
Tpc solvent	full	normal	no visible change	no visible change	no visible change
Aerosolve 2000	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Alk-660	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Callasolve 120	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Parts Prep	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
ShopMaster	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Solvall 5234	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change

Un-Painted Surfaces

PH 13-8

	Conc.	Initial Appearance of PH 13-8	3-5 Minutes of Immersion of PH 13-8	After Oven (30 min) Cycle And Rinsing	After 30 Min Drying Time
Cleaners					
DS-108	full	normal	no visible change	no visible change	no visible change
Electron NDE	full	normal	no visible change	no visible change	no visible change
Iso Propyl	full	normal	no visible change	no visible change	no visible change
P-D 680	full	normal	no visible change	no visible change	no visible change
Citrex	full	normal	no visible change	no visible change	no visible change
Desoclean 45	full	normal	no visible change	no visible change	no visible change
Magnuflux SKC-HF	full	normal	no visible change	no visible change	no visible change
BioAct 113	full	normal	no visible change	no visible change	no visible change
Teksol EP	full	normal	no visible change	no visible change	no visible change
Axarel 56	full	normal	no visible change	no visible change	no visible change
Tpc solvent	full	normal	no visible change	no visible change	no visible change
Aerosolve 2000	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Alk-660	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Callasolve 120	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Parts Prep	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
ShopMaster	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Solvall 5234	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change

Un-Painted Surfaces

C-250

	Conc.	Initial Appearance of C 250	3-5 Minutes of Immersion of C-250	After Oven (30 min) Cycle And Rinsing	After 30 Min Drying Time
Cleaners					
DS-108	full	normal	no visible change	no visible change	no visible change
Electron NDE	full	normal	no visible change	no visible change	no visible change
Iso Propyl	full	normal	no visible change	no visible change	no visible change
P-D 680	full	normal	no visible change	no visible change	no visible change
Citrex	full	normal	no visible change	no visible change	no visible change
Desoclean 45	full	normal	no visible change	no visible change	no visible change
Magnuflux SKC-HF	full	normal	no visible change	no visible change	no visible change
BioAct 113	full	normal	no visible change	no visible change	no visible change
Teksol EP	full	normal	no visible change	no visible change	no visible change
Axarel 56	full	normal	no visible change	no visible change	no visible change
Tpc solvent	full	normal	no visible change	no visible change	no visible change
Aerosolve 2000	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Alk-660	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Callasolve 120	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Parts Prep	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
ShopMaster	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Solvall 5234	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change

Un-Painted Surfaces

4340 Steel

	Conc.	Initial Appearance of 4340	3-5 Minutes of Immersion of 4340	After Oven (30 min) Cycle And Rinsing	After 30 Min Drying Time
Cleaners					
DS-108	full	normal	no visible change	no visible change	no visible change
Electron NDE	full	normal	no visible change	no visible change	no visible change
Iso Propyl	full	normal	no visible change	no visible change	no visible change
P-D 680	full	normal	no visible change	no visible change	no visible change
Citrex	full	normal	no visible change	no visible change	no visible change
Desoclean 45	full	normal	no visible change	no visible change	no visible change
Magnuflux SKC-HF	full	normal	no visible change	no visible change	no visible change
BioAct 113	full	normal	no visible change	no visible change	no visible change
Teksol EP	full	normal	no visible change	no visible change	no visible change
Axarel 56	full	normal	no visible change	no visible change	no visible change
Tpc solvent	full	normal	no visible change	no visible change	no visible change
Aerosolve 2000	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Alk-660	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Callasolve 120	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Parts Prep	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
ShopMaster	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change
Solvall 5234	100%	normal	no visible change	no visible change	no visible change
	10%	normal	no visible change	no visible change	no visible change

Sandwich Corrosion

A,C,E,G,I,K are tops; B, D, F, H, J, L are bottoms

Titanium						
Cleaners		Number	Panel	Initial Appearance	Corrosion Severity Rating	General Comments
1,1,1 Trichloroethane		1	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
Aqueous						
Aerosolve 2000	Concentrated	2	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
	Dilution (1:10)	3	G	LS	0	unaffected
			H	LS	0	unaffected
			I	LS	0	unaffected
			J	LS	0	unaffected
			K	LS	0	unaffected
			L	LS	0	unaffected
ALK 660	Concentrated	4	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
	Dilution (1:10)	5	G	LS	0	unaffected
			H	LS	0	unaffected
			I	LS	0	unaffected
			J	LS	0	unaffected
			K	LS	0	unaffected
			L	LS	0	unaffected

Callasolve 120	Concentrated	6	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
	Dilution (1:10)	7	G	LS	0	unaffected
			H	LS	0	unaffected
			I	LS	0	unaffected
			J	LS	0	unaffected
			K	LS	0	unaffected
			L	LS	0	unaffected
Parts Prep	Concentrated	8	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
	Dilution (1:10)	9	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
Shop Master	Concentrated	10	A	LS	1	very light staining
			B	LS	1	corrosion is greater on bottom
			C	LS	1	very light staining
			D	LS	1	corrosion is greater on bottom
			E	LS	1	very light staining
			F	LS	1	corrosion is greater on bottom
	Dilution (1:10)	11	A	LS	0	outline of filter paper
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
Solvall 5234	Concentrated	12	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
	Dilution (1:10)	13	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected

Solvents						
AXAREL 56		14	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
BioAct 113		15	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
Citrex		16	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
Desoclean 45		17	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
Iso Propyl		18	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
Spotcheck SKC-HF		19	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected

P-D 680		20	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
Teksol EP		21	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
TPC solvent		22	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
Distilled Water		23	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
DS-108		24	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
Electron NDE		25	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected

Aluminum						
Cleaners		Number	Panel	Initial Appearance	Corrosion Severity Rating	General Comments
111 Trichloroethane		1	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
Aqueous						
Aerosolve 2000	Concentrated	2	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	3	G	G	0	unaffected
			H	G	0	unaffected
			I	G	0	unaffected
			J	G	0	unaffected
			K	G	0	unaffected
			L	G	0	unaffected
ALK 660	Concentrated	4	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	5	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Callasolve 120	Concentrated	6	A	G	2	moderate discoloration
			B	G	1	slight discoloration
			C	G	2	moderate discoloration
			D	G	1	slight discoloration
			E	G	2	moderate discoloration
			F	G	1	slight discoloration
	Dilution (1:10)	7	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	1	slight discoloration

Parts Prep	Concentrated	8	A	G	1	very slight discoloration
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	9	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Shop Master	Concentrated	10	A	G	0	unaffected
			B	G	0	unaffected
			C	G	1	very slight discoloration
			D	G	1	slight discoloration
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	11	A	G	0	unaffected
			B	G	1	discoloration around edges
			C	G	1	discoloration around edges
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Solvall 5234	Concentrated	12	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	13	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected

Solvents						
AXAREL 56		14	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
BioAct 113		15	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Citrex		16	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Desoclean 45		17	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Iso Propyl		18	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Spotcheck SKC-HF		19	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected

P-D 680		20	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Teksol EP		21	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
TPC solvent		22	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Distilled Water		23	A	G	0	unaffected
			B	G	0	unaffected
			A	G	0	unaffected
			B	G	0	unaffected
			A	G	0	unaffected
			B	G	0	unaffected
DS-108		24	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	1	spotty discoloration
			E	G	0	unaffected
			F	G	0	unaffected
Electron NDE		25	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected

AM-355						
Cleaners		Number	Panel	Initial Appearance	Corrosion Severity Rating	General Comments
111 Trichloroethane		1	A			unaffected
			B			unaffected
			C			unaffected
			D			unaffected
			E			unaffected
			F			unaffected
Aqueous						
Aerosolve 2000	Concentrated	2	A	G	1	slight discoloration
			B	G	1	spotty discoloration
			C	G	0	outline of filter paper
			D	G	1	slight discoloration
			E	G	0	unaffected
			F	G	1	slight discoloration
	Dilution (1:10)	3	G	G	0	unaffected
			H	G	0	outline of filter paper
			I	G	0	outline of filter paper
			J	G	0	outline of filter paper
			K	G	0	outline of filter paper
			L	G	0	outline of filter paper
ALK 660	Concentrated	4	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	5	G	G	0	unaffected
			H	G	0	unaffected
			I	G	0	unaffected
			J	G	0	unaffected
			K	G	0	unaffected
			L	G	0	unaffected
Callasolve 120	Concentrated	6	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	7	G	G	0	unaffected
			H	G	0	unaffected
			I	G	0	unaffected
			J	G	0	unaffected
			K	G	0	unaffected
			L	G	0	unaffected

Parts Prep	Concentrated	8	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	9	A	G	0	outline of filter paper
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	outline of filter paper
			E	G	0	outline of filter paper
			F	G	0	unaffected
Shop Master	Concentrated	10	A	G	0	outline of filter paper
			B	G	0	outline of filter paper
			C	G	1	slight discoloration
			D	G	0	outline of filter paper
			E	G	0	unaffected
			F	G	1	slight discoloration
	Dilution (1:10)	11	A	G	0	outline of filter paper
			B	G	0	outline of filter paper
			C	G	0	outline of filter paper
			D	G	0	outline of filter paper
			E	G	0	outline of filter paper
			F	G	0	outline of filter paper
Solvall 5234	Concentrated	12	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	13	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	outline of filter paper
			E	G	0	unaffected
			F	G	0	unaffected

Solvents						
AXAREL 56		14	A	G	0	
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
BioAct 113		15	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Citrex		16	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	1	spots of discoloration
			F	G	0	unaffected
Desoclean 45		17	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Iso Propyl		18	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Spotcheck SKC-HF		19	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected

P-D 680		20	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Teksol EP		21	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
TPC solvent		22	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Distilled Water		23	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
DS-108		24	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Electron NDE		25	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected

PH 13-8						
Cleaners		Number	Panel	Initial Appearance	Corrosion Severity Rating	General Comments
111 Trichloroethane		1	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Aqueous						
Aerosolve 2000	Concentrated	2	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	3	G	G	0	unaffected
			H	G	0	unaffected
			I	G	0	unaffected
			J	G	0	unaffected
			K	G	0	unaffected
			L	G	0	unaffected
ALK 660	Concentrated	4	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	5	G	G	0	unaffected
			H	G	0	unaffected
			I	G	0	unaffected
			J	G	0	unaffected
			K	G	0	unaffected
			L	G	0	unaffected
Callasolve 120	Concentrated	6	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	7	G	G	0	unaffected
			H	G	0	unaffected
			I	G	0	unaffected
			J	G	0	unaffected
			K	G	0	unaffected
			L	G	0	unaffected

Parts Prep	Concentrated	8	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	9	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Shop Master	Concentrated	10	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	11	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Solvall 5234	Concentrated	12	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	13	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected

Solvents						
AXAREL 56		14	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
BioAct 113		15	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Citrex		16	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Desoclean 45		17	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Iso Propyl		18	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Spotcheck SKC-HF		19	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected

P-D 680		20	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Teksol EP		21	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
TPC solvent		22	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Distilled Water		23	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
DS-108		24	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Electron NDE		25	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected

C-250						
Cleaners		Number	Panel	Initial Appearance	Corrosion Severity Rating	General Comments
111 Trichloroethane		1	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Aqueous						
Aerosolve 2000	Concentrated	2	A	G	1	slight discoloration
			B	G	1	slight discoloration
			C	G	1	slight discoloration
			D	G	1	slight discoloration
			E	G	1	slight discoloration
			F	G	1	slight discoloration
	Dilution (1:10)	3	G	G	0	unaffected
			H	G	0	unaffected
			I	G	0	unaffected
			J	G	0	unaffected
			K	G	0	unaffected
			L	G	0	unaffected
ALK 660	Concentrated	4	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	5	G	G	0	unaffected
			H	G	0	unaffected
			I	G	0	unaffected
			J	G	0	unaffected
			K	G	0	unaffected
			L	G	0	unaffected
Callasolve 120	Concentrated	6	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	7	G	G	0	unaffected
			H	G	0	unaffected
			I	G	0	unaffected
			J	G	0	unaffected
			K	G	0	unaffected
			L	G	0	unaffected

Parts Prep	Concentrated	8	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	9	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Shop Master	Concentrated	10	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	11	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Solvall 5234	Concentrated	12	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
	Dilution (1:10)	13	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected

Solvents						
AXAREL 56		14	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
BioAct 113		15	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Citrex		16	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Desoclean 45		17	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Iso Propyl		18	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Spotcheck SKC-HF		19	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected

P-D 680		20	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Teksol EP		21	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
TPC solvent		22	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Distilled Water		23	A	G	2	moderate corrosion
			B	G	2	moderate corrosion
			C	G	1	slight corrosion
			D	G	1	slight corrosion
			E	G	2	moderate corrosion
			F	G	2	moderate corrosion
DS-108		24	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected
Electron NDE		25	A	G	0	unaffected
			B	G	0	unaffected
			C	G	0	unaffected
			D	G	0	unaffected
			E	G	0	unaffected
			F	G	0	unaffected

4340						
Cleaners		Number	Panel	Initial Appearance	Corrosion Severity Rating	General Comments
111 Trichloroethane		1	A	LS	3	moderate corrosion, light pitting
			B	LS	3	moderate corrosion, light pitting
			C	LS	3	moderate corrosion, light pitting
			D	LS	3	moderate corrosion, light pitting
			E	LS	3	moderate corrosion, light pitting
			F	LS	3	moderate corrosion, light pitting
Aqueous						
Aerosolve 2000	Concentrated	2	A	LS	2	slight corrosion, light pitting
			B	LS	2	slight corrosion, light pitting
			C	LS	2	slight corrosion, light pitting
			D	LS	2	slight corrosion, light pitting
			E	LS	2	slight corrosion, light pitting
			F	LS	2	slight corrosion, light pitting
	Dilution (1:10)	3	G	LS	3	moderate corrosion, light pitting
			H	LS	3	moderate corrosion, light pitting
			I	LS	3	moderate corrosion, light pitting
			J	LS	3	moderate corrosion, light pitting
			K	LS	3	moderate corrosion, light pitting
			L	LS	3	moderate corrosion, light pitting
ALK 660	Concentrated	4	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
	Dilution (1:10)	5	G	LS	2	slight corrosion, light pitting
			H	LS	2	slight corrosion, light pitting
			I	LS	2	slight corrosion, light pitting
			J	LS	2	slight corrosion, light pitting
			K	LS	2	slight corrosion, light pitting
			L	LS	2	slight corrosion, light pitting
Callasolve 120	Concentrated	6	A	LS	1-2	slight corrosion, light pitting
			B	LS	1-2	slight corrosion, light pitting
			C	LS	1-2	slight corrosion, light pitting
			D	LS	1-2	slight corrosion, light pitting
			E	LS	1-2	slight corrosion, light pitting
			F	LS	1-2	slight corrosion, light pitting
	Dilution (1:10)	7	G	LS	1-2	slight corrosion, light pitting
			H	LS	1-2	slight corrosion, light pitting
			I	LS	1-2	slight corrosion, light pitting
			J	LS	1-2	slight corrosion, light pitting
			K	LS	1-2	slight corrosion, light pitting
			L	LS	1-2	slight corrosion, light pitting

Parts Prep	Concentrated	8	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
	Dilution (1:10)	9	A	LS	1-2	slight corrosion, light pitting
			B	LS	1-2	slight corrosion, light pitting
			C	LS	1-2	slight corrosion, light pitting
			D	LS	1-2	slight corrosion, light pitting
			E	LS	1-2	slight corrosion, light pitting
			F	LS	1-2	slight corrosion, light pitting
Shop Master	Concentrated	10	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
	Dilution (1:10)	11	A	LS	2	slight corrosion,light pitting
			B	LS	2	slight corrosion,light pitting
			C	LS	2	slight corrosion,light pitting
			D	LS	2	slight corrosion,light pitting
			E	LS	1	corrosion outline
			F	LS	1	corrosion outline
Solvall 5234	Concentrated	12	A	LS	1-2	slight corrosion,light pitting
			B	LS	1-2	slight corrosion,light pitting
			C	LS	1-2	slight corrosion,light pitting
			D	LS	1-2	slight corrosion,light pitting
			E	LS	1-2	slight corrosion,light pitting
			F	LS	1-2	slight corrosion,light pitting
	Dilution (1:10)	13	A	LS	2	slight corrosion,light pitting
			B	LS	2	slight corrosion,light pitting
			C	LS	2	slight corrosion,light pitting
			D	LS	2	slight corrosion,light pitting
			E	LS	2	slight corrosion,light pitting
			F	LS	2	slight corrosion,light pitting

Solvents						
AXAREL 56		14	A	LS	1-2	slight corrosion,light pitting
			B	LS	1-2	slight corrosion,light pitting
			C	LS	1-2	slight corrosion,light pitting
			D	LS	1-2	slight corrosion,light pitting
			E	LS	1-2	slight corrosion,light pitting
			F	LS	1-2	slight corrosion,light pitting
BioAct 113		15	A	LS	2	slight corrosion, light pitting
			B	LS	2	slight corrosion, light pitting
			C	LS	2	slight corrosion,light pitting
			D	LS	2	slight corrosion,light pitting
			E	LS	2	slight corrosion, light pitting
			F	LS	2	slight corrosion, light pitting
Citrex		16	A	LS	0	unaffected
			B	LS	0	unaffected
			C	LS	0	unaffected
			D	LS	0	unaffected
			E	LS	0	unaffected
			F	LS	0	unaffected
Desoclean 45		17	A	LS	2	mild corrosion, light pitting
			B	LS	2	mild corrosion, light pitting
			C	LS	2	mild corrosion, light pitting
			D	LS	2	mild corrosion, light pitting
			E	LS	2	mild corrosion, light pitting
			F	LS	2	mild corrosion, light pitting
Iso Propyl		18	A	LS	2-3	slight corrosion,light pitting
			B	LS	2-3	slight corrosion,light pitting
			C	LS	2-3	slight corrosion,light pitting
			D	LS	2-3	slight corrosion,light pitting
			E	LS	2-3	slight corrosion,light pitting
			F	LS	2-3	slight corrosion,light pitting
Spotcheck SKC-HF		19	A	LS	2	mild corrosion, light pitting
			B	LS	2	mild corrosion, light pitting
			C	LS	2	mild corrosion, light pitting
			D	LS	2	mild corrosion, light pitting
			E	LS	2	mild corrosion, light pitting
			F	LS	2	mild corrosion, light pitting

P-D 680		20	A	LS	2	mild corrosion, light pitting
			B	LS	2	mild corrosion, light pitting
			C	LS	2	mild corrosion, light pitting
			D	LS	2	mild corrosion, light pitting
			E	LS	2	mild corrosion, light pitting
			F	LS	2	mild corrosion, light pitting
Teksol EP		21	A	LS	2	mild corrosion, light pitting
			B	LS	2	mild corrosion, light pitting
			C	LS	2	mild corrosion, light pitting
			D	LS	2	mild corrosion, light pitting
			E	LS	2	mild corrosion, light pitting
			F	LS	2	mild corrosion, light pitting
TPC solvent		22	A	LS	2	mild corrosion, light pitting
			B	LS	2	mild corrosion, light pitting
			C	LS	2	mild corrosion, light pitting
			D	LS	2	mild corrosion, light pitting
			E	LS	2	mild corrosion, light pitting
			F	LS	2	mild corrosion, light pitting
Distilled Water		23	A	LS	3	mild corrosion
			B	LS	3	mild corrosion
			C	LS	3	mild corrosion
			D	LS	3	mild corrosion
			E	LS	3	mild corrosion
			F	LS	3	mild corrosion
DS-108		24	A	LS	2	mild corrosion, light pitting
			B	LS	2	mild corrosion, light pitting
			C	LS	2	mild corrosion, light pitting
			D	LS	2	mild corrosion, light pitting
			E	LS	2	mild corrosion, light pitting
			F	LS	2	mild corrosion, light pitting
Electron NDE		25	A	LS	2	mild corrosion, light pitting
			B	LS	2	mild corrosion, light pitting
			C	LS	2	mild corrosion, light pitting
			D	LS	2	mild corrosion, light pitting
			E	LS	2	mild corrosion, light pitting
			F	LS	2	mild corrosion, light pitting

Stress Corrosion

Titanium

Susceptibility to stress corrosion cracking				
Agent	Sample Number	Time	Temp. (F)	Optical and Metallurgical Examination
3% NaCl Solution	1	8 hrs.	900	visible cracking
	2	8 hrs.	900	visible cracking
Time - 8 hrs.	3	8 hrs.	900	visible cracking
Temp. - 900F for all cleaners	4	8 hrs.	900	visible cracking
	5	8 hrs.	900	visible cracking
Control Specimens	1	8 hrs.	900	unaffected
	2	8 hrs.	900	unaffected
	3	8 hrs.	900	unaffected
Cleaners		Number	Sample	
111 Trichloroethane		1	A	unaffected
			B	unaffected
			C	unaffected
Aqueous		Number	Sample	
Aerosolve 2000	Concentrated	2	A	unaffected
			B	unaffected
			C	unaffected
ALK 660	Concentrated	4	A	unaffected
			B	unaffected
			C	unaffected
Callasolve 120	Concentrated	6	A	unaffected
			B	unaffected
			C	unaffected
Parts Prep	Concentrated	8	A	unaffected
			B	unaffected
			C	unaffected
Shop Master	Concentrated	10	A	unaffected
			B	unaffected
			C	unaffected
Solvall 5234	Concentrated	12	A	unaffected
			B	unaffected
			C	unaffected
Solvents				
AXAREL 56		14	A	unaffected
			B	unaffected
			C	unaffected
BioAct 113		15	A	unaffected
			B	unaffected
			C	unaffected
Citrex		16	A	unaffected
			B	unaffected
			C	unaffected
Desoclean 45		17	A	unaffected
			B	unaffected
			C	unaffected
Iso Propyl		18	A	unaffected
			B	unaffected
			C	unaffected
Spotcheck SKC-HF		19	A	unaffected
			B	unaffected
			C	unaffected
P-D 680		20	A	unaffected
			B	unaffected
			C	unaffected
Teksol EP		21	A	unaffected
			B	unaffected
			C	unaffected
TPC solvent		22	A	unaffected
			B	unaffected
			C	unaffected
Distilled Water		23	A	unaffected
			B	unaffected
			C	unaffected
DS-108		24	A	unaffected
			B	unaffected
			C	unaffected
Electron NDE		25	A	unaffected
			B	unaffected
			C	unaffected

Aluminum				
Susceptibility to stress corrosion cracking				
Agent	Sample Number	Time	Temp. (F)	Optical and Metallurgical Examination
3% NaCl Solution	1	104 hrs.	350	visible cracking
	2	104 hrs.	350	visible cracking
	3	104 hrs.	350	visible cracking
	4	104 hrs.	350	visible cracking
	5	104 hrs.	350	visible cracking
Control Specimens	1	104 hrs.	350	unaffected
	2	104 hrs.	350	unaffected
	3	104 hrs.	350	unaffected
Cleaners			Sample	
111 Trichloroethane			A	unaffected
			B	unaffected
			C	unaffected
Aqueous				
Aerosolve 2000	Concentrated	2	A	unaffected
			B	unaffected
			C	unaffected
ALK 660	Concentrated	4	A	unaffected
			B	unaffected
			C	unaffected
Callasolve 120	Concentrated	6	A	unaffected
			B	unaffected
			C	unaffected
Parts Prep	Concentrated	8	A	unaffected
			B	unaffected
			C	unaffected
Shop Master	Concentrated	10	A	unaffected
			B	unaffected
			C	unaffected
Solvall 5234	Concentrated	12	A	unaffected
			B	unaffected
			C	unaffected
Solvents				
AXAREL 56		14	A	unaffected
			B	unaffected
			C	unaffected
BioAct 113		15	A	unaffected
			B	unaffected
			C	unaffected
Citrex		16	A	unaffected
			B	unaffected
			C	unaffected
Desoclean 45		17	A	unaffected
			B	unaffected
			C	unaffected
Iso Propyl		18	A	unaffected
			B	unaffected
			C	unaffected
Spotcheck SKC-HF		19	A	unaffected
			B	unaffected
			C	unaffected
P-D 680		20	A	unaffected
			B	unaffected
			C	unaffected
Teksol EP		21	A	unaffected
			B	unaffected
			C	unaffected
TPC solvent		22	A	unaffected
			B	unaffected
			C	unaffected
Distilled Water		23	A	unaffected
			B	unaffected
			C	unaffected
DS-108		24	A	unaffected
			B	unaffected
			C	unaffected
Electron NDE		25	A	unaffected
			B	unaffected
			C	unaffected

AM-355				
Susceptibility to stress corrosion cracking				
Agent	Sample Number	Time	Temp. (F)	Optical and Metallurgical Examination
3% NaCl Solution	1	92 hrs.	825	unaffected
	2	92 hrs.	825	unaffected
	3	92 hrs.	825	unaffected
	4	92 hrs.	825	unaffected
	5	92 hrs.	825	unaffected
	6	92 hrs.	825	unaffected
Control Specimens	1	92 hrs.	825	unaffected
	2	92 hrs.	825	unaffected
	3	92 hrs.	825	unaffected
Cleaners			Sample	
111 Trichloroethane			A	unaffected
			B	unaffected
			C	unaffected
Aqueous				
Aerosolve 2000	Concentrated	2	A	unaffected
			B	unaffected
			C	unaffected
ALK 660	Concentrated	4	A	unaffected
			B	unaffected
			C	unaffected
Callasolve 120	Concentrated	6	A	unaffected
			B	unaffected
			C	unaffected
Parts Prep	Concentrated	8	A	unaffected
			B	unaffected
			C	unaffected
Shop Master	Concentrated	10	A	unaffected
			B	unaffected
			C	unaffected
Solvall 5234	Concentrated	12	A	unaffected
			B	unaffected
			C	unaffected
Solvents				
AXAREL 56		14	A	unaffected
			B	unaffected
			C	unaffected
BioAct 113		15	A	unaffected
			B	unaffected
			C	unaffected
Citrex		16	A	unaffected
			B	unaffected
			C	unaffected
Desoclean 45		17	A	unaffected
			B	unaffected
			C	unaffected
Iso Propyl		18	A	unaffected
			B	unaffected
			C	unaffected
Spotcheck SKC-HF		19	A	unaffected
			B	unaffected
			C	unaffected
P-D 680		20	A	unaffected
			B	unaffected
			C	unaffected
Teksol EP		21	A	unaffected
			B	unaffected
			C	unaffected
TPC solvent		22	A	unaffected
			B	unaffected
			C	unaffected
Distilled Water		23	A	unaffected
			B	unaffected
			C	unaffected
DS-108		24	A	unaffected
			B	unaffected
			C	unaffected
Electron NDE		25	A	unaffected
			B	unaffected
			C	unaffected

PH 13-8

Susceptibility to stress corrosion cracking

Agent	Sample Number	Time	Temp. (F)	Optical and Metallurgical Examination
3% NaCl Solution	1	120 hrs.	825	visible cracking
	2	120 hrs.	825	visible cracking
	3	120 hrs.	825	visible cracking
	4	120 hrs.	825	visible cracking
	5	120 hrs.	825	visible cracking
	6	120 hrs.	825	visible cracking
Control Specimens	1	120 hrs.	825	unaffected
	2	120 hrs.	825	unaffected
	3	120 hrs.	825	unaffected
Cleaners			Sample	
111 Trichloroethane			A	unaffected
			B	unaffected
			C	unaffected
Aqueous				
Aerosolve 2000	Concentrated	2	A	unaffected
			B	unaffected
			C	unaffected
ALK 660	Concentrated	4	A	unaffected
			B	unaffected
			C	unaffected
Callasolve 120	Concentrated	6	A	unaffected
			B	unaffected
			C	unaffected
Parts Prep	Concentrated	8	A	unaffected
			B	unaffected
			C	unaffected
Shop Master	Concentrated	10	A	unaffected
			B	unaffected
			C	unaffected
Solvall 5234	Concentrated	12	A	unaffected
			B	unaffected
			C	unaffected
Solvents				
AXAREL 56		14	A	unaffected
			B	unaffected
			C	unaffected
BioAct 113		15	A	unaffected
			B	unaffected
			C	unaffected
Citrex		16	A	unaffected
			B	unaffected
			C	unaffected
Desoclean 45		17	A	unaffected
			B	unaffected
			C	unaffected
Iso Propyl		18	A	unaffected
			B	unaffected
			C	unaffected
Spotcheck SKC-HF		19	A	unaffected
			B	unaffected
			C	unaffected
P-D 680		20	A	unaffected
			B	unaffected
			C	unaffected
Teksol EP		21	A	unaffected
			B	unaffected
			C	unaffected
TPC solvent		22	A	unaffected
			B	unaffected
			C	unaffected
Distilled Water		23	A	unaffected
			B	unaffected
			C	unaffected
DS-108		24	A	unaffected
			B	unaffected
			C	unaffected
Electron NDE		25	A	unaffected
			B	unaffected
			C	unaffected

C-250				
Susceptibility to stress corrosion cracking				
Agent	Sample Number	Time	Temp. (F)	Optical and Metallurgical Examination
3% NaCl Solution	1	168 hrs.	750	visible cracking
	2	168 hrs.	750	visible cracking
	3	168 hrs.	750	visible cracking
	4	168 hrs.	750	visible cracking
	5	168 hrs.	750	visible cracking
	6	168 hrs.	750	visible cracking
Control Specimens	1	168 hrs.	750	unaffected
	2	168 hrs.	750	unaffected
	3	168 hrs.	750	unaffected
Cleaners			Sample	
111 Trichloroethane			A	unaffected
			B	unaffected
			C	unaffected
Aqueous				
Aerosolve 2000	Concentrated	2	A	unaffected
			B	unaffected
			C	unaffected
ALK 660	Concentrated	4	A	unaffected
			B	unaffected
			C	unaffected
Callasolve 120	Concentrated	6	A	unaffected
			B	unaffected
			C	unaffected
Parts Prep	Concentrated	8	A	unaffected
			B	unaffected
			C	unaffected
Shop Master	Concentrated	10	A	unaffected
			B	unaffected
			C	unaffected
Solvall 5234	Concentrated	12	A	unaffected
			B	unaffected
			C	unaffected
Solvents				
AXAREL 56		14	A	unaffected
			B	unaffected
			C	unaffected
BioAct 113		15	A	unaffected
			B	unaffected
			C	unaffected
Citrex		16	A	unaffected
			B	unaffected
			C	unaffected
Desoclean 45		17	A	unaffected
			B	unaffected
			C	unaffected
Iso Propyl		18	A	unaffected
			B	unaffected
			C	unaffected
Spotcheck SKC-HF		19	A	unaffected
			B	unaffected
			C	unaffected
P-D 680		20	A	unaffected
			B	unaffected
			C	unaffected
Teksol EP		21	A	unaffected
			B	unaffected
			C	unaffected
TPC solvent		22	A	unaffected
			B	unaffected
			C	unaffected
Distilled Water		23	A	unaffected
			B	unaffected
			C	unaffected
DS-108		24	A	unaffected
			B	unaffected
			C	unaffected
Electron NDE		25	A	unaffected
			B	unaffected
			C	unaffected

4340				
Susceptibility to stress corrosion cracking				
Agent	Sample Number	Time	Temp. (F)	Optical and Metallurgical Examination
3% NaCl Solution	1	168 hrs.	825	unaffected
	2	168 hrs.	825	unaffected
	3	168 hrs.	825	unaffected
	4	168 hrs.	825	unaffected
	5	168 hrs.	825	unaffected
	6	168 hrs.	825	unaffected
Control Specimens	1	168 hrs.	825	unaffected
	2	168 hrs.	825	unaffected
	3	168 hrs.	825	unaffected
Cleaners			Sample	
111 Trichloroethane			A	unaffected
			B	unaffected
			C	unaffected
Aqueous				
Aerosolve 2000	Concentrated	2	A	unaffected
			B	unaffected
			C	unaffected
ALK 660	Concentrated	4	A	unaffected
			B	unaffected
			C	unaffected
Callasolve 120	Concentrated	6	A	unaffected
			B	unaffected
			C	unaffected
Parts Prep	Concentrated	8	A	unaffected
			B	unaffected
			C	unaffected
Shop Master	Concentrated	10	A	unaffected
			B	unaffected
			C	unaffected
Solvall 5234	Concentrated	12	A	unaffected
			B	unaffected
			C	unaffected
Solvents				
AXAREL 56		14	A	unaffected
			B	unaffected
			C	unaffected
BioAct 113		15	A	unaffected
			B	unaffected
			C	unaffected
Citrex		16	A	unaffected
			B	unaffected
			C	unaffected
Desoclean 45		17	A	unaffected
			B	unaffected
			C	unaffected
Iso Propyl		18	A	unaffected
			B	unaffected
			C	unaffected
Spotcheck SKC-HF		19	A	unaffected
			B	unaffected
			C	unaffected
P-D 680		20	A	unaffected
			B	unaffected
			C	unaffected
Teksol EP		21	A	unaffected
			B	unaffected
			C	unaffected
TPC solvent		22	A	unaffected
			B	unaffected
			C	unaffected
Distilled Water		23	A	unaffected
			B	unaffected
			C	unaffected
DS-108		24	A	unaffected
			B	unaffected
			C	unaffected
Electron NDE		25	A	unaffected
			B	unaffected
			C	unaffected

Hydrogen Embrittlement

4340 Steel

Determination of Notch Bend Strength

Sample Number	Initial Diameter (in.)	Diameter at Fracture (in.)	Change in Diameter (in.)	
1	1.973	1.855	0.118	
2	1.967	1.851	0.116	
3	1.972	1.862	0.110	
4	1.970	1.863	0.107	
5	1.973	1.863	0.110	
6	1.971	1.846	[redacted]	Bad data operator error
7	1.971	1.855	0.116	
8	1.969	1.851	0.118	
9	1.968	1.853	0.115	
10	1.968	1.861	0.107	
11	1.970	1.866	0.104	
12	1.972	1.868	0.104	

Average Change	65% of Average	75% of Average
0.113 in.	0.073 in.	0.085 in.

Establishment of Sensitivity

Bright Cadmium Plating

Sample Number	Initial Diameter (in.)	Diameter at 75% (in.)	Time to Fracture
1	1.971	1.886	2 min. 0 sec.
2	1.971	1.886	3 min. 32 sec.
3	1.970	1.885	4 min. 35 sec.

Dull Cadmium Plating

Sample Number	Initial Diameter (in.)	Diameter at 75% (in.)	Total Test Time	Comments
1	1.969	1.884	168 hrs.	no fracture
2	1.971	1.886	168 hrs.	no fracture
3	1.970	1.885	168 hrs.	no fracture

Cleaners				
Tests discontinued after 150 hours				
NA indicates that no fracture occurred				
Name		Number	Sample	Comments
111 Trichloroethane		1	A	unaffected
			B	unaffected
			C	unaffected
Aqueous				
Aerosolve 2000	Concentrated	2	A	cracking within .5 hrs.
			B	cracking within .5 hrs.
			C	cracking within .5 hrs.
	Dilution (1:10)	3	A	cracking within 8-24 hrs.
			B	cracking within 8-24 hrs.
			C	cracking within 48-150 hrs.
ALK 660	Concentrated	4	A	unaffected
			B	cracking within 24 hrs.
			C	cracking within 32-48 hrs.
			D	cracking within 8-24 hrs.
	Dilution (1:10)	5	A	cracking within 8-24 hrs.
			B	unaffected
			C	cracking within 8-24 hrs.
Callasolve 120	Concentrated	6	A	cracking within 120-150 hrs.
			B	cracking within 120-150 hrs.
			C	cracking within 120-150 hrs.
	Dilution (1:10)	7	A	unaffected
			B	cracking within 32-48 hrs.
			C	cracking within 8-24 hrs.
Parts Prep	Concentrated	8	A	unaffected
			B	unaffected
			C	unaffected
	Dilution (1:10)	9	A	cracking within 8-24 hrs.
			B	cracking within 48-150 hrs.
			C	cracking within 8-24 hrs.
Shop Master	Concentrated	10	A	cracking within 150 hrs.
			B	cracking within 150 hrs.
			C	unaffected
	Dilution (1:10)	11	A	unaffected
			B	unaffected
			C	cracking within 8-24 hrs.
Solvall 5234	Concentrated	12	A	unaffected
			B	unaffected
			C	unaffected
	Dilution (1:10)	13	A	cracking within 24 hrs.
			B	cracking within 48-150 hrs.
			C	cracking within 24 hrs.

Solvents				
AXAREL 56		14	A	unaffected
			B	unaffected
			C	cracking within 150 hrs.
			D	unaffected
BioAct 113		15	A	unaffected
			B	unaffected
			C	unaffected
Citrex		16	A	unaffected
			B	unaffected
			C	unaffected
Desoclean 45		17	A	unaffected
			B	unaffected
			C	unaffected
Iso Propyl		18	A	unaffected
			B	unaffected
			C	unaffected
Spotcheck SKC-HF		19	A	unaffected
			B	unaffected
			C	unaffected
P-D 680		20	A	unaffected
			B	unaffected
			C	unaffected
Teksol EP		21	A	unaffected
			B	unaffected
			C	unaffected
TPC solvent		22	A	unaffected
			B	unaffected
			C	unaffected
Distilled Water		23	A	unaffected
			B	unaffected
			C	unaffected
DS-108		24	A	unaffected
			B	unaffected
			C	unaffected
Electron NDE		25	A	unaffected
			B	unaffected
			C	cracked within 72 hrs.
			D	unaffected

Discussion of Materials Compatibility Results:

The following is a discussion of the materials compatibility results. They are presented by test method as opposed to materials for convenience:

Total Immersion Corrosion

Specification Mil-C-87937 B states the following requirements for immersion corrosion when tested in accordance with ASTM-F-493:

Material	Average Weight Loss Maximum (mg/cm^2/168 hrs)
Aluminum 7075-T6	0.49
Titanium 6Al-4V	0.35
Steel 1020	1.40

It does not specifically identify requirements for AM-355, PH 13-8, C-250, or 4340 steel. However, one can extrapolate that these values would be less than that for the low grade carbon steel, 1020, for which a requirement is given.

The results indicate that the alternative cleaners tested all easily pass the requirement after 24 and 168 hours for Titanium 6Al-4V (ranged from 0.0 to 0.0353), Aluminum 7075-T6 (ranged from 0.0 to 0.1017), AM-355 (ranged from -0.0233 to 0.0465), PH 13-8 (ranged from-0.0035 to 0.0461), C-250 (ranged from -0.0035 to 0.2466), and 4340 (ranged from -0.0012 to 0.3056). These values were all well within acceptable limits. Additionally, all cleaners tested did not cause excessive pitting, localized attack, staining, etching, or even mild discoloration.

Un-Painted Surfaces

Specification Mil-C-87937 states that a 10% solution of the cleaning compound in distilled water shall not cause streaking, stains, or other deposits that can not be easily removed with water when tested in accordance with ASTM-F-485. The alternatives were tested in both the concentrated and diluted (10%) solution to be thorough. All of the cleaners tested passed this requirement easily. None of the cleaners stained , streaked, or contained other deposits that could not be removed easily with water. All test panels subjected to both the concentrated and 10% diluted solution of test cleaner appeared completely normal during all phases of the testing procedure.

Sandwich Corrosion

Specification Mil-C-87937 states that when any cleaner is tested in accordance with ASTM-F-1110 no cleaner shall have a corrosion rating greater than “2” on any given test panel. It must be understood that the test panels indicated by ASTM-F-1110 were Aluminum 2024 and 7075 only.

This program expounded on the specification requirements by testing panels of all six materials. None of the test panels had a corrosion rating greater than 2 for the aluminum material. Therefore, the specification requirements were easily passed. The aluminum test panels were most affected by the concentrated Callosolve and both the concentrated and diluted Shopmaster products with moderate and slight discoloration, respectively. Neither product had significantly corroded the aluminum test panels. Corrosion ratings never exceed "2" as outlined by ASTM-F-1110.

The titanium 6Al-4V test panels were unaffected by all test cleaners except the concentrated Shopmaster product. None of the corrosion ratings given were greater than "1" as outlined by ASTM-F-1110. Shopmaster left slight staining and/or corrosion on some tests panels. The degree of the staining/corrosion was very small and the product seems to be viable for sandwich corrosion resistance on titanium 6Al-4V.

The AM-355 test panels were unaffected by all cleaners except for those exposed to Aerosolve 2000, diluted Parts Prep, and Shopmaster products. The extent of the corrosive attack did not exceed discoloration and no ratings higher than "1" were assessed according to ASTM-F-1110 guidelines. All alternative cleaners appear be compatible form a sandwich corrosion standpoint with AM-355.

The PH 13-8 appeared to be unaffected by all test cleaners. No corrosive attack or even discoloration was present.

The C-250 test panels were only affected by the concentrated Aerosolve 2000 and distilled water. Aerosolve 2000 caused a slight discoloration of the surface. A rating of "1" was given to these panels according to ASTM-F-1110. Distilled water caused both slight corrosion and slight discoloration of the surfaces of the test panels. A rating of "1" and "2" were given to the panels exposed to distilled water. Aerosolve 2000 does not appear to have a significant impact on C-250 steel from the sandwich corrosion testing performed.

The 4340 test panels were mildly affected by all test cleaners except the concentrated forms of Alk-660, Parts Prep, Shopmaster, and Citrex products. Since 4340 is a relatively active alloy, this was expected. However, even in this instance all ratings were less than or equal to "2" as outlined in ASTM-F-1110 except for those panels exposed to 1,1,1 trichloroethane, isopropyl alcohol, and distilled water. All of these panels approached or were given ratings equal to "3", signifying moderate corrosion or extensive discoloration.

Stress Corrosion

The stress corrosion specifications utilized provided general guidelines for the procedures and qualifications of alternative cleaners for use on limited materials. These guidelines were expounded to carry out stress corrosion testing on the variety of materials investigated under this program. The qualification conditions defined by the specifications utilized may be summarized by stating that if the material tested and subjected to a stress corrosive environment does indeed contain stress corrosion cracks as a result of this treatment, the material may be utilized for testing alternative cleaners. If a similar treatment were performed by utilizing the alternative cleaner instead of sodium chloride (a known contributor to stress corrosion cracking in most materials) and no stress corrosion cracks were found by optical and metallurgical examination of the material then it can be extrapolated from the data that the tested alternative does not readily contribute to stress corrosion cracking. The control specimens were not subjected to any stress corrosive treatment and were therefore not expected to embody stress corrosion cracks.

The results of the stress corrosion testing performed demonstrate that none of the alternative cleaners tested contributed to stress corrosion cracking of the materials investigated under these testing conditions. The AM-355 material failed to stress corrosion crack under various treatments. The results of the testing performed on AM-355 can, therefore, only be interpreted such that the alternative cleaners did not contribute to stress corrosion cracking the material under the treatment administered. It cannot be stated that the alternative cleaners will not contribute to stress corrosion cracking the material(s) in all instances. However, from the results it appears unlikely that the alternative cleaners contribute significantly to stress corrosion cracking of the materials studied under this program.

Hydrogen Embrittlement

Specification Mil-C-87937 states that when tested in accordance with ASTM-F-519 a concentrated solution of the tested alternative cleaner shall not cause hydrogen embrittlement of cadmium plated steel. ARL-MD tested both concentrated and 10% solutions of each alternative cleaner. The results indicate that dilutions of the aqueous cleaners may cause hydrogen embrittlement if the solutions remain in contact with cadmium plated steel for extended lengths of time. Concentrated solutions of Solvall 5234 and Parts Prep appear not to cause hydrogen embrittlement even over extended periods of time. None of the solvents caused hydrogen embrittlement of the cadmium plated steel, as expected. When dealing with cadmium plated steel, it appears that if any of the aqueous cleaners tested are utilized in dilution for cleaning they must be rinsed thoroughly to prevent hydrogen embrittlement.

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Section 5:

Alternative Cleaner Effects on Adhesive Bonding: ARDEC Report - "1,1,1 Trichloroethane Replacement Study"

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The actual number of alternate cleaners that could be utilized for adhesive bonding tests was decreased based upon the extensive amount of specimen preparation, testing, and the combination of materials to be tested. Therefore, the top cleaners from the downsized comprehensive list were chosen for testing. Since the top two cleaners were of the same general chemical make-up, it was thought that choosing two from the top five would provide a better guideline. In addition to the control, trichloroethane and isopropyl alcohol were utilized along with two prospective aqueous cleaners. The objective was to demonstrate that a replacement for 1,1,1 in the adhesive bonding process was feasible in both a manufacturing and a repair environment. The approach was to compare the effectiveness of the potential replacement on various metal substrates utilizing 1,1,1 trichloroethane as a baseline control group. ARL-MD contracted ARDEC, Picatinny, NJ, to perform the adhesive bonding testing. The report generated is included within this section.

Effects of the Candidates on Adhesive Bonds

The metal substrates included AM-355 stainless steel, Ti-6Al-4V, electro-formed nickel, and 7075-T6 aluminum. The respective performance of the cleaners could be evaluated by baking on a standard contaminant (mixture of MIL-H-83282 and MIL-G-81322) and applying either a manufacturing simulation or a repair simulation. Manufacturing simulations utilized an ultrasonic cleaner, while the repair simulations utilized common solvent wiping techniques. The adhesive bonding performed included the floating roller peel test method (ASTM-D-3167) under cryogenic (-67° F), room temperature, and 130° F 95% relative humidity conditions. The manufacturing simulation employed EA9210 primer and EA9628H film adhesive. The repair simulation utilized EA9309.3 two-part modified epoxy. Standard surface preparation techniques were also utilized during both simulations. The test plan for the adhesive bonding part of the program was as follows:

Substrates:
Aluminum alloy (7075-T6 Bare)
Stainless steel (AM-355)
Titanium (6Al-4V)
Electro-Formed Nickel

Adhesives/Primers:
EA9210H (Dexter Hysol) - primer
EA9628H (Dexter Hysol) - film adhesive
EA9309.3NA (Dexter Hysol) - paste adhesive

Standard Contaminants:
Two parts by weight MIL-H-83282 hydraulic fluid
One part by weight MIL-G-81322 or MIL-G-21164 grease.

Apply uniform thin coat to surfaces with cheesecloth and bake 2 hrs. @ 130° F

Test Methods:

Peel Strength (ASTM D -3167) @ −67° F, 75° F, and 180° F wet (95% R.H.)

General Sample Preparation & Evaluation Procedure:

1. Apply standardized contamination to primed or unprimed substrate surfaces (i.e., oil/grease mixture).
2. Use standard surface preparation process for each substrate with:
   a. Original cleaning solvent (ODC or hazardous materials).
   b. Proposed substitute cleaning solution.
3. Prepare peel and lap shear samples using the standard application assembly and curing processes that are appropriate for the particular substrate and adhesive/primer combination being evaluated.
4. Measure peel and lap shear strength levels and compare failure surface characteristics (i.e., adhesive/cohesive percentages).

Accept/Reject Criteria:

The proposed substitute cleaning process must produce surface conditions that are statistically equivalent or superior to the surface conditions that are produced by the present cleaning process:

1) Equal or higher percentage of cohesive failure.

Specific Sample Preparation/Tests Procedures:

Metal Substrates (Manufacturing Simulation)

1) Apply standardized contamination to bare metal surface.
2) Clean surface with:
   Original cleaning process
   Proposed substitute cleaning process.
3) Prepare surfaces for bonding, using standard procedures for the specific metal type (i.e., etch, grit blast).
4) Apply and cure primer.
5) Make peel and lap shear samples using film adhesive with like substrates and a typical curing process.
6) Test and evaluate sample coupons.

Metal Substrates (Repair Simulation)

1) Prepare bare metal surfaces for bonding using the original cleaning process and the standard surface preparation procedure for the specific metal type.
2) Apply and cure primer.
3) Apply standardized contaminant to primed surfaces.
4) Clean surfaces with:
   a) Original cleaning process
   b) Proposed substitute cleaning process.
5) Make peel and lap shear samples, using film adhesive with like substrates and a typical curing process.
6) Test and evaluate sample coupons.

Standard surface preparation procedures:

(Note whenever vapor degreasing is called out, ultrasonic aqueous cleaning may be used instead)

Aluminum- ASTM D-3933
Stainless Steel MDHS HP 4-121
Titanium - Mil-HDBK-691 (section 5.3.5.1.17.2 - vapor honing/Pasa Jell 107),
    Sikorsky SS8752 (section 3.2.15.3), or MDHS HP 4-120

Standard Adhesive Application/Cure Process:

Primer - MDHS HP 4-100 (Spray, air dry, 30 min. @ 300° F)
Film Adhesive - MDHS HP 16-21 (1 hr @ 255–270° F, 50 PSI)
Paste Adhesive - MDHS HP 16-25 (24 hrs. @ RT, 50 PSI)

Mechanical Test Guidelines:

Use minimum of six samples for each variable combination tested.
Cold - soak all samples at −67° F for 24 hrs. minimum: test at same temp.
Hot - Condition all samples for 30 days at 180° F/95% R.H.: test at same temp.

Results

The technical report received from ARDEC concerning all aspects of replacing 1,1,1 trichloroethane as a cleaner prior to adhesive bonding with the alternatives described previously is presented on the following pages. ARL-MD worked in close conjunction with ARDEC in developing the test procedures, processing conditions, and parameters.

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1 1 1 Trichloroethane Replacement Study

Joseph A. Brescia
William S. DePiero
Karen L. Meyler

March 1996

US Army Armament Research, Development and Engineering Center (ARDEC)
Armament Engineering Directorate
Picatinny Arsenal, New Jersey 07806-5000

1 1 1 TRICHLOROETHANE REPLACEMENT STUDY

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INTRODUCTION

This report discusses the results of a study conducted by the US Army Armament Research, Development and Engineering Center (ARDEC) at the request of the US Army Research Laboratory (ARL), Watertown, MA, which evaluated the effectiveness of four cleaners/ degreasers under conditions simulating adhesive bonding operations at Army aircraft maintenance facilities. The baseline control cleaner/degreaser, 1 1 1 trichloroethane (methyl chloroform), has been identified as a Class 1 ozone depleting chemical (ODC). The objective of the study was to identify an effective, non-ODC substitute for 1 1 1 trichloroethane that would be suitable for use in large scale tank immersion processes as well as in off-line adhesive bonding repair of metallic structures. Three replacement candidates were selected by ARL for this study: isopropyl alcohol (2-propanol), Parts Prep (aqueous based degreaser), and Callasolve 120 (citrus based cleaner). The effectiveness of each cleaner/degreaser in removing a standard contaminant mixture of grease and hydraulic fluid was determined on the following aerospace alloys: 7075-T6 aluminum, electroformed nickel, AM355 stainless steel, and 6Al-4V titanium. Bond performance was measured using the floating roller peel method, recognized as a good discriminator for the degree of surface cleanliness, particularly when performed at a temperature of -67°F. Peel strength values were obtained for test panels at -67 °F, 75°F, and at 140 °F after 30 days in a 140 °F/condensing humidity environment.

MATERIALS LIST

The materials utilized during this study were as follows:

Adhesives

- EA 9628H modified epoxy structural film, knit scrim support, 1 hour - 250 °F cure, 0.06 lb/ft^2 weight, Dexter Aerospace
- EA 9309.3NA two-part modified epoxy paste, 24 hour room temperature cure; contains 9 mil glass beads for bondline control, Dexter Aerospace

Adhesive Primer

- EA 9210H, solvent-based, chromated, 1 hour - 250 °F cure, Dexter Aerospace

Adherends

7075-T6 Aluminum	(0.063 in. and 0.025 in. thick panels)
Electroformed Nickel	(0.040 in. and 0.012 in. thick panels)
AM355 Stainless Steel	(0.040 in. and 0.009 in. thick panels)
6Al-4V Titanium	(0.063 in. and 0.025 in. thick panels)

Cleaners/Degreasers

- 1 1 1 Trichloroethane
- Isopropyl Alcohol (2-Propanol)
- Parts Prep, International Specialty Products
- Callasolve 120, Zip-Chem Products

Chemicals

For contaminating metal surfaces prior to surface preparation:

- MIL-H-83282 Hydraulic Fluid
- MIL-G-81322 Lubricating Grease

For 7075-T6 aluminum treatment:

- Isoprep 188, deoxidizer, Richardson Company
- Phosphoric Acid, 85%

For electroformed nickel treatment:

- Turco HTC, Turco Products
- Ferric Chloride, 40% solution
- Hydrochloric Acid, 37%
- Turco 4104, Turco Products
- Nitric Acid, 70%

For AM355 stainless steel treatment:

- Turco HTC, Turco Products
- Ferric Chloride, 40% solution
- Hydrochloric Acid, 37%

For 6Al-4V titanium treatment:

- Oakite 90, Oakite Products
- Hydrofluoric Acid, 70%
- Sodium Sulfate
- Nitric Acid, 70%
- Trisodium Phosphate
- Potassium Fluoride

PROCEDURE

General

A standardized contaminant mixture of two parts by weight hydraulic fluid (MIL-H-83282) to one part by weight lubricating grease (MIL-G-81322) was applied to as-received metal surfaces and baked for 2 hours at 130 °F. The standardized surface preparation process for each metallic substrate/simulation combination was then performed with the baseline control and the three potential replacement cleaners / degreasers. EA 9628H film adhesive/EA 9210H primer was used to fabricate samples for the manufacturing simulation and EA 9309.3NA paste adhesive was used to fabricate samples for the repair simulation. Peel strengths were then measured at -67 °F, 75 °F, and at 140 °F after 30 days in a 140 °F/condensing humidity environment. Surfaces were visually inspected for failure modes.

Surface Preparation - Manufacturing Simulation

The standardized contaminant was applied to the metal panels and baked for 2 hours at 130 °F. The panels were then immersed in a 2 gallon capacity ultrasonic degreaser filled with the appropriate cleaner/degreaser and rinsed as follows:

1 1 1 Trichloroethane
- Panels immersed for 3 minutes at 75 °F.
- Panels immediately rinsed upon removal from bath with clean 1 1 1 trichloroethane and visually checked for water break.

2-Propanol
- Panels immersed for 3 minutes at 75 °F
- Panels immediately rinsed upon removal from bath with clean 2-Propanol and visually checked for water break.

Parts Prep
- Panels immersed for 3 minutes at 150 °F
- Panels immediately immersed upon removal from bath (before the Parts Prep could dry on the surface) in deionized water at 190 °F for 4 minutes
- Panels rinsed in running deionized water at 75 °F and visually checked for water break.

Callasolve 120
- Panels immersed for 3 minutes at 75 °F
- Panels immediately rinsed upon removal from bath (before the Callasolve 120 could dry on the surface) in running deionized water at 75 °F and visually checked for water break.

The metals were then prepared for bonding using the respective surface preparation techniques described below.

7075-T6 Aluminum

Surfaces were prepared in accordance with ASTM D3933 (ref 1) as follows:

(1) Panels were immersed in a solution of Isoprep 188 and deionized water (120 grams Isoprep/liter solution) for 5 minutes at 75 °F.

(2) Panels were rinsed in running deionized water for 3 minutes at 75 °F.

(3) A water break test was performed.

(4) Panels were immersed in a solution of phosphoric acid and deionized water (70 ml of 85% phosphoric acid/liter H_2O) at 75 °F where a 10 volt (V) potential was applied. The initial voltage applied (2 V) was raised at a rate of 2 V/minute to a maximum of 10 V and then held at 10 V for 20 minutes.

(5) Panels were rinsed in running deionized water for 3 minutes at 75 °F.

(6) Panels were dried for 30 minutes at 175 ∞F and then primed within 2 hours of completing the drying cycle.

Electroformed Nickel

Surfaces were prepared in accordance with McDonnell Douglas Helicopter Company Specification HP 4-49 (ref 2) as follows:

(1) Panels were immersed in a solution of Turco HTC and deionized water (10 ounces Turco HTC/gallon solution) for 15 minutes at 180 °F-200 °F with agitation system engaged.

(2) Panels were immediately immersed (being careful to not allow any Turco HTC solution to dry on the metal) in a deionized water rinse tank for 4 minutes at 75 °F with agitation system engaged.

(3) Panels were rinsed in running deionized water at 75 °F.

(4) A water break test was performed.

(5) Panels were immersed in a solution of 50% by volume ferric chloride (40% solution) and 50% by volume hydrochloric acid (37%) for 15 minutes at 75 °F.

(6) Panels were immersed in agitated deionized water for 4 minutes at 75 °F.

(7) Panels were rinsed in running deionized water at 75 °F.

(8) Panels were immersed in a desmut solution (35% by volume nitric acid (70%),15% by volume Turco 4104, 50% by volume deionized water)for 6-30 seconds as required at 75 °F. The panels must not exhibit any shiny areas after desmutting. All areas must exhibit a uniform, dull matte finish.

(9) Panels were immersed in agitated deionized water for 4 minutes at 75 °F.

(10) Panels were rinsed in running deionized water at 75 °F.

(11) Panels were immersed in deionized water for 2 minutes at 180 °F-190 °F.

(12) Panels were dried for 30 minutes at 150 °F and then primed within 2 hours of completing the drying cycle.

AM355 Stainless Steel

Surfaces were prepared in accordance with McDonnell Douglas Helicopter Company Specification HP 4-121 (ref 3) as follows:

(1) Panels were immersed in a solution of Turco HTC and deionized water (10 ounces Turco HTC/gallon solution) for 10 minutes at 180 °F-200 °F with agitation system engaged.

(2) Panels were immediately immersed (being careful to not allow any Turco HTC solution to dry on the metal) in a deionized water rinse tank for 4 minutes at 120 °F-150 °F with agitation system engaged.

(3) Panels were rinsed in running deionized water at 75 °F.

(4) A water break test was performed.

(5) Panels were immersed in a solution of 50% by volume ferric chloride (40% solution) and 50% by volume hydrochloric acid (37%) for 5 minutes at 75 °F.

(6) Panels were immersed in agitated deionized water for 4 minutes at 75 °F.

(7) Panels were rinsed in running deionized water at 75 °F.

(8) Panels were immersed in agitated deionized water for 4 minutes at 150 °F.

(9) Panels were dried for 30 minutes at 175 °F and then primed within 2 hours of completing the drying cycle.

6Al-4V Titanium

Surfaces were prepared in accordance with McDonnell Douglas Helicopter Company Specification HP 4-120 (ref 4) as follows:

(1) Panels were immersed in a solution of Oakite 90 alkaline cleaner and deionized water (12 ounces Oakite 90/gallon H_2O) for 10 minutes at 150 °F-170 °F with agitation system engaged.

(2) Panels were immediately immersed (being careful to not allow any Oakite 90 solution to dry on the metal) in a deionized water rinse tank for 4 minutes at 75 °F with agitation system engaged.

(3) Panels were rinsed in running deionized water at 75 °F.

(4) A water break test was performed.

(5) Panels were immersed in an aqueous pickle solution (2.0-3.0 fluid ounces of hydrofluoric acid/gallon of solution, 1.5-2.5 ounces of sodium sulfate/gallon of solution, 40.0-50.0 fluid ounces of nitric acid (70%)/gallon of solution, balance deionized water) for 2.5 minutes at 75 °F.

(6) Panels were immersed in agitated deionized water for 4 minutes at 75 °F.

(7) Panels were rinsed in running deionized water at 75 °F.

(8) Panels were immersed in a conversion coating aqueous solution (6.5-7.0 ounces of trisodium phosphate/gallon of solution, 2.5-3.0 ounces of

potassium fluoride/gallon of solution, 2.2-2.5 fluid ounces of hydrofluoric acid (70%)/gallon of solution, balance deionized water) for 1.5-2.5 minutes at 75 °F.

(9) Panels were immersed in agitated deionized water for 4 minutes at 75 °F.

(10) Panels were rinsed in running deionized water at 75 °F.

(11) Panels were immersed in agitated deionized water for 15 minutes at 145 °F-155 °F.

(12) Panels were rinsed in running deionized water at 75 °F.

(13) Panels were dried for 30 minutes at 160 °F and then primed within 2 hours of completing the drying cycle.

Application/Curing of Primer

The EA 9210H primer was stored, mixed, and sprayed according to manufacturer recommendations. Airline pressure was 35 psi. The primer was sprayed to a dry film thickness between 0.25-0.35 mils as verified by a Fisher Isoscope model MP. Following primer application, the primer was allowed to air dry for 30 minutes and was then oven cured for 30 minutes at 300 °F.

Surface Preparation - Repair Simulation

The standardized contaminant was applied to the metal panels and baked for two hours at 130 °F. The panels were then hand-wiped with laboratory tissues soaked in the appropriate cleaner/degreaser at room temperature until no visible residue remained on the tissues. The panels cleaned with Parts Prep and Callasolve 120 were rinsed in deionized water at room temperature immediately after wiping so that the cleaner residue would not dry on the parts. Panels cleaned with 1 1 1 trichloroethane and 2-propanol were not rinsed. A water break test was then performed on each panel, followed by abrading with 220 grit paper. The panels were then hand-wiped again with the appropriate cleaner/degreaser and rinsed in deionized water, if necessary. A second water break test was performed prior to bonding.

Fabrication of Test Specimens - Manufacturing Simulation

The manufacturing simulation samples were prepared in accordance with ASTM D3167 (ref 5) guidelines. Lay-up and curing of the panels was accomplished using a special fixture designed to be placed between the platens of a Dake press. First, a piece of breather material was placed on the template, followed by a piece of perforated release ply. The thin adherend panel was then centered on the release ply (with the drill hole at the bottom). A piece of EA 9628H film adhesive cut to the dimensions of the thick adherend panel was then applied to the thin adherend panel, aligned along the top edge making sure that all air bubbles were eliminated. The thick adherend panel was then placed on top of the film adhesive, aligned along the top edge, and pressed down with evenly applied pressure.

A perforated release ply and a breather cloth were then placed over the lay-up, and a thermocouple fed through a thermocouple hole. The thermocouple was taped down in the middle of the template and the thermocouple holes covered with vacuum bag tape. The template pegs were also covered with pieces of vacuum bag tape to prevent them from puncturing the vacuum bag. A strip of vacuum bag material was placed over the tape on each side of the template followed by a full sheet of vacuum bag material. The template fixture was assembled and placed between the platens of a Dake press. The press was pumped to a 4000 lb clamping load. Air pressure of 50 psi was then applied to the fixture. The set point temperature was then adjusted to 250°F. Once the temperature reached 250°F, a 1 hour cure at that temperature was initiated. After 1 hour, the heaters were shut off and cold water was run through the platens. When the temperature reached 140°F (or below), the air pressure was released and the fixture removed from the press.

Fabrication of Test Specimens - Repair Simulation

The repair simulation samples were prepared in accordance with ASTM D3167 (ref 5). The panels were bonded using the same fixture mentioned above. First, a piece of breather material was placed on the template, followed by a piece of perforated release ply. EA 9309.3NA paste adhesive was mixed according to manufacturer's instructions. The mixed adhesive was applied to the thin adherend panel, which was then centered on the release ply (with the drill hole at the bottom). Paste adhesive was then applied to the thick adherend panel, which was then placed on top of the thin adherend panel, aligned along the top edge, and pressed down with evenly applied pressure from the center outward. Bondline control was maintained by 9 mil glass beads formulated in the as-received adhesive.

A perforated release ply and a breather cloth were then placed over the lay-up. The template pegs were covered with pieces of vacuum bag tape to prevent them from puncturing the vacuum bag. A strip of vacuum bag material was placed over the tape on each side of the template followed by a full sheet of vacuum bag material. The template fixture was assembled and placed between the platens of a Dake press. The press was pumped to a 4000 lb clamping load. Air pressure of 50 psi was then applied to the fixture. The samples were then cured for 24 hours at room temperature (75 ∞F). After 24 hours, the air pressure was released and the fixture removed from the press.

Peel Strength Studies

Floating roller peel testing was performed in accordance with the procedures outlined in ASTM D3167 (ref 5), except that a crosshead speed of 5.0 inches/minute was used instead of 6.0 inches/minute. Testing was performed at -67 °F, 75 °F, and at 140 °F after 30 days in a 140 °F/condensing humidity environment using an Instron universal testing machine. For both simulations, 6 specimens were tested for each metal/cleaner combination at the designated temperatures. Prior to testing, the samples were conditioned at the testing temperature for 24 hours.

DISCUSSION AND RESULTS

Manufacturing Simulation

FRP test results for 7075-T6 aluminum are shown in tables 1-3. The data indicates that Parts Prep worked especially well on this alloy. Statistical analysis using the t-Test for a 95% confidence interval showed that Parts Prep was equal or superior to the control under the conditions tested. In contrast, parts cleaned with 2-Propanol did not perform as well as the control under any of the test conditions. Indeed, water break checks performed on panels after the initial ultrasonic soak showed that 2-Propanol was the least effective of the cleaners. In fact, a number of panels clearly showed evidence of unremoved fingerprints. Statistical treatment of the FRP data obtained for Callasolve 120 showed that although it was not as effective as the control(in 2/3 tests), bond strengths obtained were still fairly good.

In general the FRP values obtained for the 7075-T6 alloy at 75°F and at 140°F (after accelerated aging) were quite good; however, concern was expressed regarding the peel strengths obtained at -67°F, which ranged from 8-22 pli. Previous studies conducted by ARDEC in conjunction with the Naval Air Warfare Center on 2024-T3 series aluminum resulted in peel strengths of 60 pli at 75°F and 58 pli at -67°F. This could be attributable to differences in flexural stiffness and/or chemical reactivity of the two alloys, but this does not explain the similarity in results obtained at 75°F. A more likely explanation for the discrepancy would be related to possible differences in EA9210 primer thickness. The Dexter product description sheet for EA9210 specifies a primer thickness range of 0.3-0.5 mils. This range is somewhat higher than most other adhesive primers which normally specify ranges between 0.05-0.25 mils. Indeed, subsequent conversations with engineers at McDonnell Douglas Helicopter Company indicated that they normally specify a primer thickness range of 0.1-0.3 mils for bonding applications with EA9210. Since a range of 0.25-0.35 mils was used in this study, it would be correct to assume that in many instances the MDHC maximum limit of 0.30 mils may have been met or exceeded. It should be noted that a primer applied too thick ceases to act as an adhesion-promoting layer but rather a weak boundary layer in the adhesive bondline under certain conditions. At elevated temperatures the effect is less pronounced or may even slightly improve peel performance as the primer material becomes more elastic; however, at low temperatures the brittle nature of the primer becomes more pronounced and failure initiates preferentially in the primer layer rather than in the adhesive. It is quite possible then that the data obtained in this study reflects that 0.3 mil is the maximum practical limit for bonding with EA9210 primer.

The FRP data for electroformed nickel is shown in tables 7-9. Among the cleaners evaluated, only 2-Propanol provided peel strengths statistically equivalent to the control under all test conditions. These results contrast significantly with those obtained for aluminum. The fact that 2-Propanol performed as well as the control may be due to the lack of significant amounts of oils or contaminants on the as-received nickel surface. A more probable explanation may be that subsequent immersion in the strong alkaline detergent solution Turco HTC negated the effectiveness of initial degreasing step, regardless of what cleaner was used.

The observation that panels cleaned with Parts Prep and Callasolve 120 produced good water breaks after etching suggests that the lower than expected peel strengths may have again been attributable to a primer coat which was too thick. Low peel values at -67°F would be consistent with those obtained previously in the case of aluminum. The low peel values obtained at 75°F for the electroformed nickel could be related to its significantly higher flexural stiffness. Flexural bending stresses which are normally introduced during the FRP testing had resulted in significant deformation of the 7075-T6 metal; however in the case of the electroformed nickel, little deformation of the metal occurred and stresses were immediately transferred to the brittle primer layer resulting in failure and subsequent propagation along the primer/metal interface. Use of a lighter gauge electroformed nickel panel and thinner primer coatings in future studies should improve peel values.

FRP results for AM355 stainless steel are shown in tables 13-15. The results at all test conditions were much lower than expected, even for the control. At 75°F, peel strengths ranged from 2.4-6.8 pli; the expected average should have been 20-30 pli. One possible explanation for the results involves the time the panels were immersed in the ferric chloride etch. HP-4-121 specifies an etch time of 5 minutes; subsequent conversations with MDHC engineers indicated that the panels should have been immersed 5-12 minutes. Despite this information, the color and water breaks on the panels appeared acceptable following processing. This would bring us back to the possibility that the primer coating was too thick. In any event, the low peel values prevent any real comparisons to be made with regard to gauging cleaner effectiveness on the stainless steel.

FRP results for 6Al-4V titanium alloy are shown in tables 19-21. Again 75°F results ranging between 8-14.8 pli were slightly lower than the expected range of 15-20 pli. This again would probably be related to variation in primer thickness since coloration and water breaks were acceptable. In any event, the data appears to be of a sufficient magnitude so that at least some comparisons can be made. Statistical treatment of the data indicates that panels cleaned with 2-Propanol, Parts Prep and Callasolve 120 performed equal or superior to panels cleaned with the control solvent under the conditions tested. However, as in the case of the electroformed nickel, it is believed that the results reflect the cleaning effectiveness of the hot Oakite 90 alkaline detergent rather than the initial degreasing step. A more effective means therefore may be to determine the useful life of the alkaline detergent solutions which theoretically would be accumulating contaminants that the initial degreasing step left unremoved.

Repair Simulation

FRP results for 7075-T6 aluminum are shown in tables 4-6. Statistical treatment of the results at 75°F indicated that none of the proposed replacements matched the effectiveness of the 111 trichloroethane, although Parts Prep performed reasonably well with a 10.5 pli average. As expected, 2-Propanol was least effective of the three. At 140°F after heat/humidity aging, Parts Prep and Callasolve 120 again performed reasonably well (about 10 pli), but the average for the control was approximately 17 pli. At -67°F, there was a noticeable drop in peel strength for all the cleaners (except for 2-Propanol which was low to begin with), with Parts Prep cleaned panels averaging slightly higher than the control. Based on the data obtained, Parts Prep appeared to come closest to matching the performance of the control. However, it would probably be suitable only for off-aircraft repair situations where complete flushing of the repair area with water can be accomplished without adversely affecting adjacent areas to the repair.

FRP results for electroformed nickel and AM 355 stainless are shown in tables 10-12 and 16-18, respectively. The peel strengths obtained for all the degreasers, including the control, were extremely low. This was not unexpected in light of the high flexural stiffness of the metals combined with the chemically inert nature of their surfaces. Slight increases in peel strength were noticed after heat/humidity aging, but this was probably due to post-curing of the two-part room temperature curing adhesive. Still, no valid comparisons can be made for these two metals based upon the results obtained. FRP results for 6Al-4V are shown in tables 22-24. Since peel values were low, it is unclear whether the FRP test could be considered a viable discriminator under this particular set circumstances. However, statistical treatment of the data suggested Parts Prep and Callasolve 120 performed equal or superior to the control under the conditions tested.

CONCLUSIONS/RECOMMENDATIONS

1. FRP tests on 7075-T6 aluminum panels processed in a simulated manufacturing environment indicated that Parts Prep may be an effective replacement for 111 trichloroethane. FRP tests on 7075-T6 aluminum in a simulated repair environment indicated that Parts Prep could be an effective replacement for 111 trichloroethane in off-aircraft repairs provided that the repair could be completely flushed with water without damage to adjacent structure.

2. FRP tests on 6Al-4V titanium panels processed in a simulated manufacturing environment indicated that 2-Propanol, Parts Prep, or Callasolve 120 would be adequate replacements for 111 trichloroethane. However, this was probably more indicative of the effectiveness of the Oakite 90 alkaline detergent soak rather than the initial degreasing step. In the repair simulation, FRP values were low (as expected), but statistical treatment of the data indicated that Parts Prep and Callasolve 120 may be suitable replacements in situations described as above for 7075-T6 aluminum.

3. Despite strict adherence to the previously referenced surface preparation specifications and manufacturer recommendations for the primer and film adhesive, the numeric peel strength results obtained for several of the manufacturing simulations were considerably lower than expected . Visual inspection of the manufacturing samples revealed a high incidence (90-95%) of primer to metal failure. These failures are believed to be a result of applied EA9210H primer thicknesses in excess of 0.3 mils. The effect was less pronounced for 7075-T6 aluminum which has a lower flexural stiffness compared to electroformed nickel, AM 355 stainless steel, and 6Al-4V titanium. Future studies should establish a dry primer thickness range of 0.1-0.3 mils and attempt to use lighter gauges of the nickel and AM 355 stainless steel for FRP tests.

4. Numeric peel strength results obtained for the repair simulation were extremely low, especially in the case of electroformed nickel and AM 355 stainless steel. Visual inspection of the repair samples revealed a high incidence (90-99%) of adhesive to metal failure. These results were expected due to the combination of minimal surface preparation performed on the metal panels, low surface reactivity, and the complex loads introduced by the FRP test on the adhesive bondline.

Table 1. Room Temperature (75 F) Peel Strength Values for Aluminum (Manufacturing Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	2		32.0		64.0
1 1 1	5		30.5		61.0
1 1 1	8		28.6		57.2
1 1 1	11		29.7		59.4
1 1 1	13		29.2		58.4
1 1 1	15		28.9		57.8
		Average	29.8		59.6
		Standard Deviation	1.3		2.5
2-Propanol	2		13.5		27.0
2-Propanol	5		21.0		42.0
2-Propanol	9		21.5		43.0
2-Propanol	12		20.0		40.0
2-Propanol	13		10.5		21.0
2-Propanol	16		11.5		23.0
		Average	16.3		32.7
		Standard Deviation	5.0		10.1
Parts Prep	2		26.4		52.8
Parts Prep	4		28.9		57.8
Parts Prep	10		28.0		56.0
Parts Prep	12		26.6		53.2
Parts Prep	14		31.0		62.0
Parts Prep	15		33.0		66.0
		Average	29.0		58.0
		Standard Deviation	2.6		5.2
Callasolve 120	2		28.1		56.2
Callasolve 120	6		28.4		56.8
Callasolve 120	8		28.6		57.2
Callasolve 120	10		27.8		55.6
Callasolve 120	15		28.6		57.2
Callasolve 120	17		28.9		57.8
		Average	28.4		56.8
		Standard Deviation	0.4		0.8

Table 2. Elevated Temperature (140 F) Peel Strength Values for Aluminum (Manufacturing Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	1		32.0		64.0
1 1 1	3		32.0		64.0
1 1 1	7		27.5		55.0
1 1 1	9		28.0		56.0
1 1 1	16		27.5		55.0
1 1 1	17		27.0		54.0
		Average	29.0		58.0
		Standard Deviation	2.3		4.7
2-Propanol	3		19.5		39.0
2-Propanol	6		16.5		33.0
2-Propanol	7		24.5		49.0
2-Propanol	11		24.0		48.0
2-Propanol	15		8.5		17.0
2-Propanol	17		20.5		41.0
		Average	18.9		37.8
		Standard Deviation	5.9		11.8
Parts Prep	3		25.5		51.0
Parts Prep	6		24.0		48.0
Parts Prep	7		35.5		71.0
Parts Prep	8		35.5		71.0
Parts Prep	13		31.5		63.0
Parts Prep	16		31.5		63.0
		Average	30.6		61.2
		Standard Deviation	4.9		9.8
Callasolve 120	1		23.5		47.0
Callasolve 120	4		23.0		46.0
Callasolve 120	9		25.0		50.0
Callasolve 120	12		28.0		56.0
Callasolve 120	13		23.5		47.0
Callasolve 120	14		23.0		46.0
		Average	24.3		48.7
		Standard Deviation	1.9		3.9

Table 3. Low Temperature (-67 F) Peel Strength Values for Aluminum (Manufacturing Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	4		5.2		10.4
1 1 1	6		4.8		9.6
1 1 1	10		4.8		9.6
1 1 1	12		4.6		9.2
1 1 1	14		4.8		9.6
1 1 1	18		4.4		8.8
		Average	4.8		9.5
		Standard Deviation	0.3		0.5
2-Propanol	1		2.9		5.8
2-Propanol	4		2.7		5.4
2-Propanol	8		2.6		5.2
2-Propanol	10		2.8		5.6
2-Propanol	14		2.8		5.6
2-Propanol	18		2.5		5.0
		Average	2.7		5.4
		Standard Deviation	0.1		0.3
Parts Prep	1		4.4		8.8
Parts Prep	5		5.4		10.8
Parts Prep	9		6.2		12.4
Parts Prep	11		5.7		11.4
Parts Prep	17		10.3		20.6
Parts Prep	18		10.8		21.6
		Average	7.1		14.3
		Standard Deviation	2.7		5.4
Callasolve 120	3		10.3		20.6
Callasolve 120	5		8.8		17.6
Callasolve 120	7		7.0		14.0
Callasolve 120	11		7.2		14.4
Callasolve 120	16		6.7		13.4
Callasolve 120	18		7.2		14.4
		Average	7.9		15.7
		Standard Deviation	1.4		2.8

Table 4. Room Temperature (75 F) Peel Strength Values for Aluminum (Repair Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	2		9.8		19.6
1 1 1	4		5.4		10.8
1 1 1	7		7.8		15.6
1 1 1	10		6.4		12.8
1 1 1	14		7.4		14.8
1 1 1	18		5.2		10.4
		Average	7.0		14.0
		Standard Deviation	1.7		3.4
2-Propanol	1		3.2		6.4
2-Propanol	4		2.4		4.8
2-Propanol	8		3.2		6.4
2-Propanol	12		2.8		5.6
2-Propanol	15		3.0		6.0
2-Propanol	17		3.0		6.0
		Average	2.9		5.9
		Standard Deviation	0.3		0.6
Parts Prep	3		6.6		13.2
Parts Prep	4		4.4		8.8
Parts Prep	8		4.0		8.0
Parts Prep	12		4.3		8.6
Parts Prep	13		5.8		11.6
Parts Prep	17		6.4		12.8
		Average	5.3		10.5
		Standard Deviation	1.2		2.3
Callasolve 120	3		2.5		5.0
Callasolve 120	5		2.5		5.0
Callasolve 120	10		3.4		6.8
Callasolve 120	12		3.2		6.4
Callasolve 120	13		3.4		6.8
Callasolve 120	16		4.0		8.0
		Average	3.2		6.3
		Standard Deviation	0.6		1.2

Table 5. Elevated Temperature (140 F) Peel Strength Values for Aluminum (Repair Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	1		9.6		19.2
1 1 1	5		10.6		21.2
1 1 1	8		5.8		11.6
1 1 1	9		5.8		11.6
1 1 1	13		11.6		23.2
1 1 1	16		7.0		14.0
		Average	8.4		16.8
		Standard Deviation	2.5		5.1
2-Propanol	3		1.2		2.4
2-Propanol	5		1.1		2.2
2-Propanol	7		1.0		2.0
2-Propanol	11		1.0		2.0
2-Propanol	13		1.0		2.0
2-Propanol	18		1.4		2.8
		Average	1.1		2.2
		Standard Deviation	0.2		0.3
Parts Prep	1		4.2		8.4
Parts Prep	2		4.8		9.6
Parts Prep	10		2.6		5.2
Parts Prep	11		2.6		5.2
Parts Prep	15		4.0		8.0
Parts Prep	18		11.6		23.2
		Average	5.0		9.9
		Standard Deviation	3.4		6.7
Callasolve 120	4		6.0		12.0
Callasolve 120	6		7.0		14.0
Callasolve 120	8		5.4		10.8
Callasolve 120	9		4.8		9.6
Callasolve 120	14		3.0		6.0
Callasolve 120	15		5.6		11.2
		Average	5.3		10.6
		Standard Deviation	1.3		2.7

Table 6. Low Temperature (-67 F) Peel Strength Values for Aluminum (Repair Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	3		2.8		5.6
1 1 1	6		2.7		5.4
1 1 1	11		2.4		4.8
1 1 1	12		2.8		5.6
1 1 1	15		2.8		5.6
1 1 1	17		2.6		5.2
		Average	2.7		5.4
		Standard Deviation	0.2		0.3
2-Propanol	2		1.9		3.8
2-Propanol	6		1.7		3.4
2-Propanol	9		1.6		3.2
2-Propanol	10		1.6		3.2
2-Propanol	14		2.2		4.4
2-Propanol	16		2.0		4.0
		Average	1.8		3.7
		Standard Deviation	0.2		0.5
Parts Prep	5		2.2		4.4
Parts Prep	6		3.7		7.4
Parts Prep	7		3.4		6.8
Parts Prep	9		3.3		6.6
Parts Prep	14		2.8		5.6
Parts Prep	16		2.6		5.2
		Average	3.0		6.0
		Standard Deviation	0.6		1.1
Callasolve 120	1		2.0		4.0
Callasolve 120	2		2.2		4.4
Callasolve 120	7		2.2		4.4
Callasolve 120	11		2.3		4.6
Callasolve 120	17		1.6		3.2
Callasolve 120	18		1.9		3.8
		Average	2.0		4.1
		Standard Deviation	0.3		0.5

Table 7. Room Temperature (75 F) Peel Strength Values for Nickel (Manufacturing Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	1		11.0		22.0
1 1 1	4		16.4		32.8
1 1 1	5		16.2		32.4
1 1 1	13		13.8		27.6
1 1 1	16		13.4		26.8
1 1 1	20		14.0		28.0
		Average	14.1		28.3
		Standard Deviation	2.0		4.0
2-Propanol	1		10.6		21.2
2-Propanol	5		12.5		25.0
2-Propanol	8		13.0		26.0
2-Propanol	11		11.4		22.8
2-Propanol	15		14.6		29.2
2-Propanol	20		15.4		30.8
		Average	12.9		25.8
		Standard Deviation	1.8		3.7
Parts Prep	2		3.4		6.8
Parts Prep	5		3.6		7.2
Parts Prep	7		3.3		6.6
Parts Prep	12		2.8		5.6
Parts Prep	17		2.6		5.2
Parts Prep	20		2.4		4.8
		Average	3.0		6.0
		Standard Deviation	0.5		1.0
Callasolve 120	1		5.2		10.4
Callasolve 120	4		1.6		3.2
Callasolve 120	8		0.8		1.6
Callasolve 120	10		2.2		4.4
Callasolve 120	13		2.8		5.6
Callasolve 120	16		3.8		7.6
		Average	2.7		5.5
		Standard Deviation	1.6		3.2

Table 8. Elevated Temperature (140 F) Peel Strength Values for Nickel (Manufacturing Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	2		2.6		5.2
1 1 1	6		4.9		9.8
1 1 1	9		2.5		5.0
1 1 1	11		3.0		6.0
1 1 1	12		3.8		7.6
1 1 1	19		2.9		5.8
		Average	3.3		6.6
		Standard Deviation	0.9		1.8
2-Propanol	2		1.5		3.0
2-Propanol	7		1.2		2.4
2-Propanol	9		4.2		8.4
2-Propanol	10		3.7		7.4
2-Propanol	13		4.3		8.6
2-Propanol	21		4.2		8.4
		Average	3.2		6.4
		Standard Deviation	1.4		2.9
Parts Prep	3		4.0		8.0
Parts Prep	4		3.8		7.6
Parts Prep	6		3.2		6.4
Parts Prep	11		1.4		2.8
Parts Prep	14		1.9		3.8
Parts Prep	19		1.7		3.4
		Average	2.7		5.3
		Standard Deviation	1.1		2.3
Callasolve 120	2		1.6		3.2
Callasolve 120	5		1.8		3.6
Callasolve 120	6		1.3		2.6
Callasolve 120	9		1.0		2.0
Callasolve 120	12		0.8		1.6
Callasolve 120	18		2.1		4.2
		Average	1.4		2.9
		Standard Deviation	0.5		1.0

Table 9. Low Temperature (-67 F) Peel Strength Values for Nickel (Manufacturing Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	3		7.6		15.2
1 1 1	7		4.4		8.8
1 1 1	8		4.1		8.2
1 1 1	10		4.0		8.0
1 1 1	14		3.6		7.2
1 1 1	18		3.0		6.0
		Average	4.5		8.9
		Standard Deviation	1.6		3.2
2-Propanol	3		3.6		7.2
2-Propanol	6		3.8		7.6
2-Propanol	12		4.0		8.0
2-Propanol	14		7.0		14.0
2-Propanol	16		7.1		14.2
2-Propanol	19		7.8		15.6
		Average	5.6		11.1
		Standard Deviation	1.9		3.9
Parts Prep	1		3.0		6.0
Parts Prep	9		2.2		4.4
Parts Prep	10		1.8		3.6
Parts Prep	13		2.4		4.8
Parts Prep	16		2.5		5.0
Parts Prep	18		2.0		4.0
		Average	2.3		4.6
		Standard Deviation	0.4		0.8
Callasolve 120	3		0.8		1.6
Callasolve 120	7		0.2		0.4
Callasolve 120	11		0.6		1.2
Callasolve 120	14		3.0		6.0
Callasolve 120	15		3.4		6.8
Callasolve 120	17		1.0		2.0
		Average	1.5		3.0
		Standard Deviation	1.3		2.7

Table 10. Room Temperature (75 F) Peel Strength Values for Nickel (Repair Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	2		0.3		0.6
1 1 1	4		0.3		0.6
1 1 1	10		0.4		0.8
1 1 1	13		0.4		0.8
1 1 1	16		0.5		1.0
1 1 1	20		0.4		0.8
		Average	0.4		0.8
		Standard Deviation	0.1		0.2
2-Propanol	3		0.2		0.4
2-Propanol	6		0.2		0.4
2-Propanol	10		0.7		1.4
2-Propanol	12		0.6		1.2
2-Propanol	18		0.6		1.2
2-Propanol	20		0.3		0.6
		Average	0.4		0.9
		Standard Deviation	0.2		0.5
Parts Prep	1		0.6		1.2
Parts Prep	5		0.8		1.6
Parts Prep	8		0.5		1.0
Parts Prep	9		0.6		1.2
Parts Prep	14		0.4		0.8
Parts Prep	18		0.3		0.6
		Average	0.5		1.1
		Standard Deviation	0.2		0.4
Callasolve 120	2		0.4		0.8
Callasolve 120	3		0.4		0.8
Callasolve 120	8		0.6		1.2
Callasolve 120	10		0.6		1.2
Callasolve 120	14		0.4		0.8
Callasolve 120	17		0.6		1.2
		Average	0.5		1.0
		Standard Deviation	0.1		0.2

Table 11. Elevated Temperature (140 F) Peel Strength Values for Nickel (Repair Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	3		1.8		3.6
1 1 1	5		0.6		1.2
1 1 1	9		0.6		1.2
1 1 1	12		2.7		5.4
1 1 1	14		2.2		4.4
1 1 1	18		1.8		3.6
		Average	1.6		3.2
		Standard Deviation	0.9		1.7
2-Propanol	1		1.8		3.6
2-Propanol	7		2.4		4.8
2-Propanol	9		1.6		3.2
2-Propanol	11		1.0		2.0
2-Propanol	14		1.0		2.0
2-Propanol	17		2.0		4.0
		Average	1.6		3.3
		Standard Deviation	0.6		1.1
Parts Prep	2		1.2		2.4
Parts Prep	6		2.2		4.4
Parts Prep	10		1.8		3.6
Parts Prep	11		1.0		2.0
Parts Prep	15		0.6		1.2
Parts Prep	17		1.1		2.2
		Average	1.3		2.6
		Standard Deviation	0.6		1.2
Callasolve 120	1		0.9		1.8
Callasolve 120	6		0.8		1.6
Callasolve 120	9		2.0		4.0
Callasolve 120	11		1.4		2.8
Callasolve 120	13		1.7		3.4
Callasolve 120	16		1.3		2.6
		Average	1.4		2.7
		Standard Deviation	0.5		0.9

Table 12. Low Temperature (-67 F) Peel Strength Values for Nickel (Repair Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	1		0.3		0.6
1 1 1	6		0.4		0.8
1 1 1	8		0.2		0.4
1 1 1	11		0.2		0.4
1 1 1	17		0.2		0.4
1 1 1	19		0.3		0.6
		Average	0.3		0.5
		Standard Deviation	0.1		0.2
2-Propanol	2		0.2		0.4
2-Propanol	4		0.2		0.4
2-Propanol	8		0.3		0.6
2-Propanol	13		0.4		0.8
2-Propanol	15		0.3		0.6
2-Propanol	19		0.2		0.4
		Average	0.3		0.5
		Standard Deviation	0.1		0.2
Parts Prep	4		0.4		0.8
Parts Prep	5		0.4		0.8
Parts Prep	7		0.4		0.8
Parts Prep	12		0.3		0.6
Parts Prep	15		0.2		0.4
Parts Prep	18		0.2		0.4
		Average	0.3		0.6
		Standard Deviation	0.1		0.2
Callasolve 120	3		0.4		0.8
Callasolve 120	7		0.4		0.8
Callasolve 120	11		0.3		0.6
Callasolve 120	14		0.4		0.8
Callasolve 120	15		0.3		0.6
Callasolve 120	17		0.4		0.8
		Average	0.4		0.7
		Standard Deviation	0.1		0.1

Table 13. Room Temperature (75 F) Peel Strength Values for Stainless Steel (Manufacturing Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	1		2.0		4.0
1 1 1	4		1.6		3.2
1 1 1	8		1.9		3.8
1 1 1	9		2.0		4.0
1 1 1	14		2.0		4.0
1 1 1	17		1.8		3.6
		Average	1.9		3.8
		Standard Deviation	0.2		0.3
2-Propanol	1		2.1		4.2
2-Propanol	5		1.5		3.0
2-Propanol	7		1.6		3.2
2-Propanol	13		1.6		3.2
2-Propanol	17		1.8		3.6
2-Propanol	20		1.7		3.4
		Average	1.7		3.4
		Standard Deviation	0.2		0.4
Parts Prep	1		1.4		2.8
Parts Prep	3		1.2		2.4
Parts Prep	7		1.4		2.8
Parts Prep	12		1.2		2.4
Parts Prep	14		1.2		2.4
Parts Prep	19		1.2		2.4
		Average	1.3		2.5
		Standard Deviation	0.1		0.2
Callasolve 120	2		3.4		6.8
Callasolve 120	4		3.0		6.0
Callasolve 120	9		2.7		5.4
Callasolve 120	12		2.8		5.6
Callasolve 120	18		2.2		4.4
Callasolve 120	20		2.0		4.0
		Average	2.7		5.4
		Standard Deviation	0.5		1.0

Table 14. Elevated Temperature (140 F) Peel Strength Values for Stainless Steel (Manufacturing Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	3		2.0		4.0
1 1 1	7		2.5		5.0
1 1 1	10		1.3		2.6
1 1 1	12		1.5		3.0
1 1 1	15		2.0		4.0
1 1 1	18		1.9		3.8
		Average	1.9		3.7
		Standard Deviation	0.4		0.8
2-Propanol	3		2.3		4.6
2-Propanol	4		2.4		4.8
2-Propanol	8		2.4		4.8
2-Propanol	11		2.1		4.2
2-Propanol	14		2.2		4.4
2-Propanol	19		2.6		5.2
		Average	2.3		4.7
		Standard Deviation	0.2		0.4
Parts Prep	2		2.0		4.0
Parts Prep	5		1.7		3.4
Parts Prep	9		2.3		4.6
Parts Prep	11		1.9		3.8
Parts Prep	15		1.6		3.2
Parts Prep	17		1.6		3.2
		Average	1.9		3.7
		Standard Deviation	0.3		0.5
Callasolve 120	3		6.7		13.4
Callasolve 120	6		2.1		4.2
Callasolve 120	7		7.0		14.0
Callasolve 120	11		3.8		7.6
Callasolve 120	15		4.7		9.4
Callasolve 120	17		4.4		8.8
		Average	4.8		9.6
		Standard Deviation	1.8		3.7

Table 15. Low Temperature (-67 F) Peel Strength Values for Stainless Steel (Manufacturing Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	2		1.4		2.8
1 1 1	5		1.4		2.8
1 1 1	6		1.2		2.4
1 1 1	11		1.6		3.2
1 1 1	13		1.0		2.0
1 1 1	16		1.5		3.0
		Average	1.4		2.7
		Standard Deviation	0.2		0.4
2-Propanol	2		1.0		2.0
2-Propanol	6		1.4		2.8
2-Propanol	10		1.2		2.4
2-Propanol	12		1.4		2.8
2-Propanol	16		1.2		2.4
2-Propanol	18		1.3		2.6
		Average	1.3		2.5
		Standard Deviation	0.2		0.3
Parts Prep	4		1.2		2.4
Parts Prep	8		1.2		2.4
Parts Prep	10		1.2		2.4
Parts Prep	13		1.6		3.2
Parts Prep	16		1.3		2.6
Parts Prep	20		1.4		2.8
		Average	1.3		2.6
		Standard Deviation	0.2		0.3
Callasolve 120	1		1.4		2.8
Callasolve 120	5		1.2		2.4
Callasolve 120	8		1.3		2.6
Callasolve 120	10		1.2		2.4
Callasolve 120	13		1.4		2.8
Callasolve 120	14		1.4		2.8
		Average	1.3		2.6
		Standard Deviation	0.1		0.2

Table 16. Room Temperature (75 F) Peel Strength Values for Stainless Steel (Repair Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	2		0.1		0.2
1 1 1	3		0.1		0.2
1 1 1	8		0.1		0.2
1 1 1	12		0.1		0.2
1 1 1	15		0.1		0.2
1 1 1	20		0.1		0.2
		Average	0.1		0.2
		Standard Deviation	0.0		0.0
2-Propanol	4		0.2		0.4
2-Propanol	7		0.3		0.6
2-Propanol	10		0.3		0.6
2-Propanol	13		0.4		0.8
2-Propanol	17		0.3		0.6
2-Propanol	19		0.4		0.8
		Average	0.3		0.6
		Standard Deviation	0.1		0.2
Parts Prep	5		0.9		1.8
Parts Prep	8		0.8		1.6
Parts Prep	12		0.8		1.6
Parts Prep	15		0.4		0.8
Parts Prep	17		0.4		0.8
Parts Prep	21		0.4		0.8
		Average	0.6		1.2
		Standard Deviation	0.2		0.5
Callasolve 120	1		0.9		1.8
Callasolve 120	7		0.9		1.8
Callasolve 120	8		0.8		1.6
Callasolve 120	14		0.8		1.6
Callasolve 120	17		0.9		1.8
Callasolve 120	19		0.7		1.4
		Average	0.8		1.7
		Standard Deviation	0.1		0.2

Table 17. Elevated Temperature (140 F) Peel Strength Values for Stainless Steel (Repair Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	4		2.2		4.4
1 1 1	6		3.4		6.8
1 1 1	9		2.8		5.6
1 1 1	14		3.6		7.2
1 1 1	17		1.3		2.6
1 1 1	19		1.7		3.4
		Average	2.5		5.0
		Standard Deviation	0.9		1.9
2-Propanol	2		1.6		3.2
2-Propanol	5		2.2		4.4
2-Propanol	9		1.6		3.2
2-Propanol	11		2.5		5.0
2-Propanol	14		1.6		3.2
2-Propanol	18		2.4		4.8
		Average	2.0		4.0
		Standard Deviation	0.4		0.9
Parts Prep	1		1.6		3.2
Parts Prep	4		1.5		3.0
Parts Prep	9		1.4		2.8
Parts Prep	13		1.5		3.0
Parts Prep	18		1.2		2.4
Parts Prep	20		1.2		2.4
		Average	1.4		2.8
		Standard Deviation	0.2		0.3
Callasolve 120	2		2.9		5.8
Callasolve 120	3		3.0		6.0
Callasolve 120	6		2.1		4.2
Callasolve 120	10		2.6		5.2
Callasolve 120	15		2.5		5.0
Callasolve 120	18		2.4		4.8
		Average	2.6		5.2
		Standard Deviation	0.3		0.7

Table 18. Low Temperature (-67 F) Peel Strength Values for Stainless Steel (Repair Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	1		0.3		0.6
1 1 1	5		0.2		0.4
1 1 1	7		0.2		0.4
1 1 1	10		0.4		0.8
1 1 1	13		0.2		0.4
1 1 1	16		0.2		0.4
		Average	0.3		0.5
		Standard Deviation	0.1		0.2
2-Propanol	1		0.4		0.8
2-Propanol	3		0.4		0.8
2-Propanol	8		0.2		0.4
2-Propanol	12		0.2		0.4
2-Propanol	16		0.4		0.8
2-Propanol	20		0.2		0.4
		Average	0.3		0.6
		Standard Deviation	0.1		0.2
Parts Prep	3		0.2		0.4
Parts Prep	6		0.3		0.6
Parts Prep	10		0.2		0.4
Parts Prep	14		0.2		0.4
Parts Prep	16		0.4		0.8
Parts Prep	19		0.2		0.4
		Average	0.3		0.5
		Standard Deviation	0.1		0.2
Callasolve 120	4		0.3		0.6
Callasolve 120	5		0.3		0.6
Callasolve 120	9		0.4		0.8
Callasolve 120	11		0.4		0.8
Callasolve 120	13		0.3		0.6
Callasolve 120	16		0.2		0.4
		Average	0.3		0.6
		Standard Deviation	0.1		0.2

Table 19. Room Temperature (75 F) Peel Strength Values for Titanium (Manufacturing Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	6		5.3		10.6
1 1 1	8		4.4		8.8
1 1 1	11		4.8		9.6
1 1 1	12		5.5		11.0
1 1 1	17		3.5		7.0
1 1 1	19		4.0		8.0
		Average	4.6		9.2
		Standard Deviation	0.8		1.5
2-Propanol	2		6.7		13.4
2-Propanol	5		4.6		9.2
2-Propanol	9		5.3		10.6
2-Propanol	13		4.2		8.4
2-Propanol	18		6.6		13.2
2-Propanol	20		5.1		10.2
		Average	5.4		10.8
		Standard Deviation	1.0		2.1
Parts Prep	3		6.2		12.4
Parts Prep	4		6.2		12.4
Parts Prep	8		7.0		14.0
Parts Prep	12		6.1		12.2
Parts Prep	15		6.8		13.6
Parts Prep	18		4.8		9.6
		Average	6.2		12.4
		Standard Deviation	0.8		1.5
Callasolve 120	2		7.0		14.0
Callasolve 120	5		7.4		14.8
Callasolve 120	11		4.6		9.2
Callasolve 120	14		4.9		9.8
Callasolve 120	18		4.6		9.2
Callasolve 120	19		4.5		9.0
		Average	5.5		11.0
		Standard Deviation	1.3		2.7

Table 20. Elevated Temperature (140 F) Peel Strength Values for Titanium (Manufacturing Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	1		2.7		5.4
1 1 1	2		2.4		4.8
1 1 1	5		3.0		6.0
1 1 1	10		2.5		5.0
1 1 1	16		2.2		4.4
1 1 1	20		3.1		6.2
		Average	2.7		5.3
		Standard Deviation	0.4		0.7
2-Propanol	3		2.4		4.8
2-Propanol	6		3.0		6.0
2-Propanol	11		1.4		2.8
2-Propanol	14		1.6		3.2
2-Propanol	17		2.5		5.0
2-Propanol	21		2.2		4.4
		Average	2.2		4.4
		Standard Deviation	0.6		1.2
Parts Prep	1		3.7		7.4
Parts Prep	6		3.8		7.6
Parts Prep	7		4.6		9.2
Parts Prep	14		4.1		8.2
Parts Prep	17		3.3		6.6
Parts Prep	19		3.0		6.0
		Average	3.8		7.5
		Standard Deviation	0.6		1.1
Callasolve 120	1		4.6		9.2
Callasolve 120	4		3.4		6.8
Callasolve 120	6		3.0		6.0
Callasolve 120	12		2.1		4.2
Callasolve 120	15		3.0		6.0
Callasolve 120	20		2.6		5.2
		Average	3.1		6.2
		Standard Deviation	0.8		1.7

Table 21. Low Temperature (-67 F) Peel Strength Values for Titanium (Manufacturing Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	4		3.4		6.8
1 1 1	7		4.1		8.2
1 1 1	9		3.8		7.6
1 1 1	13		3.0		6.0
1 1 1	15		2.3		4.6
1 1 1	18		2.9		5.8
		Average	3.3		6.5
		Standard Deviation	0.7		1.3
2-Propanol	1		4.7		9.4
2-Propanol	4		3.8		7.6
2-Propanol	8		5.2		10.4
2-Propanol	12		5.0		10.0
2-Propanol	15		4.4		8.8
2-Propanol	19		4.5		9.0
		Average	4.6		9.2
		Standard Deviation	0.5		1.0
Parts Prep	2		4.1		8.2
Parts Prep	5		3.8		7.6
Parts Prep	9		4.6		9.2
Parts Prep	10		4.6		9.2
Parts Prep	13		3.5		7.0
Parts Prep	16		3.6		7.2
		Average	4.0		8.1
		Standard Deviation	0.5		1.0
Callasolve 120	3		4.2		8.4
Callasolve 120	7		3.4		6.8
Callasolve 120	9		3.8		7.6
Callasolve 120	10		3.8		7.6
Callasolve 120	13		4.4		8.8
Callasolve 120	16		4.1		8.2
		Average	4.0		7.9
		Standard Deviation	0.4		0.7

Table 22. Room Temperature (75 F) Peel Strength Values for Titanium (Repair Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	2		2.8		5.6
1 1 1	5		2.8		5.6
1 1 1	7		2.8		5.6
1 1 1	12		1.6		3.2
1 1 1	16		2.4		4.8
1 1 1	19		2.4		4.8
		Average	2.5		4.9
		Standard Deviation	0.5		0.9
2-Propanol	1		1.4		2.8
2-Propanol	6		1.6		3.2
2-Propanol	7		1.4		2.8
2-Propanol	11		1.8		3.6
2-Propanol	13		2.4		4.8
2-Propanol	20		2.6		5.2
		Average	1.9		3.7
		Standard Deviation	0.5		1.0
Parts Prep	2		3.9		7.8
Parts Prep	4		4.2		8.4
Parts Prep	7		3.0		6.0
Parts Prep	11		4.0		8.0
Parts Prep	15		3.3		6.6
Parts Prep	20		3.2		6.4
		Average	3.6		7.2
		Standard Deviation	0.5		1.0
Callasolve 120	1		3.6		7.2
Callasolve 120	5		3.2		6.4
Callasolve 120	9		2.9		5.8
Callasolve 120	11		2.8		5.6
Callasolve 120	15		3.2		6.4
Callasolve 120	18		3.5		7.0
		Average	3.2		6.4
		Standard Deviation	0.3		0.6

Table 23. Elevated Temperature (140 F) Peel Strength Values for Titanium (Repair Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	3		7.2		14.4
1 1 1	6		6.2		12.4
1 1 1	13		4.0		8.0
1 1 1	14		5.2		10.4
1 1 1	18		6.6		13.2
1 1 1	20		6.4		12.8
		Average	5.9		11.9
		Standard Deviation	1.2		2.3
2-Propanol	2		2.3		4.6
2-Propanol	4		2.9		5.8
2-Propanol	9		4.0		8.0
2-Propanol	14		2.8		5.6
2-Propanol	16		3.0		6.0
2-Propanol	19		3.2		6.4
		Average	3.0		6.1
		Standard Deviation	0.6		1.1
Parts Prep	1		4.4		8.8
Parts Prep	3		4.4		8.8
Parts Prep	9		5.8		11.6
Parts Prep	13		4.5		9.0
Parts Prep	16		5.0		10.0
Parts Prep	19		5.0		10.0
		Average	4.9		9.7
		Standard Deviation	0.5		1.1
Callasolve 120	4		5.2		10.4
Callasolve 120	7		5.6		11.2
Callasolve 120	8		5.0		10.0
Callasolve 120	13		5.2		10.4
Callasolve 120	14		5.2		10.4
Callasolve 120	19		5.4		10.8
		Average	5.3		10.5
		Standard Deviation	0.2		0.4

Table 24. Low Temperature (-67 F) Peel Strength Values for Titanium (Repair Simulation)

Degreaser	Specimen #		Peel Strength (lbs/0.5 in)		Peel Strength (pli)
1 1 1	4		2.8		5.6
1 1 1	8		2.4		4.8
1 1 1	10		2.0		4.0
1 1 1	11		2.1		4.2
1 1 1	15		1.6		3.2
1 1 1	21		2.0		4.0
		Average	2.2		4.3
		Standard Deviation	0.4		0.8
2-Propanol	3		2.4		4.8
2-Propanol	8		3.0		6.0
2-Propanol	10		2.8		5.6
2-Propanol	12		2.8		5.6
2-Propanol	17		2.4		4.8
2-Propanol	18		2.5		5.0
		Average	2.7		5.3
		Standard Deviation	0.3		0.5
Parts Prep	5		3.4		6.8
Parts Prep	8		3.4		6.8
Parts Prep	10		3.7		7.4
Parts Prep	12		3.4		6.8
Parts Prep	14		3.3		6.6
Parts Prep	17		3.0		6.0
		Average	3.4		6.7
		Standard Deviation	0.2		0.5
Callasolve 120	2		2.1		4.2
Callasolve 120	3		1.8		3.6
Callasolve 120	6		2.8		5.6
Callasolve 120	10		2.4		4.8
Callasolve 120	12		3.0		6.0
Callasolve 120	17		3.3		6.6
		Average	2.6		5.1
		Standard Deviation	0.6		1.1

Table 25. Peel Strength t-Test Results for a 95% Confidence Interval (Manufacturing Simulation)

T (°F)	Adherends	Sample 1	Sample 2	t	t Critical	P (one-tail)
75	7075-T6 Aluminum	1 1 1 Trichloroethane	2-Propanol	6.27192	2.01505	0.00076
75	7075-T6 Aluminum	1 1 1 Trichloroethane	Parts Prep	0.59037	2.01505	0.29031
75	7075-T6 Aluminum	1 1 1 Trichloroethane	Callasolve 120	2.28333	2.01505	0.03562
75	Electroformed Nickel	1 1 1 Trichloroethane	2-Propanol	1.30973	2.01505	0.12362
75	Electroformed Nickel	1 1 1 Trichloroethane	Parts Prep	14.06973	2.01505	0.00002
75	Electroformed Nickel	1 1 1 Trichloroethane	Callasolve 120	7.99205	2.01505	0.00025
75	AM355 Stainless Steel	1 1 1 Trichloroethane	2-Propanol	2.33126	2.01505	0.03355
75	AM355 Stainless Steel	1 1 1 Trichloroethane	Parts Prep	9.42847	2.01505	0.00011
75	AM355 Stainless Steel	1 1 1 Trichloroethane	Callasolve 120	-3.65148	2.01505	0.00736
75	6Al-4V Titanium	1 1 1 Trichloroethane	2-Propanol	-1.40237	2.01505	0.10987
75	6Al-4V Titanium	1 1 1 Trichloroethane	Parts Prep	-3.76427	2.01505	0.00655
75	6Al-4V Titanium	1 1 1 Trichloroethane	Callasolve 120	-1.70139	2.01505	0.07480
140	7075-T6 Aluminum	1 1 1 Trichloroethane	2-Propanol	3.76912	2.01505	0.00652
140	7075-T6 Aluminum	1 1 1 Trichloroethane	Parts Prep	-0.55101	2.01505	0.30267
140	7075-T6 Aluminum	1 1 1 Trichloroethane	Callasolve 120	3.27715	2.01505	0.01101
140	Electroformed Nickel	1 1 1 Trichloroethane	2-Propanol	0.12199	2.01505	0.45383
140	Electroformed Nickel	1 1 1 Trichloroethane	Parts Prep	1.12660	2.01505	0.15553
140	Electroformed Nickel	1 1 1 Trichloroethane	Callasolve 120	4.46291	2.01505	0.00331
140	AM355 Stainless Steel	1 1 1 Trichloroethane	2-Propanol	-2.70434	2.01505	0.02128
140	AM355 Stainless Steel	1 1 1 Trichloroethane	Parts Prep	0.06378	2.01505	0.47581
140	AM355 Stainless Steel	1 1 1 Trichloroethane	Callasolve 120	-3.36576	2.01505	0.00999
140	6Al-4V Titanium	1 1 1 Trichloroethane	2-Propanol	1.38350	2.01505	0.11255
140	6Al-4V Titanium	1 1 1 Trichloroethane	Parts Prep	-4.21831	2.01505	0.00417
140	6Al-4V Titanium	1 1 1 Trichloroethane	Callasolve 120	-1.22506	2.01505	0.13756
-67	7075-T6 Aluminum	1 1 1 Trichloroethane	2-Propanol	26.84080	2.01505	0.00000
-67	7075-T6 Aluminum	1 1 1 Trichloroethane	Parts Prep	-2.00562	2.01505	0.05061
-67	7075-T6 Aluminum	1 1 1 Trichloroethane	Callasolve 120	-6.24175	2.01505	0.00077
-67	Electroformed Nickel	1 1 1 Trichloroethane	2-Propanol	-0.82448	2.01505	0.22360
-67	Electroformed Nickel	1 1 1 Trichloroethane	Parts Prep	3.94941	2.01505	0.00543
-67	Electroformed Nickel	1 1 1 Trichloroethane	Callasolve 120	3.00276	2.01505	0.01500
-67	AM355 Stainless Steel	1 1 1 Trichloroethane	2-Propanol	1.16775	2.01505	0.14778
-67	AM355 Stainless Steel	1 1 1 Trichloroethane	Parts Prep	0.43853	2.01505	0.33965
-67	AM355 Stainless Steel	1 1 1 Trichloroethane	Callasolve 120	0.29881	2.01505	0.38855
-67	6Al-4V Titanium	1 1 1 Trichloroethane	2-Propanol	-3.80571	2.01505	0.00628
-67	6Al-4V Titanium	1 1 1 Trichloroethane	Parts Prep	-3.01257	2.01505	0.01483
-67	6Al-4V Titanium	1 1 1 Trichloroethane	Callasolve 120	-1.77229	2.01505	0.06827

Table 26. Peel Strength t-Test Results for a 95% Confidence Interval (Repair Simulation)

T (°F)	Adherends	Sample 1	Sample 2	t	t Critical	P (one-tail)
75	7075-T6 Aluminum	1 1 1 Trichloroethane	2-Propanol	6.52490	2.01505	0.00063
75	7075-T6 Aluminum	1 1 1 Trichloroethane	Parts Prep	2.41792	2.01505	0.03014
75	7075-T6 Aluminum	1 1 1 Trichloroethane	Callasolve 120	4.62898	2.01505	0.00284
75	Electroformed Nickel	1 1 1 Trichloroethane	2-Propanol	-0.69561	2.01505	0.25884
75	Electroformed Nickel	1 1 1 Trichloroethane	Parts Prep	-1.56670	2.01505	0.08898
75	Electroformed Nickel	1 1 1 Trichloroethane	Callasolve 120	-2.44451	2.01505	0.02916
75	AM355 Stainless Steel	1 1 1 Trichloroethane	2-Propanol	-7.05024	2.01505	0.00044
75	AM355 Stainless Steel	1 1 1 Trichloroethane	Parts Prep	-5.27016	2.01505	0.00164
75	AM355 Stainless Steel	1 1 1 Trichloroethane	Callasolve 120	-22.00000	2.01505	0.00000
75	6Al-4V Titanium	1 1 1 Trichloroethane	2-Propanol	1.81458	2.01505	0.06465
75	6Al-4V Titanium	1 1 1 Trichloroethane	Parts Prep	-3.76848	2.01505	0.00652
75	6Al-4V Titanium	1 1 1 Trichloroethane	Callasolve 120	-4.29806	2.01505	0.00386
140	7075-T6 Aluminum	1 1 1 Trichloroethane	2-Propanol	7.01615	2.01505	0.00045
140	7075-T6 Aluminum	1 1 1 Trichloroethane	Parts Prep	1.96621	2.01505	0.05322
140	7075-T6 Aluminum	1 1 1 Trichloroethane	Callasolve 120	2.52163	2.01505	0.02653
140	Electroformed Nickel	1 1 1 Trichloroethane	2-Propanol	-0.03111	2.01505	0.48819
140	Electroformed Nickel	1 1 1 Trichloroethane	Parts Prep	0.52597	2.01505	0.31070
140	Electroformed Nickel	1 1 1 Trichloroethane	Callasolve 120	0.68299	2.01505	0.26248
140	AM355 Stainless Steel	1 1 1 Trichloroethane	2-Propanol	1.52837	2.01505	0.09348
140	AM355 Stainless Steel	1 1 1 Trichloroethane	Parts Prep	3.29670	2.01505	0.01078
140	AM355 Stainless Steel	1 1 1 Trichloroethane	Callasolve 120	-0.22741	2.01505	0.41455
140	6Al-4V Titanium	1 1 1 Trichloroethane	2-Propanol	4.33917	2.01505	0.00372
140	6Al-4V Titanium	1 1 1 Trichloroethane	Parts Prep	1.69269	2.01505	0.07565
140	6Al-4V Titanium	1 1 1 Trichloroethane	Callasolve 120	1.53574	2.01505	0.09260
-67	7075-T6 Aluminum	1 1 1 Trichloroethane	2-Propanol	8.87796	2.01505	0.00015
-67	7075-T6 Aluminum	1 1 1 Trichloroethane	Parts Prep	-1.22390	2.01505	0.13776
-67	7075-T6 Aluminum	1 1 1 Trichloroethane	Callasolve 120	4.69505	2.01505	0.00268
-67	Electroformed Nickel	1 1 1 Trichloroethane	2-Propanol	0.00000	2.01505	0.50000
-67	Electroformed Nickel	1 1 1 Trichloroethane	Parts Prep	-1.16775	2.01505	0.14778
-67	Electroformed Nickel	1 1 1 Trichloroethane	Callasolve 120	-3.87298	2.01505	0.00586
-67	AM355 Stainless Steel	1 1 1 Trichloroethane	2-Propanol	-0.80757	2.01505	0.22801
-67	AM355 Stainless Steel	1 1 1 Trichloroethane	Parts Prep	0.00000	2.01505	0.50000
-67	AM355 Stainless Steel	1 1 1 Trichloroethane	Callasolve 120	-2.00000	2.01505	0.05097
-67	6Al-4V Titanium	1 1 1 Trichloroethane	2-Propanol	-2.68543	2.01505	0.02177
-67	6Al-4V Titanium	1 1 1 Trichloroethane	Parts Prep	-6.84308	2.01505	0.00051
-67	6Al-4V Titanium	1 1 1 Trichloroethane	Callasolve 120	-1.11514	2.01505	0.15775

Table 27. 1 1 1 Trichloroethane Performance versus the Proposed Replacements

T (°F)	Simulation	Adherends	1 1 1 Peformance Superior to:	1 1 1 Performance Equivalent to:.	1 1 1 Performance Inferior to:
75	Manufacturing	7075-T6 Aluminum	2-Propanol	Parts Prep	
			Callasolve 120		
75	Manufacturing	Electroformed Nickel	Parts Prep	2-Propanol	
			Callasolve 120		
75	Manufacturing	AM355 Stainless Steel	2-Propanol		Callasolve 120
			Parts Prep		
75	Manufacturing	6Al-4V Titanium		2-Propanol	Parts Prep
				Callasolve 120	
140	Manufacturing	7075-T6 Aluminum	2-Propanol	Parts Prep	
			Callasolve 120		
140	Manufacturing	Electroformed Nickel	Callasolve 120	2-Propanol	
				Parts Prep	
140	Manufacturing	AM355 Stainless Steel		Parts Prep	2-Propanol
					Callasolve 120
140	Manufacturing	6Al-4V Titanium		2-Propanol	Parts Prep
				Callasolve 120	
-67	Manufacturing	7075-T6 Aluminum	2-Propanol	Parts Prep	Callasolve 120
-67	Manufacturing	Electroformed Nickel	Parts Prep	2-Propanol	
			Callasolve 120		
-67	Manufacturing	AM355 Stainless Steel		2-Propanol	
				Parts Prep	
				Callasolve 120	
-67	Manufacturing	6Al-4V Titanium		Callasolve 120	2-Propanol
					Parts Prep
75	Repair	7075-T6 Aluminum	2-Propanol		
			Parts Prep		

Table 27. 1 1 1 Trichloroethane Performance versus the Proposed Replacements

T (°F)	Simulation	Adherends	1 1 1 Peformance Superior to:	1 1 1 Performance Equivalent to;	1 1 1 Performance Inferior to:
			Callasolve 120		
75	Repair	Electroformed Nickel		2-Propanol	Callasolve 120
				Parts Prep	
75	Repair	AM355 Stainless Steel			2-Propanol
					Parts Prep
					Callasolve 120
75	Repair	6Al-4V Titanium		2-Propanol	Parts Prep
					Callasolve 120
140	Repair	7075-T6 Aluminum	2-Propanol	Parts Prep	
			Callasolve 120		
140	Repair	Electroformed Nickel		2-Propanol	
				Parts Prep	
				Callasolve 120	
140	Repair	AM355 Stainless Steel	Parts Prep	2-Propanol	
				Callasolve 120	
140	Repair	6Al-4V Titanium	2-Propanol	Parts Prep	
				Callasolve 120	
-67	Repair	7075-T6 Aluminum	2-Propanol	Parts Prep	
			Callasolve 120		
-67	Repair	Electroformed Nickel		2-Propanol	Callasolve 120
				Parts Prep	
-67	Repair	AM355 Stainless Steel		2-Propanol	
				Parts Prep	
				Callasolve 120	
-67	Repair	6Al-4V Titanium		Callasolve 120	2-Propanol
					Parts Prep

REFERENCES

1. ASTM D3933-80, Standard Practice for Preparation of Aluminum Surfaces for Structural Adhesive Bonding (Phosphoric Acid Anodizing).

2. HP 4-49, Bonding, Adhesive - Processing for Nickel and CRES Alloys, McDonnell Douglas Helicopter Company.

3. HP 4-121, Etching of Precipitation-Hardening AM355 Stainless Steel for Adhesive Bonding, McDonnell Douglas Helicopter Company.

4. HP 4-120, Preparation of Titanium for Adhesive Bonding, McDonnell Douglas Helicopter Company.

5. ASTM D3167-76, Standard Test Method for Floating Roller Peel Resistance of Adhesives.

Section 6:

Alternative Cleaner Effects on Non-Destructive Inspection

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The main focus of this portion of the program was to find a cleaner that could be utilized as a replacement for 1,1,1 on the Depot Maintenance Work Requirements (DMWRs). It has been determined that the most excessive utilization of 1,1,1 trichloroethane in all of the NDI techniques is for the fluorescent penetrant inspection method according to MIL-STD-6866, specifically the solvent removable and the post-emulsifiable methods. Additionally, since those FPI methods require the highest level of cleanliness, if a replacement cleaner works well with these processes, it will work for all other NDI procedures as long as material compatibility is maintained.

Effects of Candidates on NDI

Both methods of FPI employ 1,1,1 trichloroethane during the pre-cleaning stages. The solvent removable method uses 1,1,1 trichloroethane during the crucial stage of removing the penetrant dye from the area where the indication is to be seen. The function of a solvent remover is to remove the excess penetrant from the part after allowing penetrant to seep into the crack or discontinuity. Ideally, the solvent remover would completely remove all the penetrant from the surface only, and any penetrant within a discontinuity would remain. During the final step of FPI, a developer would be applied to the surface and the discontinuity would be highlighted by the penetrant dye as a result of capillary action. If the solvent remover dissolved or mixed with the penetrant and carried it out of the discontinuity, the flaw would not be able to be detected during the developer stage. The solvent removal process involves removing excess penetrant with successive clean rags or towels until penetrant cannot be seen on the rag or towel. Then a clean rag or towel is dampened (not saturated) with solvent remover, and the remaining excess penetrant is removed. The 1,1,1 trichloroethane utilized as a solvent remover is very effective. When using 1,1,1 trichloroethane, it is not necessary to adhere to the exact procedures, since the process variables are very tolerant to slight changes in procedure. Since 1,1,1 trichloroethane solubilizes debris and grease-containing contaminants in addition to the dyes utilized in the FPI process, it has the ability to remove most contaminants and excess dye without affecting the dye within a discontinuity. Class 2 solvent removers will not be as tolerant of changes in the procedure. The exact procedures must, therefore, be closely followed in order to achieve consistent results.

The technique for determining a feasible replacement for 1,1,1 trichloroethane in the FPI process was to utilize the most prospective cleaners in both the solvent removable and post-emulsifiable methods in addition to their use as a pre-cleaner of a standard contaminant. Indications are typically interpreted by a certified inspector. Since there can be considerable variation in interpretation from inspector to inspector, a light photometer was employed to detect the brightness of the indications achieved from each prospective replacement, thereby making the FPI results quantitative rather than qualitative. The most difficult indications to detect and achieve reliable and consistent results are the smallest cracks and discontinuities. Therefore, testing was performed on three (3) cracked bars fabricated from the specified materials of Ti-6Al-4V or Inconel 718 that contained minute cracks between 20 and 60 mils, 0.020 and 0.060 inches in length. Results were then compared with the control group, which employed cleaning with 1,1,1 trichloroethane. There also existed concern that some of the replacement cleaners or solvent removers would wash out an indication from a large or wide crack. Therefore, a larger crack, 0.372 inch long was utilized in conjunction with 1,1,1 trichloroethane and the alternatives to determine their effectiveness on large cracks and discontinuities.

The following discussion has been condensed and provides a general overview of the manner in which cracks of known size were propagated in FPI test panels. The cracked test specimens were prepared by machining a specimen geometry that could be fitted into a fatigue testing machine and cycled until a specific crack size was obtained. Calculations were made to pre-determine the proper loading configuration prior to fatigue testing, and a lot of trial and error prevailed during this phase of the program. In order to quantify the exact length and depth of the crack, a number of cracks had to be opened and measured. Measurements of crack depth and length were determined by fractographic analysis utilizing the scanning electron microscope (SEM). The actual fatigue crack region would contain a transgranular morphology that could easily be distinguished from that of the laboratory-induced overload, which would yield a dimpled topography. Once a particular crack size was attained repeatedly, as confirmed by breaking open the crack and examining the fracture surface under the SEM, the exact parameters of the fatigue test already tested would simply be repeated an additional time to produce another specimen. However, this time the crack was left intact, ready for FPI.

The following instruments and/or materials were utilized in the FPI portion of the program:

1) **MoS_2 Grease:** 5% molybdenum disulfide grease was prepared by blending MoS_2 with KSL performance grease from Keystone Lubricants Inc. (MIL-G-81322 or MIL-G-21164). For both methods, the grease was mixed with Mobil 25 hydraulic fluid (MIL-H-83282) at a ratio of two parts hydraulic fluid to one part grease.

2) **Photo Research, Model UBD, PR-1500 Spectra Spotmeter, Photomultiplier-tube Optical Photometer.** Utilized to obtain light or indication brightness from test coupons during solvent removable and post-emulsifiable methods of FPI.

3) **Developer** - D-1, Type I, Form A, Dry Powder, Magnaflux ZP-4B.

4) **Emulsifier** - 20 % FE-2, Type I, Method D, Magnaflux ZR-10B.

5) **Penetrant** - FP-4, Type I, Level 4, Method B-C and D, Sherwin RC-77.

6) **Test Coupons** - 4 different test coupons were utilized:
   a) Inconel 718 - Bar, 1 × 6 × 0.25 inch with a 0.021-inch crack in the center of its surface labeled "R-91."
   b) Inconel 718 - Bar, 1 × 6 × 0.25 inch with a 0.052-inch crack in the center of its surface labeled "R-70."
   c) Ti-6Al-4V - Bar, 1 × 6 × 0.25 inch with a 0.054-inch crack in the center of its surface labeled "T-62."
   d) Ti-6Al-4V - Bar, 1 × 6 × 0.25 inch with a 0.372-inch crack in the center of its surface labeled "T-1."

Procedure

Solvent Removable Method - MIL-STD-6866

1) All test bars were pre-cleaned in the following manner:
    a) Hand wash with soapy water (typical Alconox solution).
    b) Dip bar in methanol.
    c) Place bar in 1,1,1 trichloroethane an ultrasonically clean for 10 minutes.

2) Application of Contaminant
    a) Utilizing a clean glass rod, apply two drops of the contaminant to the test bar.
    b) Utilizing a wooden applicator, evenly spread the contaminant over the surface of the bar.
    c) Place the bar in a dry air circulating oven for 2 hours @ 130° F.

3) Cleaning of Contaminant
    a) Apply cleaner to rag/paper towel to remove large deposits.
    b) Continue to wipe bar, changing wiping area of rag frequently until there does not appear to be any more contaminant to be removed form the surface (rag is clean).
    c) Submerge bars in bath of candidate cleaner and place in ultrasonic cleaner for 10 minutes.
    d) Remove bars from bath and place in oven at 130° F for 5 minutes (additional time may be necessary for some cleaners). Allow to cool for approximately 3 minutes.

4) Liquid Penetrant
    a) Dip bar in liquid penetrant (LP) or apply LP to the bar with an acid brush.
    b) Allow the LP to sit for 5 minutes.
    c) Wipe excess LP off the bar with a clean rag until no more LP is being removed (i.e., the rag remains clean). DO NOT use any solvent on the rag at this time.
    d) With a solvent-dampened (the one used for pre-cleaning) clean rag, wipe the bar. Place the bar occasionally under the black light to observe the amount of the LP on the surface. Continue to wipe until there is no longer any streaks of LP on the surface of the bar.
    e) Place the bars in the oven at 130° F for 5 minutes.

5) Developer
    a) Remove bars from oven.
    b) Place bar in developer, allowing the developer to glide off the bar, and then let sit for 5 minutes.

6) Brightness Measurements
    a) Calibrate instrument.
    b) Measure the background value on the surface near the crack in the bar.
    c) Measure the value of the crack indication.
    d) For the total value of the indication, subtract the background reading from the crack reading.
    e) Record all measurements and observations.

7) Post-Wash
    a) Clean off developer from the bar in soapy water (Alconox solution).
    b) Rinse with clean water.
    c) Dip bar in methanol.
    d) Place bar in 1,1,1 trichloroethane and put in an ultrasonic cleaner for 10 minutes.
    e) Check bars with black light to ensure penetrant has been removed from indications.
    f) Oven dry bars at 130° F for 5 minutes and allow to cool for 3 minutes before reusing.

Post-Emulsifiable Method - MIL-STD-6866

The testing for the post-emulsifiable method was performed utilizing two separate testing procedures. These testing procedures are defined as follows:

Test # 1:

1) All test bars were pre-cleaned in the following manner:
    a) Hand wash with soapy water (typical Alconox solution).
    b) Dip bar in methanol.
    c) Place bar in 1,1,1 trichloroethane and ultrasonically clean for 10 minutes.

2) Application of Contaminant
    a) Utilizing a clean glass rod, apply two drops of the contaminant to the test bar.
    b) Utilizing a wooden applicator, evenly spread the contaminant over the surface of the bar.
    c) Place the bar in a dry air circulating oven for 2 hours @ 130° F.

3) Cleaning of Contaminant
    a) Aqueous cleaner with brush to remove heavy deposits.
    b) Rinse with clean water.
    c) Dip in methanol and lightly agitate to remove excess fluid.
    d) Submerge bars in bath of candidate cleaner and place in ultrasonic cleaner for 10 minutes.
    e) Remove bars from bath and place in oven at 130° F for 5 minutes (additional time may be necessary for some cleaners). Remove bars and allow to cool for approximately 3 minutes.

4) Application of Liquid Penetrant
    a) Dip bar in liquid penetrant (LP) or apply LP to the bar with an acid brush.
    b) Allow the LP to sit for 5 minutes.
    c) With black light on, rinse bars to remove the bulk of the surface penetrant by:
        - Manual spray utilizing a maximum water pressure of 40 PSI and a water temperature of 50° F–100° F. A coarse spray nozzle should be at an angle of 45°, and at a distance of approximately 12 inches between the bar and the nozzle tip. Washing times should be kept to a minimum.
    d) After rinsing, blot bars dry utilizing a clean absorbent material.

5) Application of Hydrophilic Emulsifier (20% by Volume)
   - a) Dip bar in emulsifier, hold for approximately 5 seconds, and then remove and stand specimens upright for remainder of dwell time. Total dwell time should not exceed 2 minutes. Optimum dwell time is approximately 1 minute 50 seconds.
   - b) With black light on, rinse bars to remove visible surface penetrant by:
     - Manual spray utilizing a maximum water pressure of 40 PSI and a water temperature of 50° F–100° F. A coarse spray nozzle should be at an angle of 45°, and at a distance of approximately 12 inches between the bar and the nozzle tip. Washing times should be kept to a minimum.
   - c) Place bars in oven at 130° F for 5 minutes.
   - d) Remove from oven and allow to cool for 3 minutes.

6) Application of Developer
   - a) Dip bar in developer and allow developer to glide off the bar.
   - b) Dwell time of 5 minutes.

7) Brightness Measurements
   - a) Ensure spotmeter has been zeroed, calibrated, and focused at daily start-up. Check zeroing periodically.
   - b) Take all measurements in similar sequence and minimize the amount of time between readings to ensure similar dwell times.
   - c) Measure the value of the crack indication.
   - d) Measure the background value on the surface near the crack.
   - e) For the total value, subtract the background reading from the crack value.
   - f) Record all measurements and observations.

8) Photography
   - a) Set camera for approximately 2x mag. photos.
   - b) Use white paper background.
   - c) Align specimen under camera.
   - d) Set aperture to f16.
   - e) Hold a yellow filter over lens.
   - f) For R 70 and T61, shot time shall be 40 seconds. For R 91 use 60 seconds (for ISO 800 Type 53 film).
   - g) Remove film form camera and wait 30 seconds for film to develop.

9) Post-Wash
   - a) Clean off developer from the bar in soapy water (Alconox solution).
   - b) Rinse with clean water.
   - c) Dip bar in methanol.
   - d) Place bar in 1,1,1 trichloroethane and put in an ultrasonic cleaner for 10 minutes.
   - e) Check bars with black light to ensure penetrant has been removed from indications.
   - f) Oven dry bars at 130° F for 5 minutes and allow to cool for 3 minutes before reusing.

Test # 2:

1) All test bars were pre-cleaned in the following manner:
   a) Hand wash with soapy water (typical Alconox solution).
   b) Dip bar in methanol.
   c) Place bar in 1,1,1 trichloroethane an ultrasonically clean for 10 minutes.

2) Application of Contaminant
   a) Utilizing a clean glass rod, apply two drops of the contaminant to the test bar.
   b) Utilizing a wooden applicator, evenly spread the contaminant over the surface of the bar.
   c) Place the bar in a dry air circulating oven for 2 hours @ 130° F.

3) Cleaning of Contaminant
   a) Wipe off contaminant with a clean dry cloth until visually clean.
   b) Place bar in alternative solvent and place in ultrasonic tank for 10 minutes.
   c) Place the bar in a dry air circulating oven for 2 hours @ 130° F.
   d) Remove bars from oven and allow to cool for approximately 3 minutes.

4) Application of Liquid Penetrant
   a) Dip bar in LP or apply LP to the bar with an acid brush.
   b) Allow the LP to sit for 5 minutes.
   c) With black light on, rinse bars to remove the bulk of the surface penetrant by:
      - Manual spray utilizing a maximum water pressure of 40 PSI and a water temperature of 50° F–100° F. A coarse spray nozzle should be at an angle of 45°, and at a distance of approximately 12 inches between the bar and the nozzle tip. Washing times should be kept to a minimum.
   d) After rinsing, blot bars dry utilizing a clean absorbent material.

5) Application of Hydrophilic Emulsifier (20% by Volume)
   a) Dip bar in emulsifier, hold for approximately 5 seconds, and then remove and stand specimens upright for remainder of dwell time. Total dwell time should not exceed 2 minutes. Optimum dwell time is approximately 1 minute 50 seconds.
   b) With black light on, rinse bars to remove visible surface penetrant by:
      - Manual spray utilizing a maximum water pressure of 40 PSI and a water temperature of 50° F–100° F. A coarse spray nozzle should be at an angle of 45°, and at a distance of approximately 12 inches between the bar and the nozzle tip. Washing times should be kept to a minimum.
   c) Place bars in oven at 130° F for 5 minutes.
   d) Remove from oven and allow to cool for 3 minutes.

6) Application of Developer
   a) Dip bar in developer and allow developer to glide off the bar.
   b) Dwell time of 5 minutes.

7) Brightness Measurements
   a) Ensure spotmeter has been zeroed, calibrated, and focused at daily start-up. Check zeroing periodically.
   b) Take all measurements in similar sequence and minimize the amount of time between readings to ensure similar dwell times.
   c) Measure the value of the crack indication.
   d) Measure the background value on the surface near the crack.
   e) For the total value, subtract the background reading from the crack value.
   f) Record all measurements and observations.

8) Photography
   a) Set camera for approximately 2x mag. photos.
   b) Use white paper background.
   c) Align specimen under camera.
   d) Set aperture to f16.
   e) Hold a yellow filter over lens.
   f) For R 70 and T61, shot time shall be 40 seconds. For R 91 use 60 seconds (for ISO 800 Type 53 film).
   g) Remove film form camera and wait 30 seconds for film to develop.

9) Post Wash
   a) Clean off developer from the bar in soapy water (Alconox solution).
   b) Rinse with clean water.
   c) Dip bar in methanol.
   d) Place bar in 1,1,1 trichloroethane and put in an ultrasonic cleaner for 10 minutes.
   e) Check bars with black light to ensure penetrant has been removed from indications.
   f) Oven dry bars at 130° F for 5 minutes and allow to cool for 3 minutes before reusing.

Results:

The data presented on the following pages represent the solvent removable and post-emulsifiable methods of FPI as they were utilized to test the alternative cleaners in comparison with 1,1,1 trichloroethane. An analysis of this data can be found immediately thereafter.

FPI Test Results

Solvent Removable Method

	Specimen	Spotmeter Background Reading	Spotmeter Indication Reading	Total Reading	Difference From 1,1,1 Trichloroethane	Relative Ranking (1-5)	Date Testing Performed
Cleaners							
1,1,1	T-62	0.10	20.80	20.70	-	2	
	R-70	0.14	10.60	10.46	-	2	5/10/95
	R-91	0.16	0.85	0.69	-	2	
Citrex	T-62	1.55	4.77	3.22	17.48	4	
	R-70	0.86	7.50	6.64	3.82	4	5/10/95
	R-91	0.08	0.09	0.01	0.68	5	
Teksol EP	T-62	0.34	12.08	11.74	8.96	4	
	R-70	0.23	7.30	7.07	3.39	3	5/10/95
	R-91	0.24	0.25	0.01	0.68	5	
1,1,1	T-62	0.63	41.30	40.67	---	2	
	R-70	0.24	41.50	41.26	---	1	5/11/95
	R-91	0.28	1.50	1.22	---	2	
Magnuflux SKC-HF	T-62	0.42	16.06	15.64	25.03	3	
	R-70	0.37	12.05	11.68	29.58	3	5/11/95
	R-91	0.08	0.69	0.61	0.61	2	
Axarel 56	T-62	0.20	47.50	47.30	-6.63	3	
	R-70	0.22	27.80	27.58	13.68	2	5/11/95
	R-91	0.12	0.14	0.02	1.20	3	
1,1,1	T-62	0.32	45.20	44.88	---	1	
	R-70	0.23	44.20	43.97	---	1	5/12/95
	R-91	0.28	1.39	1.11	---	1	
DS-108	T-62	0.07	22.70	22.63	22.25	2	
	R-70	0.06	22.10	22.04	21.93	2	5/12/95
	R-91	0.07	---	---	---	5	
TPC Solvent	T-62	0.33	23.60	23.27	21.61	3	
	R-70	0.43	17.10	16.67	27.30	3	5/12/95
	R-91	0.25	0.33	0.08	1.03	3	

1,1,1	T-62	0.14	24.60	24.46	---	1	
	R-70	0.21	30.80	30.59	---	1	5/15/95
	R-91	0.13	0.64	0.51	---	1	
BioAct 113	T-62	0.01	15.35	15.34	9.12	2	
	R-70	0.09	20.50	20.41	10.18	2	5/15/95
	R-91	0.07	0.22	0.15	0.36	2	
Electron NDE	T-62	0.13	13.81	13.68	10.78	3*	
	R-70	0.31	7.94	7.63	22.96	4*	5/15/95
	R-91	0.14	---	---	---	5*	
	* Not enough cleaner available for ultrasonic immersion						
Desoclean 45	T-62	0.07	37.10	37.03	-12.57	1	
	R-70	0.09	10.70	10.61	19.98	1	5/15/95
	R-91	0.07	1.60	1.53	-1.02	1	
1,1,1	T-62	0.20	42.80	42.60	---	1	
	R-70	0.22	30.60	30.38	---	1	5/16/95
	R-91	0.21	1.61	1.40	---	1	
P-D-680	T-62	0.62	19.66	19.04	23.56	3	
	R-70	0.26	28.60	28.34	2.04	3	5/16/95
	R-91	0.16	0.19	0.03	1.37	3	
Isopropyl Alcohol	T-62	0.09	24.20	24.11	18.49	2	
	R-70	0.13	42.90	42.77	-12.39	1	5/16/95
	R-91	0.09	0.61	0.52	0.88	2	
Citrex	T-62	1.37	5.79	4.42	14.62	4	
	R-70	0.07	21.30	21.23	7.11	3	5/16/95
	R-91	0.06	---	---	---	5	

FPI Test Results
Post-Emusifiable Method - Test # 1

	Specimen	Spotmeter Background Reading	Spotmeter Indication Reading	Total Reading	Difference From 1,1,1 Trichloroethane	Relative Ranking (1-5)	Date Testing Performed
Cleaners							
1,1,1	T-62	0.80	21.40	20.60	-	2	6/21/95
	R-70	0.90	28.00	27.10	-	2	
	R-91	1.00	2.30	1.30	-	1	
Citrex	T-62	0.60	23.10	22.50	-1.90	2	6/21/95
	R-70	0.60	38.50	37.90	-10.80	1	
	R-91	0.70	1.50	0.80	0.50	1	
Teksol EP	T-62	0.60	49.50	48.90	-28.30	1	6/21/95
	R-70	0.60	34.50	33.90	-6.80	1	
	R-91	0.70	1.80	1.10	0.20	1	
1,1,1	T-62	0.70	30.50	29.80	---	1	6/22/95
	R-70	0.60	39.00	38.40	---	1	
	R-91	0.70	1.40	0.70	---	1	
Magnuflux SKC-HF	T-62	0.60	31.50	30.90	-1.10	1	6/22/95
	R-70	0.60	36.00	35.40	3.00	1	
	R-91	0.80	2.60	1.80	-1.10	1	
DS-108	T-62	0.70	15.90	15.20	14.60	2	6/22/95
	R-70	0.70	37.60	36.90	1.50	1	
	R-91	0.70	1.50	0.80	-0.10	1	
Axarel 56	T-62	0.70	21.00	20.30	9.50	3	6/22/95
	R-70	0.70	20.00	19.30	19.10	3	
	R-91	0.80	1.20	0.40	0.30	2	

1,1,1	T-62	0.70	18.10	17.40	---	2	
	R-70	0.70	37.00	36.30	---	1	6/23/95
	R-91	0.70	2.20	1.50	---	1	
TPC Solvent	T-62	0.70	19.50	18.80	-1.40	1	
	R-70	0.70	24.10	23.40	12.90	2	6/23/95
	R-91	0.70	1.10	0.40	1.10	2	
TPC Solvent	T-62	0.70	12.60	11.90	5.50	3	
	R-70	0.70	28.40	27.70	8.60	3	6/23/95
	R-91	0.80	1.10	0.30	1.20	2	
Isopropyl Alcohol	T-62	0.80	23.00	22.20	-4.80	1	
	R-70	0.80	38.20	37.40	-1.10	1	6/23/95
	R-91	0.80	1.26	0.46	1.04	2	
1,1,1	T-62	0.72	25.20	24.48	---	2	
	R-70	0.65	44.00	43.35	---	1	6/24/95
	R-91	0.71	1.50	0.79	---	1	
P-D-680	T-62	0.70	37.60	36.90	-12.42	1	
	R-70	0.70	43.20	42.50	0.85	2	6/24/95
	R-91	0.70	1.30	0.60	0.19	1	
Electron NDE	T-62	0.68	33.90	33.22	-8.74	1	
	R-70	0.61	43.20	42.59	0.76	2	6/24/95
	R-91	0.76	1.30	0.54	0.25	1	
Desoclean 45	T-62	0.60	37.10	36.50	-12.02	1	
	R-70	0.65	10.70	10.05	33.30	2	6/24/95
	R-91	0.68	1.60	0.92	-0.13	1	

FPI Test Results

Post-Emusifiable Method - Test # 2

	Specimen	Spotmeter Background Reading	Spotmeter Indication Reading	Total Reading	Difference From 1,1,1 Trichloroethane	Relative Ranking (1-5)	Date Testing Performed
Cleaners							
1,1,1	T-62	0.79	17.60	16.81	-	1	6/25/95
	R-70	0.72	37.00	36.28	-	2	
	R-91	0.80	1.20	0.40	-	2	
Citrex	T-62	0.73	17.20	16.47	0.34	2	6/25/95
	R-70	0.74	43.90	43.16	-6.88	1	
	R-91	0.83	1.33	0.50	-0.10	1	
Teksol EP	T-62	0.78	27.60	26.82	-10.01	1	6/25/95
	R-70	0.80	43.60	42.80	-6.52	1	
	R-91	0.85	1.34	0.49	-0.09	1	
1,1,1	T-62	0.79	28.30	27.51	---	1	6/26/95
	R-70	0.77	40.10	39.33	---	1	
	R-91	0.82	1.29	0.47	---	1	
Magnuflux SKC-HF	T-62	0.87	16.70	15.83	11.68	2	6/26/95
	R-70	0.86	46.30	45.44	-6.11	1	
	R-91	0.92	1.27	0.35	0.12	2	
Axarel 56	T-62	0.81	21.50	20.69	6.82	3	6/26/95
	R-70	0.77	31.70	30.93	8.40	2	
	R-91	0.85	1.70	0.85	-0.38	1	
Magnuflux SKC-HF	T-62	0.85	19.10	18.25	9.26	3	6/26/95
	R-70	0.85	17.10	16.25	23.08	2	
	R-91	0.91	1.70	0.79	-0.32	1	

1,1,1	T-62	0.80	29.60	28.80	---	1	
	R-70	0.82	41.00	40.18	---	1	6/27/95
	R-91	0.89	2.50	1.61	---	1	
DS-108	T-62	0.76	25.50	24.74	4.06	2	
	R-70	0.70	41.10	40.40	-0.22	1	6/27/95
	R-91	0.83	2.80	1.97	-0.36	1	
TPC Solvent	T-62	0.83	21.90	21.07	7.73	3	
	R-70	0.81	33.40	32.59	7.59	3	6/27/95
	R-91	0.88	2.00	1.12	0.49	3	
Bioact 113	T-62	0.87	17.50	16.63	12.17	4	
	R-70	0.90	24.20	23.30	16.88	5	6/27/95
	R-91	0.90	1.58	0.68	0.93	4	
Electron NDE	T-62	0.79	21.10	20.31	8.49	3	
	R-70	0.80	39.10	38.30	1.88	3	6/27/95
	R-91	0.81	1.75	0.94	0.67	3	
1,1,1	T-62	0.80	20.70	19.90	---	1	
	R-70	0.79	47.90	47.11	---	1	6/28/95
	R-91	0.86	2.26	1.40	---	1	
Desoclean 45	T-62	0.84	20.70	19.86	0.04	1	
	R-70	0.81	47.90	47.09	0.02	1	6/28/95
	R-91	1.00	2.52	1.52	-0.12	1	
P-D-680	T-62	0.95	15.70	14.75	5.15	3	
	R-70	0.90	42.20	41.30	5.81	3	6/28/95
	R-91	0.97	2.26	1.29	0.11	2	
Isopropyl Alcohol	T-62	0.93	17.00	16.07	3.83	3	
	R-70	0.95	38.70	37.75	9.36	4	6/28/95
	R-91	0.93	1.45	0.52	0.88	3	

Discussion of Non-Destructive Inspection Results:

Results obtained from the FPI portion of the testing were somewhat diverse. It has been widely accepted that complications exist in acquiring distinctions among the related test data, specifically brightness indications, from separate cleaners. In other words, there has been difficulty in precisely showing cleaner A works better than cleaner B in the FPI process. However, distinctions can be made between cleaners that appear to work well and cleaners that do not. The testing executed in this program achieved numerically different brightness readings for each cleaner in both the solvent removable and the post-emulsifiable methods through the use of a state-of-the-art optical photometer. Therefore, by comparing these values to those obtained utilizing 1,1,1 trichloroethane, a determination of the cleaners' replacement feasibility can be made as long as repeatability of the results is accounted for. Also, a relative ranking of the cleaners' respective FPI feasibility can be deduced from both the numerical data and the operator's observations during actual testing and use of the individual cleaners. It was apparent from the testing performed that the processing procedure and the manner in which the alternative chemicals were utilized were extremely critical. Ultrasonic immersion appears to be the most prospective process for the post-emulsifiable method of FPI, when the components being cleaned are rigid enough to withstand the vibration. Several types and sizes of heavy-duty ultrasonic tanks are commercially available. The tanks used under this program were far inferior to the capabilities of the industrial size tanks. It is suspected, and has been reported elsewhere, that surprising results can be obtained by making use of industrial-type ultrasonic tanks. An improvement over the results of this program should be achievable by making use of this technology. Based upon the data acquired, the ranking of the tested cleaners is as follows for the solvent removable method and the post-emulsifiable method:

Cleaner	Rank	Solvent Removable Accept/Non-Accept	Rank	Post-Emulsifiable Accept/Non-Accept
Desoclean 45	1	A	3	A
Bioact 113	2	A	10	NA
DS-108	3	A	5	A
TPC Solvent	4	A	8	A
Spotcheck SKC-HF	5	A	4	A
Electron NDT	6	A	7	A
TEKSOL EP	7	A	1	A
Citrex	8	A	2	A
Isopropyl Alcohol	9	A	9	NA
PD-680	10	NA	6	A
Axarel 56	11	NA	11	NA

This testing is in agreement with that of the approved replacements from Wright-Patterson Air Force Base (WPAFB). Electron NDE, DS-108, Magnaflux Spot-check, and PD-680 have all been approved for use by WPAFB for the solvent removable method. Desoclean 45 works very well for both processes but is compromised by a low flash point and certain constituents that are regulated, specifically MEK, MIK, and toluene.

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Appendix A:

Dialog Search for TCA Alternative Cleaners

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```
### Status: Dialog Basic Connection Path #1

### Status: Initializing modem ...
AT&FE1Q0V1X4&C1&D2&K4
OK
### Status: Dialing primary number (448-4611)...

ATDT448-4611
CONNECT 9600
### Status: Connection established at 9600 baud


please type your terminal identifier
-3523:01-002-
please log in: DIALOG


DIALOG: call connected
### Status: Connected


DIALOG INFORMATION SERVICES
PLEASE LOGON:
 ******** HHHHHHHH SSSSSSSS?
### Status: Signing onto Dialog
 ********
ENTER PASSWORD:
 ******** HHHHHHHH SSSSSSSS? ********
Welcome to DIALOG
### Status: Connected

Dialog level 36.08.01D

Last logoff:  26jul94 11:58:29
Logon file405 04aug94 13:54:48
ANNOUNCEMENT    ****    ANNOUNCEMENT    ****    ANNOUNCEMENT


***Dialog's new pricing plan effective August 1.                 ***
   See Homebase Announcements for details.

***New Health Economic News Online in PHIND (File 130).          ***

***CANADIAN NEWSPAPERS (File 727) release delayed until early
   August.                                                       ***

***Coming in August: TRADEMARKSCAN(R) - AUSTRIA, FRANCE, and ITALY
   (Files 662, 657, and 673).  See Homebase for details.         ***

***NEW on Data-Star: SUMMARY OF WORLD BROADCASTS and
   INTERNATIONAL MARKET RESEARCH INFORMATION.  See Homebase
   for details.                                                  ***
```

```
 ***DialogLink Now Available for the Macintosh!                      ***
 ***The Enhanced DIALOG Menus is NOW Available - BEGIN MENUS to
    Use the New DIALOG Menus.                                        ***

 ***The FAMILY RESOURCES Database (File 291) No Longer Updated. ***

 ***CAREER PLACEMENT REGISTRY (File 162) Removed from DIALOG.    ***

      >>> Enter BEGIN HOMEBASE for Dialog Announcements <<<
      >>>    of new databases, price changes, etc.      <<<
      >>>    Announcements last updated for 29jul94     <<<
Banner display set OFF.
HILIGHT set on as '*'
KWIC is set to 5.
BLIP set on
NOTICE set ON to $25.00
You will be prompted to confirm each output request that exceeds $25.00
COST       = ONESEARCH.
Please enter SUBACCOUNT name/number:
?
?bulluck
Is BULLUCK the SUBACCOUNT you want to use? (Y/N)
?y
Subaccount is set to BULLUCK
SYSTEM:HOME
Menu System II: D2 version 1.7.1 term=ASCII
Terminal set to DLINK
                     *** DIALOG HOMEBASE(SM) Main Menu ***

Information:
 1.  Announcements (new files, free connect time, price changes, etc.)
 2.  Database, Rates, & Command Descriptions
 3.  Help in Choosing Databases for Your Topic
 4.  Customer Services (telephone assistance, training, seminars, etc.)
 5.  Product Descriptions

Connections:
 6.  DIALOG Menus(SM)
 7.  DIALOG Business Connection(R), Headlines(SM), Medical Connection(SM
)
 8.  DIALOG SourceOne(SM) Document Delivery
 9.  Data-Star
10.  Other Online Menu Services & Files (MoneyCenter(R), OAG, TNT, etc.)


    /H = Help            /L = Logoff           /NOMENU = Command Mode


Enter an option number to view information or to connect to an online
service.  Enter a BEGIN command plus a file number to search a database
(e.g., B1 for ERIC).
?b 411
```

```
        04aug94 13:55:25 User036172 Session D436.1
        Sub account: BULLUCK
             $0.00    0.010 Hrs FileHomeBase
      $0.00  Estimated cost FileHomeBase
      $0.11  TYMNET
      $0.11  Estimated cost this search
      $0.11  Estimated total session cost   0.010 Hrs.

File 411:DIALINDEX(R)

DIALINDEX(R)
   (c) 1994 Dialog Info.Svcs.

*** DIALINDEX search results display in an abbreviated ***
*** format unless you enter the SET DETAIL ON command. ***
?sf chembus, chemlit, chemprop, chemsubs
   You have 51 files in your file list.
   (To see banners, use SHOW FILES command)
?s (trichloroethane and replac?)
 Your SELECT statement is:
   s (trichloroethane and replac?)
             Items   File
             -----   ----
               157     16: PTS PROMT(TM)_1972-1994/Aug 04
                 4     18: PTS F&S INDEX(R)_1980-1994/JulW5
                44     19: Chem.Industry Notes_1974-1994/ISS 31
                 1    111: Natl.Newspaper Index(TM)_1979-1994/Aug
                 5    148: Trade & Industry Index(TM)_1981-1994/Jul W4
                 3    257: API Energy Bus News_1975-1994/Jul W4
                 1    269: Materials Bus.File(TM)_1985-1994/May
                51    319: Chem Bus NewsBase_1984-1994/Iss 29
                92    545: Investext(R)_1982-1994/Aug 03
                 2    563: ICC Int.Bus.Res_1986-1994/Jul W3
                17    624: McGraw-Hill Publications Online_1985-1994/Aug 01

                 5    637: Journal of Commerce_1986-1994/Aug 03
               184    648: Trade & Industry ASAP(TM)_1983-1994/Jul W4
               118    669: Fed.Register_1988-1994/Aug 04
                62    763: Freedonia Market Res._1990-1994/Jul 20
                18    764: BCC Market Research
                52    799: Textline Curr.Glob.News_1993-1994/Aug 04
                51    772: Textline Global News_1990-1992
                 5    771: Textline Global News_1980-1989
                 9      2: INSPEC_1969-1994/Jul W5
                18      8: Ei Compendex*Plus(TM)_1970-1994/Aug W4
                 5     32: METADEX(R)_1966-1994/May
                 1     33: Aluminium Industry Abs._1968-1994/May
                 3    144: Pascal_1973-1994/Jul
                17    302: Kirk-Othmer Online_
                 2    305: Analytical Abstracts Online_1980-1994/Aug
                 3    315: ChemEng & Biotec Abs_1970-1994/Aug
                12    317: Chemical Safety Newsbase_1981-1994/Aug
```

```
                 40    323: RAPRA Abstracts_1972-1994/Jul B2
                 30    340: CLAIMS(R)/US Patents Abs_1950-1994/Jun
                 38    351: DERWENT WPI_1981-1994/UD=9423;UA=9420UM=9411
                 10    350: Derwent World Pat._1963-1980/UD=9420
                 15    353: APIPAT_1964-1994/May
                 63    354: APILIT_1964-1994/Jun
                 13    399: CA Search(R)_1967-1994/UD=12104
                  8    434: Scisearch(R)_1974-1994/Jul W2
         Examined  50 files

     36 files have one or more items; file list includes 51 files.

 ?rf
 Your last SELECT statement was:
    S (TRICHLOROETHANE AND REPLAC?)

 Ref         Items    File
 ---         -----    ----
 N1            184    648: Trade & Industry ASAP(TM)_1983-1994/Jul W4
 N2            157     16: PTS PROMT(TM)_1972-1994/Aug 04
 N3            118    669: Fed.Register_1988-1994/Aug 04
 N4             92    545: Investext(R)_1982-1994/Aug 03
 N5             63    354: APILIT_1964-1994/Jun
 N6             62    763: Freedonia Market Res._1990-1994/Jul 20
 N7             52    799: Textline Curr.Glob.News_1993-1994/Aug 04
 N8             51    319: Chem Bus NewsBase_1984-1994/Iss 29
 N9             51    772: Textline Global News_1990-1992
 N10            44     19: Chem.Industry Notes_1974-1994/ISS 31
    36 files have one or more items; file list includes 51 files.
```

F

```
        - Enter P or PAGE for more -
 ?p
 Your last SELECT statement was:
    S (TRICHLOROETHANE AND REPLAC?)
```

PY = 19

```
 Ref         Items    File
 ---         -----    ----
 N11            40    323: RAPRA Abstracts_1972-1994/Jul B2
 N12            38    351: DERWENT WPI_1981-1994/UD=9423;UA=9420UM=9411
 N13            30    340: CLAIMS(R)/US Patents Abs_1950-1994/Jun
 N14            18    764: BCC Market Research
 N15            18      8: Ei Compendex*Plus(TM)_1970-1994/Aug W4
 N16            17    624: McGraw-Hill Publications Online_1985-1994/Aug 01

 N17            17    302: Kirk-Othmer Online_
 N18            15    353: APIPAT_1964-1994/May
 N19            13    399: CA Search(R)_1967-1994/UD=12104
 N20            12    317: Chemical Safety Newsbase_1981-1994/Aug
    36 files have one or more items; file list includes 51 files.

        - Enter P or PAGE for more -
 ?p
 Your last SELECT statement was:
```

```
   S (TRICHLOROETHANE AND REPLAC?)

 Ref         Items   File
 ---         -----   ----
 N21            10   350: Derwent World Pat._1963-1980/UD=9420
 N22             9     2: INSPEC_1969-1994/Jul W5
 N23             8   434: Scisearch(R)_1974-1994/Jul W2
 N24             5   148: Trade & Industry Index(TM)_1981-1994/Jul W4
 N25             5   637: Journal of Commerce_1986-1994/Aug 03
 N26             5   771: Textline Global News_1980-1989
 N27             5    32: METADEX(R)_1966-1994/May
 N28             4    18: PTS F&S INDEX(R)_1980-1994/JulW5
 N29             3   257: API Energy Bus News_1975-1994/Jul W4
 N30             3   144: Pascal_1973-1994/Jul
   36 files have one or more items; file list includes 51 files.

        - Enter P or PAGE for more -
?p
Your last SELECT statement was:
   S (TRICHLOROETHANE AND REPLAC?)

 Ref         Items   File
 ---         -----   ----
 N31             3   315: ChemEng & Biotec Abs_1970-1994/Aug
 N32             2   563: ICC Int.Bus.Res_1986-1994/Jul W3
 N33             2   305: Analytical Abstracts Online_1980-1994/Aug
 N34             1   111: Natl.Newspaper Index(TM)_1979-1994/Aug
 N35             1   269: Materials Bus.File(TM)_1985-1994/May
 N36             1    33: Aluminium Industry Abs._1968-1994/May
 N37             0   158: Diogenes(R)_1976-1994/Jul 25
 N38             0   211: Newsearch(TM)_1994/Aug 03
 N39             0   318: Chemplant Plus_1994/Jun
 N40             0   360: Fine Chemicals Database_1991/S1
   36 files have one or more items; file list includes 51 files.

        - Enter P or PAGE for more -
?save temp
Temp SearchSave "TD098" stored
?l
>>>"L" command not valid in DIALINDEX.
?logoff
       04aug94 13:58:09 User036172 Session D436.2
       Sub account: BULLUCK
            $1.50    0.050 Hrs File411
     $1.50  Estimated cost File411
     $0.57  TYMNET
     $2.07  Estimated cost this search
     $2.18  Estimated total session cost   0.060 Hrs.


### Status: Signed Off.
```

```
### Status: Dialog Basic Connection Path #1

### Status: Initializing modem ...
AT&FE1Q0V1X4&C1&D2&K4
OK
### Status: Dialing primary number (448-4611)...

ATDT448-4611
CONNECT 9600
### Status: Connection established at 9600 baud


please type your terminal identifier
-3523:01-005-
please log in: DIALOG


DIALOG: call connected
### Status: Connected


DIALOG INFORMATION SERVICES
PLEASE LOGON:
 ******** HHHHHHHH SSSSSSSS?
### Status: Signing onto Dialog
 ********
ENTER PASSWORD:
 ******** HHHHHHHH SSSSSSSS? ********
Welcome to DIALOG
### Status: Connected

Dialog level 36.08.01D

Last logoff:  04aug94 13:58:09
Logon file405 04aug94 15:46:45
Banner display set OFF.
HILIGHT set on as '*'
KWIC is set to 5.
BLIP set on
NOTICE set ON to $25.00
You will be prompted to confirm each output request that exceeds $25.00
COST       = ONESEARCH.
Please enter SUBACCOUNT name/number:
?
?bulluck/f7411
Is BULLUCK/F7411 the SUBACCOUNT you want to use? (Y/N)
?y
Subaccount is set to BULLUCK/F7411
SYSTEM:HOME
Menu System II: D2 version 1.7.1 term=ASCII
Terminal set to DLINK
                    *** DIALOG HOMEBASE(SM) Main Menu ***
```

```
 Information:
  1.  Announcements (new files, free connect time, price changes, etc.)
  2.  Database, Rates, & Command Descriptions
  3.  Help in Choosing Databases for Your Topic
  4.  Customer Services (telephone assistance, training, seminars, etc.)
  5.  Product Descriptions

 Connections:
  6.  DIALOG Menus(SM)
  7.  DIALOG Business Connection(R), Headlines(SM), Medical Connection(SM
 )
  8.  DIALOG SourceOne(SM) Document Delivery
  9.  Data-Star
 10.  Other Online Menu Services & Files (MoneyCenter(R), OAG, TNT, etc.)


      /H = Help            /L = Logoff          /NOMENU = Command Mode


 Enter an option number to view information or to connect to an online
 service.  Enter a BEGIN command plus a file number to search a database
 (e.g., B1 for ERIC).
 ?b chembus,chemlit,chemprop,chemsubs

         04aug94 15:47:55 User036172 Session D437.1
         Sub account: BULLUCK/F7411
              $0.00    0.033 Hrs FileHomeBase
       $0.00  Estimated cost FileHomeBase
       $0.38  TYMNET
       $0.38  Estimated cost this search
       $0.38  Estimated total session cost   0.033 Hrs.


 SYSTEM:OS  - DIALOG OneSearch
 *File  19: Use is subject to the terms of your user/customer agreement.
 *File 304: Type HELP FILE 304 for Merck Index Online background info.
 *File 317: Some records in accession number range 001725-002806 are
 having retrieval problems.  Type in HELP NEWS317 for more info.
 *File 340:  Effective August 1, the prices are $120 per hour,
  $1.70 for Type or Print (Full record), and $1.00 for View.
 *File 351: No VIEW fee.  Price of RANK command is $.02 per record.
 *File 350: No VIEW fee.  Price of RANK command is $.02 per record.
  *File 353: Total usage of APIPAT/APILIT is not to exceed
  2 hrs/yr on all services. For disclaimer, type HELP NEWS 353.
 *File 354: Total usage of APIPAT/APILIT is not to exceed
 2 hrs/yr on all services. For disclaimer, type HELP NEWS 354.
 *File 399: Use is subject to the terms of your user/customer agreement.
 *File 398: Use is subject to the terms of your user/customer agreement.
 You have  51 files in your file list.
 (To see file names, coverage dates, and copyright notices, enter SHOW FI
 LES.)
```

```
        Set  Items  Description
        ---  -----  -----------
 ?exs td098
 >>>SET HILIGHT: use ON, OFF, or 1-5 characters
 KWIC is set to 5.
 KWIC option is not available in file(s) 19, 32-33, 52, 257, 269, 303-304
 , -
 306, 319, 398, 399
 Processed  20 of  51 files ...
 Completed processing all files
             13461  TRICHLOROETHANE
           1366270  REPLAC?
       S1     1159  (TRICHLOROETHANE AND REPLAC?)
 ?s s1 and py=1985:1994
  >>>One or more prefixes are unsupported
 >>>  or undefined in one or more files.
 Processed  10 of  51 files ...
   Processed  20 of  51 files ...
   Processed  30 of  51 files ...
 Processed  40 of  51 files ...
 Processed  50 of  51 files ...
 Completed processing all files
              1159  S1
          57490901  PY=1985 : PY=1994
       S2     1073  S1 AND PY=1985:1994
 ?rd s2
 >>>Duplicate detection is not supported for File 19.
 >>>Duplicate detection is not supported for File 158.
 >>>Duplicate detection is not supported for File 318.
 >>>Duplicate detection is not supported for File 360.
 >>>Duplicate detection is not supported for File 449.
 >>>Duplicate detection is not supported for File 545.
 >>>Duplicate detection is not supported for File 563.
 >>>Duplicate detection is not supported for File 763.
 >>>Duplicate detection is not supported for File 764.
 >>>Duplicate detection is not supported for File 125.
 >>>Duplicate detection is not supported for File 302.
 >>>Duplicate detection is not supported for File 304.
 >>>Duplicate detection is not supported for File 322.
 >>>Duplicate detection is not supported for File 340.
 >>>Duplicate detection is not supported for File 351.
 >>>Duplicate detection is not supported for File 350.
 >>>Duplicate detection is not supported for File 353.
 >>>Duplicate detection is not supported for File 303.
 >>>Duplicate detection is not supported for File 306.
 >>>Duplicate detection is not supported for File 321.
 >>>Duplicate detection is not supported for File 390.
 >>>Duplicate detection is not supported for File 52.
 >>>Duplicate detection is not supported for File 398.

 >>>Records from unsupported files will be retained in the RD set.
 ...examined 50 records  (50)
 ...examined 50 records  (100)
```

```
...examined 50 records  (150)
...examined 50 records  (200)
...examined 50 records  (250)
...examined 50 records  (300)
...examined 50 records  (350)
...examined 50 records  (400)
...examined 50 records  (450)
...examined 50 records  (500)
...examined 50 records  (550)
...examined 50 records  (600)
...examined 50 records  (650)
...examined 50 records  (700)
...examined 50 records  (750)
...examined 50 records  (800)
...examined 50 records  (850)
...examined 50 records  (900)
...examined 50 records  (950)
...examined 50 records  (1000)
...examined 50 records  (1050)
...completed examining records
      S3     986  RD S2 (unique items)
?s s3/eng
>>>Term "ENG" is not defined in one or more files
      S4     955  S3/ENG
?s s4/ti,de
>>>Term "DE" is not defined in one or more files
>>>Term "TI" is not defined in one or more files
      S5     228  S4/TI,DE
?t 5/6/all

 5/6/1     (Item 1 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

05108303
HCFC 141b  Replacement Developed
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT:  119


 5/6/2     (Item 2 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

05082264
New product line  replaces 1,1,1 and CFC-113
   replaces   1,1,1 and CFC-113^New Oxsol non-ozone depleting solvents c
an
    replace CFC-113 or 1,1,1-trichloroethane in many uses


 5/6/3     (Item 3 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

05041939
Mid-Size Firms Slow to  Replace  Trichloroethane
```

```
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT:  127


 5/6/4     (Item 4 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

04806655
Dow Restructures Solvents To  Replace Methyl Chloroform
  Replace  Methyl Chloroform^Will spend some $100 mil to reorganize glob
al
    chlorinated hydrocarbons bsns
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT:  364


 5/6/5     (Item 5 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

04532957
Lower solvent use fails to hit production
  Europe:  Use  of 1,1,1-trichloroethane should be cut 50% by 1994 & ban
ned
    totally in 1995
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 193


 5/6/6     (Item 6 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

04524903
Fujitsu   General   to  Eliminate  Freon,   Trichloroethane  from  Cleani
ng
   Processes
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 87


 5/6/7     (Item 7 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

04452598
2 U.S. Chemical Firms To Sell CFC Alternatives In Japan
  Occidental   Chemical:   To   introduce   1,1,1-trichloroethane   solv
ent
    alternative as CFC replacement, Japan


 5/6/8     (Item 8 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

04422615
1,1,1 Demand Chips Into Rationed Supply
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 865
```

```
 5/6/9     (Item 9 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

04290140
Recyclable Metal Cleaner To  Replace Ozone Depleter
    Replace    Ozone   Depleter^Nikko  Petrochemical:  Develops  NS  Cle
an
    hydrocarbon-based recyclable metal cleaner


 5/6/10     (Item 10 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

04284621
Murata promises a Freon spring clean
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 138


 5/6/11     (Item 11 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

04267510
The new agenda for chlorinated solvents
  W  Europe:  Chlorinated  solvents  use  falls  50%  since  1974,  due
 to
    chlorine-linked concerns & matrl recycling


 5/6/12     (Item 12 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

04231489
MATERIALS  &  COMPONENT  NEWS:  ROSSTECH  (TM)  CFC-FREE FORMULA  REPLAC
ES
    TRICHLOROETHANE
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 247


 5/6/13     (Item 13 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

04213782
FOOD FLAVORING  REPLACES  TRICHLOROETHANE
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 72


 5/6/14     (Item 14 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

04115966
New Cleaning Agents  Replace Ozone-Depleting Solvents
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 241
```

```
 5/6/15     (Item 15 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

03908318
SAVING THE OZONE LAYER
  Hewlett-Packard:  Managers  cease  using CFCs on Montreal Protocol lis
t &
    others
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 551


 5/6/16     (Item 16 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

03907279
Honda to Discontinue Use of  Trichloroethane and CFCs
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 138


 5/6/17     (Item 17 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

03907255
Nissan to Phase Out Use of  Trichloroethane
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 118


 5/6/18     (Item 18 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

03851878
Zexel to Phase Out Use of CFCs and  Trichloroethane


 5/6/19     (Item 19 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

03842155
Nissan to Phase Out Use of 1,1,1- Trichloroethane


 5/6/20     (Item 20 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

03738349
ASAHI TO REDUCE 1,1,1-TRI SALES BY 50%
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 62


 5/6/21     (Item 21 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.
```

```
03670977
ASAHI'S 1,1,1,-TRI  REPLACEMENTS
   REPLACEMENTS  ^Asahi  Chemical  Industry:  Develops series of aqueous
 &
    semiaqueous cleaning agents
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 100


 5/6/22      (Item 22 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

03668978
Asahi Chemical develops new aqueous and semi-aqueous cleaning agents
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 183


 5/6/23      (Item 23 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

03552915
Detergent NewsFront: ISP Launches CFC  Replacement Cleaner
   Replacement   Cleaner^Intnl  Specialty  Products:  Introduces PartsPr
ep
    metal degreaser
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 416


 5/6/24      (Item 24 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

03071886
Dow Talks  Replacing 1,1,1- Trichloroethane
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 263


 5/6/25      (Item 25 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

02645461
Methyl Chloroform Is Seen A Major Problem for Ozone
*FULL TEXT AVAILABLE IN FORMAT 9* WORD COUNT: 654


 5/6/26      (Item 26 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

02613441
Consumer boycott of  trichloroethane urged
   trichloroethane   urged^Natural  Resources  Defense  Council  calls f
or
    boycott of household products containing trichloroethane
```

```
 5/6/27     (Item 27 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

02106091
Chemical profile: 1,1,1- trichloroethane
  trichloroethane ^Demand for 1,1,1-trichloroethane to total 705 mil lb
in
    1989 and 735 mil lb in 1993


 5/6/28     (Item 28 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

01975271
Finishers and paint formulators can use 1,1,1- trichloroethane
   trichloroethane  ^Inhibited grades of 1,1,1-trichloroethane can be us
ed
    in coatings in place of VOC-type solvents


 5/6/29     (Item 29 from file: 16)
DIALOG(R)File  16:(c) 1994 Information Access Co. All rts. reserv.

01804689
DOW  OFFERS  NEW  LOW-VOC  GRADE  OF  1,1,1-TRICHLORETHANE  FOR  CALIFOR
NIA
   COATINGS MARKET


 5/6/30     (Item 1 from file: 19)
DIALOG(R)File  19:(c) 1994 Amer.Chem.Soc. All rts. reserv.

1041890
  New powerful washing agent to replace trichloroethane
Major Descriptor:  *washing agent trichloroethane replacement Perclean


 5/6/31     (Item 2 from file: 19)
DIALOG(R)File  19:(c) 1994 Amer.Chem.Soc. All rts. reserv.

1040569
  German-made hydrocarbon solvents make debut
Major Descriptor:  *hydrocarbon solvent sales Japan


 5/6/32     (Item 3 from file: 19)
DIALOG(R)File  19:(c) 1994 Amer.Chem.Soc. All rts. reserv.

1033611
  Wipe solvents
Major Descriptor:  *solvent organic freon substitute sealant use US
```

```
 5/6/33     (Item 4 from file: 19)
DIALOG(R)File  19:(c) 1994 Amer.Chem.Soc. All rts. reserv.

1023982
  OxyChem adds solvent line
Major Descriptor:  *solvent nonozone depleting trichloroethane replaceme
nt
Oxsol


 5/6/34     (Item 5 from file: 19)
DIALOG(R)File  19:(c) 1994 Amer.Chem.Soc. All rts. reserv.

1007343
  Planning for 1,1,1's demise
Major Descriptor:  *cos plan for phaseout


 5/6/35     (Item 6 from file: 19)
DIALOG(R)File  19:(c) 1994 Amer.Chem.Soc. All rts. reserv.

1005626
  Mass-production of alternative cleaner moves into top gear
Major Descriptor:  *cleaner plant Japan


 5/6/36     (Item 7 from file: 19)
DIALOG(R)File  19:(c) 1994 Amer.Chem.Soc. All rts. reserv.

981884
  2 US chemical firms to sell CFC alternatives in Japan
Major Descriptor:  *trichloroethane sales Japan


 5/6/37     (Item 8 from file: 19)
DIALOG(R)File  19:(c) 1994 Amer.Chem.Soc. All rts. reserv.

963921
  Recyclable metal cleaner to replace ozone depleter
Major Descriptor:  *metal cleaning agent sales Japan


 5/6/38     (Item 9 from file: 19)
DIALOG(R)File  19:(c) 1994 Amer.Chem.Soc. All rts. reserv.

953698
  Researchers say melons may be ozone-friendly
Major Descriptor:  *emission ozone depleting research cantaloupe compoun
d
replacement


 5/6/39     (Item 10 from file: 19)
```

DIALOG(R)File 19:(c) 1994 Amer.Chem.Soc. All rts. reserv.

945406
Oxychem's alternative solvents
Major Descriptor: *solvent alternative blend development

5/6/40 (Item 11 from file: 19)
DIALOG(R)File 19:(c) 1994 Amer.Chem.Soc. All rts. reserv.

944223
New cleaning agents replace ozone-depleting solvents
Major Descriptor: *cleaning product general use Primaclean

5/6/41 (Item 12 from file: 19)
DIALOG(R)File 19:(c) 1994 Amer.Chem.Soc. All rts. reserv.

909778
Major Descriptor: *cleaning agent trichloroethane substitute development

5/6/42 (Item 13 from file: 19)
DIALOG(R)File 19:(c) 1994 Amer.Chem.Soc. All rts. reserv.

842568
Major Descriptor: *cleaning agent metal use Axarel

5/6/43 (Item 14 from file: 19)
DIALOG(R)File 19:(c) 1994 Amer.Chem.Soc. All rts. reserv.

745860
Major Descriptor: *trichloroethane market US

5/6/44 (Item 15 from file: 19)
DIALOG(R)File 19:(c) 1994 Amer.Chem.Soc. All rts. reserv.

581398
Major Descriptor: *solvent metal degreasing use Inhibisolve

5/6/45 (Item 1 from file: 111)
DIALOG(R)File 111:(c) 1994 Information Access Co. All rts. reserv.

12933348
Researchers say melons may be ozone-friendly. (American Telephone & Telegraph Co. researchers find compound from fruit can replace ozone-depleting trichloroethane used in manufacturing integrate

```
d
   circuits)


 5/6/46     (Item 1 from file: 148)
DIALOG(R)File 148:(c) 1994 Inform. Access Co. All rts. reserv.

14632212
          *Use Format 9 for FULL TEXT*
TITLE: Planning for 1,1,1's demise. (emissive use of 1,1,1- trichloroeth
ane
    , or methyl chloroform, to end by December 31, 1993) (Aliphat
ic
    Organics)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00093  WORD COUNT: 1,186


 5/6/47     (Item 2 from file: 148)
DIALOG(R)File 148:(c) 1994 Inform. Access Co. All rts. reserv.

14532232
          *Use Format 9 for FULL TEXT*
TITLE:  The demise of 1, 1, 1. ( Trichloroethane) (Thoughts from Our Sho
p)
    (Editorial)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00064  WORD COUNT: 716


 5/6/48     (Item 3 from file: 148)
DIALOG(R)File 148:(c) 1994 Inform. Access Co. All rts. reserv.

14529567
          *Use Format 9 for FULL TEXT*
TITLE:  Time's  running  out  on  CFCs. (chlorofluorocarbons) (Focal Poi
nt)
    (Column)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00041  WORD COUNT: 397


 5/6/49     (Item 1 from file: 257)
DIALOG(R)File 257:(c) 1994 Amer. Petroleum Inst. All rts. reserv.

0616056
  Article Number: BS00557
 Metalworking Fluids Demand To Grow In '93...Enviro-Friendly Products Wi
ll
Be Bright Spot (Photo) (L)


 5/6/50     (Item 2 from file: 257)
DIALOG(R)File 257:(c) 1994 Amer. Petroleum Inst. All rts. reserv.

0605318
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  Article Number: BR25778
  Ashland  Oil Inc Has Notified EPA It Has More Than Met Its First G
To
Voluntarily Reduce Chemical Emissions One Year Before Company's Targ
ate
(M)


 5/6/51     (Item 3 from file: 257)
DIALOG(R)File 257:(c) 1994 Amer. Petroleum Inst. All rts. reserv.

0554406
  Article Number: BQ13151
  Ashland  Oil  Plans  To Participate In New EPA Industrial Toxics P
ct
Designed  To  Stem Flow Of Chemical Pollution From Nearly 11,000 Ind
ial
Facilities In US (M)


 5/6/52     (Item 1 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

15139004
         *Use Format 9 for FULL TEXT*
TITLE:   CFC   replacement   technologies:   help   is   on   the
y.
   (chlorofluorocarbons)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00146  WORD COUNT: 2,08


 5/6/53     (Item 2 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

14609560
         *Use Format 9 for FULL TEXT*
TITLE:  No end in sight. (solvent-borne adhesives have not been  rep
d)
   (Adhesives '93) (Industry Overview)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00131  WORD COUNT: 1,69


 5/6/54     (Item 3 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

14562626
         *Use Format 9 for FULL TEXT*
TITLE:   Chemical  substitutes  for  1,1,1-  trichloroethane  in  ad
ve
   formulations.
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00149  WORD COUNT: 2,04
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 5/6/55     (Item 4 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

13902606
          *Use Format 9 for FULL TEXT*
TITLE:  Dangerous fluid alert. (use of fluids containing methyl chloro
rm)
    (The Leading Edge)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00071  WORD COUNT: 751


 5/6/56     (Item 5 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

13884488
          *Use Format 9 for FULL TEXT*
TITLE:  Vapor degreasers put on 'death row.' (1,1,1- trichloroethane f
es
    regulatory  production  bans  and  labeling  requirements)  (incl
es
    related articles)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00090  WORD COUNT: 1,130


 5/6/57     (Item 6 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

13815887
          *Use Format 9 for FULL TEXT*
TITLE: 1,1,1 demand chips into rationed supply. ( trichloroethane supp
es
    decreasing, driving up price) (Aliphatic Organics)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00084  WORD COUNT: 1,026


 5/6/58     (Item 7 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

11829098
          *Use Format 9 for FULL TEXT*
TITLE:  1,1,1-  trichloroethane. (producers, demand, uses, etc.) (Chem
al
    Profile)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00034  WORD COUNT: 418


 5/6/59     (Item 8 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

11289762
          *Use Format 9 for FULL TEXT*
TITLE: Methyl chloroform still cleans best. (includes related articles
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00063  WORD COUNT: 845
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 5/6/60     (Item 9 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

11199730
          *Use Format 9 for FULL TEXT*
TITLE: A delicate balance. (weighing the merits of  replacing hi
gh
    volatile  organic compounds with environmentally friendly substitute
s)
    (Cover Story)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00262  WORD COUNT: 3,920


 5/6/61     (Item 10 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

10381826
          *Use Format 9 for FULL TEXT*
TITLE: US regs catalyze changes in solvents.
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00105  WORD COUNT: 1,513


 5/6/62     (Item 11 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

09397747
          *Use Format 9 for FULL TEXT*
TITLE:  Study supports industry position on use of 1,1,1- trichloroethan
e.
    (methyl chloroform)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00126  WORD COUNT: 1,803


 5/6/63     (Item 12 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

09368150
          *Use Format 9 for FULL TEXT*
TITLE:  Future  of  1,1,1- trichloroethane. (Business Review and Forecas
t:
    the State of the Industry ... and What's Ahead)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00051  WORD COUNT: 656


 5/6/64     (Item 13 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

09108052
          *Use Format 9 for FULL TEXT*
TITLE:  Toxicity  characteristics  leaching procedure  replaces extracti
on
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   procedure toxicity. (Environmental Protection Agency changes method
of
   evaluating industrial wastes)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00152  WORD COUNT: 2,113


 5/6/65     (Item 14 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

08983143
          *Use Format 9 for FULL TEXT*
TITLE:  Still  working  on  the  ozone  hole: beyond the Montreal Protoc
ol.
   (includes related article on CFC substitutes)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00303  WORD COUNT: 4,483


 5/6/66     (Item 15 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

08523977
          *Use Format 9 for FULL TEXT*
TITLE: Methyl chloroform hit in new charges.
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00084  WORD COUNT: 1,191


 5/6/67     (Item 16 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

08200585
          *Use Format 9 for FULL TEXT*
TITLE: Methyl chloroform: freeze is proposed.
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00084  WORD COUNT: 1,189


 5/6/68     (Item 17 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

08106930
          *Use Format 9 for FULL TEXT*
TITLE:   Now  it's  time  to  fix  the  sky.  (finding  replacements  f
or
   chlorofluorocarbons  in  the  semiconductor industry)(includes relat
ed
   articles on IBM's and the Department of Defense's activities)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00306  WORD COUNT: 4,358


 5/6/69     (Item 18 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

08041333
          *Use Format 9 for FULL TEXT*
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TITLE: Ultrasonic cleaner  replaces vapor degreaser.
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00044  WORD COUNT: 581


 5/6/70     (Item 19 from file: 648)
DIALOG(R)File 648:(c) 1994 Inform. Access Co. All rts. reserv.

07842509
          *Use Format 9 for FULL TEXT*
TITLE:  New technology reduces VOC emissions by 30 to 70%. (recycled
bon
    dioxide  replacement for volatile organic compounds)
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00107  WORD COUNT: 1,531


 5/6/71     (Item 1 from file: 763)
DIALOG(R)File 763:(c) 1994 Freedonia Group Inc. All rts. reserv.

00052334
CHLORINATED SOLVENTS: 1,1,1- Trichloroethane - Solvent Markets
Main Report Title:  SOLVENTS
 Word Count: 796 (2 pp.)
          *FOR FULL TEXT, USE FORMAT 9*


 5/6/72     (Item 2 from file: 763)
DIALOG(R)File 763:(c) 1994 Freedonia Group Inc. All rts. reserv.

00052332
CHLORINATED SOLVENTS: 1,1,1- Trichloroethane - Supply & Demand
Main Report Title:  SOLVENTS
 Word Count: 384 (1 pp.)
          *FOR FULL TEXT, USE FORMAT 9*


 5/6/73     (Item 3 from file: 763)
DIALOG(R)File 763:(c) 1994 Freedonia Group Inc. All rts. reserv.

00052330
CHLORINATED   SOLVENTS:   Chloroethane/Chloroethylene   Solvents   -   1
,1-
          Trichloroethane
Main Report Title:  SOLVENTS
 Word Count: 678 (2 pp.)
          *FOR FULL TEXT, USE FORMAT 9*


 5/6/74     (Item 4 from file: 763)
DIALOG(R)File 763:(c) 1994 Freedonia Group Inc. All rts. reserv.

00027328
C2  CHLOROHYDROCARBONS:  1,1,1- Trichloroethane - Adhesives, Electroni
 &
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          Other Uses
Main Report Title:  CHLORINATED HYDROCARBONS
 Word Count: 508 (1 pp.)
          *FOR FULL TEXT, USE FORMAT 9*


 5/6/75     (Item 5 from file: 763)
DIALOG(R)File 763:(c) 1994 Freedonia Group Inc. All rts. reserv.

00027327
C2 CHLOROHYDROCARBONS: 1,1,1- Trichloroethane - Aerosol Applications
Main Report Title:  CHLORINATED HYDROCARBONS
 Word Count: 432 (2 pp.)
          *FOR FULL TEXT, USE FORMAT 9*


 5/6/76     (Item 6 from file: 763)
DIALOG(R)File 763:(c) 1994 Freedonia Group Inc. All rts. reserv.

00027325
C2 CHLOROHYDROCARBONS: 1,1,1- Trichloroethane - General
Main Report Title:  CHLORINATED HYDROCARBONS
 Word Count: 790 (2 pp.)
          *FOR FULL TEXT, USE FORMAT 9*


 5/6/77     (Item 7 from file: 763)
DIALOG(R)File 763:(c) 1994 Freedonia Group Inc. All rts. reserv.

00021201
CHLORINATED SOLVENTS: 1,1,1- Trichloroethane Used in Electronics and Oth
er
          Markets
Main Report Title:  SOLVENTS AND THE ENVIRONMENT
 Word Count: 148 (1 pp.)
          *FOR FULL TEXT, USE FORMAT 9*


 5/6/78     (Item 8 from file: 763)
DIALOG(R)File 763:(c) 1994 Freedonia Group Inc. All rts. reserv.

00021200
CHLORINATED SOLVENTS: 1,1,1- Trichloroethane Used in Coatings
Main Report Title:  SOLVENTS AND THE ENVIRONMENT
 Word Count: 107 (1 pp.)
          *FOR FULL TEXT, USE FORMAT 9*


 5/6/79     (Item 9 from file: 763)
DIALOG(R)File 763:(c) 1994 Freedonia Group Inc. All rts. reserv.

00021199
CHLORINATED   SOLVENTS:  1,1,1-  Trichloroethane  Used  in  Adhesives
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nd
          Printing Inks
Main Report Title:  SOLVENTS AND THE ENVIRONMENT
 Word Count: 135 (1 pp.)
          *FOR FULL TEXT, USE FORMAT 9*


 5/6/80     (Item 10 from file: 763)
DIALOG(R)File 763:(c) 1994 Freedonia Group Inc. All rts. reserv.

00021198
CHLORINATED SOLVENTS: 1,1,1- Trichloroethane Used in Aerosols
Main Report Title:  SOLVENTS AND THE ENVIRONMENT
 Word Count: 169 (1 pp.)
          *FOR FULL TEXT, USE FORMAT 9*


 5/6/81     (Item 11 from file: 763)
DIALOG(R)File 763:(c) 1994 Freedonia Group Inc. All rts. reserv.

00021197
CHLORINATED SOLVENTS: 1,1,1- Trichloroethane Used in Metal Cleaning
Main Report Title:  SOLVENTS AND THE ENVIRONMENT
 Word Count: 290 (1 pp.)
          *FOR FULL TEXT, USE FORMAT 9*


 5/6/82     (Item 12 from file: 763)
DIALOG(R)File 763:(c) 1994 Freedonia Group Inc. All rts. reserv.

00021193
CHLORINATED SOLVENTS: 1,1,1- Trichloroethane
Main Report Title:  SOLVENTS AND THE ENVIRONMENT
 Word Count: 659 (2 pp.)
          *FOR FULL TEXT, USE FORMAT 9*


 5/6/83     (Item 1 from file: 764)
DIALOG(R)File 764:(c) 1994 Business Communication Co. All rts. reserv.

00022577
PRINTED  CIRCUIT  PROCESSING, ASSEMBLY AND CLEANING: SOLVENT SUBSTITUTE
 TO
           REPLACE CFCs: COMMENT & EVALUATION
Main  Report  Title:   ENVIRONMENTALLY  ACCEPTABLE MATERIALS AND SYSTEM
 IN
          ELECTRONICS
 Word Count: 218 (1 pp.)
          *FOR FULL TEXT, USE FORMAT 9*


 5/6/84     (Item 1 from file: 799)
DIALOG(R)File 799:(c) 1994 Reuters Info.Svcs. All rts. reserv.
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12599679
JAPAN: NEW POWERFUL WASHING AGENT TO  REPLACE  TRICHLOROETHANE
Japan Chemical Week (JCHWAC)
Word Count: 218


 5/6/85     (Item 2 from file: 799)
DIALOG(R)File 799:(c) 1994 Reuters Info.Svcs. All rts. reserv.

12345172
JAPAN: HCFC 141B  REPLACEMENT DEVELOPED - TOPPAN PRINTING, COSMO PETROTE
C
Comline News Service,Nikkan Kogyo Shimbun (COMLN,NKOGS)
Word Count: 108


 5/6/86     (Item 3 from file: 799)
DIALOG(R)File 799:(c) 1994 Reuters Info.Svcs. All rts. reserv.

12115916
JAPAN: MID-SIZE FIRMS SLOW TO  REPLACE  TRICHLOROETHANE
Comline News Service,Asahi Shimbun (COMLN,ASHB)
Word Count: 102


 5/6/87     (Item 4 from file: 799)
DIALOG(R)File 799:(c) 1994 Reuters Info.Svcs. All rts. reserv.

11146465
JAPAN: NIPPON OIL MARKETING CFC  REPLACEMENTS
Comline News Service,Nikkan Kogyo Shimbun (COMLN,NKOGS)
Word Count: 75


 5/6/88     (Item 5 from file: 799)
DIALOG(R)File 799:(c) 1994 Reuters Info.Svcs. All rts. reserv.

10848023
JAPAN:  FUJITSU GENERAL TO ELIMINATE FREON,  TRICHLOROETHANE FROM CLEANI
NG
PROCESSES
Comline  News Service,Japan Industrial Journal,Nikkan Kogyo Shimbun (COM
LN,
JAPIJ,NKOGS)
Word Count: 83


 5/6/89     (Item 6 from file: 799)
DIALOG(R)File 799:(c) 1994 Reuters Info.Svcs. All rts. reserv.

10713190
UK: ORANGE OIL SAID MAY  REPLACE OZONE-HARMING CHEMICAL
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Reuter,Reuter Newswire - United Kingdom,Reuter Economic News (REUTR,REU
UK,
LBA)
Word Count: 197


 5/6/90     (Item 7 from file: 799)
DIALOG(R)File 799:(c) 1994 Reuters Info.Svcs. All rts. reserv.

10713189
UK: ORANGE PEEL COULD  REPLACE OZONE-HARMING CHEMICAL
Reuter,Reuter  Newswire - United Kingdom,Reuter General News (REUTR,REU
UK,
LBY)
Word Count: 214


 5/6/91     (Item 8 from file: 799)
DIALOG(R)File 799:(c) 1994 Reuters Info.Svcs. All rts. reserv.

10295471
JAPAN: RECYCLABLE METAL CLEANER TO  REPLACE OZONE DEPLETER
Chemical Business Newsbase,Japan Chemical Week (CBNB,JCHWAC)
Word Count: 72


 5/6/92     (Item 9 from file: 799)
DIALOG(R)File 799:(c) 1994 Reuters Info.Svcs. All rts. reserv.

10151040
USA:   DELCO  ELECTRONICS  AND  KYZEN  GRANTED  PATENT  ON  OZONE-SAFE
CFC
 REPLACEMENT
Businesswire (BUSW)
Word Count: 408


 5/6/93     (Item 1 from file: 772)
DIALOG(R)File 772:(c) 1994 Reuters Info.Svcs. All rts. reserv.

09817646
JAPAN: RACE TO  REPLACE CFCS LEADS TO OVERCAPACITY FEARS
Japan Economic Jrnl./nikkei Weekly (JEJ)
Word Count: 536


 5/6/94     (Item 2 from file: 772)
DIALOG(R)File 772:(c) 1994 Reuters Info.Svcs. All rts. reserv.

09718440
USA: NEW CLEANING AGENTS  REPLACE OZONE-DEPLETING SOLVENTS
Chemical Business Newsbase,Chemical Marketing Reporter (CBNB,CMKRA)
Word Count: 125
```

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 5/6/95     (Item 3 from file: 772)
DIALOG(R)File 772:(c) 1994 Reuters Info.Svcs. All rts. reserv.

08610793
JAPAN: HONDA TO DISCONTINUE USE OF  TRICHLOROETHANE AND CFCS
Comline  News Service,Nihon Keizai Shimbun,Japan Industrial Journal (COM
LN,
NKSN,JAPIJ)
Word Count: 135


 5/6/96     (Item 4 from file: 772)
DIALOG(R)File 772:(c) 1994 Reuters Info.Svcs. All rts. reserv.

08608980
JAPAN: ZEXEL TO PHASE OUT USE OF CFCS AND  TRICHLOROETHANE
Comline News Service,Japan Industrial Journal (COMLN,JAPIJ)
Word Count: 147


 5/6/97     (Item 5 from file: 772)
DIALOG(R)File 772:(c) 1994 Reuters Info.Svcs. All rts. reserv.

08608709
JAPAN: NISSAN TO PHASE OUT USE OF  TRICHLOROETHANE
Comline News Service,Nikkan Kogyo Shimbun (COMLN,NKOGS)
Word Count: 121


 5/6/98     (Item 6 from file: 772)
DIALOG(R)File 772:(c) 1994 Reuters Info.Svcs. All rts. reserv.

08103488
JAPAN:  ASAHI  CHEMICAL  IMPROVES  AQUEOUS  CLEANING AGENT, REDUCING 1,1
,1-
 TRICHLOROETHANE SHIPMENTS
Comline News Service,Nikkan Kogyo Shimbun (COMLN,NKOGS)
Word Count: 116


 5/6/99     (Item 1 from file: 771)
DIALOG(R)File 771:(c) 1994 Reuters Info.Svcs. All rts. reserv.

05069752
USA: CHEMICAL PROFILE: 1,1,1- TRICHLOROETHANE
Chemical Business Newsbase,Chemical Marketing Reporter (CBNB,CMKRA)
Word Count: 105


 5/6/100     (Item 1 from file: 2)
DIALOG(R)File   2:(c) 1994 Institution of Electrical Engineers. All rts.
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reserv.

4705880   INSPEC Abstract Number: B9408-2330-001
 Title:  Aqueous  cleaning  of  vacuum tube components,  replacing 1,1,1
,
 trichloroethane


 5/6/101      (Item 2 from file: 2)
DIALOG(R)File   2:(c) 1994 Institution of Electrical Engineers. All rts.

reserv.

03833234   INSPEC Abstract Number: B91016735
 Title:  Influence  on  semiconductor devices by the flux cleaning solve
nt
 replacing CFC


 5/6/102      (Item 3 from file: 2)
DIALOG(R)File   2:(c) 1994 Institution of Electrical Engineers. All rts.

reserv.

03479948   INSPEC Abstract Number: B89068868
 Title:  Dependence  of breakdown voltage on molar concentration of 1,1,
1,
 trichloroethane (TCA) in thermal SiO/sub 2/


 5/6/103      (Item 1 from file: 8)
DIALOG(R)File   8:(c) 1994 Engineering Info. Inc. All rts. reserv.

03887485
  Title:  Cleaning  aluminum  heat  pipe  casings  with  replacements fo
r
ozone-depleting chemicals
  Conference  Title:  Proceedings  of  the  Symposium on the Replacement
 of
Chlorofluorocarbon  (CFC)  Fluids  in  the Cleaning of Oxygen and Aerosp
ace
Systems and Components


 5/6/104      (Item 2 from file: 8)
DIALOG(R)File   8:(c) 1994 Engineering Info. Inc. All rts. reserv.

03821533
 Title: Semi-aqueous solvent cleaners to  replace fluorochlorocarbons an
d
1,1,- trichloroethane for metal cleaning
```

5/6/105 (Item 3 from file: 8)
DIALOG(R)File 8:(c) 1994 Engineering Info. Inc. All rts. reserv.

03794394
Title: Solvent recovery technique and purification of environment
in
adjustment to replacing CFCs and trichloroethane

5/6/106 (Item 4 from file: 8)
DIALOG(R)File 8:(c) 1994 Engineering Info. Inc. All rts. reserv.

03786874
Title: Replacement of 1,1,1- trichloroethane for cleaning turbine

generator components and nondestructive examination applications
Conference Title: Proceedings of the 1993 International Joint Po
wer
Generation Conference

5/6/107 (Item 5 from file: 8)
DIALOG(R)File 8:(c) 1994 Engineering Info. Inc. All rts. reserv.

03662310
Title: Recycling paint and solvents and reducing use of 1,1,
1-
trichloroethane

5/6/108 (Item 6 from file: 8)
DIALOG(R)File 8:(c) 1994 Engineering Info. Inc. All rts. reserv.

03439106
Title: Chemical substitution for 1,1,1- trichloroethane and methanol i
n
an industrial cleaning operation.

5/6/109 (Item 7 from file: 8)
DIALOG(R)File 8:(c) 1994 Engineering Info. Inc. All rts. reserv.

03326453
Title: Replacements for methyl chloroform in carpet applications.

5/6/110 (Item 8 from file: 8)
DIALOG(R)File 8:(c) 1994 Engineering Info. Inc. All rts. reserv.

03206402
Title: New technology alkaline cleaners replace chlorinated solven
t

degreasers.

5/6/111 (Item 9 from file: 8)
DIALOG(R)File 8:(c) 1994 Engineering Info. Inc. All rts. reserv.

02757901
Title: 1,1,1- trichloroethane solvent for lower VOC, high performance
maintenance coatings.

5/6/112 (Item 1 from file: 32)
DIALOG(R)File 32:(c) 1994 ASM/Inst. of Materials. All rts. reserv.

1777580
New Technology Alkaline Cleaners Replace Chlorinated Solvent Degreasers
in the Metalworking Industry.

5/6/113 (Item 2 from file: 32)
DIALOG(R)File 32:(c) 1994 ASM/Inst. of Materials. All rts. reserv.

1777282
Application of the Taguchi Design of Experiments Method in a Rule 1168
Solvent Replacement Study.

5/6/114 (Item 3 from file: 32)
DIALOG(R)File 32:(c) 1994 ASM/Inst. of Materials. All rts. reserv.

1764524
Here Today, Gone Tomorrow: Replacing Methyl Chloroform in the Penetrant
Process.

5/6/115 (Item 1 from file: 144)
DIALOG(R)File 144:(c) 1994 INIST/CNRS. All rts. reserv.

10491369 PASCAL No.: 93-0000620
Replacing 1,1,1- trichloroethane : consider other chlorinated solvents

5/6/116 (Item 1 from file: 317)
DIALOG(R)File 317:(c) 1994 Royal Soc Chemistry. All rts. reserv.

029088
Phasing out 1,1,1- trichloroethane

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 5/6/117      (Item 1 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

505862
TITLE: THE 5 TRILLION US DOLLAR MISTAKE


 5/6/118      (Item 2 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

505656
TITLE: 1990 CLEAN AIR ACT AMENDMENTS: CHARTING A COURSE TO COMPLIANCE


 5/6/119      (Item 3 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

504069
TITLE: CHLORINE COMPANIES ADOPT DEFIANT STAND


 5/6/120      (Item 4 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

503485
TITLE: TRENDS POSE CHALLENGES FOR ADHESIVES MAKERS


 5/6/121      (Item 5 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

501806
TITLE: UPDATE: SOLVENT SELECTION FOR PROCESSING SILICONE ELASTOMERS


 5/6/122      (Item 6 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

497955
TITLE: LOOMING BAN ON PRODUCTION OF CFCS, HALONS SPURS SWITCH TO
   SUBSTITUTES


 5/6/123      (Item 7 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

494203
TITLE: CLEANING AGENT DEVELOPED TO  REPLACE   TRICHLOROETHANE


 5/6/124      (Item 8 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.
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492585
TITLE: REPLACEMENT OF HALOGENATED HYDROCARBONS IN CLEANING PROCESSES

5/6/125 (Item 9 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

479910
TITLE: PROPOSAL FOR A COUNCIL DECISION CONCERNING THE CONCLUSIONS OF THE AMENDMENT TO THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER AS ADOPTED IN NOVEMBER 1992 IN COPENHAGEN BY THE PARTIES TO THE PROTOCOL (93/C 103/08) COM(93) 102 FINAL

5/6/126 (Item 10 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

479904
TITLE: DOE CONSULTS ON "ESSENTIAL" USES OF OZONE DEPLETERS

5/6/127 (Item 11 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

474567
TITLE: GOVERNMENT HIGHLIGHTS BAN ON OZONE DEPLETERS

5/6/128 (Item 12 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

473562
TITLE: EC BRINGS FORWARD CONTROLS ON CFCs

5/6/129 (Item 13 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

470016
TITLE: OZONE DEPLETER BAN: RETHINKING NEEDED FOR REFRIGERATION AND FIRE FIGHTING

5/6/130 (Item 14 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

469545
TITLE: IMPERIAL ADHESIVES INC.

5/6/131 (Item 15 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

469161
TITLE: EARLIER EXIT FOR OZONE DEPLETERS?

5/6/132 (Item 16 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

468638
TITLE: COUNTDOWN TO COPENHAGEN

5/6/133 (Item 17 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

467960
TITLE: SAFER AEROSOL ADHESIVE FOR NEW REGS.

5/6/134 (Item 18 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

466541
TITLE: NEW AGENDA FOR CHLORINATED SOLVENTS

5/6/135 (Item 19 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

466117
TITLE: HCFCs TO GO BY 2030

5/6/136 (Item 20 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

465567
TITLE: MOULD RELEASE AGENTS: A DIFFERENT VIEW

5/6/137 (Item 21 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

463532
TITLE: LARGE HOLE IN THE OZONE AGREEMENT

5/6/138 (Item 22 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

456506
TITLE: RIPPLE EFFECT

5/6/139 (Item 23 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

455979
TITLE: CONSENSUS ON CFC PHASEOUT FOR END-1995

5/6/140 (Item 24 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

451830
TITLE: INDUSTRY, CONSUMERS PREPARE FOR COMPLIANCE WITH PENDING CFC BAN

5/6/141 (Item 25 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

451438
TITLE: SAFETY SOLVENT

5/6/142 (Item 26 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

450365
TITLE: FORMULATORS FACE ENVIRONMENTAL LAWS

5/6/143 (Item 27 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

447858
TITLE: SOLVENTS: NEW ALTERNATIVES. I.

5/6/144 (Item 28 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

439742
TITLE: EUROPE BANS CFCs

5/6/145 (Item 29 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

416762
TITLE: DOW SEMINAR FORECASTS MCF USE IN CHEMICALS

```
 5/6/146     (Item 30 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

416710
TITLE: CFC REDUCTION AND ELIMINATION


 5/6/147     (Item 31 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

400213
TITLE: WATER-BASED AGENTS OFFER ALTERNATIVE


 5/6/148     (Item 32 from file: 323)
DIALOG(R)File 323:(c) 1994 RAPRA Technology Ltd. All rts. reserv.

378898
TITLE: CHLORINATED SOLVENTS OFFER PERFORMANCE AND LOW VOC


 5/6/149     (Item 1 from file: 340)
DIALOG(R)File 340:(c) 1994 IFI/Plenum Data Corp. All rts. reserv.

2117647   9103454
C/HALOGEN EXCHANGE FLUORINATION; REACTING HALOCARBONS HAVING A  REPLACAB
LE
     HALOGEN OTHER THAN FLUORINE WITH CESIUM OR RUBIDIUM FLUORO COMPOUNDS


 5/6/150     (Item 2 from file: 340)
DIALOG(R)File 340:(c) 1994 IFI/Plenum Data Corp. All rts. reserv.

1913540   8902066   2906423
CM/DRY CLEANING METHOD USING AT LEAST TWO KINDS OF SOLVENTS; 1,1,1
    TRICHLOROETHANE, PERCHLOROETHYLENE, TURPENTINE; REDUCES WRINKLING,
   SHRINKAGE


 5/6/151     (Item 1 from file: 351)
DIALOG(R)File 351:(c) 1994 Derwent Info Ltd. All rts. reserv.

009353377  WPI Acc No: 93-046856/06
Related WPI Accession(s): 89-371928
XRAM Acc No: C93-021096
   1,1,1-Trifluoro-2,2-dichloroethane prodn. in high yield - by reacting

   trifluoro-2-chloroethane with chlorine@ at controlled mol. ratio,
   useful as  replacement for trichlorofluoromethane; CHLOROMETHANE


 5/6/152     (Item 2 from file: 351)
```

```
DIALOG(R)File 351:(c) 1994 Derwent Info Ltd. All rts. reserv.

009107115  WPI Acc No: 92-234546/28
XRAM Acc No: C92-105787
   Dichlorofluoroethane purificn. by vapour phase photochlorination -
   removes vinylidene chloride and other unsatd. cpds. to leave a
   potential  replacement refrigerant for CFC; CHLORO FLUOROCARBON


 5/6/153     (Item 3 from file: 351)
DIALOG(R)File 351:(c) 1994 Derwent Info Ltd. All rts. reserv.

008582859  WPI Acc No: 91-086891/12
XRAM Acc No: C91-036940
   Prodn. of ioversol, X-ray contrast agent - from corresp. hexaacetate
by
   removal of solvent using 1,1,2- trichloroethane and hydrolysis


 5/6/154     (Item 4 from file: 351)
DIALOG(R)File 351:(c) 1994 Derwent Info Ltd. All rts. reserv.

008419590  WPI Acc No: 90-306591/41
XRAM Acc No: C90-132360
   1,1-Dichloro-1-fluoroethane and 1-chloro-1,1-difluoroethane prepn. -
by
   reacting 1,1,1- trichloroethane with hydrogen fluoride in presence of

   Lewis acid catalysts


 5/6/155     (Item 5 from file: 351)
DIALOG(R)File 351:(c) 1994 Derwent Info Ltd. All rts. reserv.

007788965  WPI Acc No: 89-054077/07
XRAM Acc No: C89-023962
   Alternative blowing agent to r-11 for plastic, esp. urethane! foam -
   comprises mixt. of r-22 and  trichloroethane in wt. ratio of 1 to 3 o
r
   less, opt. contg. small amt. of propane, butane or pentane


 5/6/156     (Item 1 from file: 353)
DIALOG(R)File 353:(c) 1994 American Petroleum Institute. All rts. reserv
.

0233311
Catalytic hydrodehalogenation of halogenated hydrocarbon(s) - in presenc
e
   of nickel-contg. zeolite catalyst and hydrogen donor


 5/6/157     (Item 2 from file: 353)
```

DIALOG(R)File 353:(c) 1994 American Petroleum Institute. All rts. reserv
.

0219624
New substitute for freon - contains
fluoromethyl-1,1,1,3,3,3-hexafluoroisopropyl ether, and has high
detergency against fats, oils and fluxes

5/6/158 (Item 3 from file: 353)
DIALOG(R)File 353:(c) 1994 American Petroleum Institute. All rts. reserv
.

0216327
Surface-cleaning lubricant for paper-making drier - consists of oil
material(s), nonionic surfactant(s) and mixt. of cationic and
amphoteric surfactants, to improve surface glossiness

5/6/159 (Item 4 from file: 353)
DIALOG(R)File 353:(c) 1994 American Petroleum Institute. All rts. reserv
.

0216164
Detergent compsn. effective for CFC 113 and 1,1,1,- trichloroethane -
contains middle petroleum oil, polyoxyethylene alkyl ether type
nonionic surfactant and anionic surfactant e.g. morpholine salt

5/6/160 (Item 5 from file: 353)
DIALOG(R)File 353:(c) 1994 American Petroleum Institute. All rts. reserv
.

0211042
Azeotropic or pseudoazeotropic compsn. - contains mainly of
trichlorodifluoroethane, useful as alternate solvents

5/6/161 (Item 6 from file: 353)
DIALOG(R)File 353:(c) 1994 American Petroleum Institute. All rts. reserv
.

0210632
1,2-Dichloroethane prodn. by chlorination of ethylene - with a
phenolate-chloro complex as catalyst, e.g. sodium o-cresolate
trichloroferrate, pref. in dichloroethane as reaction medium

5/6/162 (Item 7 from file: 353)
DIALOG(R)File 353:(c) 1994 American Petroleum Institute. All rts. reserv
.

0205620

Compsn. contg. polybutylene, and polyethylene terephthalate(s) - and high
level of zinc oxide, prepd. by melt blending, provides moulded articles
with ceramic-like feel and density

5/6/163 (Item 8 from file: 353)
DIALOG(R)File 353:(c) 1994 American Petroleum Institute. All rts. reserv.

0204229
Pseudo)azeotropic fluorohydrocarbon mixt. - comprises
1,2-dichloro-1-fluoroethane and 1,1,1 trichloroethane, useful as
freon substitute

5/6/164 (Item 9 from file: 353)
DIALOG(R)File 353:(c) 1994 American Petroleum Institute. All rts. reserv.

0204228
Pseudo)azeotropic fluorohydrocarbon mixt. - comprises
1,1,2-trichloro-2,2-difluoroethane and 1,1,1- trichloroethane, useful
as freon substitute

5/6/165 (Item 10 from file: 353)
DIALOG(R)File 353:(c) 1994 American Petroleum Institute. All rts. reserv.

0204227
Pseudo)azeotropic fluorohydrocarbon compsn. - comprises
1,2-difluorotetrachloroethane and 1 1,1- trichloroethane, useful as
freon substitute

5/6/166 (Item 11 from file: 353)
DIALOG(R)File 353:(c) 1994 American Petroleum Institute. All rts. reserv.

0200864
Degradation of halogenated aliphatic hydrocarbon(s) - with methanotrophic
bacteria in presence of oxygen and lower alkanol as carbon source

5/6/167 (Item 12 from file: 353)
DIALOG(R)File 353:(c) 1994 American Petroleum Institute. All rts. reserv.

0196375

High levels of fluorine substitution in tantalum pentafluoride - catalysed
reactions between hydrogen fluoride and halogenated alkene or alkane derivs

5/6/168 (Item 13 from file: 353)
DIALOG(R)File 353:(c) 1994 American Petroleum Institute. All rts. reserv.

0158195
LIQUID CLEANING AND PROTECTING COMPSN. - CONTG. POLY(METHYLHYDROSILOXANE),
ZINC OCTOATE AND TIN OCTOATE IN SELECTED SOLVENT

5/6/169 (Item 1 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv.

0524188
Substitution of organic solvents and hazardous binders by bonding with
adhesives in the manufacture of fabricated metal products, machinery,
and equipment

5/6/170 (Item 2 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv.

0520832
Toward catalysis in the 21st century chemical industry

5/6/171 (Item 3 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv.

0520577
High technology aids plant maintenance. (A survey of new equipment and
materials for CPI plant maintenance)

5/6/172 (Item 4 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv.

0514999
Utilizing hydrogen carrier gas in volatiles analysis for maximum resolution
in the shortest analysis time

5/6/173 (Item 5 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0514943
Here today, gone tomorrow...Halogenated solvents in analytical chemistry

5/6/174 (Item 6 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0513435
New life for old solvents

5/6/175 (Item 7 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0512296
Canada pushes innovative remediation technology

5/6/176 (Item 8 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0511872
Heirs to the throne: Alternative cleaners vie with methyl chloroform and
CFC-113 for reign over the parts-cleaning empire

5/6/177 (Item 9 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0511027
Chemical detoxification of trichloroethylene and 1,1,1- trichloroethane
in
a microwave discharge plasma reactor at atmospheric pressure

5/6/178 (Item 10 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0509638
Kinetics of purging for the priority volatile organic compounds in water

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 5/6/179     (Item 11 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0509006
Environmental News/Amoco (Corp) cuts annual emissions (and) Exxon Chemic
al
   (Co) offers alternatives to ozone depleting cleaners


 5/6/180     (Item 12 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0506717
Duriron (Company Inc) taking leadership role in waste minimization


 5/6/181     (Item 13 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0506514
Department of Energy solvent substitution


 5/6/182     (Item 14 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0494784
A high pressure method of bitumen extraction from asphalt pavement


 5/6/183     (Item 15 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0488628
Clean Air Act compliance through process change


 5/6/184     (Item 16 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0488477
Aqueous cleaners challenge chlorinated solvents


 5/6/185     (Item 17 from file: 354)
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DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0483093
Environmental rules move chlorine's goalposts


 5/6/186     (Item 18 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0481298
CFC phaseout/processing costs spur PU ((polyurethane)) catalysts


 5/6/187     (Item 19 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0480129
"Green" cleaner


 5/6/188     (Item 20 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0476406
Protection of stratospheric ozone


 5/6/189     (Item 21 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0475186
Stability of low level aromatic and halogenated hydrocarbons in SUMMA(TM
)
   canisters


 5/6/190     (Item 22 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0472851
Fluorination of 1,1,1- trichloroethane ((F140)) with HF and SbCl5 at low
   temperatures


 5/6/191     (Item 23 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0471606
CFC substitutes probably safe, EPA judges

5/6/192 (Item 24 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0448724
Model assessment of the atmospheric CFC(PRIME)s and substitutes: A two-dimensional model assessment

5/6/193 (Item 25 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0446988
Montreal Protocol: Gandhi wins support

5/6/194 (Item 26 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0446972
A novel method of bitumen extraction from asphalt pavement

5/6/195 (Item 27 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0446171
India & China set to sign strengthened CFC protocol

5/6/196 (Item 28 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0445975
Consumer boycott of (1,1,1-) trichloroethane (is) urged

5/6/197 (Item 29 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0440099
Letters/(Toxicity of CFC(PRIME)s.)

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 5/6/198     (Item 30 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0440045
Methyl chloroform under scrutiny


 5/6/199     (Item 31 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0438353
NASA calls for faster CFC phaseout


 5/6/200     (Item 32 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0437613
Source reduction of chlorinated solvents ((CS)): A multimedia approach

 5/6/201     (Item 33 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0421370
Now HCFC-22 feels the pressure


 5/6/202     (Item 34 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0421209
EPA plans health, environmental safety review of CFC substitutes

 5/6/203     (Item 35 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0420605
Evaluating CFC alternatives from the atmospheric viewpoint

 5/6/204     (Item 36 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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 0420366
 Letters (to the editor)/Ozone-depleting chemicals: (The U.S. seeks tight
er
    rules on ozone protection.)


 5/6/205     (Item 37 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0420111
International gathering plans ways to safeguard atmospheric ozone


 5/6/206     (Item 38 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0419737
(The) U.S. seeks tighter rules on ozone protection


 5/6/207     (Item 39 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0419665
Protection of stratospheric ozone


 5/6/208     (Item 40 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0418134
Rough sledding in raw materials


 5/6/209     (Item 41 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv

0417916
Urethane makers feel CFC squeeze


 5/6/210     (Item 42 from file: 354)
IALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv

417105
Letters (to the editor)/Methyl chloroform concern: (International gather
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ing
   plans ways to safeguard atmospheric O3)


 5/6/211     (Item 43 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
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0413475
R. G. Shannon Co. announces new cutting oil


 5/6/212     (Item 44 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0402767
RETROFITTING AN INDUSTRIAL LIQUID/SLUDGE INCINERATOR


 5/6/213     (Item 45 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0402694
EXPERIENCE IN GASEOUS TOXIC MONITORING IN THE SAN FRANCISCO BAY AREA


 5/6/214     (Item 46 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0402481
SOIL-GAS SURVEYING TECHNIQUES


 5/6/215     (Item 47 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0399696
IMPACT ON OZONE ATTAINMENT OF CFC ((CHLOROFLUOROCARBON)) CONTROLS USED T
O
   PREVENT FUTURE DEPLETION OF STRATOSPHERIC OZONE


 5/6/216     (Item 48 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0384644
EPA PROPOSES RULES FOR INERT INGREDIENTS
```

5/6/217 (Item 49 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0384503
EPA TO REGULATE "INERT" PESTICIDE INGREDIENTS

5/6/218 (Item 50 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0383312
NEW MATERIALS CRACK CORROSION PROBLEMS

5/6/219 (Item 51 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0382645
CHEMICAL WASTES...FROM HAZARDOUS PROBLEM TO SAFE VALUE RECOVERY

5/6/220 (Item 52 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

0374822
LEGAL BRIEFS/(1,1,1- TRICHLOROETHANE) EXTREMELY HAZARDOUS WASTE

5/6/221 (Item 53 from file: 354)
DIALOG(R)File 354:(c) 1994 American Petroleum Institute. All rts. reserv
.

374001
ODIFICATION AND EVALUATION OF A THERMALLY DESORBABLE PASSIVE SAMPLER
(DEVICE, PSD) FOR VOLATILE ORGANIC COMPOUNDS IN AIR

5/6/222 (Item 1 from file: 399)
IALOG(R)File 399:(c) 1994 American Chemical Society. All rts. reserv.

A new process alternative for replacing ozone-depleting solvent cleaner
:

5/6/223 (Item 2 from file: 399)
IALOG(R)File 399:(c) 1994 American Chemical Society. All rts. reserv.

Conversion from solvent to aqueous chemistries for the final cleaning o

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f
printed wiring boards in a printed wiring board facility: final report

  5/6/224      (Item 3 from file: 399)
DIALOG(R)File 399:(c) 1994 American Chemical Society. All rts. reserv.

 Printed circuit board defluxing:  alternatives to ozone depleting
substances


  5/6/225      (Item 4 from file: 399)
DIALOG(R)File 399:(c) 1994 American Chemical Society. All rts. reserv.

 Process for production of 1,1-dichloro-1-fluoroethane and/or
1-chloro-1-1-difluoroethane


  5/6/226      (Item 1 from file: 434)
DIALOG(R)File 434:(c) 1994 Inst for Sci Info. All rts. reserv.

13147076   Genuine Article#: NR413   Number of References: 25
Title: TRANSFORMATION AND DECOMPOSITION OF 1,1,1- TRICHLOROETHANE ON
   TITANIUM-DIOXIDE IN THE DARK AND UNDER PHOTOILLUMINATION  (Abstract
    Available)


  5/6/227      (Item 2 from file: 434)
DIALOG(R)File 434:(c) 1994 Inst for Sci Info. All rts. reserv.

11459856   Genuine Article#: HK197   Number of References: 4
Title: CABLE CLEANING SOLVENTS - ENVIRONMENTAL-ISSUES AND EFFECTIVE
    REPLACEMENTS    (Abstract Available)


  5/6/228      (Item 3 from file: 434)
IALOG(R)File 434:(c) 1994 Inst for Sci Info. All rts. reserv.

1136236   Genuine Article#: GK019   Number of References: 0
itle: CFC ALTERNATIVE CLEANING SYSTEMS  (Abstract Available)
logoff
       04aug94 16:01:04 User036172 Session D437.2
       Sub account: BULLUCK/F7411
          $19.69  0.233 Hrs FileOS
           $5.50  228 Types
           $0.92  View Fee
   $26.11  Estimated cost FileOS
           OneSearch, 51 files,  0.233 Hrs FileOS
    $2.66  TYMNET
   $28.77  Estimated cost this search
   $29.15  Estimated total session cost   0.266 Hrs.
```

```
### Status: Signed Off.
```

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Appendix B:

Annotated Bibliography Based on Dialog/DTIC Searches

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JWB

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### Status: Dialog Basic Connection Path #1

### Status: Initializing modem ...
AT&FE1Q0V1X4&C1&D2&K4
OK
### Status: Dialing primary number (448-4611)...

ATDT448-4611
CONNECT 9600
### Status: Connection established at 9600 baud


please type your terminal identifier
-3523:01-004-
please log in: DIALOG


DIALOG: call connected
### Status: Connected


DIALOOG INFORMATION SERVICES
PLEASE LOGON:
 ******** HHHHHHHH SSSSSSSS?
### Status: Signing onto Dialog
 ********
ENTER PASSWORD:
 ******** HHHHHHHH SSSSSSSS? ********
Welcome to DIALOG
### Status: Connected

Dialog level 36.08.02D

Last logoff:  04aug94 16:01:05
Logon file405 08aug94 08:51:48
*****************************************************************
As of 08:51 EST on 08/08/94 you had 1 DIALMAIL message(s) waiting.
*****************************************************************
ANNOUNCEMENT   ****   ANNOUNCEMENT   ****   ANNOUNCEMENT
```

```
***Dialog's new pricing plan effective August 1.                    ***
   See Homebase Announcements for details.

***New Health Economic News Online in PHIND (File 130).             ***

***CANADIAN NEWSPAPERS (File 727) release delayed until early
   August.                                                          ***

***Coming in August: TRADEMARKSCAN(R) - AUSTRIA, FRANCE, and ITALY
   (Files 662, 657, and 673).  See Homebase for details.            ***

***NEW on Data-Star: SUMMARY OF WORLD BROADCASTS and
   INTERNATIONAL MARKET RESEARCH INFORMATION.  See Homebase
   for details.                                                     ***
***DialogLink Now Available for the Macintosh!                      ***

***The Enhanced DIALOG Menus is NOW Available - BEGIN MENUS to
   Use the New DIALOG Menus.                                        ***

***The FAMILY RESOURCES Database (File 291) No Longer Updated.      ***

***CAREER PLACEMENT REGISTRY (File 162) Removed from DIALOG.        ***

     >>> Enter BEGIN HOMEBASE for Dialog Announcements <<<
     >>>    of new databases, price changes, etc.      <<<
     >>>    Announcements last updated for 29jul94     <<<
Banner display set OFF.
HILIGHT set on as '*'
KWIC is set to 5.
BLIP set on
NOTICE set ON to $25.00
You will be prompted to confirm each output request that exceeds $25.00
COST          = ONESEARCH.
Please enter SUBACCOUNT name/number:
?
?bulluck/f7411
Is BULLUCK/F7411 the SUBACCOUNT you want to use? (Y/N)
?y
Subaccount is set to BULLUCK/F7411
SYSTEM:HOME
Menu System II: D2 version 1.7.1 term=ASCII
Terminal set to DLINK
```

```
                     *** DIALOG HOMEBASE(SM) Main Menu ***

 Information:
  1.  Announcements (new files, free connect time, price changes, etc.)
  2.  Database, Rates, & Command Descriptions
  3.  Help in Choosing Databases for Your Topic
  4.  Customer Services (telephone assistance, training, seminars, etc.)
  5.  Product Descriptions

 Connections:
  6.  DIALOG Menus(SM)
  7.  DIALOG Business Connection(R), Headlines(SM), Medical Connection(SM)
  8.  DIALOG SourceOne(SM) Document Delivery
  9.  Data-Star
 10.  Other Online Menu Services & Files (MoneyCenter(R), OAG, TNT, etc.)

      /H = Help          /L = Logoff          /NOMENU = Command Mode


Enter an option number to view information or to connect to an online
service.  Enter a BEGIN command plus a file number to search a database
(e.g., B1 for ERIC).
?b 16

        08aug94 08:52:27 User036172 Session D438.1
        Sub account: BULLUCK/F7411
             $0.00    0.010 Hrs FileHomeBase
      $0.00  Estimated cost FileHomeBase
      $0.11  TYMNET
      $0.11  Estimated cost this search
      $0.11  Estimated total session cost   0.010 Hrs.


File  16:PTS PROMT(TM)  1972-1994/Aug 08
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      Set  Items  Description
      ---  -----  -----------
?k 04806655;k 04532957;k 04524903;k 04452598;k 04290140;k 04267510;k 04231489;k 042137
82;k 03908318;k 03851878;k 03670977;k 03668978;k 03552915;k 02645461;k 02613441;k 0197
5271;k 01804689
      S0        1  04806655
```

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        S0          2  04532957
        S0          3  04524903
        S0          4  04452598
        S0          5  04290140
        S0          6  04267510
        S0          7  04231489
        S0          8  04213782
        S0          9  03908318
        S0         10  03851878
        S0         11  03670977
        S0         12  03668978
        S0         13  03552915
        S0         14  02645461
        S0         15  02613441
        S0         16  01975271
        S0         17  01804689
?t s0/5/all

Estimated cost of output requested is: $28.05
Are you ready to receive all output? (Yes/No/Help)
?yes

 0/5/1
DIALOG(R)File  16:PTS PROMT(TM)
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04806655
Dow Restructures Solvents To Replace Methyl Chloroform
  Will  spend  some  $100 mil to reorganize global chlorinated hydrocarbons
    bsns

Chemical Marketing Reporter   November 8, 1993   p. 3
ISSN: 0900-0907

    Dow  Chemical  Company is spending close to $100 million to restructure
its  global  chlorinated  hydrocarbons  business in order to replace methyl
chloroform   (MCF)  and  provide  feedstock  for  fluorocarbons  and  other
intermediate applications.
     In  addition  to halting global production of MCF with the closures of
plants in Freeport, Tex., and Stade, Germany, as well as making adjustments
to its three chloromethanes plants which produce methyl chloride, methylene
chloride  and chloroform, Dow hopes to modify its two perchloroethylene and
```

carbon tetrachloride (per/tet) plants to produce only perchloroethylene.

Demand for MCF, or 1,1,1-trichloroethane, has fallen off some 70 percent since 1989, as users converted to alternative products in preparation for the end-of-1995 phaseout mandated by the London and Copenhagen Amendments to the Montreal Protocol. Dow also plans to go ahead with plans to build a new trichloroethylene plant in Stade.

Dow plans to complete the shutdown of its 500-million-pound MCF plant in Freeport on or about April 1, 1994, and says it will help customers evaluate alternatives such as methylene chloride, perchloroethylene and trichloroethylene. In addition, the company hopes to convert its Stade facility from MCF to trichloroethylene production by the end of 1994.

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FULL TEXT AVAILABLE IN FORMAT 9
WORD COUNT: 364

PRODUCT: *Halogenated Hydrocarbons (2868100); Methyl Chloroform (2868114); Trichloroethylene (2868121)
EVENT: *Capital Expenditures (43); Facilities & Equipment (44)
COUNTRY: *United States (1USA); Texas (1548); Germany (4GER)

0/5/2
DIALOG(R)File 16:PTS PROMT(TM)
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04532957
Lower solvent use fails to hit production
Europe: Use of 1,1,1-trichloroethane should be cut 50% by 1994 & banned totally in 1995

Engineer July 8, 1993 p. 12
ISSN: 0013-7758

EUROPEAN industry has cut back its use of environmentally-damaging chlorinated solvents by an eighth in the past two years, although there is no corresponding fall off in production.

The reduction is due to better conservation techniques, which have led to reduced emissions, and increased recycling.

But with many of the substances facing bans by 1995 under the Montreal Protocol the use of replacement chemicals is also playing a part, says the European Chlorinated Solvent Association (ECSA).

The protocol says that use of the metal-cleaning chemical 1,1,1-trichloroethane should be cut by 50% by next year and banned altogether in 1995.

In the UK the Engineering Employers' Federation has launched a roadshow to help companies find safe alternatives, as many replacement chemicals can cause health or safety problems.

ECSA recommends methylene chloride, perchloroethylene or trichloroethylene as substitute cleaning agents. It says these solvents are recyclable, involve very little change to cleaning equipment and have low flammability. Other organizations promote solvent-free cleaning.

Export demand and the use of some solvents in the production of fluorocarbons, which are used to replace chemicals banned under the protocol, are blamed for the largely unchanged level of European production. Environmentalists are critical of these replacement solvents.

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WORD COUNT: 193

PRODUCT: *Trichloroethane (2868119)
EVENT: *Government Regulation (93)
COUNTRY: *Europe (4 E)

0/5/3
DIALOG(R)File 16:PTS PROMT(TM)

04524903
Fujitsu General to Eliminate Freon, Trichloroethane from Cleaning Processes

Comline Electronics July 21, 1993 p. 6

Fujitsu General Ltd. (6755) has announced its intention to eliminate the use of Freon and trichloroethane from cleaning processes in the production of PCBs and heat exchangers by the end of 1995. The firm will also replace Freon used as a refrigerant and as a foaming agent in the production of adiabetic urethane resin. Fujitsu General will replace CFC12 with HFC134a for refrigeration and CFC11 with HCFC141b for use as a foaming agent.

COMLINE NEWS SERVICE, Sugetsu Building, 3-12-7 Kita-Aoyama, Minato-Ku, Tokyo 107, Japan. Telex 2428134 COMLN J.

THIS IS THE FULL TEXT: Copyright 1993 COMLINE NEWS SERVICE
WORD COUNT: 87

COMPANY:
*Fujitsu General
PRODUCT: *Printed Circuit Boards (3679410); Heat Exchangers (3443110)
EVENT: *Use of Materials & Supplies (46)
COUNTRY: *Japan (9JPN)

0/5/4
DIALOG(R)File 16:PTS PROMT(TM)
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04452598
2 U.S. Chemical Firms To Sell CFC Alternatives In Japan
Occidental Chemical: To introduce 1,1,1-trichloroethane solvent alternative as CFC replacement, Japan

Japan Chemical Week June 3, 1993 p. 1
ISSN: 0047-1755

Occidental Chemical will begin selling its 1,1,1-trichloroethane solvent alternative in Japan as a replacement for the CFC, according to a company annoucement. DuPont will also introduce its dibasic ester alternative to triethane for use in cleaning epoxy-resin casting machines. The chemical has no ozone-depletion potential.

COMPANY:
*Occidental Chemical
DuPont

PRODUCT: *Trichloroethane (2868119)
EVENT: *Product Design & Development (33)
COUNTRY: *Japan (9JPN)

0/5/5
DIALOG(R)File 16:PTS PROMT(TM)
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04290140

Recyclable Metal Cleaner To Replace Ozone Depleter
  Nikko Petrochemical: Develops NS Clean hydrocarbon-based recyclable metal cleaner

Japan Chemical Week   February 4, 1993   p. 3
ISSN: 0047-1755

Nikko Petrochemicals (Japan) has developed NS Clean, a hydrocarbon-based recyclable metal cleaner. The n-paraffin based agent will substitute for trichloroethane and fluorocarbons that deplete the ozone layer and will be banned by late 1995. Sales of the new cleaner are expected to reach $48 mil by FY95.

COMPANY:
  *Nikko Petrochemical

PRODUCT: *Acid-Type Metal Cleaners (2841170)
EVENT: *Product Design & Development (33)
COUNTRY: *Japan (9JPN)

0/5/6
DIALOG(R)File 16:PTS PROMT(TM)

04267510
The new agenda for chlorinated solvents
  W Europe: Chlorinated solvents use falls 50% since 1974, due to chlorine-linked concerns & matrl recycling

European Chemical News   January 18, 1993   p. 14
ISSN: 0014-2875

W Europe: Chlorinated solvents consumption has fallen 50% since 1974, due to chlorine-linked concerns and increasing focus on recycling, good housekeeping and closed systems, according to the European Chlorinated Solvent Association (ECSA). Less material is being used, but part of the reason is that more efficient systems need less new solvent to be added to the cycle. Technological improvements that have reduced solvent emissions and increased use of recycled product have cut virgin solvent use 15-20%, according to ECSA.

The most modern solvents--111-trichloroethane (111-TCE) and

CFC-113--have seen the most dramatic turnaround, with 111-TCE the only commonly used chlorinated solvent to be regulated under the Montreal Protocol. Its use will be cut 50% by 1/1/94 and phased out by 1/1/96, and Germany banned it at start-1993. It is mainly used in metal cleaning and electronics, but has smaller applications in adhesives, pharmaceuticals and as a chemical intermediate. ECSA recommends its replacement with the more traditional solvents--trichloroethylene and perchloroethylene in metal cleaning and methylene chloride in such applications as pharmaceuticals--before resorting to its introduction. CFC-113 is a more specialized solvent used in the electronics industry. Its use will be cut 75% by 1/1/94 and phased out by 1/1/96, in line with other CFCs, under the revised Montreal agreement. Article discusses other solvents, table details W European chlorinated solvent capacity in 1990 by product, company and country, and graphs detail European chlorinated hydrocarbon demand in 1991-2000 and the pros and cons of solvent cleaning alternatives by product.

PRODUCT: *Chlorinated Solvents (2868138); Trichloroethane (2868119); Fluorocarbons (2868160)
EVENT: *Sales & Consumption (65)
COUNTRY: *West Europe (4 W)

0/5/7
DIALOG(R)File 16:PTS PROMT(TM)

04231489
MATERIALS & COMPONENT NEWS: ROSSTECH (TM) CFC-FREE FORMULA REPLACES TRICHLOROETHANE

SMT Trends December, 1992 p. N/A

JNJ Industries (Milford, MA; 800-554-9994) has introduced a replacement solvent for 1,1,1 trichloroethane, called ROSSTECH (TM) Formula 119EC (enhanced cleaning) Safety Solvent. Formulated primarily of glycol ethers and alkanolamines, the solvent is DOT rated non-flammable, is of moderate toxicity, and does not require reporting under CERCLA. The clear, colorless solvent has a mild odor and is designed for use in benchtop or batch cleaners and degreasers including ultra sonic systems; but due to its high boiling point (150 degs -160 degs C), it is not intended for use in vapor degreasers.

Repeated cleaning tests have demonstrated that the product cleans flux, inks, grease, oils, adhesives and other materials commonly cleaned with trichloroethane equally well. In addition, it is 100% soluble in water and, although it leaves no residue, can be completely rinsed off when a water rinse is desired.

The ROSSTECH formulas are alternative solvent cleaners formulated to replace toxic and hazardous solvents such as xylene, trichlorethylene, aromatics, and especially ozone-depleting chlorofluorocarbons (CFCs). ROSSTECH solvents are compatible with virtually all emulsion systems.

Two other formulations are available--ROSSTECH 119ME and ROSSTECH 106FE (fast evaporator). Both are effective cleaners for screens and stencils. They remove flux, solder paste, cermet and graphics inks, grease, oils, etc. by wiping, immersion, or ultrasonic cleaning. They clean misprints from ceramic or PCB substrates. 106FE is a faster drying solvent than the 119ME and is therefore better suited for quick evaporation from screens and substrates.

The solvents are available in bulk or in JNJ Industries' SuperSaturated SMARTWIPES (R).

WORD COUNT: 247

COMPANY:
*JNJ Industries

PRODUCT: *Semiconductor Devices (3674000); Semiconductor Production Equip (3559581)
EVENT: *Manufacturing Processes (32); Use of Materials & Supplies (46)
COUNTRY: *United States (1USA)

0/5/8
DIALOG(R)File 16:PTS PROMT(TM)

04213782
FOOD FLAVORING REPLACES TRICHLOROETHANE

Chemical Week December 16, 1992 p. 40
ISSN: 0009-272X

AT&T (New York) says that it has found a food flavoring, n-butyl butyrate, that can work as a solvent in place of ozone-depleting 1,1,1,-trichloroethane. The chemical, which can be derived from cantaloupe, has been tested for two years, and should be in use in multichip manufacturing plants by the end of 1992. AT&T says it has spent $25 million to develop replacements for ozone-depleting solvents and has cut chlorofluorocarbon emissions by 76%.

WORD COUNT: 72

COMPANY:
  *American Tel & Tel

PRODUCT: *Food Flavorings (2869140); Fluorocarbons (2868160); Electronic Components (3670000)
EVENT: *Product Design & Development (33); Use of Materials & Supplies (46)
COUNTRY: *United States (1USA)

0/5/9
DIALOG(R)File 16:PTS PROMT(TM)

03908318
SAVING THE OZONE LAYER
  Hewlett-Packard: Managers cease using CFCs on Montreal Protocol list & others

Chemical Business June, 1992 p. 11
ISSN: 0731-8774

One device manufacturer which today goes beyond the call of duty when replacing chemicals harmful to the Earth's ozone layer is Hewlett-Packard Co. H-P managers not only have stopped using CFCs (chlorofluorocarbons) listed on the Montreal Protocol list, but have also eliminated suspicious CFCs not mentioned on the list.

"Our goal is to be years ahead of the requirements expressed in the Montreal Protocol," asserts John Jacobi, materials engineering manager at H-P's Integrated Circuit Business Division (ICBD) and a member of the CFC corporate task force. "We replace dangerous chemicals with environmentally safe materials and when suitable replacements cannot be found, the company frequently changes or eliminates the offending chemical processes."

For decades, CFCs were selected as premier cleaning solvents within the electronics and other industries due to their safety, stability and compatibility with most materials. Today these admirable properties are overshadowed by their negative effect on the world's ozone layer. Indeed, stability is a main problem of CFCs. They are so stable that they cannot be easily extracted from the atmosphere and can linger for generations to the detriment of the planet.

Not surprisingly, much of Hewlett-Packard's new chemical development efforts are focused on solving environmental issues. H-P has a program in effect for photoresists after they are spun, exposed, developed and stripped away. Certain H-P integrated circuit sites uses N-methyl pyrrolidine (NMP) to neutralize acid in the system. This solution is acceptable in certain regions, but in other areas, NMP is considered a combustible fluid and must be captured separately.

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FULL TEXT AVAILABLE IN FORMAT 9
WORD COUNT: 551

COMPANY:
*Hewlett-Packard

PRODUCT: *Computers & Auxiliary Equip (3573000); Fluorocarbons (2868160); Intnl Environmental Law (9103525); Trichloroethane (2868119); Digital Integrated Circuits (3674120)
EVENT: *Use of Materials & Supplies (46); Goods & Services Distribution (69); Production Management (23); Intnl Politics (96)
COUNTRY: *United States (1USA); World (0 W)

0/5/10
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03851878
Zexel to Phase Out Use of CFCs and Trichloroethane

PRS Automotive Service June 15, 1992 p. N/A

Car air conditioner maker Zexel of Japan plans to phase out the use of CFCs by the end of 1994 and 1,1,1-trichloroethane by the end of 1995. CFCs and 1,1,1-trichloroethane are thought to damage the Earth's ozone layer. Zexel uses 900 tonnes of CFCs a year, of which 400 tonnes are used for cleaning parts and 500 tonnes for air conditioner coolant. The firm will gradually replace the cleaning chemical with water-based cleaning equipment and replace the CFC coolant with a substitute.

Annual use of 1,400 tonnes of 1,1,1-trichloroethane for cleaning parts, will be replaced by a water-based cleaning system, according to the company.

Separately, Toyota will phase out its use of 1,1,1-trichloroethane by the end of 1995, while Nissan hopes to discontinue use of the chemical by the end of 1994.

Source: Japan Industrial Journal (p7)
Date: 920604
Ref No: WA92.4907

FOR FURTHER INFORMATION, PLEASE CONTACT PRS INTERNATIONAL. TEL: 203/426-0800.

COMPANY:
*Zexel

PRODUCT: *Auto Air Conditioners (3585172); Trichloroethane (2868119); Fluorocarbons (2868160)
EVENT: *Use of Materials & Supplies (46); Goods & Services Distribution (69)
COUNTRY: *Japan (9JPN)

0/5/11
DIALOG(R)File 16:PTS PROMT(TM)

03670977
ASAHI'S 1,1,1,-TRI REPLACEMENTS
Asahi Chemical Industry: Develops series of aqueous & semiaqueous cleaning agents

Chemical Week March 4, 1992 p. 19
ISSN: 0009-272X

Asahi Chemical has developed a series of aqueous and semiaqueous cleaning agents as substitutes for 1,1,1-trichloroethane. The aqueous cleaning agents are a mix of alkaline ingredients and a surfactant; the semiaqueous agents combine glycol ether solvents and a surfactant and are also meant to replace CFC-113 in metal-cleaning applications. Because the aqueous types are nonflammable and the semiaqueous types have a flash point of over 70 C, they could be safer than other alternatives to 1,1,1-tri, such as petroleum-based and alcohol-based products. However, the Asahi replacements need a specialized cleaning system, and their cleaning effectiveness has yet to be established.

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WORD COUNT: 100
COMPANY:
*Asahi Chemical Industry

PRODUCT: *Commercial & Industrial Cleaning Solvents (2841186)
EVENT: *Product Design & Development (33)
COUNTRY: *Japan (9JPN)

0/5/12
DIALOG(R)File 16:PTS PROMT(TM)
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03668978
Asahi Chemical develops new aqueous and semi-aqueous cleaning agents

Electronic Chemicals News February 28, 1992 p. N/A
ISSN: 0886-5671

Aqueous and semi-aqueous cleaning agents have been developed by Asahi Chemical Industry Co. as alternatives to 1,1,1- trichloroethane, production of which is to be subjected to new restrictions this year.

The aqueous cleaning agent, which consists of pure water mixed with alkaline ingredients and a surfactant, comes in seven grades for applications including the cleaning of automobile parts, and electric and electronic parts. The semi-aqueous cleaning agent, which consists of pure water mixed with glycolether solvents and a surfactant, comes in four grades. This agent can also replace CFC-113 in metal-cleaning applications. Because the aqueous type is non-flammable and the semi-aqueous type has a flash point of over 70 C, the new cleaning agents are safer than other alternatives to trichloroethane, such as petroleum-based and alcohol-based agents.

However, to use the cleaning agents, a specialized cleaning system, consisting of a cleaning unit, an oil-water separation unit, and a drying unit, needs to be installed. Furthermore, the cleaning method's effectiveness has yet to be established. The company is evaluating the cleaning agents in cooperation with leading users in an effort to establish an effective cleaning system.

WORD COUNT: 183

COMPANY:
Asahi Chemical Industry

PRODUCT: *Trichloroethane (2868119); Nonhousehold Alkaline Detergents (2841120); Electronic Components (3670000); Motor Vehicle Parts (3714000); Metal Degreasing Compounds (2899554)
EVENT: *Government Regulation (93); Production Information (62); Pollutants Produced & Recycled (42); Product Design & Development (33); Use of Materials & Supplies (46)
COUNTRY: *Japan (9JPN)

0/5/13
DIALOG(R)File 16:PTS PROMT(TM)

03552915
Detergent NewsFront: ISP Launches CFC Replacement Cleaner
Intnl Specialty Products: Introduces PartsPrep metal degreaser

Chemical Marketing Reporter December 16, 1991 p. 27
ISSN: 0900-0907

International Specialty Products, a subsidiary of GAF Corporation, has introduced 'PartsPrep' degreaser, an alternative metal cleaning system to replace chlorofluorocarbons, solvents and vapor degreasing. The system - which consists of spray or immersion cleaners, a two-stage rinse cycle and a drying stage - penetrates, loosens and removes deposits of carbon, smut, grease, lubricants, drawing and buffing compounds and epoxy resins from most metals. The cleaner is based on pyrrolidone chemistry.

As an alternative to CFC-113, 1,1,1-trichloroethane, halogenated solvents and vapor degreasing, the new cleaning system will see wide use in the coatings, automotive, metalworking, assembly, aerospace and electronic industries, the company says. However, 'PartsPrep' is not a one-for-one CFC substitute, according to Dr. Anthony Durante, market manager for ISP. 'It is a professional, residue-free system that requires some new equipment and methods. Once adopted, however, it is an environmentally friendly cleaner that does not emit harmful fumes and can replace CFC's,' he says.

The cleaner purports to be non-flammable, non-toxic, non-carcinogenic and can be recycled with 90 percent yield each time, reducing disposal costs and problems. It has low VOC emissions, increased worker safety and can be used in spray or immersion systems, depending upon local plant conditions, ISP says.

As for pyrrolidone's effectiveness compared to glycol ethers, Bud Lee, a technical manager for glycol ethers at Dow Chemical company says, 'We test our products on chicken fat, clay, oils, mineral spirits and waxes. I don't know that you can find any other soils to test.'

FULL TEXT AVAILABLE IN FORMAT 9
WORD COUNT: 416

COMPANY:
*Intnl Specialty Products

PRODUCT: *Metal Degreasing Compounds (2899554)
EVENT: *Product Design & Development (33)
COUNTRY: *United States (1USA)

0/5/14
DIALOG(R)File 16:PTS PROMT(TM)

02645461
Methyl Chloroform Is Seen A Major Problem for Ozone

Chemical Marketing Reporter June 25, 1990 p. 9
ISSN: 0900-0907

Many aerosol cans and other consumer products contain methyl chloroform (1,1,1-trichloroethane), a chemical that contributes to destruction of the ozone layer, despite a 1978 ban on chlorofluorocarbons (CFC's) in aerosols, according to a report issued last week by Natural Resources Defense Council.

The chemical industry is concerned that methyl chloroform will be banned in the US before adequate substitutes are found. Because the chemical has only about 15 percent of the ozone depleting potential f fully halogenated CFC's, the industry says methyl chloroform should be viewed as a 'bridge' chemical in society's efforts to move away from more damaging substances.

Methyl chloroform is widely used throughout industry in metal and precision cleaning, aerosols, adhesives and coatings. It is the solvent of choice for many of the applications because of its low flammability, relatively low toxicity, and high potential for recycling and recovery.

Three companies - Dow Chemical Company, PPG Industries Inc. and Vulcan Chemical - produce about 600 million to 700 million pounds of methyl chloroform annually for the US market.

Mr. Doniger acknowledges that methyl chloroform is less damaging to the ozone layer than CFC's on a pound for pound basis, he says more of the chemical is produced each year than all CFC's combined. Because of its massive production volume, he says methyl chloroform is responsible for 16 percent of current levels of ozone-destroying chlorine compounds in the atmosphere due to human activities.

The NRDC report identifies 141 common household and office products that contain the chemical. The products include hair sprays, spot removers, solvents and cleaners, art supplies, contact cements, carpet cleaners, furniture polish, water repellents, insecticides, automotive products and shoe sprays.

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WORD COUNT: 654

PRODUCT: *Trichloroethane (2868119)
EVENT: *Government Regulation (93)
COUNTRY: *United States (1USA)

0/5/15
DIALOG(R)File 16:PTS PROMT(TM)

02613441
Consumer boycott of trichloroethane urged
Natural Resources Defense Council calls for boycott of household products

containing trichloroethane

Chemical & Engineering News June 25, 1990 p. 6
ISSN: 0009-2347

The Natural Resources Defense Council is urging that consumers boycott household products containing 1,1,1-trichloroethane or methylchloroform. There is general agreement that 1,1,1-trichloroethane contributes to ozone depletion and industry sources are in favor of its replacement. However, David Doniger of the NRDC claims that the US is wavering in its support of an early phaseout and ban on all uses. Products containing trichloroethane may include aerosol hair sprays, insecticides, and soil and stain resistant fabric treatments. Some 700 mil lb of trichloroethane worth $280 mil is produced in the US. The household products affected by the boycott account for only 8% of trichloroethane use. Larger quantities of trichloroethane are used as industrial and electronics cleaners and degreasers. W Europe and Japan produce 300 mil lb/yr of trichloroethane.

PRODUCT: *Soaps, Detergents & Toiletries (2840000)
EVENT: *Public Affairs (29)
COUNTRY: *United States (1USA)

0/5/16
DIALOG(R)File 16:PTS PROMT(TM)

01975271
Finishers and paint formulators can use 1,1,1-trichloroethane
Inhibited grades of 1,1,1-trichloroethane can be used in coatings in place of VOC-type solvents

Modern Paint & Coatings July, 1988 p. 43-51
ISSN: 0098-7786

Inhibited grades of 1,1,1-trichloroethane can be used in coatings in place of some VOC-type solvents, according to WL Archer of Dow Chemical USA. The compound has been listed by EPA plus 46 state agencies as an exempt solvent for calculations of VOC. Coating formulations have been developed using epoxy, alkyd, acrylic, phenolic, polyester, nitrocellulose, vinyl and urethane resins, with 1,1,1-trichloroethane present as 1 of several solvents. It is important to match the new 1,1,1-trichloroethane solvent blends with replaced blends using Hansen solubility parameters. It is also important to determine the solvent blends' evaporation profiles. Dow has a computer program called Chemcomp that can furnish Hansen values and predict evaporation behavior.

PRODUCT: *Trichloroethane (2868119); Paints & Allied Products (2850000)
EVENT: *Product Design & Development (33)
COUNTRY: *United States (1USA)

0/5/17
DIALOG(R)File 16:PTS PROMT(TM)

01804689
DOW OFFERS NEW LOW-VOC GRADE OF 1,1,1-TRICHLORETHANE FOR CALIFORNIA COATINGS MARKET

News Release October 23, 1987 p. 1

Exclusively for the Southern California paint and coatings market, The Dow Chemical Company now offers PROACT (TM), a new low- VOC grade of 1,1,1-trichloroethane to help meet stricter Volatile Organic Compound (VOC) regulations now in effect. During the last decade, Dow has helped many coatings and ink formulators comply with air quality regulations by reducing VOC content with compliance solvents. The new grade incorporates a proprietary inhibitor package and contains only 0.75 percent VOCs by weight (one percent by volume). As a developmental product, PROACT, is intended for use only in California. The more stringent VOC limits went into effect July 1 for The South Coast Air Quality Management District's (SCAQMD) Rule 1107. It applies to coatings for metal parts and products manufactured in Los Angeles and surrounding counties. The rule requires air-dry coatings to contain no more than 340 grams of VOC per liter (2.8 lb/gal), and baked coatings no more than 275 g/1 VOC (2.3 lb/gal). Most coatings that met interim limits previously in effect now require an additional 20 percent or more reduction of VOC. Most commercial grades of 1,1,1-trichloroethane contain 3.5 percent or more inhibitors by volume and these inhibitors are not exempt from VOC regulations. Coatings formulated or thinned with these solvents may not comply with California regulations. Because the inhibitor package in PROACT has been minimized, the low- VOC grade of 1,1,1-trichloroethane and coatings containing this solvent should not come in contact with wetted aluminum parts found in some pressurized spray equipment. Dow and equipment manufacturers are providing advice on the

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proper  mild  or stainless steel replacement parts. Also this developmental
product  should  not  be  used  in vapor degreasers or for room temperature
metal   cleaning.  Commerical  grades  of  1,1,1-trichloroethane,  such  as
CHLOROTHENE  (TM)  SM,  are  available for these applications. And finally,
aluminum  zinc  powders and parts should not be used in coatings containing
the low-VOC grade of 1,1,1-trichloroethane.
    Full text available on PTS New Product Announcements.

COMPANY:
    *Dow Chemical DUNS: 00-138-1581 TICKER: DOW (NYSE) CUSIP: 260543

PRODUCT: *Trichloroethane (2868119)
EVENT:   *Product Design & Development (33)
COUNTRY: *United States (1USA)
?b 19
       08aug94 08:57:49 User036172 Session D438.2
       Sub account: BULLUCK/F7411
            $9.00    0.100 Hrs File16
           $28.05  17 Types
            $1.00  View Fee
    $38.05  Estimated cost File16
     $1.14  TYMNET
    $39.19  Estimated cost this search
    $39.30  Estimated total session cost   0.110 Hrs.


File  19:Chem.Industry Notes  1974-1994/ISS 31
       (c) 1994 Amer.Chem.Soc.
*File  19: Use is subject to the terms of your user/customer agreement.

      Set  Items  Description
      ---  -----  -----------
?k 1041890;k 1040569;k 1033611;k 1023982;k 1007343;k 963921;k 945406;k 944223;k 909778
;k 581398
      S0       1  1041890
      S0       2  1040569
      S0       3  1033611
      S0       4  1023982
      S0       5  1007343
      S0       6  963921
      S0       7  945406
      S0       8  944223
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       S0        9  909778
       S0       10  581398
?t s0/5/all

 0/5/1
DIALOG(R)File  19:Chem.Industry Notes
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1041890
  New powerful washing agent to replace trichloroethane
Journal: Jpn Chem Week  35 (1782) p. 10 Date: 940707
ISSN: 0047-1755   CODEN: JCHWAC
    Fujitsu Ltd. and Nitto Chemical Industry Co., have announced the
creation of a tie-up for production and sales of a new washing agent.  The
product, tagged Perclean, has five times the strength of trichloroethane,
which it will replace.  This has been developed by Fujitsu as a
flux-residue remover for supercomputer CPUs.  Ahead of the total
prohibition of trichloroethane due to become effective at the end of 1995,
the two companies anticipate large general demand for the agent.
Descriptors:  *washing agent trichloroethane replacement Perclean; Fujitsu
Ltd.; Nitto Chemical Industry Co.; Japan washing agent trichloroethane
replacement Perclean; supercomputer CPU flux residue remover washing agent
Perclean
EC = 3 (Products and Processes)


 0/5/2
DIALOG(R)File  19:Chem.Industry Notes
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1040569
  German-made hydrocarbon solvents make debut
Journal: Jpn Chem Week  35 (1781) p. 3 Date: 940630
ISSN: 0047-1755   CODEN: JCHWAC
    Shell Japan Ltd. has started to market a series of hydrocarbon
solvents, which have been commercialized by Deutsche Shell Chemie (DSC) in
Germany where production and imports of ethane were totally banned at the
end of 1992.  The Japanese company forecasts that some 70,000 tons of
chlorine- and 1,1,1-trichloroethane-based solvents will be replaced in
Japan by hydrocarbon solvents, 25% of which market it targets to gain.
Descriptors:  *hydrocarbon solvent sales Japan; Shell Japan Ltd.; Deutsche
Shell Chemie; chlorine based hydrocarbon solvent sales Japan;
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trichloroethane based hydrocarbon solvent sales Japan
EC = 6 (Market Data)

0/5/3
DIALOG(R)File 19:Chem.Industry Notes
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1033611
Wipe solvents
Journal: Adhes Age 37 (5) p. 10 Date: 940500
ISSN: 0001-821X CODEN: ADHAAO

Dynamold Solvents' line of low vapor pressure, organic solvents is used for hand-wipe surface applications. The DS-Series wipe solvents is developed to replace solvents containing freon, MEK, 1,1,1-trichloroethane and other banned chemicals. Typical applications include final surface preparation prior to application of sealants, adhesive paints and coatings and the removal of uncured residue of these materials.

Descriptors: *solvent organic freon substitute sealant use US; adhesive paint use organic solvent MEK substitute; coating use organic solvent trichloroethane substitute; Dynamold Solvents
EC = 3 (Products and Processes)

0/5/4
DIALOG(R)File 19:Chem.Industry Notes
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1023982
OxyChem adds solvent line
Journal: Chem Week 154 (10) p. 21 Date: 940316
ISSN: 0009-272X CODEN: CHWKA9

OxyChem (Dallas) has introduced Oxsol, a line of nonozone-depleting solvents. Oxsol blends, which are chlorinated fluorinated toluene derivatives, are used to replace 1,1,1-trichloroethane. End uses include building and packaging adhesives, automotive cleaners, electronic cleaners, and solvent carriers. The solvents are produced at OxyChem's Niagara Falls, NY plant.

Descriptors: *solvent nonozone depleting trichloroethane replacement Oxsol ; OxyChem; US solvent nonozone depleting trichloroethane replacement Oxsol
EC = 3 (Products and Processes)

0/5/5
DIALOG(R)File 19:Chem.Industry Notes

1007343
Planning for 1,1,1's demise
Journal: Chem Mark Rep 244 (22) p. 5, 15 Date: 931129
ISSN: 0090-0907 CODEN: CMKRA5

Federal regulations on 1,1,1-trichloroethane are closing in, and producers are scrambling for strategies to keep customers and deal with conversion by end users in vapor degreasing and other industries. The three US producers of 1,1,1 Dow Chemical Company, Vulcan Chemicals and PPG Industries, are now faced with either coming up with replacement solvents or assisting end users in switching to new systems. Dow, with an annual capacity of 500 million pounds, is the largest producer in the US, and has gotten a comparatively early start in working around the coming phaseout. The company will halt all production of 1,1,1 by April of 1994.

Descriptors: *cos plan for phaseout; US trichloroethane production phaseout strategy; Dow Chemical Co.; Vulcan Chemicals; PPG Industries Inc.
EC = 9 (Government and Society)

0/5/6
DIALOG(R)File 19:Chem.Industry Notes

963921
Recyclable metal cleaner to replace ozone depleter
Journal: Jpn Chem Week 34 (1711) p. 3 Date: 930204
ISSN: 0047-1755 CODEN: JCHWAC

Nikko Petrochemicals Co. will market a recyclable metal cleaning agent in February as a substitute for ozone depleting chemicals. The hydrocarbon-based agent, named NS Clean, consists mainly of n-paraffin and expected to serue as a substitute for ozone-depleting chemicals such as trichloroethane and fluorocarbon-based agents which will be banned by the end of 1995.

Descriptors: *metal cleaning agent sales Japan; Nikko Petrochemicals Co.; recyclable metal cleaning agent sales Japan; NS Clean metal cleaning agent sales Japan; hydrocarbon based metal cleaning agent sales Japan; ozone depleting chemical substituents metal cleaning agent sales Japan
EC = 6 (Market Data)

0/5/7
DIALOG(R)File 19:Chem.Industry Notes

945406
Oxychem's alternative solvents
Journal: Chem Week 151 (13) p. 33 Date: 921007
ISSN: 0009-272X CODEN: CHWKA9

OxyChem (Dallas) is introducing a line of solvent blends aimed at replacing 1,1,1-trichloroethane and chlorofluorocarbon-113. The company will make the product at its Niagara Falls, NY plant.

Descriptors: *solvent alternative blend development; US solvent alternative blend development; Occidental Chemical Corp.; trichloroethane replacement solvent blend development; chlorofluorocarbon replacement solvent blend development
EC = 3 (Products and Processes)

0/5/8
DIALOG(R)File 19:Chem.Industry Notes

944223
New cleaning agents replace ozone-depleting solvents
Journal: Chem Mark Rep 242 (14) p. 27 Date: 921005
ISSN: 0090-0907 CODEN: CMKRA5

In anticipation of a new labeling law for products manufactured with methyl chloroform effective next May, and the phaseout of the chemical in December 1995, Dow Chemical Co. has created its advanced cleaning systems business unit to help producers of surface cleaners make an efficient transition from 1,1,1-trichloroethane (methyl chloroform) to an alternative process. The unit will operate out of Dow headquarters in Midland, Mich. One part of the advanced cleaning systems business is the development and introduction of Primaclean surface cleaning products, a new line of aqueous, water rinsable and general cleaning products. The other is operation of a new state-of-the-art cleaning center in which customers can test the effectiveness of various cleaning processes and methods.

Descriptors: *cleaning product general use Primaclean; Dow Chemical Co.; US cleaning product general use Primaclean
EC = 3 (Products and Processes)

```
 0/5/9
DIALOG(R)File  19:Chem.Industry Notes
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909778
Journal: Chem Week  150 (9) p. 19 Date: 920304
ISSN: 0009-272X   CODEN: CHWKA9
   Asahi Chemical has developed a series of aqueous and semiaqueous
cleaning agents as substitutes for 1,1,1-trichloroethane.  The aqueous
cleaning agents are a mix of alkaline ingredients and a surfactant; the
semiaqueous agents combine glycol ether solvents and a surfactant and are
also meant to replace CFC-113 in metal-cleaning applications.
Descriptors:  *cleaning agent trichloroethane substitute development; Japan
cleaning agent trichloroethane substitute development; Asahi Chemical
EC = 3 (Products and Processes)


 0/5/10
DIALOG(R)File  19:Chem.Industry Notes
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581398
Journal: Chem Mark Rep  228 (15) p. 59 Date: 851007
ISSN: 0090-0907   CODEN: CMKRA5
   Chemical Solvents Inc., Cleveland, Ohio, has introduced Inhibisolve, a
degreasing solvent additive which minimizes solvent-metal reactions,
reduces the development of metal chlorides and replaces inhibitors lost to
the atmsophere during cleaning operations.  Addition of Inhibisolve can
dramatically reduce the cost of degreasing operations by extending the life
of 1,1,1, trichloroethane, trichloroethylene, perchloroethylene and
methylene chloride compounds for vapor degreasing.
Descriptors:  *solvent metal degreasing use Inhibisolve; Chemical Solvents
Inc.; US solvent metal degreasing use Inhibisolve; trichloroethane solvent
metal degreasing use Inhibisolve; trichloroethylene solvent metal
degreasing use Inhibisolve; perchloroethylene solvent metal degreasing use
Inhibisolve; methylene chloride solvent metal degreasing use Inhibisolve;
additive solvent metal degreasing use Inhibisolve
EC = 3 (Products and Processes)
?b 148
      08aug94 09:00:37 User036172 Session D438.3
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       Sub account: BULLUCK/F7411
            $4.50     0.050 Hrs File19
           $15.00   10 Types
            $1.00   View Fee
     $20.50  Estimated cost File19
      $0.57  TYMNET
     $21.07  Estimated cost this search
     $60.37  Estimated total session cost    0.160 Hrs.


File 148:Trade & Industry Index(TM)  1981-1994/Aug W1
       (c) 1994 Inform. Access Co

      Set  Items  Description
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?k 14632212;k 14532232
      S0       1  14632212
      S0       2  14532232
?t s0/5/all

 0/5/1
DIALOG(R)File 148:Trade & Industry Index(TM)
(c) 1994 Inform. Access Co. All rts. reserv.

14632212
          *Use Format 9 for FULL TEXT*
TITLE: Planning for 1,1,1's demise. (emissive use of 1,1,1-trichloroethane,
    or  methyl  chloroform,  to  end  by  December  31,  1993)  (Aliphatic
    Organics)
 AUTHOR: Cavanaugh, Tim
 JOURNAL: Chemical Marketing Reporter
 VOL: v244   ISSUE: n22   PG: p5(2)
 PUB DATE: Nov 29, 1993
 ISSN: 0090-0907
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00093  WORD COUNT: 1,186
 SUBFILE: ADV  Advertising, Marketing and Public Relations
          CHEM  Chemicals, Plastics and Rubber
 SOURCE FILE: TI File 148
 ILLUSTRATION: illustration; table
 ABSTRACT: The 1992 amendments to the Clean Air Act will call for the
emissive use of methyl chloroform, or 1,1,1-trichloroethane, (1,1,1) to be
phased out by Dec 31, 1995. Also, on Jan 1, 1994, the federal excise tax on
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methyl chloroform will increase from 21 cents per pound to 34 cents per
pound. Jeff Sullivan of Dow Chemical Co says that perchloroethylene,
methylene chloride and trichloroethylene can be used as replacements for
1,1,1.
 PRODUCT: 2868114  (Methyl Chloroform)
 SIC CODE: 2860  Industrial Organic Chemicals
 STATUTE: Clean Air Act
 DESCRIPTORS: Trichloroethane--Laws, regulations, etc.; Chemical industry--
    Laws, regulations, etc.


 0/5/2
DIALOG(R)File 148:Trade & Industry Index(TM)
(c) 1994 Inform. Access Co. All rts. reserv.

14532232
          *Use Format 9 for FULL TEXT*
TITLE:  The  demise  of 1, 1, 1. (Trichloroethane) (Thoughts from Our Shop)
    (Editorial)
 AUTHOR: DeDad, John A.
 JOURNAL: EC&M Electrical Construction & Maintenance
 VOL: v92   ISSUE: n10   PG: p11(1)
 PUB DATE: Oct, 1993
 ISSN: 0013-4260
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00064  WORD COUNT: 716
 SUBFILE: ELEC  Electronics
 SOURCE FILE: TI File 148
 ARTICLE TYPE: Editorial
 ABSTRACT: The production of 1,1,1 Trichloroethane will be banned in the US
beginning Jan 1996 as required by Clean Air Act Amendments of 1990. The EPA
had earlier assessed the solvent as harmful to the ozone layer.
Trichloroethane is used as a general purpose cable cleaner for
medium-voltage power cables. The replacement for the substance is deemed a
remote possibility considering factors such as maintaining cleaning
effectiveness, minimizing short- and long-term effects on cable materials
and maintaining worker safety.
 PRODUCT: 9105283  (Product Safety-Toxic Substances NEC)
 STATUTE: Clean Air Act Amendments of 1990
 DESCRIPTORS: United States. Environmental Protection Agency--Laws,
    regulations, etc.; Trichloroethane--Laws, regulations, etc.
?b 648
      08aug94 09:01:38 User036172 Session D438.4
```

```
     Sub account: BULLUCK/F7411
          $2.97    0.033 Hrs File148
          $2.60  2 Types
          $1.00  View Fee
   $6.57  Estimated cost File148
   $0.38  TYMNET
   $6.95  Estimated cost this search
  $67.32  Estimated total session cost   0.194 Hrs.

### Status: Signing Off...

### Status: Break Sent.

?logoff hold
       08aug94 09:05:36 User036172 Session D438.5
       Sub account: BULLUCK/F7411
            $5.94    0.066 Hrs File648
     $5.94  Estimated cost File648
     $0.75  TYMNET
     $6.69  Estimated cost this search
    $74.01  Estimated total session cost   0.260 Hrs.


### Status: Signed Off.

### Status: Dialog Basic Connection Path #1

### Status: Initializing modem ...
n4
OK
### Status: Dialing primary number (448-4611)...

ATDT448-4611
CONNECT 9600
### Status: Connection established at 9600 baud
n

please type your terminal identifier
-3523:01-003-
please log in: DIALOG
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DIALOG: call connected
### Status: Connected
n

DIALOG INFORMATION SERVICES
PLEASE LOGON:
 ******** HHHHHHHH SSSSSSSS?
### Status: Signing onto Dialog
 ********
ENTER PASSWORD:
 ******** HHHHHHHH SSSSSSSS? ********
Welcome to DIALOG
### Status: Connected

Dialog level 36.08.02D

Reconnected in file 648 08aug94 09:06:56
Banner display set OFF.
HILIGHT set on as '*'
KWIC is set to 5.
BLIP set on
NOTICE set ON to $25.00
You will be prompted to confirm each output request that exceeds $25.00
COST       = ONESEARCH.
Please enter SUBACCOUNT name/number:
?
?
```

JWB 2

```
### Status: Dialog Basic Connection Path #1

### Status: Initializing modem ...
AT&FE1Q0V1X4&C1&D2&K4
OK
### Status: Dialing primary number (448-4611)...

ATDT448-4611
CONNECT 9600
### Status: Connection established at 9600 baud


please type your terminal identifier
-3523:01-003-
please log in: DIALOG


DIALOG: call connected
### Status: Connected


DIALOG INFORMATION SERVICES
PLEASE LOGON:
 ******** HHHHHHHH SSSSSSSS?
### Status: Signing onto Dialog
 ********
ENTER PASSWORD:
 ******** HHHHHHHH SSSSSSSS? ********
Welcome to DIALOG
### Status: Connected

Dialog level 36.08.02D


>>> Cost Estimate prior to Disconnect, information only
>>>        08aug94 09:08:19 User036172 Session D438.6
>>>             $2.97    0.033 Hrs File648
>>>      $2.97  Estimated cost File648
>>>      $0.38  TYMNET
>>>      $3.35  Estimated cost this search
>>>      $3.35  Estimated total session cost   0.033 Hrs.
```

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>>>
Reconnected in file 648 08aug94 09:09:09
Banner display set OFF.
HILIGHT set on as '*'
KWIC is set to 5.
BLIP set on
NOTICE set ON to $25.00
You will be prompted to confirm each output request that exceeds $25.00
COST       = ONESEARCH.
Please enter SUBACCOUNT name/number:
?
?
### Status: Signing Off...
logoff
Is LOGOFF the SUBACCOUNT you want to use? (Y/N)
?
### Status: Signed Off.

### Status: Dialog Basic Connection Path #1

### Status: Initializing modem ...
AT&FE1Q0V1X4&C1&D2&K4
OK
### Status: Dialing primary number (929-3622)...

ATDT929-3622
CONNECT 9600
### Status: Connection established at 9600 baud


TELENET
512 110C

TERMINAL=

@
 ?

@c Dialog


DIALOG CONNECTED
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### Status: Connected


DIALOG INFORMATION SERVICES
PLEASE LOGON:
 ******** HHHHHHHH SSSSSSSS?
### Status: Signing onto Dialog
 ********
ENTER PASSWORD:
 ******** HHHHHHHH SSSSSSSS? ********
Welcome to DIALOG
### Status: Connected

Dialog level 36.08.02B

Last logoff:  04feb94 09:36:23
Logon file405 08aug94 09:10:46
******************************************************************
As of 09:10 EST on 08/08/94 you had 1 DIALMAIL message(s) waiting.
******************************************************************
ANNOUNCEMENT    ****    ANNOUNCEMENT    ****    ANNOUNCEMENT


***Dialog's new pricing plan effective August 1.                   ***
   See Homebase Announcements for details.

***New Health Economic News Online in PHIND (File 130).            ***

***CANADIAN NEWSPAPERS (File 727) release delayed until early
   August.                                                         ***

***Coming in August: TRADEMARKSCAN(R) - AUSTRIA, FRANCE, and ITALY
   (Files 662, 657, and 673).  See Homebase for details.           ***

***NEW on Data-Star: SUMMARY OF WORLD BROADCASTS and
   INTERNATIONAL MARKET RESEARCH INFORMATION.  See Homebase
   for details.                                                    ***
***DialogLink Now Available for the Macintosh!                     ***

***The Enhanced DIALOG Menus is NOW Available - BEGIN MENUS to
   Use the New DIALOG Menus.                                       ***
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***The FAMILY RESOURCES Database (File 291) No Longer Updated. ***

***CAREER PLACEMENT REGISTRY (File 162) Removed from DIALOG.   ***

      >>> Enter BEGIN HOMEBASE for Dialog Announcements <<<
      >>>    of new databases, price changes, etc.     <<<
      >>>    Announcements last updated for 29jul94     <<<
Banner display set OFF.
HILIGHT set on as '*'
KWIC is set to 5.
BLIP set on
NOTICE set ON to $25.00
You will be prompted to confirm each output request that exceeds $25.00
COST       = ONESEARCH.
Please enter SUBACCOUNT name/number:
?
?b 648bulluck/f7411
Is B 648BULLUCK/F7411 the SUBACCOUNT you want to use? (Y/N)
?
Do you want to specify another SUBACCOUNT? (Y/N)
?
No subaccount set.
SYSTEM:HOME
Menu System II: D2 version 1.7.1 term=ASCII
Terminal set to DLINK
                    *** DIALOG HOMEBASE(SM) Main Menu ***

Information:
 1.  Announcements (new files, free connect time, price changes, etc.)
 2.  Database, Rates, & Command Descriptions
 3.  Help in Choosing Databases for Your Topic
 4.  Customer Services (telephone assistance, training, seminars, etc.)
 5.  Product Descriptions

Connections:
 6.  DIALOG Menus(SM)
 7.  DIALOG Business Connection(R), Headlines(SM), Medical Connection(SM)
 8.  DIALOG SourceOne(SM) Document Delivery
 9.  Data-Star
10.  Other Online Menu Services & Files (MoneyCenter(R), OAG, TNT, etc.)

    /H = Help             /L = Logoff           /NOMENU = Command Mode
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Enter an option number to view information or to connect to an online
service.  Enter a BEGIN command plus a file number to search a database
(e.g., B1 for ERIC).
?
                      *** DIALOG HOMEBASE(SM) Main Menu ***

Information:
 1.  Announcements (new files, free connect time, price changes, etc.)
 2.  Database, Rates, & Command Descriptions
 3.  Help in Choosing Databases for Your Topic
 4.  Customer Services (telephone assistance, training, seminars, etc.)
 5.  Product Descriptions

Connections:
 6.  DIALOG Menus(SM)
 7.  DIALOG Business Connection(R), Headlines(SM), Medical Connection(SM)
 8.  DIALOG SourceOne(SM) Document Delivery
 9.  Data-Star
10.  Other Online Menu Services & Files (MoneyCenter(R), OAG, TNT, etc.)

     /H = Help           /L = Logoff          /NOMENU = Command Mode


Enter an option number to view information or to connect to an online
service.  Enter a BEGIN command plus a file number to search a database
(e.g., B1 for ERIC).
?bulluck/f7411

>>>"ULLUCK" is not a valid category or service name
>>>"/" is invalid in a filelist.
?
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?bulluck/f7411
>>>"ULLUCK" is not a valid category or service name
>>>"/" is invalid in a filelist.
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?bulluck/f7411
>>>"ULLUCK" is not a valid category or service name
>>>"/" is invalid in a filelist.
?
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?
?b 648
       08aug94 09:12:17 User036172 Session B134.1
            $0.00    0.033 Hrs FileHomeBase
     $0.00  Estimated cost FileHomeBase
     $0.40  SPRNTNET
     $0.40  Estimated cost this search
     $0.40  Estimated total session cost   0.033 Hrs.

File 648:Trade & Industry ASAP(TM)  1983-1994/Aug W1
       (c) 1994 Inform. Access Co

      Set  Items  Description
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?k 15139004;k 14562626;k 13884488;k 11289762;k 11199730;k 10381826;k 09397747;k 093681
50;k 08983143;k 08523977;k 08041333
      S0        1  15139004
      S0        2  14562626
      S0        3  13884488
      S0        4  11289762
      S0        5  11199730
      S0        6  10381826
      S0        7  09397747
      S0        8  09368150
      S0        9  08983143
      S0       10  08523977
      S0       11  08041333
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?t s0/5/all
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 0/5/1
DIALOG(R)File 648:Trade & Industry ASAP(TM)
(c) 1994 Inform. Access Co. All rts. reserv.

15139004
          *Use Format 9 for FULL TEXT*
TITLE:    CFC    replacement    technologies:    help    is    on    the    way.
    (chlorofluorocarbons)
 AUTHOR: Glanz, James
 JOURNAL: R & D
 VOL: v34  ISSUE: n14  PG: p28(4)
 PUB DATE: Dec, 1992
 ISSN: 0746-9179
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00146  WORD COUNT: 2,082
 SUBFILE:  ENG  Engineering and Manufacturing
 SOURCE FILE: MI File 47
 ILLUSTRATION: illustration; photograph; graph
 ABSTRACT: There is a general agreement in industry that
chlorofluorocarbons (CFCs) should be phased out as soon as possible.
Although there are some reservations about government-mandated schedules,
there are indications that these timetables will be eventually met.
 DESCRIPTORS: Chlorofluorocarbons--Research; Research, Industrial--
    Evaluation


 0/5/2
DIALOG(R)File 648:Trade & Industry ASAP(TM)
(c) 1994 Inform. Access Co. All rts. reserv.

14562626
          *Use Format 9 for FULL TEXT*
TITLE:   Chemical   substitutes   for   1,1,1-trichloroethane   in   adhesive
    formulations.
 AUTHOR: Ostrowski, Philip J.
 JOURNAL: Adhesives Age
 VOL: v36  ISSUE: n11  PG: p43(3)
 PUB DATE: Oct, 1993
 ISSN: 0001-821X
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00149  WORD COUNT: 2,042
 SUBFILE:  CNST  Construction and Materials
 SOURCE FILE: TI File 148
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ILLUSTRATION: illustration; table; chart
COMPANY: Occidental Chemical Corp.--Innovations
PRODUCT: 2868119  (Trichloroethane); 2891003  (Solvent Borne Adhesives)
SIC CODE: 2812  Alkalies and chlorine
          2841  Soap and other detergents
          2860  Industrial Organic Chemicals
          2891  Adhesives and sealants
DESCRIPTORS: Adhesives industry--Innovations; Trichloroethane--
   Environmental aspects


 0/5/3
DIALOG(R)File 648:Trade & Industry ASAP(TM)
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13884488
     *Use Format 9 for FULL TEXT*
TITLE:  Vapor  degreasers  put on 'death row.' (1,1,1-trichloroethane faces
   regulatory  production  bans  and  labeling  requirements)  (includes
   related articles)
AUTHOR: Schrantz, Joe
JOURNAL: Industrial Finishing
VOL: v68  ISSUE: n11  PG: p22(2)
PUB DATE: Nov, 1992  .
ISSN: 0019-8323
AVAILABILITY: FULL TEXT Online  LINE COUNT: 00090  WORD COUNT: 1,130
SUBFILE:  METL  Metals, Metalworking and Machinery
SOURCE FILE: TI File 148
ILLUSTRATION: illustration; photograph
ABSTRACT: Conventional vapor degreasers frequently use
1,1,1-trichloroethane, a known chemical that depletes the ozone layer which
faces a labeling requirement as stipulated in the Clean Air Act Amendments
of 1990, effective May 15, 1993. Title 6 of the Act states that products
made after that date must be labeled identifying it as harmful to health
and the environment. As the US is phasing out all emissive 1,1,1 on Dec.
31, 1995, suppliers are rushing to find chemical alternates for the market.
It is estimated that 825 million pounds of ozone-depleting chemicals are
used in the United States alone.
SIC CODE: 9511  Air, water, & solid waste management
STATUTE: Clean Air Act Amendments of 1990
DESCRIPTORS: Vapor degreasing--Environmental aspects; Environmental
   protection--Economic aspects
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DIALOG(R)File 648:Trade & Industry ASAP(TM)
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11289762
        *Use Format 9 for FULL TEXT*
TITLE: Methyl chloroform still cleans best. (includes related articles)
 JOURNAL: Appliance Manufacturer
 VOL: v39  ISSUE: n9  PG: p55(1)
 PUB DATE: Sept, 1991
 ISSN: 0003-679X
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00063  WORD COUNT: 845
 SUBFILE:  HOME  Home Furnishings
           ELEC  Electronics
           ENG  Engineering and Manufacturing
 SOURCE FILE: TI File 148
 DESCRIPTORS: Trichloroethane--Usage; Cleaning compounds--Usage; Chlorine--
    Laws, regulations, etc.


 0/5/5
DIALOG(R)File 648:Trade & Industry ASAP(TM)
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11199730
        *Use Format 9 for FULL TEXT*
TITLE:  A delicate balance. (weighing the merits of replacing high volatile
    organic  compounds  with  environmentally friendly substitutes) (Cover
    Story)
 AUTHOR: Petersen, Debbie
 JOURNAL: American Printer
 VOL: v207  ISSUE: n5  PG: p26(5)
 PUB DATE: August, 1991
 ISSN: 0744-6616
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00262  WORD COUNT: 3,920
 SUBFILE:  PUBL  Publishing
 SOURCE FILE: TI File 148
 ARTICLE TYPE: Cover Story
 ILLUSTRATION: illustration; photograph
 SIC CODE: 9511  Air, water, & solid waste management
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           7336  Commercial art and graphic design
           2893  Printing ink
           2869  Industrial organic chemicals, not elsewhere classified
 DESCRIPTORS: Volatile organic compounds--Laws, regulations, etc.; United
    States. Environmental Protection Agency--Laws, regulations, etc.;
    Graphic arts industry--Equipment and supplies; Alcohol--Environmental
    aspects; Environmentally safe products--Usage; Printing-ink--
    Environmental aspects


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DIALOG(R)File 648:Trade & Industry ASAP(TM)
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10381826
          *Use Format 9 for FULL TEXT*
TITLE: US regs catalyze changes in solvents.
 JOURNAL: Chemical Marketing Reporter
 VOL: v239  ISSUE: n3  PG: p5(2)
 PUB DATE: Jan 21, 1991
 ISSN: 0900-0907
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00105  WORD COUNT: 1,513
 SUBFILE:  ADV  Advertising, Marketing and Public Relations
           CHEM  Chemicals, Plastics and Rubber
 SOURCE FILE: TI File 148
 ILLUSTRATION: illustration; photograph; table
 CAPTION: MCF countdown. (table)
 SIC CODE: 2869  Industrial organic chemicals, not elsewhere classified
           9511  Air, water, & solid waste management
 DESCRIPTORS: Solvents industry--Laws, regulations, etc.; Trichloroethane--
    Product discontinuation; Metal cleaning--Equipment and supplies


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DIALOG(R)File 648:Trade & Industry ASAP(TM)
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09397747
          *Use Format 9 for FULL TEXT*
TITLE:  Study  supports  industry position on use of 1,1,1-trichloroethane.
    (methyl chloroform)
 AUTHOR: Dombrowski, S.L.S.
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JOURNAL: Modern Paint and Coatings
VOL: v80  ISSUE: n4  PG: p35(2)
PUB DATE: April, 1990
ISSN: 0098-7786
AVAILABILITY: FULL TEXT Online  LINE COUNT: 00126  WORD COUNT: 1,803
SUBFILE:  CHEM  Chemicals, Plastics and Rubber
SOURCE FILE: TI File 148
ILLUSTRATION: illustration; graph
CAPTION:  Usage  of  methyl chloroform in U.S., Western Europe, and Japan.
   (graph); Triregional methyl chloroform demand forecasts. (graph)
SIC CODE: 2800  CHEMICALS AND ALLIED PRODUCTS
          2869  Industrial organic chemicals, not elsewhere classified
DESCRIPTORS: Trichloroethane--Usage; Ozone layer depletion--prevention;
   Chemical industry--environmental policy; Solvents--environmental
   aspects; Paint--composition


 0/5/8
DIALOG(R)File 648:Trade & Industry ASAP(TM)
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09368150
         *Use Format 9 for FULL TEXT*
TITLE:  Future of 1,1,1-trichloroethane. (Business Review and Forecast: the
   State of the Industry ... and What's Ahead)
AUTHOR: Sullivan, Jeffrey A.
JOURNAL: Modern Paint and Coatings
VOL: v81  ISSUE: n1  PG: p44(1)
PUB DATE: Jan, 1991
ISSN: 0098-7786
AVAILABILITY: FULL TEXT Online  LINE COUNT: 00051  WORD COUNT: 656
SUBFILE:  CHEM  Chemicals, Plastics and Rubber
SOURCE FILE: TI File 148
ILLUSTRATION: illustration; table
CAPTION: Overview of 1,1,1-trichloroethane legislation. (table)
SIC CODE: 2851  Paints and allied products
          2869  Industrial organic chemicals, not elsewhere classified
STATUTE: Clean Air Act Amendments of 1990---Interpretation and
   construction
DESCRIPTORS: Coatings industry--Equipment and supplies; Coatings--
   Manufacture; Trichloroethane--Supply and demand; Solvents--
   Environmental aspects
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 0/5/9
DIALOG(R)File 648:Trade & Industry ASAP(TM)
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08983143
          *Use Format 9 for FULL TEXT*
TITLE:  Still  working  on  the  ozone  hole: beyond the Montreal Protocol.
    (includes related article on CFC substitutes)
 AUTHOR: Makhijani, Arjun; Bickel, Amanda; Makhijani, Annie
 JOURNAL: Technology Review
 VOL: v93  ISSUE: n4  PG: p52(8)
 PUB DATE: May-June, 1990
 ISSN: 0040-1692
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00303  WORD COUNT: 4,483
 SUBFILE:  ENG  Engineering and Manufacturing
 SOURCE FILE: MI File 47
 ILLUSTRATION: illustration; graph
 CAPTION: Stratospheric chlorine concentrations, 1985-2100. (graph)
 SIC CODE: 9511  Air, water, & solid waste management
 DESCRIPTORS: Montreal Protocol on Substances that Deplete the Ozone Layer
    --interpretation and construction; Ozone layer depletion--prevention;
    Trichloroethane--environmental aspects; Carbon tetrachloride--
    environmental aspects; Environmental protection--International aspects;
    Developing countries--environmental policy


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DIALOG(R)File 648:Trade & Industry ASAP(TM)
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08523977
          *Use Format 9 for FULL TEXT*
TITLE: Methyl chloroform hit in new charges.
 JOURNAL: Chemical Marketing Reporter
 VOL: v237  ISSUE: n4  PG: p3(2)
 PUB DATE: Jan 22, 1990
 ISSN: 0900-0907
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00084  WORD COUNT: 1,191
 SUBFILE:  ADV  Advertising, Marketing and Public Relations
           CHEM  Chemicals, Plastics and Rubber
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 SOURCE FILE: TI File 148
 SIC CODE: 2869  Industrial organic chemicals, not elsewhere classified
           8641  Civic and social associations
 DESCRIPTORS: Trichloroethane--environmental aspects; Ozone layer depletion
    --causes of; National Resources Defense Council--reports


 0/5/11
DIALOG(R)File 648:Trade & Industry ASAP(TM)
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08041333
          *Use Format 9 for FULL TEXT*
TITLE: Ultrasonic cleaner replaces vapor degreaser.
 JOURNAL: Tooling & Production
 VOL: v55  ISSUE: n7  PG: p110(2)
 PUB DATE: Oct, 1989
 ISSN: 0040-9243
 AVAILABILITY: FULL TEXT Online  LINE COUNT: 00044  WORD COUNT: 581
 SUBFILE:  ENG  Engineering and Manufacturing
 SOURCE FILE: TI File 148
 ILLUSTRATION: illustration; photograph
 COMPANY: Filterite--Production management; Westinghouse Electric Corp.--
    equipment and supplies
 TICKER SYMBOL: WX
 SIC CODE: 3699  Electrical equipment & supplies, not elsewhere classified
 DESCRIPTORS: Ultrasonic cleaning--Usage; Machine-tools--Maintenance and
    repair
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            $8.45  11 Types
            $1.00  View Fee
    $15.39  Estimated cost File648
     $0.79  SPRNTNET
    $16.18  Estimated cost this search
    $16.58  Estimated total session cost   0.100 Hrs.


File 763:Freedonia Market Res.  1990-1994/Jul 20
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      S0       3  00021200
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      S0       5  00021197
      S0       6  00021193
?t s0/5/all

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00052332
CHLORINATED SOLVENTS: 1,1,1-Trichloroethane - Supply & Demand
Main Report Title:  SOLVENTS
Source:  THE FREEDONIA GROUP, INC.          Telephone: (216) 921-6800
OCTOBER 1993
Language: English    Word Count: 384 (1 pp.)
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Production of TCEA totaled 720 million pounds in 1992, slightly higher than volume in 1987, but below the 803 million pounds produced in 1990. Consumption declined 0.27 percent per year, while solvent use declined 0.35 percent annually. Exports reached a high of 176 million pounds in 1991 and imports also peaked in that year at 111 million pounds.

Solvent use, which accounted for 97 percent of 1992 consumption, will be zero by 1997, while use in intermediates will increase more than ten-fold to 210 million pounds in 1997. Growing demand for HCFC-141-141b and HCFC-142b replacements for CFC-13, which is banned effective January 1, 1996, will not compensate for lost volume in solvents. As a result, the three producers of TCEA -- Dow Chemical, PPG Industries and Vulcan -- are competing for survival by trying to win long term contracts for HCFC feedstocks. Increased demand for trichloroethylene as a replacement for TCEA in vapor degreasing may be an alternative use for some existing TCEA capacity, assuming that economics favor conversion. Dow has already reduced production of TCEA for emissive uses in 1993 to 60 percent of its baseline 1989 production. By 1997, production will be only 35 percent of 1992, exports will be 23 percent of 1992 and consumption will be confined to 210 million pounds of intermediate for HCFC production.

The average sales price, as computed by the USITC, dropped from 32 cents per pound in 1987 to 27 cents in 1990 and 23 cents in 1991. List prices have been consistently higher for bulk shipments -- 40.5 cents per pound in 1987, 58 cents per pound in December 1992, and as much as 65 cents per pound reported in June 1993. While producers deny they are building inventories, consumption in 1992 indicates that users are stockpiling, and export data for 1991 and 1992 indicate that export customers are doing the same. As a result, the 1992 price recovered to the 1987 level on an average sales basis, and quoted prices, excluding excise tax, increased 20 cents per pound over the 1987 level for degreasing grades inhibited at three to five percent. By 1997, all sales will be uninhibited intermediate grade on long term contacts, except for exports, at a projected price of 27 cents per pound.

THIS IS THE FULL-TEXT.
Country: UNITED STATES
Industry: CHEMICALS

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DIALOG(R)File 763:Freedonia Market Res.

00021201
CHLORINATED SOLVENTS: 1,1,1-Trichloroethane Used in Electronics and Other Markets
Main Report Title: SOLVENTS AND THE ENVIRONMENT
Source: THE FREEDONIA GROUP, INC. Telephone: (216) 921-6800
AUGUST 1991
Language: English Word Count: 148 (1 pp.)

Electronics applications accounted for 45 million pounds (6.7 percent) of 1,1,1-TCE demand in 1990. Applications in the electronics industry include the stripping of dry film photoresists in printed circuit board production and secondary cleaning of semiconductors and integrated circuits. 1,1,1-TCE has replaced Fluorocarbon 113 and fluorocarbon blends which had dominated printed circuit board cleaning. Its use is being challenged by "natural" products such as terpenes derived from citrus peels. Demand is expected to decline as electronics makers adopt new formulations and restrictions on 1,1,1-TCE come into effect.

Other markets include the textile industry, where 1,1,1-TCE is used for finishing operations including scouring, desizing and dyeing. Addition of 20 to 30 percent 1,1,1-TCE to metal cutting fluids increases tool life while increasing cutting speeds in difficult drilling and tapping operations. Due to the phase-out of 1,1,1-TCE, use will be negligible by 1995.

THIS IS THE FULL-TEXT.

Country: UNITED STATES
Industry: CHEMICALS, ENVIRONMENT

0/5/3
DIALOG(R)File 763:Freedonia Market Res.

00021200
CHLORINATED SOLVENTS: 1,1,1-Trichloroethane Used in Coatings
Main Report Title: SOLVENTS AND THE ENVIRONMENT
Source: THE FREEDONIA GROUP, INC. Telephone: (216) 921-6800
AUGUST 1991
Language: English Word Count: 107 (1 pp.)

Coatings consumed 50 million pounds of 1,1,1-TCE in 1990 as a solvent and thinner. 1,1,1-TCE has been used increasingly as a replacement for high VOC solvents in coatings and is frequently used post-manufacture to reduce viscosity while not increasing VOC emissions. The replacement of VOCs is only a temporary gain. The move to high-solids, powder coatings and water-borne coatings is reducing use of all solvents and replacement solvents exist. As a result, this will be one of the first markets to be affected by the mandated reductions in 1,1,1-TCE use and demand will decline 6.9 percent annually through 1995 to 35 million pounds.

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Country: UNITED STATES
Industry: CHEMICALS, ENVIRONMENT

0/5/4
DIALOG(R)File 763:Freedonia Market Res.

00021199
CHLORINATED SOLVENTS: 1,1,1-Trichloroethane Used in Adhesives and Printing Inks
Main Report Title: SOLVENTS AND THE ENVIRONMENT
Source: THE FREEDONIA GROUP, INC. Telephone: (216) 921-6800
AUGUST 1991
Language: English Word Count: 135 (1 pp.)

Adhesive and printing ink applications consumed nearly 70 million pounds, ten percent of 1,1,1-TCE demand in 1990. Solvents competing with 1,1,1-TCE for adhesive and ink applications include methylene chloride, perchloroethylene and trichloroethylene. 1,1,1-TCE is often used as direct substitution for toluene, which is restricted under the EPA VOC regulations. 1,1,1-TCE use is widespread in contact adhesives, which account for more than half of all chlorinated solvents applications in adhesives. Other applications for adhesives formulated with 1,1,1-TCE include bonding of polyurethane foam cushions and carpet backing, floor tile mastics and graphic arts cements. As other replacement solvents are available, demand for 1,1,1-TCE will decline 6.5 percent per year through 1995 to 50 million pounds. 1,1,1-TCE is a preferred thinner for flexographic inks and other products including typewriter correction fluids.

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Country: UNITED STATES
Industry: CHEMICALS, ENVIRONMENT

0/5/5
DIALOG(R)File 763:Freedonia Market Res.

00021197
CHLORINATED SOLVENTS: 1,1,1-Trichloroethane Used in Metal Cleaning
Main Report Title: SOLVENTS AND THE ENVIRONMENT
Source: THE FREEDONIA GROUP, INC. Telephone: (216) 921-6800
AUGUST 1991
Language: English Word Count: 290 (1 pp.)

Metal cleaning, which includes vapor degreasing and cold cleaning, accounted for two-thirds of demand in 1990. The use of 1,1,1-TCE in metal cleaning expanded rapidly through 1985 due to replacement of trichloroethylene, which produces undesirable levels of photochemical smog. However, since then, 1,1,1-TCE use has declined 4.8 percent annually. In 1990, metal cleaning used 450 million pounds of 1,1,1-TCE with vapor degreasing accounting for 340 million pounds and cold cleaning accounting for 110 million pounds. In both types of metal cleaning, virgin 1,1,1-TCE demand has been adversely affected by the use of recycled and/or reused solvents.

Vapor degreasing is used to clean metal parts, machine tool components and castings and other articles which pick up oil, grease and other contaminants during processing. With the use of inhibitors (accounting for 3.5 percent or more of the cleaning solution), 1,1,1-TCE can be used at the higher temperatures required by vapor degreasing without decomposition or metal attack.

Methylene chloride may be substituted for 1,1,1-TCE in some vapor degreasing operations. MeCl is lower in cost and can use closed-cycle vessels designed for 1,1,1-TCE with only minor modifications. Due to environmental regulations, competition from lower cost solvents and recycling and reuse, vapor degreasing demand for 1,1,1-TCE is projected to decline 3.8 percent annually through 1995 to 280 million pounds.

Cold cleaning uses 1,1,1-TCE as a liquid solvent at room temperature to clean and degrease plastics, exotic metals and other materials where elevated temperatures could cause damage. This type of cleaning may be used during the production cycle or in maintenance cleaning of industrial equipment. With the advent of regulatory restrictions, demand for 1,1,1-TCE for cold cleaning is projected to decline five percent per year through 1995 to 85 million pounds.

THIS IS THE FULL-TEXT.
Country: UNITED STATES
Industry: CHEMICALS, ENVIRONMENT

0/5/6
DIALOG(R)File 763:Freedonia Market Res.

00021193
CHLORINATED SOLVENTS: 1,1,1-Trichloroethane
Main Report Title: SOLVENTS AND THE ENVIRONMENT
Source: THE FREEDONIA GROUP, INC. Telephone: (216) 921-6800
AUGUST 1991
Language: English Word Count: 659 (2 pp.)

1,1,1-trichloroethane, also known as methyl chloroform or 1,1,1-TCE, is a colorless, nonflammable liquid. It is also marketed under various tradenames such as Aerothene-TT or Chlorothene (Dow), Solvent 111 (Vulcan), and Triethane (PPG). 1,1,1-T is commonly sold with various stabilizers in concentrations up to four or five percent. It is an excellent solvent for greases, oils, tars, waxes and a broad range of organic materials. It also has a high flash point, making it attractive for solvent, aerosol and many other applications.

The dominant process for making 1,1,1-TCE involves the the hydrochlorination of vinyl chloride to yield 1,1-dichloroethane, which is thermally chlorinated to 1,1,1-TCE. HCl from the thermal chlorination step is recycled to step one. This process is used by Vulcan at Geismar, Louisiana. Another route chlorinates ethylene or 1,1-dichloroethane to yield 1,1,2-trichloroethane which is subsequently dehydrochlorinated to vinylidene chloride. The vinylidene chloride is then reacted with byproduct HCl to form 1,1,1-TCE.

In contrast to many other chlorocarbons, 1,1,1-TCE had been, until recently, generally accepted as a safe and relatively non-toxic chemical. However, it has the potential to destroy upper atmosphere ozone. Depending upon factors such as tropospheric temperatures, solar radiation intensity and other factors, 1,1,1-trichloroethane has an atmospheric lifetime of six to seven years and an ozone depletion potential (ODP) of 0.12. That is, 1,1,1-trichloroethane has about twelve percent of the potential to destroy stratospheric ozone molecules as CFC-11, which is used as the standard measurement in ozone depletion potential.

The United Nations Environmental programme (UNEP) has suggested that a freeze on 1,1,1-TCE production by 1992 and a possible reduction ranging from 25 percent to 50 or 100 percent by 2000. The Montreal Protocol revisions of June 29, 1990, mandated that 1,1,1-TCE production be frozen at 1989 levels as of January 1, 1993, reduced by 30 percent effective January 1, 1995, reduced by 70 percent effective January 1, 2000 and phased out completely by the year 2005.

The Clean-Air Bill, signed on November 15, 1990, mandated a phase-out of 1,1,1-TCE production by 2002. After 2002, the EPA may authorize production solely for essential applications, subject to an annual cap of ten percent. An excise tax of 13.7 cents per pound has been imposed on sales, effective January 1, 1991, with the tax gradually rising to 31 cents per pound by 1995. The Bill mandated that 1995 production be reduced to 70 percent of 1989 production and that by 2000, be reduced to 20 percent of 1989 production.

Because it is not photoreactive, 1,1,1-TCE does not contribute to ground-level air quality problems by the formation of ozone, nitrogen oxides or smog. Studies on rodents indicate that it has no significant carcinogenic or mutagenic characteristics. These findings concerning its safety have been confirmed by extensive human studies. Accordingly, the EPA concluded that 1,1,1-TCE is inherently safe for solvent and other applications under conditions of chronic exposure to commonly encountered ambient levels in air.

While 1,1,1-TCE is exempt from the volatile organic compound (VOC) regulations of the EPA, several states -- Kentucky, Rhode Island, New Jersey and Michigan -- have established stricter rules. As a result, solvent use of 1,1,1-trichloroethane is declining for some applications.

In 1989, the US Occupational Safety and Health Administration (OSHA) decreased its Permissible Exposure Limit (PEL) for 1,1,1-trichloroethane in the work place from 100 parts per million in air to 50 parts per million. The characteristic odor of 1,1,1-TCE is detectable at very low levels and contributes to its safety. Vapors, being much heavier than air, tend to collect at low points and away from breathing levels, further contributing to its relative safety in the work place.

1,1,1-Trichloroethylene is unique in its properties with very high volatility and vapor pressure, fairly low surface tension and no danger of flammability. 1,1,1,-T has been exempt from VOC standards despite its volatility. This exemption and lack of flammability put 1,1,1-TCE in a class by itself. As a result, it will be very difficult to replace in many applications.

THIS IS THE FULL-TEXT.

Country: UNITED STATES
Industry: CHEMICALS, ENVIRONMENT

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      S0       7  00027328
?t s0/5/7

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DIALOG(R)File 763:Freedonia Market Res.

00021193
CHLORINATED SOLVENTS: 1,1,1-Trichloroethane
Main Report Title: SOLVENTS AND THE ENVIRONMENT
Source: THE FREEDONIA GROUP, INC. Telephone: (216) 921-6800
AUGUST 1991
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In 1989, the US Occupational Safety and Health Administration (OSHA) decreased its Permissible Exposure Limit (PEL) for 1,1,1-trichloroethane in the work place from 100 parts per million in air to 50 parts per million. The characteristic odor of 1,1,1-TCE is detectable at very low levels and contributes to its safety. Vapors, being much heavier than air, tend to collect at low points and away from breathing levels, further contributing to its relative safety in the work place.

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Country:  UNITED STATES
Industry: CHEMICALS, ENVIRONMENT
?b 799
       08aug94 09:20:38 User036172 Session B134.3
            $6.00    0.100 Hrs File763
          $105.00  7 Types
            $2.00  View Fee
    $113.00  Estimated cost File763
      $1.20  SPRNTNET
    $114.20  Estimated cost this search
    $130.78  Estimated total session cost   0.200 Hrs.


File 799:Textline Curr.Glob.News  1993-1994/Aug 05
       (c) 1994 Reuters Info.Svcs.

      Set  Items  Description
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?k 12599679;k 10848023;k 10713190;k 10713189;k 10295471
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      S0       1  12599679
      S0       2  10848023
      S0       3  10713190
      S0       4  10713189
      S0       5  10295471
?t s0/5/all

 0/5/1
DIALOG(R)File 799:Textline Curr.Glob.News
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12599679
JAPAN: NEW POWERFUL WASHING AGENT TO REPLACE TRICHLOROETHANE
Japan Chemical Week (JCHWAC) - July 7, 1994  Page: 10,
Word Count: 218

LEAD PARAGRAPH:
Fujitsu Ltd. and Nitto Chemical Industry Co., have announced the creation
of a tie-up for production and sales of a new washing agent. The product,
tagged "Perclean," has five times the strength of trichloroethane, which it
will replace.

   This has been developed by Fujitsu as a flux-residue remover for
super-computer CPUs. Ahead of the total prohibition of trichloroethane due
to become effective at the end of 1995, the two companies anticipate large
general demand for the agent.

COMPANY:  Nitto Chemical Industry (NCI); Fujitsu Ltd (FUJU)
COUNTRY OF INCORP: JAPAN ; JAPAN
RIC:      4002 (Nitto Chemical Industry); 6702 (Fujitsu Ltd)
INDUSTRY: Electronic Data Processing Equipment (3302); Office Machinery &
          Data Processing Equip (33); Soap & Toilet Preparations (258);
          Basic Industrial Chemicals (251); Chemicals (25)
COUNTRY:  Japan (JAP)
REGION:   Japan (JAP); Eastern Asia (EASIA); Asia (ASIA); Organisation for
          Economic Coop. and Dev. (OECD); United Nations (UN); Far East
          (FEAST); Pacific Rim (PACRM); Group of Five (GFIVE); Group of
          Seven (GSEVEN); Group of Ten (GTEN)
EVENT:    Corporate (CCAT); Contracts, Orders (C33)
LANGUAGE: English
```

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 0/5/2
DIALOG(R)File 799:Textline Curr.Glob.News
(c) 1994 Reuters Info.Svcs. All rts. reserv.

10848023
JAPAN:  FUJITSU  GENERAL  TO ELIMINATE FREON, TRICHLOROETHANE FROM CLEANING
PROCESSES
Comline  News Service,Japan Industrial Journal,Nikkan Kogyo Shimbun (COMLN,
JAPIJ,NKOGS) - July 21, 1993  Page: 1,1
Word Count: 83

ABSTRACT:
Fujitsu General Ltd. has announced its intention to eliminate the use of
Freon and trichloroethane from cleaning processes in the production of PCBs
and heat exchangers by the end of 1995.
The firm will also replace Freon used as a refrigerant and as a foaming
agent in the production of adiabetic urethane resin. Fujitsu General will
replace CFC12 with HFC134a for refrigeration and CFC11 with HCFC141b for
use as a foaming agent.
Contact: Tel: +81-44-866-1111
         Fax: +81-44-888-4901.

COMPANY:  Fujitsu General (GNCORP)
COUNTRY OF INCORP: JAPAN
RIC:      6755 (Fujitsu General)
INDUSTRY: Consumer & Misc. Electronic Goods (3454); Misc. Electronic
          Equipment (345); Electrical & Electronic Engineering (34)
COUNTRY:  Japan (JAP)
REGION:   Japan (JAP); Eastern Asia (EASIA); Asia (ASIA); Organisation for
          Economic Coop. and Dev. (OECD); United Nations (UN); Far East
          (FEAST); Pacific Rim (PACRM); Group of Five (GFIVE); Group of
          Seven (GSEVEN); Group of Ten (GTEN)
EVENT:    Corporate (CCAT); Capacity, Facilities (C24)
LANGUAGE: English


 0/5/3
DIALOG(R)File 799:Textline Curr.Glob.News
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10713190
UK: ORANGE OIL SAID MAY REPLACE OZONE-HARMING CHEMICAL
```

Reuter,Reuter Newswire - United Kingdom,Reuter Economic News (REUTR,REUTUK, LBA) - June 22, 1993
Word Count: 197

LEAD PARAGRAPH:
LONDON, June 22, Reuter - Oils in orange peel have been found to be a powerful industrial solvent and cleanser that could be used to replace one of the chemicals doing severe damage to the ozone layer, the Financial Times said.

The solvent, Pronatur, is made from natural oils squeezed from orange peel. It cleans stubborn materials such as oil from any surface and could be used as a substitute for 1,1,1-trichloroethane, which worldwide signatories to the Montreal protocol on onzone protection have agreed to ban by 1995, the newspaper said.

COMPANY: Billington, Edward and Son Ltd (BILL)
INDUSTRY: Wholesale Distribution (61); Distribution, Hotels and Catering;repairs (6); Industrial Gases & Other Misc. (2567); Specialised Chemical Products (IND.USE) (256); Chemicals (25)
COUNTRY: United Kingdom (UK)
REGION: United Kingdom (UK); Western Europe (WEUR); Europe (EUR); European Community (EEC); Organisation for Economic Coop. and Dev. (OECD); North Atlantic Treaty Organisation (NATO); Commonwealth (COMWH); United Nations (UN); Group of Five (GFIVE)
EVENT: Government, Social (GCAT); Environment (G14); Corporate (CCAT); New Products, Services (C22); Country Reports Economic (2ECO)
LANGUAGE: English

0/5/4
DIALOG(R)File 799:Textline Curr.Glob.News

10713189
UK: ORANGE PEEL COULD REPLACE OZONE-HARMING CHEMICAL
Reuter,Reuter Newswire - United Kingdom,Reuter General News (REUTR,REUTUK, LBY) - June 22, 1993
Word Count: 214

LEAD PARAGRAPH:
LONDON, June 22, Reuter - Oils in orange peel have been found to be a

powerful industrial solvent and cleanser and could replace a chemical severely damaging the ozone layer, a British newspaper reported on Tuesday.

The solvent, Pronatur, is made from natural oils squeezed from orange peel and cleans stubborn materials such as oil from any surface, the Financial Times said.

COMPANY: Billington, Edward and Son Ltd (BILL)
INDUSTRY: Wholesale Distribution (61); Distribution, Hotels and Catering;repairs (6)
COUNTRY: United Kingdom (UK)
REGION: United Kingdom (UK); Western Europe (WEUR); Europe (EUR); European Community (EEC); Organisation for Economic Coop. and Dev. (OECD); North Atlantic Treaty Organisation (NATO); Commonwealth (COMWH); United Nations (UN); Group of Five (GFIVE)
EVENT: Government, Social (GCAT); Environment (G14); Education, Research (G113); Social Affairs (G11); Corporate (CCAT); Research, Development (C23); Country Reports General (4GEN); Country Reports Economic (2ECO)
LANGUAGE: English

0/5/5
DIALOG(R)File 799:Textline Curr.Glob.News

10295471
JAPAN: RECYCLABLE METAL CLEANER TO REPLACE OZONE DEPLETER
Chemical Business Newsbase,Japan Chemical Week (CBNB,JCHWAC) - March 13, 1993 Page: 3
Word Count: 72

ABSTRACT:
From Feb 1993 Nikko Petrochemicals Co will market NS Clean, an n-paraffin based metal cleaning agent, to replace trichloroethane and other ozone depleting chemicals. It can be recycled and is cheaper than trichloroethane. 15,000 tonnes per year production capacity has been established at Mizushima. A cleaning product using this recyclable chemical will be marketed, and sales of Y 6bn are expected by fiscal 1995.
Jpn. Chem. Week, Vol. 34, No. 1711.

COMPANY: Nikko Kyodo Co Ltd (NPNMIN)

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COUNTRY OF INCORP: JAPAN
RIC:       5014 (Nikko Kyodo Co Ltd)
INDUSTRY:  Industrial Gases & Other Misc. (2567); Specialised Chemical
           Products (IND.USE) (256); Basic Organic Chemicals (2512); Basic
           Industrial Chemicals (251); Chemicals (25); Mining & Extraction
           Metalliferous Ores (21)
COUNTRY:   Japan (JAP)
REGION:    Japan (JAP); Eastern Asia (EASIA); Asia (ASIA); Organisation for
           Economic Coop. and Dev. (OECD); United Nations (UN); Far East
           (FEAST); Pacific Rim (PACRM); Group of Five (GFIVE); Group of
           Seven (GSEVEN); Group of Ten (GTEN)
EVENT:     Corporate (CCAT); Capacity, Facilities (C24); Markets, Marketing
           (C31)
LANGUAGE: English
?b 772
       08aug94 09:22:54 User036172 Session B134.4
            $3.00    0.050 Hrs File799
            $4.00  5 Types
            $1.00  View Fee
     $8.00  Estimated cost File799
     $0.60  SPRNTNET
     $8.60  Estimated cost this search
   $139.38  Estimated total session cost   0.250 Hrs.


File 772:Textline Global News  1990-1992
       (c) 1994 Reuters Info.Svcs.

      Set  Items  Description
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?k 08103488
      S0       1  08103488
?t s0/5/1

 0/5/1
DIALOG(R)File 772:Textline Global News
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08103488
JAPAN:   ASAHI   CHEMICAL   IMPROVES   AQUEOUS   CLEANING  AGENT,  REDUCING
1,1,1-TRICHLOROETHANE SHIPMENTS
Comline News Service,Nikkan Kogyo Shimbun (COMLN,NKOGS) - March 26, 1992
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 Page: 18,
Word Count: 116

ABSTRACT:
Asahi Chemical Industry Co., Ltd. has announced plans to replace 30% of its
1,1,1-trichloroethane sales with a non-polluting aqueous cleaning agent
within two years, and 50% by the end of 1995.
The aqueous cleaning agent is available in the "K Series," for cleaning
metals, and the semi-aqueous "M Series," for removing flux oil and wax.
To use the cleaning agents, initial washing with surfactant-containing
agents is followed by further washing and then rinsing.
Aqueous cleaning agents are difficult to use when cleaning many different
articles or articles with complex shapes.
The company has begun standardizing the cleaning procedure for specific
applications.
Contact: Tel: +81-3-3507-2056.
       Fax: +81-3-3507-2495.
COMPANY:  Asahi Chemical Industry Co (ASICHM); Asahi Chemical Industry Co
           (ASICHMX)
COUNTRY OF INCORP: JAPAN ; JAPAN
RIC:       3407.T (Asahi Chemical Industry Co); 3407.T (Asahi Chemical
           Industry Co)
INDUSTRY: Processing of Rubber & Plastics (48)
COUNTRY:  Japan (JAP)
REGION:   Japan (JAP); Eastern Asia (EASIA); Asia (ASIA); Organisation for
          Economic Coop. and Dev. (OECD); United Nations (UN); Far East
          (FEAST); Pacific Rim (PACRM); Group of Five (GFIVE); Group of
          Seven (GSEVEN); Group of Ten (GTEN)
EVENT:    Corporate (CCAT); New Products, Services (C22)
LANGUAGE: English
?b 2
       08aug94 09:23:44 User036172 Session B134.5
            $0.96    0.016 Hrs File772
            $0.80  1 Types
            $1.00  View Fee
     $2.76  Estimated cost File772
     $0.19  SPRNTNET
     $2.95  Estimated cost this search
   $142.33  Estimated total session cost   0.266 Hrs.

File   2:INSPEC  1969-1994/Aug W1
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        (c) 1994 Institution of Electrical Engineers

        Set  Items  Description
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?k 4705880;k 03833234
        S0       1  4705880
        S0       2  03833234
?t s0/5/all

 0/5/1
DIALOG(R)File   2:INSPEC
(c) 1994 Institution of Electrical Engineers. All rts. reserv.

4705880   INSPEC Abstract Number: B9408-2330-001
 Title:  Aqueous  cleaning  of  vacuum  tube  components, replacing 1,1,1,
trichloroethane
  Author(s): Alston, D.W.
  Author Affiliation: Hewlett-Packard Co., Santa Clara, CA, USA
  p.7-10
  Publisher: IEEE, New York, NY, USA
  Publication Date: 1993    Country of Publication: USA    viii+207 pp.
  ISBN: 0 7803 0829 8
  U.S. Copyright Clearance Center Code: 0 7803 0829 8/93/$03.00
  Conference  Title:  Proceedings  of  1993 IEEE International Symposium on
Electronics and the Environment
  Conference Sponsor: IEEE
  Conference  Date:  10-12  May 1993    Conference Location: Arlington, VA,
USA
  Language: English    Document Type: Conference Paper (PA)
  Treatment: Practical (P)
  Abstract:  The first process step in the production of a specialty vacuum
tube  at  the Hewlett-Packard Santa Clara Division has been to clean all of
the  hardware  in a 1,1,1, trichloroethane (TCA) degreaser. However, due to
the  inclusion  of  TCA  in  the  Montreal protocol and in the proposed EPA
labeling  regulations, a permanent environmentally suitable solution had to
be found. The challenge was to find commercially available aqueous cleaners
(saponifiers) that would remove light machine shop oils and particulates so
that  the  parts would be clean enough to be placed in moderate (10/sup -6/
torr)  vacuum  atmosphere  with no functional degradation. Sample parts and
subassemblies  were  contaminated  with  sample soils and then cleaned with
candidate cleaners. Detailed analyses have shown aqueously cleaned parts to
have  lower contamination levels than the vapor degreased parts. Details of
```

the materials cleaned, saponifiers used, and test results are presented. (2 Refs)

Descriptors: electron tube manufacture; environmental engineering; surface treatment; vacuum tubes

Identifiers: TCA degreaser; aqueous cleaning; environment; vacuum tube components; 1,1,1, trichloroethane; Montreal protocol; EPA labeling regulations; subassemblies; contamination levels; saponifiers; 10/sup -6/ torr

Class Codes: B2330 (Electron tube technology and manufacture); B2340 (Vacuum tubes)

Numerical Indexing: pressure 1.3E-04 Pa

0/5/2
DIALOG(R)File 2:INSPEC

03833234 INSPEC Abstract Number: B91016735

Title: Influence on semiconductor devices by the flux cleaning solvent replacing CFC

Author(s): Matsushima, H.; Mizugashira, S.

Author Affiliation: Matsushita Electron. Corp., Kyoto, Japan

Conference Title: International Symposium on Reliability and Maintainability 1990-Tokyo R&M ISRM '90 Tokyo p.87-91

Publisher: Union of Japanese Sci. & Eng, Tokyo, Japan

Publication Date: 1990 Country of Publication: Japan 637 pp.

Conference Date: 5-8 June 1990 Conference Location: Tokyo, Japan

Language: English Document Type: Conference Paper (PA)

Treatment: Experimental (X)

Abstract: The solder flux cleaning solvents in place of CFC-113 (chlorofluorocarbon-113) have been investigated, because of the international regulation on CFC use to protect the ozone layer. The influence on the semiconductor devices by some substitutional solvents (1.1.1.-trichloroethane, hydrogenated chlorofluorocarbon and alcohol fluoride) was studied. As the result, no problems arose in using these solvents under the actual manufacturing conditions. However, it became clear that some kinds of solvent with a 1.1.1.-trichloroethane base evolved into HCl under severe conditions, and caused Al corrosion. Hence it is necessary to examine carefully the choice and use of the solvent. (1 Refs)

Descriptors: reliability; semiconductor device manufacture; soldering; surface treatment

Identifiers: CFC replacements; hydrogenerated CFC; chlorofluorocarbon

```
substitutes; semiconductor devices; flux cleaning solvent; solder flux;
CFC-113; 1.1.1.-trichloroethane; alcohol fluoride; HCl; Al corrosion
  Class Codes: B2560  (Semiconductor devices); B0170G (General fabrication
techniques); B0170N (Reliability)
  Chemical Indexing:
  HCl bin - Cl bin - H bin (Elements -  2)
  Al sur - Al el (Elements -  1)
?b 8
       08aug94 09:25:37 User036172 Session B134.6
            $2.97    0.033 Hrs File2
            $2.10  2 Types
            $1.00  View Fee
     $6.07  Estimated cost File2
     $0.40  SPRNTNET
     $6.47  Estimated cost this search
   $148.80  Estimated total session cost   0.300 Hrs.

### Status: Signing Off...

### Status: Break Sent.

?logoff
       08aug94 09:26:45 User036172 Session B134.7
            $2.97    0.033 Hrs File8
     $2.97  Estimated cost File8
     $0.40  SPRNTNET
     $3.37  Estimated cost this search
   $152.17  Estimated total session cost   0.333 Hrs.


### Status: Signed Off.

### Status: Dialog Basic Connection Path #1

### Status: Initializing modem ...
AT&FE1Q0V1X4&C1&D2&K4
OK
### Status: Dialing primary number (448-4611)...

ATDT448-4611
CONNECT 9600
```

JWB

```
Banner display set OFF.
HILIGHT set on as '*'
KWIC is set to 5.
BLIP set on
NOTICE set ON to $25.00
You will be prompted to confirm each output request that exceeds $25.00
COST       = ONESEARCH.
Please enter SUBACCOUNT name/number:
?
?bulluck/f7411
Is BULLUCK/F7411 the SUBACCOUNT you want to use? (Y/N)
?y
Subaccount is set to BULLUCK/F7411
SYSTEM:HOME
Menu System II: D2 version 1.7.1 term=ASCII
Terminal set to DLINK
                     *** DIALOG HOMEBASE(SM) Main Menu ***

Information:
 1.  Announcements (new files, free connect time, price changes, etc.)
 2.  Database, Rates, & Command Descriptions
 3.  Help in Choosing Databases for Your Topic
 4.  Customer Services (telephone assistance, training, seminars, etc.)
 5.  Product Descriptions

Connections:
 6.  DIALOG Menus(SM)
 7.  DIALOG Business Connection(R), Headlines(SM), Medical Connection(SM)
 8.  DIALOG SourceOne(SM) Document Delivery
 9.  Data-Star
10.  Other Online Menu Services & Files (MoneyCenter(R), OAG, TNT, etc.)

     /H = Help           /L = Logoff          /NOMENU = Command Mode


Enter an option number to view information or to connect to an online
service.  Enter a BEGIN command plus a file number to search a database
(e.g., B1 for ERIC).
?b 8

       08aug94 09:31:46 User036172 Session B135.1
       Sub account: BULLUCK/F7411
```

```
### Status: Dialog Basic Connection Path #1

### Status: Initializing modem ...
AT&FE1Q0V1X4&C1&D2&K4
OK
### Status: Dialing primary number (929-3622)...

ATDT929-3622
CONNECT 9600
### Status: Connection established at 9600 baud


TELENET
512 110F

TERMINAL=

@
 ?

@c Dialog


DIALOG CONNECTED
### Status: Connected


DIALOG INFORMATION SERVICES
PLEASE LOGON:
 ******** HHHHHHHH SSSSSSSS?
### Status: Signing onto Dialog
 ********
ENTER PASSWORD:
 ******** HHHHHHHH SSSSSSSS? ********
Welcome to DIALOG
### Status: Connected

Dialog level 36.08.02B

Last logoff:  08aug94 09:26:45
Logon file405 08aug94 09:30:58
```

```
           $0.00     0.013 Hrs FileHomeBase
     $0.00  Estimated cost FileHomeBase
     $0.16  SPRNTNET
     $0.16  Estimated cost this search
     $0.16  Estimated total session cost   0.013 Hrs.


File   8:Ei Compendex*Plus(TM)  1970-1994/Sep W1
       (c) 1994 Engineering Info. Inc.

     Set  Items  Description
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?k 03887485;k 03821533;k 03794394;k 03786874;k 03439106;k 03326453;k 03206402
     S0       1  03887485
     S0       2  03821533
     S0       3  03794394
     S0       4  03786874
     S0       5  03439106
     S0       6  03326453
     S0       7  03206402
?t s0/5/all

 0/5/1
DIALOG(R)File   8:Ei Compendex*Plus(TM)
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03887485   E.I. No: EIP94061322154
  Title:  Cleaning  aluminum  heat  pipe  casings  with  replacements  for
ozone-depleting chemicals
  Author: Meyers, Barry
  Corporate  Source:  Lockheed  Missiles and space Co. Inc., Sunnyvale, CA,
USA
  Conference  Title:  Proceedings  of  the  Symposium on the Replacement of
Chlorofluorocarbon  (CFC)  Fluids  in  the Cleaning of Oxygen and Aerospace
Systems and Components
  Conference Location: Miami, FL, USA
  Sponsor: ASTM
  E.I. Conference No.: 19175
  Source:  ASTM  Special  Technical  Publication n 1181 1993. Publ by ASTM,
Philadelphia, PA, USA. p 103-145
  Publication Year: 1993
  CODEN: ASTTA8   ISSN: 0066-0558   ISBN: 0-8031-1496-6
```

Language: English
Document Type: CA; (Conference Article)   Treatment: X; (Experimental); T
; (Theoretical)
Journal Announcement: 9408W2

Abstract: The internal cleanliness of heat pipe casings used in spacecraft thermal control systems must meet strict non-volatile residue (NVR) and particulate requirements. Presently, Trichloroethane (TCA) is used in the precleaning of heat pipes and 1,1,2 trichloro 1,2,2 Trifluoroethane (CFC-113) is used for precision cleaning. TCA removes oils and other organic contaminants while CFC-113 removes particles and fibers. A new process was developed and tested for heat pipe casing cleaning using replacements for TCA and CFC-113 which meets NVR and particulate cleanliness requirements. An alkaline cleaner was used instead of TCA for precleaning and deionized water (D1) with a nitrogen gas aeration was used instead of CFC-113 for precision cleaning. (Edited author abstract) 6 Refs.

Descriptors: *Cleaning; Ozone layer; Environmental protection; Heat pipes ; Deoxidants

Identifiers: Ozone depleting chemicals (ODC); Life testing; Non condensable gas (NCG); Particulate cleanliness

Classification Codes:
454.2 (Environmental Impact & Protection); 802.3 (Chemical Operations)
454 (Environmental Engineering); 802 (Chemical Apparatus & Plants); 658
Aerospace Engineering, General); 616 (Heat Exchangers)
45 (POLLUTION & SANITARY ENGINEERING); 80 (CHEMICAL ENGINEERING); 65
(AEROSPACE ENGINEERING); 61 (PLANT & POWER ENGINEERING)

0/5/2
DIALOG(R)File 8:Ei Compendex*Plus(TM)
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03821533 E.I. No: EIP94031236863
Title: Semi-aqueous solvent cleaners to replace fluorochlorocarbons and 1,1,-trichloroethane for metal cleaning
Author: Duchi, P.J.
Source: Galvanotechnik v 84 n 11 Nov 1993. p 3664-3668
Publication Year: 1993
CODEN: GVTKAY ISSN: 0016-4232
Language: English
Document Type: JA; (Journal Article)   Treatment: A; (Applications); X;
(Experimental)
Journal Announcement: 9405W1

Abstract: As the result of a number of new laws and ordinances, there is now an urgent need to replace chlorofluorocarbons and 1,1,1-trichloroethane. Purely aqueous cleaners have a number of disadvantages when used for metal degreasing, hence a move towards the use of semi-aqueous cleaners containing organic solvents. In this technology, metal cleaning takes place using synthetic hydrocarbons, combined with an aqueous rinse. Worth noting are the biodegradability of such hydrocarbons, their good cleaning power as well as greater ease of recycling, using membrane technologies. For less demanding cleaning applications, semi-aqueous systems can be replaced by cleaners based on various new synthetic hydrocarbons. (Author abstract)

Descriptors: *Metal cleaning; Surface cleaning; Pickling; Solvents; Fluorocarbons

Identifiers: Chlorofluorocarbons; Trichloroethane; Aqueous cleaners

Classification Codes:
539.3.1 (Electroplating)
539.3 (Metal Plating)
539 (Metals Corrosion & Protection); 803 (Chemical Agents & Basic Industrial Chemicals)
53 (METALLURGICAL ENGINEERING); 80 (CHEMICAL ENGINEERING)

0/5/3
DIALOG(R)File 8:Ei Compendex*Plus(TM)

03794394 E.I. No: EIP94021199141

Title: Solvent recovery technique and purification of environment in adjustment to replacing CFCs and trichloroethane

Author: Takahara, Hiroyuki; Usui, Mitsunori

Source: R&D: Research and Development v 43 n 2 Apr 1993. p 41-43

Publication Year: 1993

CODEN: RDKSB9 ISSN: 0373-8868

Language: English; Japanese

Document Type: JA; (Journal Article) Treatment: A; (Applications); G; (General Review)

Journal Announcement: 9403W4

Abstract: Ozone destructive substances, for example CFCs (Chloro Fluoro Carbons) or trichloroethane, are scheduled to be abolished by 1995, and the industrial world must immediately address the relevant issues. As a result of assessment in recovering replacement of CFCs (Trichloroethylene, Freon-225, Fluorocarbon), it has become clear that a solvent recovery unit called ACTOCRYSTA-Series can achieve a high value of recovered solvent and that this can then be recycled. In addition, it was found that ACTOCRYSTA-C is helpful for removing harmful gas. (Translated author abstract) 1 Ref.

Descriptors: *Air pollution control; Fluorocarbons; Freons; Solvents; Recovery; Recycling

Identifiers: Solvent recovery techniques; ACTOCRYSTA C solvent recovery unit; Trichloroethane

Classification Codes:

451.2 (Air Pollution Control); 804.1 (Organic Components); 644.2 (Refrigerants); 452.4 (Industrial Wastes Treatment)

451 (Air Pollution); 804 (Chemical Products); 644 (Refrigeration & Cryogenics); 803 (Chemical Agents & Basic Industrial Chemicals); 452 (Sewage & Industrial Wastes Treatment)

45 (POLLUTION & SANITARY ENGINEERING); 80 (CHEMICAL ENGINEERING); 64 (HEAT & THERMODYNAMICS)

0/5/4
DIALOG(R)File 8:Ei Compendex*Plus(TM)

03786874 E.I. No: EIP94011179348

Title: Replacement of 1,1,1-trichloroethane for cleaning turbine generator components and nondestructive examination applications

Author: O'Shanka, Joseph J.; Bailey, Kevin P.; Corley, Thomas J.; Sadhir, Rajender K.

Corporate Source: Westinghouse Electric Corp, Orlando, FL, USA

Conference Title: Proceedings of the 1993 International Joint Power Generation Conference

Conference Location: Kansas City, MO, USA

Sponsor: The Power Division, ASME

E.I. Conference No.: 19540

Source: The Steam Turbine- Generator Today: Materials Flow Path Design Repair and Refurbishment American Society of Mechanical Engineers, Power Division (Publication) PWR v 21 1993. Publ by ASME, New York, NY, USA. p 109-113

Publication Year: 1993

CODEN: AMEPEJ ISBN: 0-7918-0996-X

Language: English

Document Type: CA; (Conference Article) Treatment: A; (Applications); X ; (Experimental)

Journal Announcement: 9403W1

Abstract: During the past two (2) years, two (2) complementary programs were conducted to find suitable replacements to 1, 1, 1-trichloroethane (methyl chloroform) as a cleaning/degreasing solvent for manual cleaning applications. These programs were prompted by changing environmental regulations and increasing concern for ozone layer depletion. The first program qualified two (2) alternative solvents as replacements for cleaning generator stator windings. The second program qualified two (2) alternative solvents as replacements for cleaning other turbine generator components and for nondestructive examination (NDE) applications. The methodology, results, discussions, and conclusions from the programs are presented. (Author abstract) 3 Refs.

Descriptors: *Turbogenerators; Machine components; Stators; Cleaning; Solvents; Nondestructive examination; Environmental protection

Identifiers: Cleaning/degreasing solvents; 1,1,1-Trichloroethane; Manual cleaning; Ozone layer depletion

Classification Codes:

617.2 (Steam Turbines); 601.2 (Machine Components); 804.2 (Inorganic Components); 801.1 (Chemistry, General); 454.2 (Environmental Impact & Protection)

617 (Turbines & Steam Engines); 601 (Mechanical Design); 803 (Chemical Agents & Basic Industrial Chemicals); 804 (Chemical Products); 801 (Chemical Analysis & Physical Chemistry); 454 (Environmental Engineering)

61 (PLANT & POWER ENGINEERING); 60 (MECHANICAL ENGINEERING); 80 (CHEMICAL ENGINEERING); 45 (POLLUTION & SANITARY ENGINEERING)

0/5/5
DIALOG(R)File 8:Ei Compendex*Plus(TM)

03439106 E.I. Monthly No: EI9206081841

Title: Chemical substitution for 1,1,1-trichloroethane and methanol in an industrial cleaning operation.

Author: Brown, Lisa M.; Springer, Johnny; Bower, Matthew

Corporate Source: U.S. Environmental Protection Agency, Cincinnati, OH, USA

Source: Journal of Hazardous Materials v 29 n 2 Jan 1992 p 179-188

Publication Year: 1992

CODEN: JHMAD9 ISSN: 0304-3894

Language: English

Document Type: JA; (Journal Article) Treatment: A; (Applications); X; (Experimental)

Journal Announcement: 9206

Abstract: Hazardous wastes are generated from cold solvent degreasing operations used in many industrial processes. The spent solvents are managed under Subtitle C of the Resource Conservation and Recovery Act (RCRA). With the land ban of spent solvents, disposal has become increasingly difficult. As a result, industries have begun investigating ways to avoid using RCRA listed cleaning solvents. The U.S. Environmental Protection Agency's (EPA) Pollution Prevention Research Branch along with APS Materials, Inc., a small metal finishing company, participated in a joint research project to evaluate the substitution of a dilute, terpene-based cleaner for 1,1,1-trichloroethane (TCA) and methanol, hazardous wastes F001 and F003 respectively, in their degreasing operations. This paper presents the results of a study evaluating the waste reduction/pollution prevention that can be achieved by substituting dilute limonene solutions for TCA and methanol in the cleaning of orthopedic implants (e.g. metal knee and hip joint replacements). This paper describes the original cleaning process, the modifications made to the process in using the dilute limonene solution, and the sampling plan used in evaluating the effectiveness of the solution. The paper presents qualitative results of the sampling tests and an economic evaluation of plant modifications. (Author abstract) 3 Refs.

Descriptors: *SOLVENTS--*Environmental Protection; ETHANE--Control; METHANOL--Control; METALS AND ALLOYS--Cleaning; ECONOMICS--Analysis
Identifiers: 1,1,1-TRICHLOROETHANE; DEGREASING
Classification Codes:
804 (Chemical Products); 454 (Environmental Engineering); 911 (Industrial Economics)
80 (CHEMICAL ENGINEERING); 45 (POLLUTION & SANITARY ENGINEERING); 91 (ENGINEERING MANAGEMENT)

0/5/6
DIALOG(R)File 8:Ei Compendex*Plus(TM)

03326453 E.I. Monthly No: EI9111131614
Title: Replacements for methyl chloroform in carpet applications.
Author: Bickley, H. Thomas
Corporate Source: Selig Chemical Industries, Atlanta, GA, USA
Source: American Dyestuff Reporter v 80 n 6 Jun 1991 p 16, 48
Publication Year: 1991
CODEN: ADREAI ISSN: 0002-8266

Language: English
Document Type: JA; (Journal Article)   Treatment: G; (General Review)
Journal Announcement: 9111

Abstract: Methyl chloroform (MCF), also known as 1,1,1-trichloroethane, has been used successfully as a cleaner and degreaser in numerous applications for over thirty years. Because it has no flash point or fire point (by Standard ASTM methods), MCF readily evaporates and has good solvency properties. It also has been a popular and versatile all-purpose solvent for cleaning and degreasing. Furthermore, MCF is considered to be the safest of the chlorinated hydrocarbons (MCF, trichloroethylene, carbon tetrachloride, perchloroethylene and methylene chloride) from a health standpoint. Many nations, including the United States, came to an agreement at the Montreal Protocol in 1987 on controls for production of products that are said to have ozone depletion potential (ODP). Though MCF has a much lower ODP than the CFCs most commonly known as freons, it is now high on the 'hit-list' for environmentalists. The reason is that despite the relatively low ODP, there is a very large volume of MCF escaping into the atmosphere due to its wide spread use. The problem of finding a replacement for MCF is complex with no simple answer. A compromise must be made. No one product will do the job for all applications, and each situation must be evaluated on its own merits.

Descriptors: *CARPET MANUFACTURE--*Cleaning; SOLVENTS--Effects; EARTH ATMOSPHERE--Ozone Layer; AIR POLLUTION--Legislation

Identifiers: METHYL CHLOROFORM (MCF); TRICHLOROETHANE; MCF REPLACEMENTS

Classification Codes:

819 (Textile & Fiber Technology); 803 (Chemical Agents & Basic Industrial Chemicals); 804 (Chemical Products); 481 (Geology & Geophysics); 657 (Space Physics); 451 (Air Pollution)

81 (CHEMICAL PROCESS INDUSTRIES); 80 (CHEMICAL ENGINEERING); 48 (ENGINEERING GEOLOGY); 65 (AEROSPACE ENGINEERING); 45 (POLLUTION & SANITARY ENGINEERING)

0/5/7
DIALOG(R)File 8:Ei Compendex*Plus(TM)

03206402 E.I. Monthly No: EI9109108768
Title: New technology alkaline cleaners replace chlorinated solvent degreasers.
Author: Quitmeyer, Joann
Corporate Source: W. R. Grace & Co.-Conn, Lexington, MA, USA

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   Source: Lubrication Engineering v 47 n 3 Mar 1991 p 162-165
   Publication Year: 1991
   CODEN: LUENAG   ISSN: 0024-7154
   Language: English
   Document Type: JA; (Journal Article)   Treatment: X; (Experimental)
   Journal Announcement: 9109
   Abstract: For many years the Metalworking Industry has cleaned metal
 parts with chlorinated solvents such as trichlorethylene, methylene
 chloride, perchloroethylene or 1, 1, 1-trichloroethane. Recently, however,
 health and disposal-related environmental concerns have increased regarding
 chlorinated solvents. The Occupational Safety and Health Administration
 (OSHA) has instituted worker vapor exposure limitations for virtually all
 of the solvents used in solvent-based cleaners. In addition, the United
 States Environmental Protection Agency (EPA) has defined virtually all
 solvent-based cleaners as hazardous. The cradle-to-grave responsibility of
 the waste generator is another factor behind concerns over chlorinated
 solvents. After using chlorinated solvents, the resulting sludge and/or
 used solvent must be treated as a hazardous waste. In the United States, a
 chlorinated solvent may cost between DLR@1.00-DLR@1.50/lb. To this
 DLR@1.37/lb. 2 Refs.
   Descriptors: *METAL CLEANING; METAL FORMING--Cold Working; SOLVENTS--
 Health Hazards
   Identifiers: METAL WORKING CLEANING PROCESS; CHLORINATED SOLVENT
 DEGRESERS; METAL WORKING VAPOR CLEANERS; AQUEOUS CLEANERS; ALKALINE
 CLEANERS; METALWORKING INDUSTRY TECHNOLOGY
   Classification Codes:
   539  (Metals Corrosion & Protection); 535  (Rolling, Forging & Forming);
 803  (Chemical Agents & Basic Industrial Chemicals); 804  (Chemical
 Products); 914  (Safety Engineering)
   53  (METALLURGICAL ENGINEERING); 80  (CHEMICAL ENGINEERING); 91
 (ENGINEERING MANAGEMENT)
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       08aug94 09:35:13 User036172 Session B135.2
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            $7.00  7 Types
            $1.00  View Fee
     $13.94  Estimated cost File8
      $0.79  SPRNTNET
     $14.73  Estimated cost this search
     $14.89  Estimated total session cost   0.080 Hrs.
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File  32:METADEX(R)  1966-1994/May
       (c) 1994 ASM/Inst. of Materials

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?k 1777580;k 1764524
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      S0       2  1764524
?t s0/5/all

 0/5/1
DIALOG(R)File  32:METADEX(R)
(c) 1994 ASM/Inst. of Materials. All rts. reserv.

1777580   MA Number: 199303-57-0355
 New  Technology  Alkaline Cleaners Replace Chlorinated Solvent Degreasers
in the Metalworking Industry.
  Quitmeyer, J A
  W.R. Grace and Co
  Conference:  Environment  in  the  1990s--a  Global  Concern,  San Diego,
California, USA,  21-23 May 1991
  Publ:  Society for the Advancement of Material and Process Engineering,
P.O. Box 2459, Covina, California 91722, USA,  1991
  125-134
  Country of Publication: USA
  Journal Announcement: 9303
  Document Type: Conference Paper
  Language: ENGLISH
  Abstract:  Chlorinated  solvents  such  as  trichloroethylene,  methylene
chloride,  perchloroethylene  or  1,1,1-trichloroethane  have been used for
many  years by the metalworking industry to clean parts. However, in recent
years,  health  and  disposal  related  problems  have  become increasingly
evident.  Under  the  Occupational Safety and Health Administration (OSHA),
there  are  worker  vapor  exposure  limitations  for  virtually all of the
solvents  used  in  solvent-based  cleaners.  In  addition,  solvent-based
cleaners  are virtually all hazardous wastes as defined by US Environmental
Protection  Agency  (EPA).  Because  of this, there now is an industry-wide
effort  to reduce or eliminate the use of solvents as cleaners. Today's new
technology water-based cleaners can be used instead of chlorinated solvents
in  many  cleaning  applications.  Volatile  organic  compounds  (VOCs) are
reduced,  employee  exposure  is less restrictive under most conditions and
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the  amount  of  hazardous  waste generated can be significantly reduced or
eliminated depending on the soils involved. 2 ref.
  Descriptors: Conference Paper; Solvents-- Physical properties; Volatility
; Health hazards; Vapor degreasing; Regulations
  Section Headings: 57  (FINISHING)


 0/5/2
DIALOG(R)File  32:METADEX(R)
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1764524   MA Number: 199212-22-0896
 Here  Today,  Gone Tomorrow: Replacing Methyl Chloroform in the Penetrant
Process.
  Robinson, S J
  Sherwin
  Materials Evaluation  50, (8),  936, 938-940, 942-943, 945-946  Aug. 1992
ISSN: 0025-5327
  Country of Publication: USA
  Journal Announcement: 9212
  Document Type: Article
  Language: ENGLISH
  Abstract:  Methyl  chloroform  (1,1,1,-trichloroethane)  is scheduled for
elimination  as an ozone layer depleting compound. Today, it is widely used
as  a  precleaning agent for fluid penetrant testing of metals and will not
be  easily replaced. The replacement must be non-toxic, non-flammable, have
high  volatility,  a  potent  solvent  of organics, and have low residuals.
HCFC-123 has all the necessary properties to replace 1,1,1 except for a low
level  potential  to  cause cancer. Alternate methods include mild alkaline
cleaners,   caustic   alkaline  cleaners,  and  steam  cleaners.  All  have
sufficient disadvantages as to make it necessary to continue the search for
replacements for methyl chloroform.
  Descriptors:  Journal  Article;  Fluid  penetrant  testing;  Surface
pretreatments; Vapor degreasing; Alkaline cleaning; Safety; Health hazards;
Toxicology
  Section Headings: 22  (TESTING AND CONTROL)
?b 144
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            $1.90  2 Types
            $1.00  View Fee
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 File 144:Pascal  1973-1994/Jul
       (c) 1994 INIST/CNRS

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 0/5/1
DIALOG(R)File 144:Pascal
(c) 1994 INIST/CNRS. All rts. reserv.

 10491369   PASCAL No.: 93-0000620
 Replacing 1,1,1-trichloroethane : consider other chlorinated solvents
  WARNER D B; MERTENS J A
  Dow Chemical USA, Dow cent., Midland MI 48674, USA
  Journal: Plating and surface finishing,  1991, 78 (11) 60-62
  ISSN: 0360-3164  CODEN: PSFMDH  Availability: INIST-3347;
354000022113820020
  Document Type: P (Serial) ; A (Analytic)
  Country of Publication: USA
  Language: English   Summary Language: English
  Metal  decreasing  and  other forms of surface cleaning form an important
part  of  the manufacturing process for a large percentage of companies. An
estimated  73,000  U.S.  firms  SUP  1  depend  on  vapor  degreasing  with
1,1,1-trichloroethane  (or  methyl  chloroform).  In view of the excise tax
placed on the solvent, and the provisions in the Clean Air Act for labeling
and  for  non-essential  for,  moot  of  these  firms  are searching for an
alternative as soon as possible. This article explores some of the options

English Descriptors: Solvent; Degreasing; Ethane derivatives; Surface
  preparation; Surface treatment
French Descriptors: Solvant; Degraissage; Ethane derive; Preparation
  surface; Traitement surface
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Classification Codes: 001D11C06; 240
?b 317
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            $0.75  1 Types
            $1.00  View Fee
     $2.71  Estimated cost File144
     $0.19  SPRNTNET
     $2.90  Estimated cost this search
    $23.07  Estimated total session cost   0.130 Hrs.


File 317:Chemical Safety Newsbase  1981-1994/Aug
       (c) 1994 Royal Soc Chemistry
*File 317: Some records in accession number range 001725-002806 are
having retrieval problems.  Type in HELP NEWS317 for more info.

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?t s0/5/1

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DIALOG(R)File 317:Chemical Safety Newsbase
(c) 1994 Royal Soc Chemistry. All rts. reserv.

029088   CSNB Acc. No.: 12-06-001263   DOC. TYPE: Journal
Phasing out 1,1,1-trichloroethane
AUTHOR: Morriss, T.
CORPORATE SOURCE: Eng. Employers London Assoc, EELA House, Station Rd.,
    Hook, Hants., RG 27 9TL,  UK
JOURNAL: Health Saf. Work,  Volume 14 ,  Issue 5,  Page(s) 25
CODEN: HSAWD2     ISSN: 0141-8246
PUBLICATION DATE: MAY 1992 (920500)   LANGUAGE: English
ABSTRACT:   The  Montreal Protocol places restrictions on the supply of the
    degreasing  agent  1,1,1-trichloroethane  (111-T),  which  is due to be
    phased  out by 1 Jan 2005 because of its health risks and the threat to
    the      ozone      layer.     A     short-term     substitute     could     be
    hydrochlorofluorocarbons;   otherwise   the   main   alternatives   are
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    hydrocarbon   systems,  stabilised  trichloroethylene,  or  aqueous  or
    semi-aqueous systems. Companies should consider the options and replace
    111-T with a cost-effective alternative before the deadline
 DESCRIPTORS: Montreal Protocol; ozone layer; degreasing agent
 CHEMICAL SUBSTANCE(S): trichloroethane (71-55-6)
 SECTION: Legislation   (11)
 ?b 323
        08aug94 09:38:05 User036172 Session B135.5
        Sub account: BULLUCK/F7411
             $1.44    0.016 Hrs File317
             $2.10  1 Types
             $1.00  View Fee
      $4.54  Estimated cost File317
      $0.19  SPRNTNET
      $4.73  Estimated cost this search
     $27.80  Estimated total session cost   0.146 Hrs.


 File 323:RAPRA Abstracts  1972-1994/Jul B2
        (c) 1994 RAPRA Technology Ltd.

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       S0        3  494203
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DIALOG(R)File 323:RAPRA Abstracts

503485
TITLE: TRENDS POSE CHALLENGES FOR ADHESIVES MAKERS
AUTHOR(S): Ray J
CORPORATE SOURCE: Fuller H.B.,Co.
SOURCE: Adhesives Age; 37, No.1, Jan.1994, p.20/2
CODEN: ADHAAO JOURNAL ANNOUNCEMENT: 9404 RAPRA UPDATE: 9406
DOCUMENT TYPE: Journal
LANGUAGE: English
SUBFILE: (R) RAPRA

ABSTRACT: A number of economic, technological and environmental trends will continue to influence the adhesive and sealant industry. The US automotive and construction industries have driven the improvement in the overall revenues and profits for the adhesive and sealant industry in 1993. However, there are continuing and increasing pressures on prices and margins. The trend towards more environmentally friendly adhesives will continue as manufacturers face increasing environmental regulation from state and federal governments. New water-based and/or low VOC products continue to be formulated. Particularly in packaging applications, the demand for recyclable/repulpable products continues to grow.

SUBJECT HEADING (RAPRA): ECONOMIC INFORMATION, adhesives, USA; ADHESIVES, economic information; USA, economic information, adhesives
SUBJECT HEADING (Adhesives): ECONOMIC INFORMATION, USA
IDENTIFIERS (Non-Polymer Terms): METHYL CHLOROFORM; TRICHLOROETHANE
GEOGRAPHIC LOCATION: USA
DESCRIPTORS: ACTIVATOR; ADHESIVE; AUTOMOTIVE APPLICATION; BUILDING APPLICATION; CERTIFICATION; CHAIR; COMPANY; CONTACT ADHESIVE; COST; DATA; DEMAND; EARNINGS; ECONOMIC INFORMATION; ENVIRONMENTAL PROTECTION; FABRIC; FOAM; GROSS DOMESTIC PRODUCT; GROWTH RATE; HYBRID; MARKET; MATERIAL REPLACEMENT; MATERIALS SUBSTITUTION; MERGER; MOISTURE CURING; OFFICE FURNITURE; PACKAGING; PAPER; PLASTIC; POLYURETHANE; POROUS; PRICE; PROFIT; PU; QUALITY CONTROL; REACTIVE MELT ADHESIVE; RECYCLING; REGULATION; REPULPABLE; SEALANT; SOLVENT; SPRAYING; STATISTICS; TAKEOVER; THERMOPLASTIC; TREND; TWO-COMPONENT; VOLATILE ORGANIC COMPOUND; WATER-BASED
RAPRA CLASSIFICATION CODE: 176; 6A1
CATEGORY CODES: CO; QB
ADHESIVES CATEGORY CODES: ACG

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 0/5/2
DIALOG(R)File 323:RAPRA Abstracts
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497955
TITLE: LOOMING BAN ON PRODUCTION OF CFCS, HALONS SPURS SWITCH TO
   SUBSTITUTES
AUTHOR(S): Zurer P S
SOURCE: Chem.Engng.News; 71, No.46, 15th Nov.1993, p.12-8
CODEN: CENEAR  JOURNAL ANNOUNCEMENT: 9402  RAPRA UPDATE: 9401
DOCUMENT TYPE: Journal
LANGUAGE: English
SUBFILE: (R) RAPRA
ABSTRACT: The latest revisions to the Montreal Protocol on Substances that
    Deplete the Ozone Layer treaty dictate an end to industrialised
    countries' production of CFCs, carbon tetrachloride and methyl
    chloroform by January 1, 1996. Halons, brominated fluorocarbons used
    for fighting fires, face a production ban on January 1, 1994. This
    article discusses the work being carried out into alternative compounds
    and technologies, in particular relating to blowing agents for PU foam,
    automotive air conditioning systems and fire fighting applications.
SUBJECT HEADING (RAPRA): BLOWING AGENTS, CFC replacement;  AUTOMOTIVE
    APPLICATIONS, air conditioning, CFC replacement;  FIRE FIGHTING
    APPLICATIONS, halon replacement
IDENTIFIERS (Non-Polymer Terms): CARBON TETRACHLORIDE; CFC; CHLORINE;
    CHLOROFLUOROCARBON; HALON; HCFC; HFC; HYDROCHLOROFLUOROCARBON;
    HYDROFLUOROCARBON; METHYL CHLOROFORM; SILICA GEL; TRICHLOROETHANE;
    TRIFLUOROMETHYL IODIDE
GEOGRAPHIC LOCATION: USA
DESCRIPTORS: AEROSPACE APPLICATION; AIR CONDITIONING; AUTOMOTIVE
    APPLICATION; BLOWING AGENT; BUILDING APPLICATION; CFC REPLACEMENT;
    CHILLER; CLEANING AGENT; COMPANY; DATA; DOMESTIC EQUIPMENT; DRYING;
    ELECTRONIC APPLICATION; EMISSION; FIRE FIGHTING; FLAMMABILITY; FOAM;
    GRAPH; GREENHOUSE EFFECT; HOSE; LUBRICANT; MACHINERY; MATERIAL
    REPLACEMENT; MATERIALS SUBSTITUTION; OUTPUT; OZONE DEPLETION; PLASTIC;
    POLYURETHANE; PRICE; PU; REFRIGERATOR; REGULATION; RETROFIT; SOLVENT;
    TABLES; TECHNICAL; THERMAL INSULATION; THERMOPLASTIC; THERMOSET;
    TOXICITY; TREATY; VACUUM PANEL; WATER-BASED
RAPRA CLASSIFICATION CODE: 57; 6N1; 63FF
CATEGORY CODES: MH; QN
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 0/5/3
DIALOG(R)File 323:RAPRA Abstracts
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494203
TITLE: CLEANING AGENT DEVELOPED TO REPLACE TRICHLOROETHANE
SOURCE: New Mat./Jap.; Oct.1993, p.15
CODEN: NMJAE6  JOURNAL ANNOUNCEMENT: 9312  RAPRA UPDATE: 9323
DOCUMENT TYPE: Journal
LANGUAGE: English
SUBFILE: (R) RAPRA
ABSTRACT: Sekisui Plastics, a foam plastics manufacturer, has begun
    marketing a cleaning system, consisting of a cleaning agent and
    equipment, to replace the use of 1-1-1-trichloroethane in industrial
    cleaning processes. Small automotive and construction machinery parts
    under manufacture are placed in a basket in the equipment, immersed in
    the cleaning agent, heated to 50C and then dried in a vacuum dryer. The
    company claims the system cuts cleaning costs in half compared with the
    use of trichloroethane. The system is priced at 8.15 million yen and
    Sekisui predicts total sales to reach 20 billion yen after two years of
    marketing. This abstract includes all the information contained in the
    original article.
SUBJECT HEADING (RAPRA): CLEANING, agents, machinery, cellular materials;
    CELLULAR MATERIALS, cleaning devices
COMPANY NAME: SEKISUI PLASTICS CO.LTD.
IDENTIFIERS (Non-Polymer Terms): TRICHLOROETHANE
GEOGRAPHIC LOCATION: JAPAN
DESCRIPTORS: AUTOMOTIVE APPLICATION; BUILDING APPLICATION; CLEANING AGENT;
    COMPANY; COST; DATA; FOAM; HEATING; MACHINERY; MATERIAL REPLACEMENT;
    MATERIALS SUBSTITUTION; PLASTIC; PRICE; SALES; SHORT ITEM; VACUUM
    DRYING
RAPRA CLASSIFICATION CODE: 8(11)347; 6124
CATEGORY CODES: SL; OC


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DIALOG(R)File 323:RAPRA Abstracts
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479910
TITLE: PROPOSAL FOR A COUNCIL DECISION CONCERNING THE CONCLUSIONS OF THE
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AMENDMENT TO THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER AS ADOPTED IN NOVEMBER 1992 IN COPENHAGEN BY THE PARTIES TO THE PROTOCOL (93/C 103/08) COM(93) 102 FINAL
SOURCE: Off.J.Eur.Comm.C Series; 36, No.C103, 14th April 1993, p.18-9
JOURNAL ANNOUNCEMENT: 9308 RAPRA UPDATE: 9314
DOCUMENT TYPE: Journal
LANGUAGE: English
SUBFILE: (R) RAPRA
ABSTRACT: Details of the amendments to the proposal are given.
SUBJECT HEADING (RAPRA): REGULATIONS, pollution control, ozone depletion, EEC; POLLUTION, control, ozone depletion, regulations; EEC, pollution control, regulations
IDENTIFIERS (Non-Polymer Terms): CARBON TETRACHLORIDE; CHLOROFLUOROCARBON; HALON; HYDROBROMOFLUOROCARBON; METHYL BROMIDE; TRICHLOROETHANE
GEOGRAPHIC LOCATION: EUROPEAN COMMUNITY; WESTERN EUROPE; WESTERN EUROPE-GENERAL
DESCRIPTORS: CONSUMPTION; DATA; EMISSION; ENVIRONMENT; MATERIAL REPLACEMENT ; OZONE DEPLETION; POLLUTION; PRODUCTION; REGULATION
RAPRA CLASSIFICATION CODE: 184
CATEGORY CODES: EA

0/5/5
DIALOG(R)File 323:RAPRA Abstracts

467960
TITLE: SAFER AEROSOL ADHESIVE FOR NEW REGS.
SOURCE: Insulation J.; Dec.1992, p.2
JOURNAL ANNOUNCEMENT: 9304 RAPRA UPDATE: 9306
DOCUMENT TYPE: Journal
LANGUAGE: English
SUBFILE: (R) RAPRA; (A) Adhesives
ABSTRACT: The reformulation of Idenden multi-purpose aerosol adhesive is reported to coincide with the publication of new draft regulations on chemical hazards and packaging. The Chemicals (Hazard Information and Packaging) Regulations are currently being circulated for comment by the Health & Safety Commission. Methylene chloride, now listed as a category 3 carcinogen, has been replaced with 1,1,1-trichloroethane in the new formulation; details are given.
SUBJECT HEADING (RAPRA): ADHESIVES, building applications; BUILDING APPLICATIONS, adhesives

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SUBJECT HEADING (Adhesives): BUILDING APPLICATIONS,
COMPANY NAME: IDENDEN ADHESIVES LTD.;  EVODE LTD.
IDENTIFIERS (Non-Polymer Terms): METHYLENE CHLORIDE; TRICHLOROETHANE
GEOGRAPHIC LOCATION: EUROPEAN COMMUNITY; UK; WESTERN EUROPE
DESCRIPTORS: ADHESIVE; AEROSOL; BUILDING APPLICATION; COMPANY; FORMULATION;
    INSULATION; LEGISLATION; MATERIAL REPLACEMENT; PLASTIC; PLASTIC;
    PRODUCT ANNOUNCEMENT; REGULATION; SOLVENT; THERMAL INSULATION
RAPRA CLASSIFICATION CODE: 63Bu;6A1
CATEGORY CODES: QP;QR
ADHESIVES CATEGORY CODES: ALF


 0/5/6
DIALOG(R)File 323:RAPRA Abstracts
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466541
TITLE: NEW AGENDA FOR CHLORINATED SOLVENTS
AUTHOR(S): Heathcote M
SOURCE: Eur.Chem.News; 59, No.1552, 18th Jan.1993, p.14-6
CODEN: ECHNAW  JOURNAL ANNOUNCEMENT: 9304  RAPRA UPDATE: 9304
DOCUMENT TYPE: Journal
LANGUAGE: English
SUBFILE: (R) RAPRA
ABSTRACT: Consumption of chlorinated solvents has declined by 50% in
    western Europe since 1974. Although environmental concerns underpin the
    shifting picture, a major part of the reduction has resulted because of
    an increasing emphasis on recycling, good housekeeping and closed
    systems. Nonetheless, linked as chlorinated hydrocarbons are with CFC
    manufacture, the overriding trend is diminishing production and a
    consolidating marketplace. Currently customers are moving in three
    divergent directions. Some are stopping cleaning altogether, while
    others are moving to aqueous solvents. A third group are reverting to
    traditional chlorinated solvents and investing in new equipment to
    limit emissions to air and ensure collection of spent solvent rather
    than allowing its loss as waste.
SUBJECT HEADING (RAPRA): ECONOMIC INFORMATION,  solvents, Western Europe;
    SOLVENTS,  economic information; WESTERN EUROPE,  solvents, economic
    information
IDENTIFIERS (Non-Polymer Terms): CARBON TETRACHLORIDE; CHLOROFLUOROCARBON;
    METAL; METHYLENE CHLORIDE; PERCHLOROETHYLENE; TRICHLOROETHANE;
    TRICHLOROETHYLENE
```

GEOGRAPHIC LOCATION: WESTERN EUROPE; WESTERN EUROPE-GENERAL
DESCRIPTORS: CAPACITY; CAPACITY UTILISATION; CHLORINATION; CLEANING AGENT; CONSOLIDATION; CONSUMPTION; DEMAND; ECONOMIC INFORMATION; ELECTRONIC APPLICATION; EMISSION CONTROL; ENVIRONMENTAL PROTECTION; EXPORT; GRAPH; GROWTH RATE; JOINT VENTURE; MACHINERY; MARKET; MATERIAL REPLACEMENT; PLANT CAPACITY; PLANT CLOSURE; PRICE; PRODUCTION CAPACITY; RECYCLING; REGULATION; SALES; SOLVENT; SOURCE REDUCTION; STATISTICS; TABLES; TREND
RAPRA CLASSIFICATION CODE: 175;58
CATEGORY CODES: CL;MI

0/5/7
DIALOG(R)File 323:RAPRA Abstracts

455979
TITLE: CONSENSUS ON CFC PHASEOUT FOR END-1995
SOURCE: Eur.Chem.News; 58, No.1530, 27th July 1992, p.21
JOURNAL ANNOUNCEMENT: 9212 RAPRA UPDATE: 9221
DOCUMENT TYPE: Journal
LANGUAGE: English
SUBFILE: (R) RAPRA
ABSTRACT: The last meeting of all contracting parties to the Montreal Protocol before it is amended in November has concluded in Geneva with broad consensus for an end-1995 date for the phaseout of CFCs. Other proposals include phaseouts of fully halogenated compounds, halons, carbon tetrachloride and methyl chloroform. A suitable phaseout mechanism for HCFCs has still to be resolved.
SUBJECT HEADING (RAPRA): REGULATIONS, chlorofluorocarbons, solvents; BLOWING AGENTS, chlorofluorocarbons, materials replacement, regulations; SOLVENTS, materials replacement, regulations
IDENTIFIERS (Non-Polymer Terms): CARBON TETRACHLORIDE; CHLOROFLUOROCARBON; HALON; HYDROCHLOROFLUOROCARBON; METHYL BROMIDE; TRICHLOROETHANE
GEOGRAPHIC LOCATION: WORLD
DESCRIPTORS: BLOWING AGENT; CONSUMPTION; ENVIRONMENT; ENVIRONMENTAL PROTECTION; MATERIAL REPLACEMENT; OZONE DEPLETION; PRODUCTION; REGULATION; SOLVENT; STATISTICS
RAPRA CLASSIFICATION CODE: 184;57;184;58
CATEGORY CODES: EA; MH; MI

0/5/8

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DIALOG(R)File 323:RAPRA Abstracts
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451438
TITLE: SAFETY SOLVENT
SOURCE: Rubb.World; 206, No.1, April 1992, p.53
JOURNAL ANNOUNCEMENT: 9210  RAPRA UPDATE: 9216
DOCUMENT TYPE: Journal
LANGUAGE: English
SUBFILE: (R) RAPRA
ABSTRACT: Dynaflush safety solvent from Dynaloy is offered for use in
    cleaning residues from equipment used in the PU foam industry.
    Dynaflush is a non-chlorinated, non-flammable, non-carcinogenic,
    non-ozone depleting solvent designed to replace solvents such as
    methylene chloride, acetone, MEK and trichloroethane. The solvent is
    said to be especially effective for cleaning and flushing mixing and
    metering equipment, feed lines and chemical holding tanks.
SUBJECT HEADING (RAPRA): URETHANE POLYMERS,  solvents, machinery;
    MACHINERY,  cleaning, PU;  CLEANING,  machinery, PU, solvents;
    SOLVENTS,  cleaning agents, PU, machinery
TRADE NAMES: DYNAFLUSH
COMPANY NAME: DYNALOY INC.
GEOGRAPHIC LOCATION: USA
DESCRIPTORS: CELLULAR MATERIAL; CLEANING AGENT; COMPANIES; COMPANY;
    FLAMMABILITY; FOAM; MACHINERY; MATERIAL REPLACEMENT; METERING; MIXING;
    OZONE FRIENDLY; PLASTIC; POLYURETHANE; PRODUCT ANNOUNCEMENT; PU; SHORT
    ITEM; SOLVENT; THERMOPLASTIC; TOXICITY
RAPRA CLASSIFICATION CODE: 243C6;58;8(11)347
CATEGORY CODES: SL; MI; KT


 0/5/9
DIALOG(R)File 323:RAPRA Abstracts
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450365
TITLE: FORMULATORS FACE ENVIRONMENTAL LAWS
AUTHOR(S): Kirschner E
SOURCE: Chem.Week; 150, No.10, 11th March 1992, p.34
JOURNAL ANNOUNCEMENT: 9209  RAPRA UPDATE: 9215
DOCUMENT TYPE: Journal
LANGUAGE: English
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SUBFILE: (R) RAPRA; (A) Adhesives
ABSTRACT: Among the challenges faced by adhesives and sealants formulators are regulations in California aimed at reducing VOC emissions by 80% within three years, and nationwide reporting and minimisation of pollutants. Most pressing is the US's new 1995 CFC phase-out deadline, which will mean a quicker end to heavily taxed 1,1,1-trichloroethane, a component of many formulations. Although waterborne formulations are expected to gain most from the replacement of solvent-based mixes, some users will continue to need solvent-based formulae.
SUBJECT HEADING (RAPRA): ADHESIVES, regulations; SEALANTS, regulations; REGULATIONS, adhesives, sealants
SUBJECT HEADING (Adhesives): REGULATIONS, adhesives, sealants
IDENTIFIERS (Non-Polymer Terms): CHLOROFLUOROCARBON; TRICHLOROETHANE
GEOGRAPHIC LOCATION: USA
DESCRIPTORS: ADHESIVE; AUTOMOBILE; AUTOMOTIVE APPLICATION; BINDER; DATA; EMISSION CONTROL; FORMULATION; GROWTH RATE; HOT MELT ADHESIVE; LEGISLATION; MARKET SHARE; MATERIAL REPLACEMENT; PACKAGING; PLASTIC; POLLUTION; POLYURETHANE; PU; RECYCLING; SEALANT; SOLVENT; STATISTICS; THERMOPLASTIC; VOLATILE ORGANIC COMPOUND; WATER-BASED
RAPRA CLASSIFICATION CODE: 184;6A
CATEGORY CODES: QB; EA
ADHESIVES CATEGORY CODES: AEA

0/5/10
DIALOG(R)File 323:RAPRA Abstracts

447858
TITLE: SOLVENTS: NEW ALTERNATIVES. I.
AUTHOR(S): Montorsi E
SOURCE: Pitture Vern.; 68, No.1, Jan.1992, p.29-31
JOURNAL ANNOUNCEMENT: 9209 RAPRA UPDATE: 9214
DOCUMENT TYPE: Journal
LANGUAGE: English
SUBFILE: (R) RAPRA
ABSTRACT: (In English, French and Italian). Legislation affecting CFCs and other chlorine-containing substances used in solvents is reviewed, and problems involved in the replacement of these materials are discussed. The possibility of using naturally derived terpenes as an alternative is briefly examined.
SUBJECT HEADING (RAPRA): REGULATIONS, solvents; SOLVENTS, regulations

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COMPANY NAME: ENVIRONMENTAL PROTECTION AGENCY
IDENTIFIERS (Non-Polymer Terms): BROMIDE; CARBON TETRACHLORIDE; CHLORINE;
    CHLOROFLUOROCARBON; HALOFLUOROCARBON; HALON; PERCHLOROETHYLENE; TERPENE
    ; TRICHLOROETHANE; TRICHLOROETHYLENE
GEOGRAPHIC LOCATION: EUROPEAN COMMUNITY; ITALY; USA; WESTERN EUROPE;
    WESTERN EUROPE-GENERAL
DESCRIPTORS: BIODETERIORATION; CARCINOGEN; CFC REPLACEMENT; COMPANIES;
    COMPANY; ENVIRONMENT; FLAMMABILITY; LEGISLATION; OZONE DEPLETION;
    PLASTIC; POLLUTION; RUBBER; SOLVENT; TECHNICAL; THERMOPLASTIC;
    THERMOSET; TOXICITY; WATER SOLUBILITY; WATER-SOLUBLE
RAPRA CLASSIFICATION CODE: 184;58
CATEGORY CODES: EA; MI


 0/5/11
DIALOG(R)File 323:RAPRA Abstracts
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439742
TITLE: EUROPE BANS CFCs
SOURCE: New Scient.; 133, No.1810, 29th Feb.1992, p.12
JOURNAL ANNOUNCEMENT: 9205  RAPRA UPDATE: 9206
DOCUMENT TYPE: Journal
LANGUAGE: English
SUBFILE: (R) RAPRA
ABSTRACT: Environment ministers of the European Community have agreed to
    ban a range of ozone-depleting substances by the end of 1995, two years
    ahead of schedule. The substances are the five 'fully halogenated' CFCs
    that are restricted under the Montreal Protocol to protect the ozone
    layer; methyl chloroform and carbon tetrachloride, both industrial
    solvents; and halons, used in fire extinguishers. The ministers did not
    agree to accelerate phasing out of partially halogenated HCFCs, e.g.
    HCF-22. Manufacturers of refrigerators and plastics want to use the
    HCFCs as substitutes for the banned CFCs. The Montreal Protocol calls
    for them to be phased out by 2040. This abstract includes all the
    information contained in the original article.
SUBJECT HEADING (RAPRA): REGULATIONS,  European Community, blowing agents,
    solvents;  BLOWING AGENTS,  regulations, CFC replacement;  SOLVENTS,
    regulations, CFC replacement;  EUROPEAN COMMUNITY,  regulations, CFC
    replacement
IDENTIFIERS (Non-Polymer Terms): CARBON TETRACHLORIDE; CFC;
    CHLOROFLUOROCARBON; HALON; HCFC; HCFC-22; HYDROCHLOROFLUOROCARBON;
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    METHYL CHLOROFORM; TRICHLOROETHANE
  GEOGRAPHIC LOCATION: EUROPEAN COMMUNITY; WESTERN EUROPE-GENERAL
  DESCRIPTORS: BLOWING AGENT; CFC REPLACEMENT; FIRE EXTINGUISHER; LEGISLATION
      ; MONTREAL PROTOCOL; OZONE LAYER; PLASTIC; REFRIGERATOR; REGULATION;
    SHORT ITEM; SOLVENT; THERMOPLASTIC
  RAPRA CLASSIFICATION CODE: 1832;57
  CATEGORY CODES: EA; MH


   0/5/12
  DIALOG(R)File 323:RAPRA Abstracts
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  416710
  TITLE: CFC REDUCTION AND ELIMINATION
  SOURCE: Plast.News(Aust.); Jan/Feb.1991, p.11-5
  JOURNAL ANNOUNCEMENT: 9105  RAPRA UPDATE: 9108
  DOCUMENT TYPE: Journal
  LANGUAGE: English
  SUBFILE: (R) RAPRA
  ABSTRACT: Australian PU manufacturers want State and Federal Governments to
    accept alternatives to CFCs in the blowing process of flexible PU
    foams. Their planned time-scale for the reduction and ultimate
    elimination of CFC use is examined. They believe that a 50% reduction
    of CFC 11 is achievable by the end of 1991 and 100% by the end of 1993
    if 1,1,1-trichloroethane and/or methylene chloride are accepted as
    replacements to produce high-density foams. They will also accept a
    minimum density of 16 kg per cu.m. for foam products to reduce CFC use.
    There would have to be legislation, adequately policed by governments,
    for all local importers and manufacturers of flexible PU foams and
    furniture for the Australian industry to remain competitive. Detailed
    figures are given for the Australian PU market for 1989. Recent
    investments in the Australian PU foam industry, its technology and its
    contribution to employment are discussed. The manufacture of PU foam in
    Australia is explained.
  SUBJECT HEADING (RAPRA): CHLOROFLUOROCARBONS,  replacements, legislation,
    Australia;  BLOWING AGENTS,  chlorofluorocarbon replacement, PU foams;
    URETHANE POLYMERS,  blowing agents, foams, economic information;
    ECONOMIC INFORMATION,  urethane polymers, Australia
  COMPANY NAME: DOW CHEMICAL (AUSTRALIA) LTD.;  DUNLOP OLYMPIC;  HENDERSONS
    FRS INDUSTRIES;  ICI;  JOUBERT & JOUBERT PTY.LTD.;  JOYCE CORP.LTD.;
    PACIFIC DUNLOP LTD.;  PLASTICS INDUSTRIES ASSN.;  VITAFOAM AUSTRALIA
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PTY.LTD.

IDENTIFIERS (Non-Polymer Terms): CFC; CFC-11; CHLOROFLUOROCARBON; HYDROCHLOROFLUOROCARBON; ISOCYANATE; METHYLENE CHLORIDE; TRICHLOROETHANE

GEOGRAPHIC LOCATION: AUSTRALIA; NEW ZEALAND

DESCRIPTORS: APPLICATIONS; BLOWING AGENT; CATALYST; CELLULAR MATERIAL; CFC REPLACEMENT; COMMERCIAL INFORMATION; COMPANIES; COMPANY; COMPETITIVENESS; COST; COSTS; DATA; DEMAND; ECONOMIC INFORMATION; EMPLOYMENT; ENVIRONMENT; FLEXIBLE; FOAM; FURNITURE; GROWTH; HIGH DENSITY; IMPORT; INVESTMENT; LEGISLATION; MANUFACTURE; MANUFACTURER; MANUFACTURING; MARKET; OZONE LAYER; PLANNING; PLASTIC; POLYETHER POLYOL ; POLYURETHANE; PROCESS; PROCESSING; PU; REVIEW; RIGID; SALES; SLABSTOCK; STATISTICS; SURFACTANT; TABLES; TECHNICAL; THERMOPLASTIC; THERMOSET; WORKING CONDITIONS

RAPRA CLASSIFICATION CODE: 43C6;57

CATEGORY CODES: KT; MH

0/5/13

DIALOG(R)File 323:RAPRA Abstracts

400213

TITLE: WATER-BASED AGENTS OFFER ALTERNATIVE

SOURCE: Rubb.Plast.News; 19, No.21, 30th April 1990, p.5

JOURNAL ANNOUNCEMENT: 9009 RAPRA UPDATE: 9016

DOCUMENT TYPE: Journal

LANGUAGE: English

SUBFILE: (R) RAPRA; (A) Adhesives

ABSTRACT: Water-based mould release agents and adhesives are a viable alternative to solvent-based agents, if changes are made to mould preparation. This was the conclusion of a panel of the Polyurethane Manufacturers Association. Solvent-based release agents are toxic, and will eventually be phased out, due to government action. Present water-based release agents need to be evaporated in the mould which requires heat, ventilation and time. Mould build-up is not a problem with the release agent provided it is built up in layers.

SUBJECT HEADING (RAPRA): MOULD RELEASE AGENTS, water based; ADHESIVES, water based

SUBJECT HEADING (Adhesives): WATER BASED ADHESIVES

COMPANY NAME: POLYURETHANE MANUFACTURERS ASSN.

IDENTIFIERS (Non-Polymer Terms): METHYL CHLOROFORM; TRICHLOROETHANE

GEOGRAPHIC LOCATION: USA
DESCRIPTORS: ADHESIVE; COMMERCIAL INFORMATION; COMPANIES; COMPANY; COST; EMULSION; EVAPORATION; HEAT; LAYER; MATERIAL REPLACEMENT; MATERIALS REPLACEMENT; MOULD RELEASE; MOULD RELEASE AGENT; PLASTIC; PRODUCT ANNOUNCEMENT; SOLVENT EVAPORATION; SURFACE FINISH; THERMOPLASTIC; TOXIC ; TOXICITY; VENTILAT; VENTILATION; WATER SOLUBLE; WATER-SOLUBLE
RAPRA CLASSIFICATION CODE: 839;59A;6A1
CATEGORY CODES: SD; MJ; QB
ADHESIVES CATEGORY CODES: AHY

0/5/14
DIALOG(R)File 323:RAPRA Abstracts

378898
TITLE: CHLORINATED SOLVENTS OFFER PERFORMANCE AND LOW VOC
AUTHOR(S): Cuzic J E
CORPORATE SOURCE: DOW CHEMICAL CO.
SOURCE: Adhesives Age; 32, No.8, July 1989, p.26-8
JOURNAL ANNOUNCEMENT: 8909 RAPRA UPDATE: 8917
DOCUMENT TYPE: Journal
LANGUAGE: English
SUBFILE: (R) RAPRA; (A) Adhesives
ABSTRACT: Formulators are seeking replacements for traditional solvents; the increasing role of chlorinated solvents in adhesive formulation. Four chlorinated solvents, methylene chloride, perchloroethylene, trichloroethylene and 1,1,-trichloroethane, are compared with reference to government regulations, environmental impact, product safety and solvent performance.
SUBJECT HEADING (RAPRA): ADHESIVES, solvents; SOLVENTS, chlorinated, adhesives
SUBJECT HEADING (Adhesives): SOLVENTS, chlorinated
IDENTIFIERS (Non-Polymer Terms): METHYLENE CHLORIDE; PERCHLOROETHYLENE; TRICHLOROETHANE; TRICHLOROETHYLENE
GEOGRAPHIC LOCATION: USA
DESCRIPTORS: ADHESIVE; CHLORINAT; COMPANY; COMPANIES; DRYING; ENVIRONMENT; MATERIALS REPLACEMENT; MATERIAL REPLACEMENT; PLASTIC; REGULATION; SAFETY; SOLVENT; TECHNICAL; TEST; TESTING
RAPRA CLASSIFICATION CODE: 58;6A1
CATEGORY CODES: MI; QB
ADHESIVES CATEGORY CODES: ATE

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      $1.20  SPRNTNET
     $26.40  Estimated cost this search
     $54.20  Estimated total session cost   0.246 Hrs.


File 340:CLAIMS(R)/US Patents Abs  1950-1994/Jun
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*File 340:  Effective August 1, the prices are $120 per hour,
 $1.70 for Type or Print (Full record), and $1.00 for View.

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?k 1913540
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?t s0/5/1

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DIALOG(R)File 340:CLAIMS(R)/US Patents Abs
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1913540   8902066   2906423
CM/DRY CLEANING METHOD USING AT LEAST TWO KINDS OF SOLVENTS; 1,1,1
   TRICHLOROETHANE, PERCHLOROETHYLENE, TURPENTINE; REDUCES WRINKLING,
   SHRINKAGE
Document Type: UTILITY
Inventors: HAGIWARA HARUO (JP); TSUBAKI YASUHIRO (JP); TSUKAMOTO HIDEO (JP)
Assignee: MITSUBISHI JUKOGYO K K JP  Assignee Code: 56271
                     Patent      Issue     Applic      Applic
                     Number       Date     Number       Date
                   ----------    ------   ---------    ------
Patent:            US 4802253    890207   US 89122     870825
Division of:       US 4712392             US 813698    851227

Priority Applic:                          US 14655     870213
                                          JP 84277497  841228
                                          JP 84277498  841228
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Abstract:
The present invention relates to a dry cleaning method in which tanks for exclusively receiving at least two kinds of solvents which are soluble in each other are provided. One treating tank and a fractionating device for recovering the two or more kinds of solvents by fractonal distillation are provided. Exclusive filters for the respective solvents are provided through the use of, a common filter or a multi-filter device composed of both the filters which is disposed between the tanks and the treating tank. The two or more kinds of solvents are used independently so that washing is carried out. Further, the present disclosure relates to a dry cleaning method in which in a dry cleaner using organic solvents such as perchloroethylene, 1,1,1trichloroethane, turpentine (oil series) and the like, the previously use solvent is replaced with another solvent which is soluble therein and has a lower boiling point, for exmple, Flon 113 or 11, during washing or immediately before drying in order to thereby shorten a drying period of time. According to this disclosure, the most proper washing method can be chosen for the greater part of materials, processings and forms of clothes, and troubles due to the wasing of the clothes can be reduced remarkably. Further, the disclosed apparatus and method can advantageously save occupation space, equipment cost, volume of facilities, maintenace cost and the like. In addition thereto, a drying time can be reduced by half.

Exemplary Claim:

D R A W I N G

1. A DRY CLEANING METHOD COMPRISING THE STEPS OF PROVIDING TANKS FOR EXCLUSIVELY RECEIVING AT LEAST TWO KINDS OF SOLVENTS WHICH ARE SOLUBLE IN EACH OTHER, CONNECTING ONE TREATING TANK TO THE TANKS, PROVIDING A FRACTIONATING DEVICE, CONNECTED TO THE TANKS AND THE TREATING TANK, RECOVERING THE TWO OR MORE KINDS OF SOLVENTS BY FRACTIONAL DISTILLATION THROUGH THE USE OF THE FRACTIONATING DEVICE, PROVIDING EXCLUSIVE FILTERS FOR THE RESPECTIVE SOLVENTS THROUGH THE USE OF A COMMON FILTER OR A MULTI-FILTER DEVICE COMPOSED OF BOTH THE FILTERS WHICH IS DISPOSED BETWEEN THE TANKS AND THE TREATING TANK, AND USING THE TWO OR MORE KINDS OF SOLVENTS INDEPENDENTLY SO THAT WASHING IS CARRIED OUT.

Class: 008158000
IPC: D06F-043/08
?b 353
08aug94 09:44:21 User036172 Session B135.7
Sub account: BULLUCK/F7411

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              $1.00  View Fee
       $3.62  Estimated cost File340
       $0.19  SPRNTNET
       $3.81  Estimated cost this search
      $58.01  Estimated total session cost   0.263 Hrs.


File 353:APIPAT  1964-1994/Jun
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?t s0/5/all

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DIALOG(R)File 353:APIPAT
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0219624  API Document No.: 9224043  Derwent WPI Accession No.: 92-320245
New substitute for freon - contains
   fluoromethyl-1,1,1,3,3,3-hexafluoroisopropyl ether, and has high
   detergency against fats, oils and fluxes
Patent Assignee: Central Glass Co Ltd
Priority (CC,No,Date): JP 90406853 901226
Patent (CC,No,Date):  JP 4224898 920814
Int Pat Class: B23K-001/20; C11D-007/50; H05K-003/26; C11D-007/50
API Bulletin Headings: OTHER SPECIALTIES; PETROLEUM PRODUCTS; PETROLEUM
    REFINING AND PETROCHEM
Index Terms: ADDITIVE; C1; C13-16; C2; C3; C4; C5-12; *CHEMICAL CLEANING;
    *CLEANING; COMPOUNDS; DEGREASING; DETERGENCY; ENVIRONMENTAL PROTECTION;
    ETHER; FLUORINE ORGANIC; FREON; HALOGEN ORGANIC; HYDROCARBON;
    *HYDROCARBON SOLVENT; MONOHYDROXY; MULTIHYDROXY; NONE; NONHYDROCARBON
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          SOLVENT; *ORGANIC SOLVENT; OZONE DEPLETION; PHYSICAL PROPERTY;
          REPLACEMENT; SATURATED CARBOCYCLIC; SATURATED CHAIN; SINGLE STRUCTURE
          TYPE; *SOLVENT; SURFACE ACTIVITY; UNSATURATED; *USE
      Sets of Linked Terms: 0007
      Linked Terms:
          FREON; NONE; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SOLVENT; USE
          C4; ETHER; FLUORINE ORGANIC; HALOGEN ORGANIC; NONHYDROCARBON SOLVENT;
              ORGANIC SOLVENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT;
              USE
          ADDITIVE; COMPOUNDS; HYDROCARBON; HYDROCARBON SOLVENT; ORGANIC SOLVENT;
              SOLVENT; USE
          COMPOUNDS; MONOHYDROXY; MULTIHYDROXY; NONHYDROCARBON SOLVENT; ORGANIC
              SOLVENT; SOLVENT; USE
          C1; C13-16; C2; C3; C4; C5-12; COMPOUNDS; HYDROCARBON; HYDROCARBON
              SOLVENT; ORGANIC SOLVENT; SOLVENT; USE
          COMPOUNDS; HYDROCARBON; HYDROCARBON SOLVENT; ORGANIC SOLVENT; SATURATED
              CARBOCYCLIC; SOLVENT; USE
          COMPOUNDS; HYDROCARBON; HYDROCARBON SOLVENT; ORGANIC SOLVENT; SOLVENT;
              UNSATURATED; USE


      0/5/2
     DIALOG(R)File 353:APIPAT
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     0216327  API Document No.: 9222767  Derwent WPI Accession No.: 92-197083
     Surface-cleaning lubricant for paper-making drier - consists of oil
        material(s), nonionic surfactant(s) and mixt. of cationic and
        amphoteric surfactants, to improve surface glossiness
     Patent Assignee: Nippon Oils & Fats Co Ltd  Nippon Yu Gyo KK
     Priority (CC,No,Date): JP 90248692 900920
     Patent (CC,No,Date):  JP 4130190 920501
     Int Pat Class: C10M-141/06; D21F-005/00; C10M-141/06
     API Bulletin Headings: LUBRICANTS AND INDUSTRIAL OILS; PETROLEUM PRODUCTS;
         PETROLEUM REFINING AND PETROCHEM; WAXES
     Index Terms: 2-ETHYL-1-HEXANOL; ADDITIVE; AMPHOTERIC; ANIMAL OIL; BLADE;
         BRANCHED CHAIN; C2; C4 MONOMER; C8; CATION; CHLOROHYDROCARBON;
         CLEANLINESS; COMPOSITION; COMPOUNDS; CONCENTRATION; DEFECT; DRYER;
         DRYING; EFFICIENCY; ETHER; GAS OIL; GLOSS; HALOHYDROCARBON; HEAT;
         HYDROCARBON; ION; KEROSINE; LIGHT GAS OIL; LOW MOLECULAR WEIGHT;
         LUBRICANT STOCK; *LUBRICANT/INDUSTRIAL OIL; MAINTENANCE;
         *MICROCRYSTALLINE WAX; MIXTURE; MOLECULAR WEIGHT; MONOHYDROXY;
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    MONOOLEFINIC MONOMER; MOTOR OIL; MULTIHYDROXY; NATURAL; NONIONIC;
    OPERATING CONDITION; OPTICAL PROPERTY; PAPER; PETROLEUM DISTILLATE;
    PETROLEUM FRACTION; *PETROLEUM WAX; PHYSICAL PROPERTY; PHYSICAL
    SEPARATION; POLISHING; POLYETHER; POWDER; PREVENTION; REPLACEMENT;
    SATURATED CHAIN; SEPARATION EQUIPMENT; SINGLE STRUCTURE TYPE; SPINDLE
    OIL; SURFACE; SURFACE ACTIVE AGENT; SURFACE ROUGHNESS; SYNTHETIC
    LUB/IND OIL; TIME; TRICHLOROETHANE; UNSATURATED CHAIN MONOMER; *USE;
    VEGETABLE OIL; VELOCITY; *WAX
CAS Registry Numbers: 104-76-7; 25323-89-1; 8008-20-6
Sets of Linked Terms: 0012
Linked Terms:
    PAPER; POWDER; SURFACE
    ADDITIVE; SURFACE ACTIVE AGENT; USE
    ANIMAL OIL; LUBRICANT/INDUSTRIAL OIL; USE; VEGETABLE OIL
    LUBRICANT/INDUSTRIAL OIL; NATURAL; USE; WAX
    LUBRICANT/INDUSTRIAL OIL; MICROCRYSTALLINE WAX; PETROLEUM WAX; USE; WAX
    8008-20-6; GAS OIL; KEROSINE; LIGHT GAS OIL; LUBRICANT/INDUSTRIAL OIL;
        PETROLEUM DISTILLATE; PETROLEUM FRACTION; USE
    25323-89-1; C2; CHLOROHYDROCARBON; HALOHYDROCARBON;
        LUBRICANT/INDUSTRIAL OIL; SATURATED CHAIN; SINGLE STRUCTURE TYPE;
        SYNTHETIC LUB/IND OIL; TRICHLOROETHANE; USE
    104-76-7; 2-ETHYL-1-HEXANOL; BRANCHED CHAIN; C8; LUBRICANT/INDUSTRIAL
        OIL; MONOHYDROXY; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SYNTHETIC
        LUB/IND OIL; USE
    C4 MONOMER; COMPOUNDS; HYDROCARBON; LUBRICANT/INDUSTRIAL OIL;
        MONOOLEFINIC MONOMER; SINGLE STRUCTURE TYPE; SYNTHETIC LUB/IND OIL;
        UNSATURATED CHAIN MONOMER; USE
    COMPOUNDS; ETHER; LUBRICANT/INDUSTRIAL OIL; MULTIHYDROXY; SATURATED
        CHAIN; SINGLE STRUCTURE TYPE; SYNTHETIC LUB/IND OIL; USE
    COMPOUNDS; ETHER; LUBRICANT/INDUSTRIAL OIL; POLYETHER; SATURATED CHAIN;
        SINGLE STRUCTURE TYPE; SYNTHETIC LUB/IND OIL; USE
    POLISHING; REPLACEMENT; TIME


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DIALOG(R)File 353:APIPAT
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0216164  API Document No.: 9222543  Derwent WPI Accession No.: 92-172547
Detergent compsn. effective for CFC 113 and 1,1,1,-trichloroethane -
   contains middle petroleum oil, polyoxyethylene alkyl ether type
   nonionic surfactant and anionic surfactant e.g. morpholine salt
```

Patent Assignee: Daiichi Kogyo Seiya
Priority (CC,No,Date): JP 90231620 900831
Patent (CC,No,Date): JP 4110400 920410
Int Pat Class: C11D-001/83; C11D-010/02; C23G-005/02
API Bulletin Headings: OTHER SPECIALTIES; PETROLEUM PRODUCTS; PETROLEUM REFINING AND PETROCHEM
Index Terms: 6 MEMBER RING; ACOUSTICS; ADDITIVE; AMMONIUM; ANION; BENZENE RING; C2; C2 MONOMER; C4; *CHEMICAL CLEANING; CHLOROHYDROCARBON; *CLEANING; COMPOUNDS; CUTTING OIL; *DEGREASING; *DETERGENT; DILUTING; ENVIRONMENTAL IMPACT; ETHER; FLAMMABILITY; FLASH POINT; FLUOROHYDROCARBON; FLUX OIL; FREON; GAS OIL; GRINDING OIL; GROUP VA; HALOHYDROCARBON; HEALTH/DISEASE; HETEROCYCLIC; HLB; *HYDROCARBON SOLVENT; HYDROPHILIC; IMMERSION; IMPURITY; ION; KINEMATIC VISCOSITY; LIGHT GAS OIL; LOW TOXICITY; LUBRICANT/INDUSTRIAL OIL; MAN; METALWORKING LUBRICANT; MIXTURE; MODIFIED HOMOPOLYMER; MONOAMINE; MONOHYDROXY; MORPHOLINE; NATURAL RESIN; NONE; NONIONIC; ORGANIC SALT; *ORGANIC SOLVENT; OXYGEN ORGANIC; PETROLEUM DISTILLATE; PETROLEUM FRACTION; *PETROLEUM SOLVENT; PHYSICAL PROPERTY; POLYETHER; POLYETHYLENE GLYCOL MOD; PREVENTION; REPLACEMENT; ROSIN; RUST; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SLUSHING OIL; *SOLVENT; SPRAYING; SULFONIC ACID; SULFUR CONTAINING ACID; *SURFACE ACTIVE AGENT; TOXIC EFFECT; TRICHLOROETHANE; TRICHLOROTRIFLUOROETHANE; ULTRASONICS; *USE; VISCOSITY; WASTE DEPOSIT; WASTE MATERIAL; WATER
CAS Registry Numbers: 110-91-8; 25323-89-1; 26523-64-8; 8050-09-7
Sets of Linked Terms: 0012
Linked Terms:
CUTTING OIL; FLUX OIL; GRINDING OIL; HYDROCARBON SOLVENT; IMPURITY; LUBRICANT/INDUSTRIAL OIL; METALWORKING LUBRICANT; ORGANIC SOLVENT; PETROLEUM SOLVENT; SLUSHING OIL; SOLVENT; USE
26523-64-8; C2; CHLOROHYDROCARBON; FLUOROHYDROCARBON; FREON; HALOHYDROCARBON; NONE; SATURATED CHAIN; SINGLE STRUCTURE TYPE; TRICHLOROTRIFLUOROETHANE
25323-89-1; C2; CHLOROHYDROCARBON; HALOHYDROCARBON; SATURATED CHAIN; SINGLE STRUCTURE TYPE; TRICHLOROETHANE
GAS OIL; HYDROCARBON SOLVENT; LIGHT GAS OIL; ORGANIC SOLVENT; PETROLEUM DISTILLATE; PETROLEUM FRACTION; PETROLEUM SOLVENT; SOLVENT; USE
ADDITIVE; C2 MONOMER; ETHER; MODIFIED HOMOPOLYMER; POLYETHER; POLYETHYLENE GLYCOL MOD; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SURFACE ACTIVE AGENT; USE
AMMONIUM; COMPOUNDS; GROUP VA; ORGANIC SALT; SURFACE ACTIVE AGENT; USE
110-91-8; 6 MEMBER RING; ADDITIVE; C4; COMPOUNDS; ETHER; HETEROCYCLIC; MONOAMINE; MORPHOLINE; ORGANIC SALT; SINGLE STRUCTURE TYPE; SURFACE

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          ACTIVE AGENT; USE
     ADDITIVE; COMPOUNDS; MONOAMINE; MONOHYDROXY; SATURATED CHAIN; SURFACE
          ACTIVE AGENT; USE
     ADDITIVE; COMPOUNDS; MONOHYDROXY; OXYGEN ORGANIC; SATURATED CHAIN;
          SINGLE STRUCTURE TYPE; SULFONIC ACID; SULFUR CONTAINING ACID;
          SURFACE ACTIVE AGENT; USE
     ADDITIVE; COMPOUNDS; OXYGEN ORGANIC; SATURATED CHAIN; SINGLE STRUCTURE
          TYPE; SULFONIC ACID; SULFUR CONTAINING ACID; SURFACE ACTIVE AGENT;
          USE
     ADDITIVE; BENZENE RING; ETHER; MODIFIED HOMOPOLYMER; POLYETHER;
          SATURATED CHAIN; SINGLE STRUCTURE TYPE; SURFACE ACTIVE AGENT; USE
     ADDITIVE; ETHER; MODIFIED HOMOPOLYMER; OXYGEN ORGANIC; POLYETHER;
          SATURATED CHAIN; SINGLE STRUCTURE TYPE; SULFONIC ACID; SULFUR
          CONTAINING ACID; SURFACE ACTIVE AGENT; USE


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DIALOG(R)File 353:APIPAT
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0211042  API Document No.: 9220409  Derwent WPI Accession No.: 91-350862
Azeotropic or pseudoazeotropic compsn. - contains mainly of
   trichlorodifluoroethane, useful as alternate solvents
Patent Assignee: Asahi Glass KK
Priority (CC,No,Date): JP 89314258 891205
Patent (CC,No,Date):  JP 32036334 911022
Int Pat Class: B01D-012/00; C07C-017/42; C07C-019/08; C09K-003/00;
    C09K-005/00; C11D-007/50; C23D-005/02; D06L-001/02; H01L-021/30;
    H05K-003/26
API Bulletin Headings: OTHER SPECIALTIES; PETROLEUM PRODUCTS; PETROLEUM
    REFINING AND PETROCHEM
Index Terms: 5 MEMBER RING; 6 MEMBER RING; ATMOSPHERIC DISTILLATION;
    AZEOTROPE; BOILING POINT; BRANCHED CHAIN; C2; C6; CHLOROHYDROCARBON;
    CLEANING; COATING MATERIAL; COLUMN; COMPOSITION; CONCENTRATION;
    CYCLOHEXANE; DEGREASING; DISTILLATION; DISTILLATION COLUMN;
    DISTILLATION EQUIPMENT; EFFICIENCY; ELECTRICAL EQUIPMENT; ENVIRONMENTAL
    PROTECTION; FLUOROHYDROCARBON; HALOHYDROCARBON; HEXANE; HYDROCARBON;
    *HYDROCARBON SOLVENT; INK; INSTRUMENT; LENS; METHYLCYCLOPENTANE;
    METHYLPENTANE; MIXTURE; NONHYDROCARBON SOLVENT; *ORGANIC SOLVENT; OZONE
    DEPLETION; PAINT; PHYSICAL PROPERTY; PHYSICAL SEPARATION; RECYCLING;
    REPLACEMENT; SATURATED CARBOCYCLIC; SATURATED CHAIN; SEPARATION
    EQUIPMENT; SINGLE STRUCTURE TYPE; *SOLVENT; STRAIGHT CHAIN; TRANSITION
```

TEMPERATURE; TRICHLOROETHANE; *USE; WASHING; WASTE DEPOSIT; WASTE MATERIAL; WAX DEPOSIT
CAS Registry Numbers: 110-54-3; 110-82-7; 25323-89-1; 43133-95-5; 96-37-7
Sets of Linked Terms: 0006
Linked Terms:
C2; CHLOROHYDROCARBON; FLUOROHYDROCARBON; HALOHYDROCARBON; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT; USE
25323-89-1; C2; CHLOROHYDROCARBON; HALOHYDROCARBON; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT; TRICHLOROETHANE; USE
110-54-3; C6; HEXANE; HYDROCARBON; HYDROCARBON SOLVENT; ORGANIC SOLVENT ; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT; STRAIGHT CHAIN; USE
43133-95-5; BRANCHED CHAIN; C6; HYDROCARBON; HYDROCARBON SOLVENT; METHYLPENTANE; ORGANIC SOLVENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT; USE
110-82-7; 6 MEMBER RING; C6; CYCLOHEXANE; HYDROCARBON; HYDROCARBON SOLVENT; ORGANIC SOLVENT; SATURATED CARBOCYCLIC; SINGLE STRUCTURE TYPE; SOLVENT; USE
96-37-7; 5 MEMBER RING; C6; HYDROCARBON; HYDROCARBON SOLVENT; METHYLCYCLOPENTANE; ORGANIC SOLVENT; SATURATED CARBOCYCLIC; SATURATED CHAIN; SOLVENT; USE

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DIALOG(R)File 353:APIPAT

0204228 API Document No.: 9121370 Derwent WPI Accession No.: 91-078696
(Pseudo)azeotropic fluorohydrocarbon mixt. - comprises 1,1,2-trichloro-2,2-difluoroethane and 1,1,1-trichloroethane, useful as freon substitute
Patent Assignee: Asahi Glass KK
Priority (CC,No,Date): JP 89159464 890623
Patent (CC,No,Date): JP 30027331 910205
Int Pat Class: B05B-009/04; C07C-019/08; C09K-005/00; C11D-007/50
API Bulletin Headings: OTHER SPECIALTIES; PETROLEUM PRODUCTS; PETROLEUM REFINING AND PETROCHEM
Index Terms: *ADDITIVE; AZEOTROPE; C2; CHEMICAL CLEANING; CHLOROHYDROCARBON ; CLEANING; COMPOSITION; COMPOUNDS; CONCENTRATION; DEGREASING; DISTILLATION; ENVIRONMENTAL PROTECTION; ETHER; FLUOROHYDROCARBON;

*FOAMING AGENT; FREON; HALOHYDROCARBON; HEALTH/DISEASE; *HEAT TRANSFER MEDIUM; HETEROCYCLIC; *HYDROCARBON; *HYDROCARBON SOLVENT; IMPURITY; INK ; KETONE; LOW TOXICITY; MIXTURE; MONOAMINE; MONOCARBOXYLIC ESTER; MONOHYDROXY; MULTICARBOXYLIC ESTER; NITRO; NONHYDROCARBON SOLVENT; OIL WASTE; *ORGANIC SOLVENT; OZONE DEPLETION; PHYSICAL PROPERTY; PHYSICAL SEPARATION; PREVENTION; PURIFYING; RECYCLING; REPLACEMENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; *SOLVENT; STABILITY; TOXIC EFFECT; TRICHLOROETHANE; UNSATURATED; UNSATURATED CHAIN; *USE; WASTE MATERIAL; WAX

CAS Registry Numbers: 25323-89-1
Sets of Linked Terms: 0012
Linked Terms:
- ADDITIVE; C2; CHLOROHYDROCARBON; FLUOROHYDROCARBON; FOAMING AGENT; FREON; HALOHYDROCARBON; HEAT TRANSFER MEDIUM; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT; USE
- 25323-89-1; ADDITIVE; C2; CHLOROHYDROCARBON; FOAMING AGENT; HALOHYDROCARBON; HEAT TRANSFER MEDIUM; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT; TRICHLOROETHANE; USE
- ADDITIVE; COMPOUNDS; FOAMING AGENT; HEAT TRANSFER MEDIUM; HYDROCARBON; HYDROCARBON SOLVENT; ORGANIC SOLVENT; SOLVENT; USE
- ADDITIVE; COMPOUNDS; FOAMING AGENT; HEAT TRANSFER MEDIUM; NITRO; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT; USE
- ADDITIVE; COMPOUNDS; FOAMING AGENT; HEAT TRANSFER MEDIUM; MONOHYDROXY; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SOLVENT; USE
- ADDITIVE; COMPOUNDS; FOAMING AGENT; HEAT TRANSFER MEDIUM; MONOAMINE; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT; UNSATURATED; UNSATURATED CHAIN; USE
- ADDITIVE; COMPOUNDS; ETHER; FOAMING AGENT; HEAT TRANSFER MEDIUM; HETEROCYCLIC; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SOLVENT; USE
- ADDITIVE; COMPOUNDS; FOAMING AGENT; HEAT TRANSFER MEDIUM; KETONE; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SOLVENT; USE
- ADDITIVE; COMPOUNDS; FOAMING AGENT; HEAT TRANSFER MEDIUM; MONOCARBOXYLIC ESTER; MULTICARBOXYLIC ESTER; NONHYDROCARBON SOLVENT ; ORGANIC SOLVENT; SOLVENT; USE
- ADDITIVE; COMPOUNDS; FOAMING AGENT; HALOHYDROCARBON; HEAT TRANSFER MEDIUM; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SOLVENT; USE
- ADDITIVE; COMPOUNDS; ETHER; FOAMING AGENT; HEAT TRANSFER MEDIUM; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SOLVENT; USE
- IMPURITY; INK; USE; WAX

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?b 354
       08aug94 09:47:23 User036172 Session B135.8
       Sub account: BULLUCK/F7411
           $18.48    0.066 Hrs File353
            $6.50  5 Types
            $0.00  View Fee
    $24.98  Estimated cost File353
     $0.79  SPRNTNET
    $25.77  Estimated cost this search
    $83.78  Estimated total session cost   0.330 Hrs.


File 354:APILIT  1964-1994/Jun
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2 hrs/yr on all services. For disclaimer, type HELP NEWS 354.

      Set  Items  Description
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?k 0524188;k 0514943;k 0511872;k 0509006;k 0506514;k 0488477;k 0480129;k 0475186;k 044
0045;k 0438353;k 0384644;k 0374822
      S0       1  0524188
      S0       2  0514943
      S0       3  0511872
      S0       4  0509006
      S0       5  0506514
      S0       6  0488477
      S0       7  0480129
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      S0      10  0438353
      S0      11  0384644
      S0      12  0374822
?t s0/5/all

 0/5/1
DIALOG(R)File 354:APILIT
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0524188  API Document No.: 4130811
Substitution of organic solvents and hazardous binders by bonding with
   adhesives in the manufacture of fabricated metal products, machinery,
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   and equipment
Author: Soerensen F; Petersen H J S
Corporate Source: Technical University of Denmark
Source: Staub - Reinhaltung der Luft (ISSN 0039-0771) V53 N.6 251-54 (June
    1993)
Language: English
ISSN: 0039-0771
CODEN: STRHAV
Journal Name: Staub: Reinhaltung der Luft
Document Type: JOURNAL ARTICLE; REVIEW
Publication Date:  930600
API Bulletin Headings: ENVIRONMENT, TRANSPORT & STORAGE; HEALTH; HEALTH &
    ENVIRONMENT
Index Terms: ADHESIVE; ALLOY; BAN; *BINDER; C2; CHEMICAL CLEANING;
    CHLOROHYDROCARBON; CLEANING; DEGREASING; DENMARK; ECONOMIC FACTOR;
    *ENVIRONMENTAL PROTECTION; EQUIPMENT; EUROPE; HALOHYDROCARBON; *HAZARD;
    INORGANIC SOLVENT; LEGAL CONSIDERATION; NONHYDROCARBON SOLVENT;
    *ORGANIC SOLVENT; REPLACEMENT; REVIEW; SATURATED CHAIN; SCANDINAVIA;
    SINGLE STRUCTURE TYPE; *SOLVENT; TRICHLOROETHANE; *USE; WATER
CAS Registry Numbers: 25323-89-1
Sets of Linked Terms: 0002
Linked Terms:
    25323-89-1; C2; CHLOROHYDROCARBON; HALOHYDROCARBON; NONHYDROCARBON
        SOLVENT; ORGANIC SOLVENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE;
        SOLVENT; TRICHLOROETHANE; USE
    INORGANIC SOLVENT; SOLVENT; USE; WATER


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DIALOG(R)File 354:APILIT
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0514943  API Document No.: 4032682
Here today, gone tomorrow...Halogenated solvents in analytical chemistry
Source: Analytical Chemistry (ISSN 0003-2700) V65 N.15 693A-695A (8/1/93)
Language: English
ISSN: 0003-2700
CODEN: ANCHAM
Journal Name: Analytical Chemistry
Document Type: JOURNAL ARTICLE
Publication Date:  930801
API Bulletin Headings: HEALTH & ENVIRONMENT; MEASUREMENT METHODS
```

Index Terms: ALKANE; ANALYTICAL METHOD; BRANCHED CHAIN; C1; C2; C5; C6; CARBON TETRACHLORIDE; CHLOROFLUOROCARBON; CHLOROHYDROCARBON; CLEAN WATER ACT; COMPOSITION; COMPOUNDS; *ECONOMIC FACTOR; ETHER; EVAPORATION ; FLUOROHYDROCARBON; FULL SCALE; GRAVIMETRY; *GREASE; HALOHYDROCARBON; HEXANE; HEXANES; HYDROCARBON; HYDROCARBON SOLVENT; *LEGAL CONSIDERATION ; LIQUID; *LUBRICANT/INDUSTRIAL OIL; MIXTURE; MONOOLEFINIC; *NONHYDROCARBON SOLVENT; OIL CONTENT; OIL WASTE; *ORGANIC SOLVENT; OZONE DEPLETION; PHASE CHANGE; *PHASEDOWN; *PHYSICAL SEPARATION; *POLLUTANT; REPLACEMENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SLUDGE ; SOLID; *SOLVENT; *SOLVENT EXTRACTION; STRAIGHT CHAIN; SUBSTANCE DETERMINED; TERMINAL OLEFINIC; TERT-BUTYL METHYL ETHER; TETRACHLOROETHYLENE; TRICHLOROETHANE; TRICHLOROTRIFLUOROETHANE; UNSATURATED CHAIN; US ENVIRONMENTAL PROTECTION AGCY; *USE; USED OIL; *WASTE MATERIAL; WASTE WATER; WATER; *WATER POLLUTANT

CAS Registry Numbers: 110-54-3; 127-18-4; 1634-04-4; 25323-89-1; 26523-64-8 ; 56-23-5

Sets of Linked Terms: 0009

Linked Terms:

CHLOROFLUOROCARBON; CHLOROHYDROCARBON; COMPOUNDS; FLUOROHYDROCARBON; HALOHYDROCARBON; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SOLVENT; USE

GREASE; LUBRICANT/INDUSTRIAL OIL; OIL WASTE; POLLUTANT; SUBSTANCE DETERMINED; USE; USED OIL; WASTE MATERIAL; WATER POLLUTANT

25323-89-1; C2; CHLOROHYDROCARBON; HALOHYDROCARBON; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT; TRICHLOROETHANE; USE

56-23-5; C1; CARBON TETRACHLORIDE; CHLOROHYDROCARBON; HALOHYDROCARBON; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT; USE

ALKANE; C6; COMPOUNDS; HEXANES; HYDROCARBON; HYDROCARBON SOLVENT; ORGANIC SOLVENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT; USE

110-54-3; C6; HEXANE; HYDROCARBON; HYDROCARBON SOLVENT; ORGANIC SOLVENT ; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT; STRAIGHT CHAIN; USE

127-18-4; C2; CHLOROHYDROCARBON; HALOHYDROCARBON; HYDROCARBON SOLVENT; MONOOLEFINIC; ORGANIC SOLVENT; SINGLE STRUCTURE TYPE; SOLVENT; TERMINAL OLEFINIC; TETRACHLOROETHYLENE; UNSATURATED CHAIN; USE

1634-04-4; BRANCHED CHAIN; C5; ETHER; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT; TERT-BUTYL METHYL ETHER; USE

26523-64-8; C2; CHLOROHYDROCARBON; FLUOROHYDROCARBON; HALOHYDROCARBON;

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     NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SATURATED CHAIN; SINGLE
     STRUCTURE TYPE; SOLVENT; TRICHLOROTRIFLUOROETHANE; USE


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0511872  API Document No.: 4003726
Heirs to the throne: Alternative cleaners vie with methyl chloroform and
   CFC-113 for reign over the parts-cleaning empire
Author: Nudo L
Source: Pollution Engineering (ISSN 0032-3640) V25 N.11 54-58 (6/1/93)
Language: English
ISSN: 0032-3640
CODEN: PLENBW
Journal Name: Pollution Engineering
Document Type: JOURNAL ARTICLE
Publication Date:  930601
API Bulletin Headings: AIR POLLUTION CONTROL; CHEMICAL PRODUCTS;
    ENVIRONMENT, TRANSPORT & STORAGE; HALOGEN COMPOUNDS; HEALTH &
    ENVIRONMENT; LEGAL CONSIDERATIONS; PETROLEUM REFINING AND PETROCHEM
Index Terms: AIR POLLUTANT; *BAN; *C2; *CHEMICAL CLEANING;
    *CHLOROHYDROCARBON; *CLEANING; DEGREASING; DEMAND; *ECONOMIC FACTOR;
    *FLUOROHYDROCARBON; *HALOHYDROCARBON; IMPORT; INORGANIC SOLVENT; *LEGAL
    CONSIDERATION; *NONHYDROCARBON SOLVENT; *ORGANIC SOLVENT; OZONE
    DEPLETION; POLLUTANT; POLLUTION CONTROL; REPLACEMENT; *SATURATED CHAIN;
    *SINGLE STRUCTURE TYPE; *SOLVENT; SUPPLY; TRADE; *TRICHLOROETHANE;
    *TRICHLOROTRIFLUOROETHANE; *USE; WASTE MATERIAL; WATER
CAS Registry Numbers: *25323-89-1; *26523-64-8
Sets of Linked Terms: 0003
Linked Terms:
    INORGANIC SOLVENT; SOLVENT; USE; WATER
    25323-89-1; AIR POLLUTANT; C2; CHLOROHYDROCARBON; HALOHYDROCARBON;
        NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; POLLUTANT; SATURATED CHAIN
        ; SINGLE STRUCTURE TYPE; SOLVENT; TRICHLOROETHANE; USE; WASTE
        MATERIAL
    26523-64-8; AIR POLLUTANT; C2; CHLOROHYDROCARBON; FLUOROHYDROCARBON;
        HALOHYDROCARBON; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; POLLUTANT
        ; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT;
        TRICHLOROTRIFLUOROETHANE; USE; WASTE MATERIAL
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DIALOG(R)File 354:APILIT
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0509006  API Document No.: 4002225
Environmental News/Amoco (Corp) cuts annual emissions (and) Exxon Chemical
   (Co) offers alternatives to ozone depleting cleaners
Source: Lubrication Engineering (ISSN 0024-7154) V49 N.3 225-26 (March
   1993)
Language: English
ISSN: 0024-7154
CODEN: LUENAG
Journal Name: Lubrication Engineering
Document Type: JOURNAL ARTICLE
Publication Date:  930300
API Bulletin Headings: AIR POLLUTION CONTROL; ATMOSPHERIC INTERACTION;
    ENVIRONMENT, TRANSPORT & STORAGE; HEALTH & ENVIRONMENT; OTHER
    SPECIALTIES; PETROLEUM PRODUCTS; PETROLEUM REFINING AND PETROCHEM
Index Terms: AIR POLLUTANT; ALLOY; AMOCO; BUSINESS OPERATION; *C2;
    *CHEMICAL CLEANING; CHLOROFLUOROCARBON; *CHLOROHYDROCARBON; CLEAN AIR
    ACT; *CLEANING; COMMERCIAL; COMPOSITION; COMPOUNDS; DEGREASING;
    ECONOMIC FACTOR; ELEMENT; EMISSION INVENTORY; *ENVIRONMENTAL PROTECTION
    ; ESSO; *FLUOROHYDROCARBON; FREON; GREASE; GROUP VIA; *HALOHYDROCARBON;
    HAZARD; HEALTH/DISEASE; *HYDROCARBON SOLVENT; LEGAL CONSIDERATION;
    LUBRICANT/INDUSTRIAL OIL; MANAGEMENT; NONHYDROCARBON SOLVENT; *ORGANIC
    SOLVENT; OXYGEN; OZONE; *OZONE DEPLETION; PHYSICAL PROPERTY; PLANNING;
    PLASTIC; POLLUTANT; RECYCLING; REPLACEMENT; SARA; *SATURATED CHAIN;
    *SINGLE STRUCTURE TYPE; SOLUBILITY; *SOLVENT; TOXIC EFFECT;
    TRICHLOROETHANE; *TRICHLOROTRIFLUOROETHANE; US ENVIRONMENTAL PROTECTION
    AGCY; *USE; VOLATILE ORGANIC COMPOUNDS; WASTE MATERIAL; WATER
CAS Registry Numbers: 10028-15-6; 25323-89-1; *26523-64-8
Sets of Linked Terms: 0005
Linked Terms:
    10028-15-6; ELEMENT; GROUP VIA; OXYGEN; OZONE
    AIR POLLUTANT; POLLUTANT; VOLATILE ORGANIC COMPOUNDS; WASTE MATERIAL
    26523-64-8; AIR POLLUTANT; C2; CHLOROHYDROCARBON; FLUOROHYDROCARBON;
        FREON; HALOHYDROCARBON; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT;
        POLLUTANT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; SOLVENT;
        TRICHLOROTRIFLUOROETHANE; USE; WASTE MATERIAL
    AIR POLLUTANT; CHLOROFLUOROCARBON; CHLOROHYDROCARBON; COMPOUNDS;
        FLUOROHYDROCARBON; HALOHYDROCARBON; NONHYDROCARBON SOLVENT; ORGANIC
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        SOLVENT; POLLUTANT; SOLVENT; USE; WASTE MATERIAL
    25323-89-1; AIR POLLUTANT; C2; CHLOROHYDROCARBON; HALOHYDROCARBON;
        NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; POLLUTANT; SATURATED CHAIN
        ; SINGLE STRUCTURE TYPE; SOLVENT; TRICHLOROETHANE; USE; WASTE
        MATERIAL


 0/5/5
DIALOG(R)File 354:APILIT
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0506514  API Document No.: 4001294
Department of Energy solvent substitution
Author: Copeland A E
Corporate Source: Idaho National Engineering Laboratory
Source: AWMA 84th Annual Meeting (Vancouver, B.C. 6/16-21/91) Proceedings
    N.91-10.6 V10B (1991) 7P
Language: English
Document Type: MEETING PAPER
Publication Date:  910616
API Bulletin Headings: ENVIRONMENT, TRANSPORT & STORAGE; HEALTH &
    ENVIRONMENT; LIQUID WASTES; OTHER SPECIALTIES; PETROLEUM PRODUCTS;
    PETROLEUM REFINING AND PETROCHEM
Index Terms: AIRCRAFT; ALLOY; BIOCHEMICAL REACTION; BIODEGRADABILITY;
    BIODEGRADATION; C1; C2; CARBON DEPOSIT; CHLOROHYDROCARBON; *CLEANING;
    COMMERCIAL; DEGREASING; EFFLUENT WATER TREATING PLANT; *ENGINE;
    FLUOROHYDROCARBON; GAS; GOVERNMENT; GREASE; HALOHYDROCARBON;
    *HYDROCARBON SOLVENT; INDUSTRIAL PLANT; INORGANIC SOLVENT; *JET ENGINE;
    LABORATORY SCALE; LOGISTICS; LOW TEMPERATURE; LUBRICANT/INDUSTRIAL OIL;
    MAINTENANCE; MATERIALS TESTING; *MECHANICAL CLEANING; MEETING PAPER;
    MILITARY; MONOOLEFINIC; NONHYDROCARBON SOLVENT; ODOR; OIL WASTE;
    OPERATING CONDITION; *ORGANIC SOLVENT; *PAINTERS NAPHTHA; *PETROLEUM
    SOLVENT; PHYSICAL PROPERTY; PILOT SCALE; *REPLACEMENT; SATURATED CHAIN;
    SINGLE STRUCTURE TYPE; *SOLVENT; STORAGE FACILITY; TANK; TEMPERATURE;
    TERMINAL OLEFINIC; TETRACHLOROETHYLENE; TRICHLOROETHANE;
    TRICHLOROFLUOROMETHANE; UNSATURATED CHAIN; US DEPARTMENT OF ENERGY;
    *USE; VAPOR; WASTE DEPOSIT; WASTE MATERIAL; WASTE WATER; WATER; WATER
    TREATING PLANT; WAX
CAS Registry Numbers: 127-18-4; 25323-89-1; 75-69-4
Sets of Linked Terms: 0005
Linked Terms:
    127-18-4; C2; CHLOROHYDROCARBON; HALOHYDROCARBON; MONOOLEFINIC;
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        NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SINGLE STRUCTURE TYPE;
        SOLVENT; TERMINAL OLEFINIC; TETRACHLOROETHYLENE; UNSATURATED CHAIN;
        USE
    25323-89-1; C2; CHLOROHYDROCARBON; HALOHYDROCARBON; NONHYDROCARBON
        SOLVENT; ORGANIC SOLVENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE;
        SOLVENT; TRICHLOROETHANE; USE
    75-69-4; C1; CHLOROHYDROCARBON; FLUOROHYDROCARBON; HALOHYDROCARBON;
        NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SATURATED CHAIN; SINGLE
        STRUCTURE TYPE; SOLVENT; TRICHLOROFLUOROMETHANE; USE
    INORGANIC SOLVENT; SOLVENT; USE; WATER
    GREASE; LUBRICANT/INDUSTRIAL OIL; OIL WASTE; USE; WASTE MATERIAL


 0/5/6
DIALOG(R)File 354:APILIT
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0488477  API Document No.: 3900328
Aqueous cleaners challenge chlorinated solvents
Author: Quitmeyer J A
Corporate Source: W. R. Grace & Co
Source: Pollution Engineering (ISSN 0032-3640) V23 N.13 88-91 (December
    1991)
Language: English
ISSN: 0032-3640
CODEN: PLENBW
Journal Name: Pollution Engineering
Document Type: JOURNAL ARTICLE
Publication Date:  911200
API Bulletin Headings: AIR POLLUTION CONTROL; CHEMICAL PRODUCTS; HALOGEN
    COMPOUNDS; HEALTH; HEALTH & ENVIRONMENT; PETROLEUM REFINING AND
    PETROCHEM
Index Terms: ACIDITY/BASICITY; AIR POLLUTANT; ALLOY; BASIC; C1; C2;
    CALIFORNIA; CARGO; *CHEMICAL CLEANING; *CHLOROHYDROCARBON; *CLEANING;
    CONSTRUCTION MATERIAL; COST; *DEGREASING; DICHLOROMETHANE; DISTRICT 1;
    DISTRICT 5; ECONOMIC FACTOR; ENVIRONMENTAL PROTECTION; GRACE (W R);
    *HALOHYDROCARBON; HAZARD; HEALTH/DISEASE; INCINERATION; *INORGANIC
    SOLVENT; LEGAL CONSIDERATION; MASSACHUSETTS; MONOOLEFINIC; NONE;
    *NONHYDROCARBON SOLVENT; NORTH AMERICA; OCCUPATIONAL HEALTH; *ORGANIC
    SOLVENT; PERSONNEL; PHYSICAL PROPERTY; POLLUTANT; REPLACEMENT; SARA;
    SATURATED CHAIN; SINGLE STRUCTURE TYPE; *SOLVENT; STATE; TERMINAL
    OLEFINIC; TETRACHLOROETHYLENE; TRICHLOROETHANE; TRICHLOROETHYLENE;
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    UNSATURATED CHAIN; USA; *USE; VOLATILE ORGANIC COMPOUNDS; WASTE
    DISPOSAL; WASTE MATERIAL; WATER
CAS Registry Numbers: 127-18-4; 25323-89-1; 75-09-2; 79-01-6
Sets of Linked Terms: 0006
Linked Terms:
    AIR POLLUTANT; POLLUTANT; VOLATILE ORGANIC COMPOUNDS; WASTE MATERIAL
    INORGANIC SOLVENT; SOLVENT; USE; WATER
    ALLOY; CONSTRUCTION MATERIAL; USE
    HAZARD; NONE
    127-18-4; 79-01-6; C2; CARGO; CHLOROHYDROCARBON; HALOHYDROCARBON;
        MONOOLEFINIC; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SINGLE
        STRUCTURE TYPE; SOLVENT; TERMINAL OLEFINIC; TETRACHLOROETHYLENE;
        TRICHLOROETHYLENE; UNSATURATED CHAIN; USE; WASTE MATERIAL
    25323-89-1; 75-09-2; C1; C2; CARGO; CHLOROHYDROCARBON; DICHLOROMETHANE;
        HALOHYDROCARBON; NONHYDROCARBON SOLVENT; ORGANIC SOLVENT; SATURATED
        CHAIN; SINGLE STRUCTURE TYPE; SOLVENT; TRICHLOROETHANE; USE; WASTE
        MATERIAL


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DIALOG(R)File 354:APILIT
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0480129  API Document No.: 3804364
"Green" cleaner
Author: Shell Chemical Co
Source: Marine Engineers Review (ISSN 0047-5955) 40 (March 1991)
Language: English
ISSN: 0047-5955
CODEN: MRERBJ
Journal Name: Marine Engineers Review
Document Type: JOURNAL ARTICLE
Publication Date:  910300
API Bulletin Headings: OTHER SPECIALTIES; PETROLEUM PRODUCTS; PETROLEUM
    REFINING AND PETROCHEM
Index Terms: *ADDITIVE; ALLOY STEEL; ALUMINUM; BRASS; BRONZE; C2; CARBON
    DEPOSIT; CARBON STEEL; CERAMIC; *CHEMICAL CLEANING; CHLOROHYDROCARBON;
    *CLEANING; COMMERCIAL; COMPATIBILITY; CONTAINER; COPPER; CORROSION
    CONTROL; CORROSION INHIBITOR; DEGREASING; DRAINING; ECONOMIC FACTOR;
    ENVIRONMENTAL PROTECTION; FERROUS ALLOY; FULL SCALE; GLASS; GROUP IB;
    GROUP IIB; GROUP IIIA; HALOHYDROCARBON; HAZARD; HIGH PRESSURE; HIGH
    TEMPERATURE; INORGANIC SOLVENT; LIMESTONE; LOW PRESSURE; LOW
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TEMPERATURE; MECHANICAL WAVE; NEWS; NONE; NONFERROUS ALLOY; OPERATING CONDITION; OPERATOR; PARAFFIN WAX; PERSONNEL; PETROLEUM WAX; PRESSURE; REPLACEMENT; ROCK; RUST; SATURATED CHAIN; SEVERITY; SHELL OIL; SINGLE STRUCTURE TYPE; SOLUTION; SOLVENT; SOOT; SOUND WAVE; SPRAYER; SPRAYING; STEEL; SURFACE; TAR; TEMPERATURE; TIME; TRICHLOROETHANE; ULTRASONIC WAVE; *USE; WASTE DEPOSIT; WASTE MATERIAL; WATER; WAX; WAX DEPOSIT; ZINC

CAS Registry Numbers: 1317-65-3; 25323-89-1; 8002-74-2
Sets of Linked Terms: 0017
Linked Terms:
- ADDITIVE; COMPATIBILITY; USE
- 25323-89-1; C2; CHLOROHYDROCARBON; HALOHYDROCARBON; NONE; SATURATED CHAIN; SINGLE STRUCTURE TYPE; TRICHLOROETHANE
- ALLOY STEEL; CARBON STEEL; COMPATIBILITY; FERROUS ALLOY; STEEL; SURFACE
- INORGANIC SOLVENT; SOLVENT; USE; WATER
- HAZARD; NONE
- 8002-74-2; PARAFFIN WAX; PETROLEUM WAX; WASTE DEPOSIT; WASTE MATERIAL; WAX; WAX DEPOSIT
- CARBON DEPOSIT; SOOT; WASTE DEPOSIT; WASTE MATERIAL
- RUST; TAR; WASTE DEPOSIT; WASTE MATERIAL
- ALUMINUM; COMPATIBILITY; GROUP IIIA; NONFERROUS ALLOY
- BRASS; BRONZE; COMPATIBILITY; NONFERROUS ALLOY
- COMPATIBILITY; COPPER; GROUP IB; NONFERROUS ALLOY
- COMPATIBILITY; GROUP IIB; NONFERROUS ALLOY; ZINC
- COMPATIBILITY; GLASS
- 1317-65-3; COMPATIBILITY; LIMESTONE; ROCK
- CERAMIC; COMPATIBILITY
- DRAINING; NONE
- CORROSION CONTROL; TIME

0/5/8
DIALOG(R)File 354:APILIT

0475186 API Document No.: 3830618
Stability of low level aromatic and halogenated hydrocarbons in SUMMA(TM) canisters
Author: Carlson J L; Dominguez R; Wadley M W
Corporate Source: South Coast Air Quality Management District
Source: AIChE 1990 Summer National Meeting (San Diego 8/19-22/90) Preprint N.73a 18P

Language: English
Document Type: MEETING PAPER
Publication Date: 900819
API Bulletin Headings: HEALTH & ENVIRONMENT; MEASUREMENT METHODS
Index Terms: AICHE; AIR; *AROMATIC HYDROCARBON; ASSOCIATION; ATMOSPHERIC
    PRESSURE; BAG; *BENZENE RING; *C1; C2; CARBON TETRACHLORIDE;
    *CHLOROFORM; *CHLOROHYDROCARBON; COMMERCIAL; COMPOSITION; *COMPOUNDS;
    CONCENTRATION; *CONTAINER; DILUTING; DRY; ELEMENT; GROUP VA;
    *HALOHYDROCARBON; HUMIDITY; *HYDROCARBON; INTEGRATED; MEETING PAPER;
    MONOOLEFINIC; NITROGEN; OPERATING CONDITION; PERMEABILITY; *PHYSICAL
    PROPERTY; PRESSURE; REFERENCE MATERIAL; REPLACEMENT; REPRODUCIBILITY;
    *SAMPLING; *SATURATED CHAIN; SIMULTANEOUS; *SINGLE STRUCTURE TYPE;
    *STABILITY; STORAGE; TERMINAL OLEFINIC; TETRACHLOROETHYLENE;
    UNSATURATED CHAIN; WALL; WATER CONTENT
CAS Registry Numbers: 127-18-4; 56-23-5; *67-66-3
Sets of Linked Terms: 0006
Linked Terms:
    BENZENE RING; COMPOUNDS; HALOHYDROCARBON
    INTEGRATED; SAMPLING; SIMULTANEOUS
    ELEMENT; GROUP VA; NITROGEN
    56-23-5; 67-66-3; C1; CARBON TETRACHLORIDE; CHLOROFORM;
        CHLOROHYDROCARBON; HALOHYDROCARBON; SATURATED CHAIN; SINGLE
        STRUCTURE TYPE
    127-18-4; C2; CHLOROHYDROCARBON; HALOHYDROCARBON; MONOOLEFINIC; SINGLE
        STRUCTURE TYPE; TERMINAL OLEFINIC; TETRACHLOROETHYLENE; UNSATURATED
        CHAIN
    AROMATIC HYDROCARBON; BENZENE RING; COMPOUNDS; HYDROCARBON

0/5/9
DIALOG(R)File 354:APILIT

0440045 API Document No.: 3731022
Methyl chloroform under scrutiny
Author: Montreal Protocol on Substances That; Dow Chemical Co; PPG
    Industries Inc; Vulcan Chemical Industries; Solvay & Cie SA;
    Halogenated Solvents Industry Alliance
Source: Chemical Week (ISSN 0009-272X) V146 N.14 40 (4/11/90)
Language: English
ISSN: 0009-272X
CODEN: CHWKA9

Journal Name: Chemical Week
Document Type: JOURNAL ARTICLE
Publication Date: 900411
API Bulletin Headings: ATMOSPHERIC INTERACTION; HEALTH & ENVIRONMENT; LEGAL CONSIDERATIONS
Index Terms: AIR POLLUTANT; *AMENDMENT; ATMOSPHERE; *C2; CHLOROFLUOROCARBON ; *CHLOROHYDROCARBON; COMPOUNDS; DOW CHEMICAL; *ECONOMIC FACTOR; ENVIRONMENTAL IMPACT; FLUOROHYDROCARBON; *HALOHYDROCARBON; *LEGAL CONSIDERATION; MANUFACTURER; NEWS; OZONE DEPLETION; *PHASEDOWN; POLLUTANT; *POLLUTION CONTROL; REPLACEMENT; *SATURATED CHAIN; *SINGLE STRUCTURE TYPE; SUPPLY; *TRICHLOROETHANE; WASTE MATERIAL; WORLD WIDE
CAS Registry Numbers: *25323-89-1
Sets of Linked Terms: 0002
Linked Terms:
  25323-89-1; AIR POLLUTANT; C2; CHLOROHYDROCARBON; HALOHYDROCARBON; POLLUTANT; SATURATED CHAIN; SINGLE STRUCTURE TYPE; TRICHLOROETHANE; WASTE MATERIAL
  AIR POLLUTANT; CHLOROFLUOROCARBON; CHLOROHYDROCARBON; COMPOUNDS; FLUOROHYDROCARBON; HALOHYDROCARBON; POLLUTANT; WASTE MATERIAL

0/5/10
DIALOG(R)File 354:APILIT

0438353 API Document No.: 3702835
NASA calls for faster CFC phaseout
Author: NASA
Source: Chemical & Engineering News (ISSN 0009-2347) V68 N.17 18 (4/23/90)
Language: English
ISSN: 0009-2347
CODEN: CENEAR
Journal Name: Chemical and Engineering News
Document Type: JOURNAL ARTICLE
Publication Date: 900423
API Bulletin Headings: AIR POLLUTION CONTROL; CHEMICAL PRODUCTS; HALOGEN COMPOUNDS; HEALTH & ENVIRONMENT; PETROLEUM REFINING AND PETROCHEM
Index Terms: AIR POLLUTANT; ANTARCTICA; BROMOHYDROCARBON; C1; C2; CARBON TETRACHLORIDE; *CHLOROFLUOROCARBON; *CHLOROHYDROCARBON; COMPOSITION; *COMPOUNDS; CONCENTRATION; *ECONOMIC FACTOR; ELEMENT; *FLUOROHYDROCARBON; GROUP VIA; *HALOHYDROCARBON; *LEGAL CONSIDERATION; MATHEMATICS; NASA; NEWS; OXYGEN; OZONE; *OZONE DEPLETION; *PHASEDOWN;

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    POLLUTANT; *POLLUTION CONTROL; POLLUTION SOURCE; REPLACEMENT; SATURATED
    CHAIN; SINGLE STRUCTURE TYPE; TRACE; TRICHLOROETHANE; WASTE MATERIAL
CAS Registry Numbers: 10028-15-6; 25323-89-1; 56-23-5
Sets of Linked Terms: 0004
Linked Terms:
    10028-15-6; ELEMENT; GROUP VIA; OXYGEN; OZONE
    AIR POLLUTANT; CHLOROFLUOROCARBON; CHLOROHYDROCARBON; COMPOUNDS;
        FLUOROHYDROCARBON; HALOHYDROCARBON; POLLUTANT; WASTE MATERIAL
    25323-89-1; 56-23-5; AIR POLLUTANT; C1; C2; CARBON TETRACHLORIDE;
        CHLOROHYDROCARBON; HALOHYDROCARBON; POLLUTANT; SATURATED CHAIN;
        SINGLE STRUCTURE TYPE; TRICHLOROETHANE; WASTE MATERIAL
    AIR POLLUTANT; BROMOHYDROCARBON; COMPOUNDS; HALOHYDROCARBON; POLLUTANT;
        WASTE MATERIAL


 0/5/11
DIALOG(R)File 354:APILIT
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0384644  API Document No.: 3403113
EPA PROPOSES RULES FOR INERT INGREDIENTS
Author: MACKERRON C B; MOORE J A; NATIONAL AGRICULTURAL CHEMICALS ASSO; U S
    ENVIRONMENTAL PROTECTION AGENCY
Corporate Source: EPA
Source: CHEMICALWEEK (ISSN 0009-272X) V140 N.17 12,14 (5/6/87)
Language: English
ISSN: 0009-272X
CODEN: CHWKA9
Journal Name: Chemical Week
Document Type: JOURNAL ARTICLE
Publication Date:  870506
API Bulletin Headings: AGRICULTURALS; HEALTH; HEALTH & ENVIRONMENT; LEGAL
    CONSIDERATIONS
Index Terms: ACTIVITY; ALDEHYDE; ASSOCIATION; CHLOROHYDROCARBON; C1; C2; C9
    ; DICHLOROMETHANE; *ECONOMIC FACTOR; ENVIRONMENTAL PROTECTION; EXPOSURE
    ; FORMALDEHYDE; HALOHYDROCARBON; *HEALTH/DISEASE; INERT; ISOPHORONE;
    KETONE; *LEGAL CONSIDERATION; MARKING; MONOOLEFINIC; *PESTICIDE;
    PHYSICAL PROPERTY; REPLACEMENT; SATURATED CHAIN; SINGLE STRUCTURE TYPE;
    *TOXIC EFFECT; TRICHLOROETHANE; UNSATURATED CARBOCYCLIC; US
    ENVIRONMENTAL PROTECTION AGCY; *USE; 6 MEMBER RING
CAS Registry Numbers: 25323-89-1; 50-00-0; 75-09-2; 78-59-1
Sets of Linked Terms: 0003
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Linked Terms:
    25323-89-1; 75-09-2; CHLOROHYDROCARBON; C1; C2; DICHLOROMETHANE;
        HALOHYDROCARBON; SATURATED CHAIN; SINGLE STRUCTURE TYPE;
        TRICHLOROETHANE
    50-00-0; ALDEHYDE; C1; FORMALDEHYDE
    78-59-1; C9; ISOPHORONE; KETONE; MONOOLEFINIC; SATURATED CHAIN;
        UNSATURATED CARBOCYCLIC; 6 MEMBER RING


 0/5/12
DIALOG(R)File 354:APILIT
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0374822  API Document No.: 3331851
LEGAL BRIEFS/(1,1,1-TRICHLOROETHANE ) EXTREMELY HAZARDOUS WASTE
Author: MORSE H N; KEY TRONIC CORP
Source: J. AIR POLLUT. CONTROL ASSOC. (ISSN 0002-2470) V36 N.7 867 (JULY
    1986) SH
Language: English
ISSN: 0002-2470
Publication Date:  860700
API Bulletin Headings: HEALTH & ENVIRONMENT; LAND POLLUTION; LEGAL
    CONSIDERATIONS
Index Terms: *CHLOROHYDROCARBON; COST; *C2; DAMAGE; DISTRICT 5; *ECONOMIC
    FACTOR; *HALOHYDROCARBON; HAZARD; *LANDFILL; *LEGAL CONSIDERATION;
    NORTH AMERICA; OWNERSHIP; PUBLIC AFFAIRS; *SATURATED CHAIN; *SINGLE
    STRUCTURE TYPE; SOIL POLLUTANT; *TRICHLOROETHANE; USA; WASHINGTON;
    *WASTE DISPOSAL; WASTE MATERIAL; WATER POLLUTANT
CAS Registry Numbers: *25323-89-1
Sets of Linked Terms: 0001
Linked Terms:
    25323-89-1; CHLOROHYDROCARBON; C2; HALOHYDROCARBON; SATURATED CHAIN;
        SINGLE STRUCTURE TYPE; SOIL POLLUTANT; TRICHLOROETHANE; WASTE
        MATERIAL; WATER POLLUTANT
?b 434
       08aug94 09:52:29 User036172 Session B135.9
       Sub account: BULLUCK/F7411
           $28.00    0.100 Hrs File354
           $15.60  12 Types
            $0.00  View Fee
    $43.60  Estimated cost File354
     $1.20  SPRNTNET
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   $44.80  Estimated cost this search
  $128.58  Estimated total session cost   0.430 Hrs.


File 434:Scisearch(R)  1974-1994/Jul W2
       (c) 1994 Inst for Sci Info

      Set  Items  Description
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?k 11459856;k 11136236
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      S0       2  11136236
?t s0/5/all

 0/5/1
DIALOG(R)File 434:Scisearch(R)
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11459856   Genuine Article#: HK197   Number of References: 4
Title: CABLE CLEANING SOLVENTS - ENVIRONMENTAL-ISSUES AND EFFECTIVE
   REPLACEMENTS
Author(s): WILCOX DP; HUNDER DN
Corporate Source: THREE M CO/AUSTIN//TX/00000
Journal: IEEE TRANSACTIONS ON POWER DELIVERY, 1992, V7, N2 (APR), P
    1023-1026
Language: ENGLISH   Document Type: ARTICLE
Geographic Location: USA
Subfile: SciSearch; CC ENGI--Current Contents, Engineering, Technology &
    Applied Sciences
Journal Subject Category: INSTRUMENTS & INSTRUMENTATION; ENGINEERING,
    ELECTRICAL & ELECTRONIC
Abstract: This paper presents the sequence of events used in selecting
    potential candidates as effective replacements for currently used
    chlorinated solvents.  It also discusses the health and environmental
    issues that surround the use of chlorinated solvents and the test
    criteria used to determine the final selection of one such replacement.
Descriptors--Author Keywords: SOLVENTS ; 1,1,1-TRICHLOROETHANE ; HEALTH
    EFFECTS ; ENVIRONMENT
Cited References:
    CHARACTERISTICS HAZA, 1990
    OCCUPATIONAL EXPOSUR, 1990
    PERRY DD, 1989, EFFECT DEGREASING SO
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   SIDNEY A, 1990, FATE EXPOSURE ASSESS


 0/5/2
DIALOG(R)File 434:Scisearch(R)
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11136236   Genuine Article#: GK019   Number of References: 0
                                     (NO REFS KEYED)
Title: CFC ALTERNATIVE CLEANING SYSTEMS
Author(s): MARTS K; HOWARD J
Corporate Source: MARTIN MARIETTA CORP,DEF SPACE & COMMUNICAT
    CO/DENVER//CO/00000
Journal: JOURNAL OF THE IES, 1991, V34, N5, P34-40
Language: ENGLISH   Document Type: ARTICLE
Geographic Location: USA
Subfile: SciSearch; CC ENGI--Current Contents, Engineering, Technology &
    Applied Sciences
Journal Subject Category: ENVIRONMENTAL SCIENCES; INSTRUMENTS &
    INSTRUMENTATION
Abstract: A multidisciplined product team comprised of Engineering,
    Operations, Safety, and Environmental Management assessed the
    feasibility of various cleaning materials and processing equipment for
    precision cleaning.  Precleaning using an aqueous-based cleaner
    followed by isopropyl alcohol spray final clean were the materials and
    methods selected to replace 1,1,1-trichloroethane preclean (vapor
    degrease) and CFC-113 final clean.
Descriptors--Author Keywords: CFC REPLACEMENT; PRECISION CLEANING
    EQUIPMENT; ALCOHOL SPRAY CHAMBERS; PRECISION CLEANING METHODS
?b 399
       08aug94 09:53:39 User036172 Session B135.10
       Sub account: BULLUCK/F7411
            $3.96    0.033 Hrs File434
            $2.50  2 Types
            $1.00  View Fee
     $7.46  Estimated cost File434
     $0.40  SPRNTNET
     $7.86  Estimated cost this search
   $136.44  Estimated total session cost   0.463 Hrs.

File 399:CA Search(R)  1967-1994/UD=12104
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*File 399: Use is subject to the terms of your user/customer agreement.

       Set  Items  Description
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?exs td098
>>>SET HILIGHT: use ON, OFF, or 1-5 characters
KWIC is set to 5.
KWIC option is not available in file(s) 399
              2033  TRICHLOROETHANE
             12242  REPLAC?
       S1       13  (TRICHLOROETHANE AND REPLAC?)
?s s1 and printed()circuit()board()defluxing/ti
                13  S1
              6955  PRINTED/TI
             13207  CIRCUIT/TI
              4325  BOARD/TI
                35  DEFLUXING/TI
                 1  PRINTED/TI(W)CIRCUIT/TI(W)BOARD/TI(W)DEFLUXING/TI
       S2        1  S1 AND PRINTED()CIRCUIT()BOARD()DEFLUXING/TI
?t 2/5/1

 2/5/1
DIALOG(R)File 399:CA Search(R)
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 117262126    CA: 117(26)262126a    CONFERENCE PROCEEDING
 Printed circuit board defluxing:  alternatives to ozone depleting
substances
  AUTHOR(S): Wolf, Katy
  LOCATION: Inst. Res. Tech. Assist., Los Angeles, CA, USA
  JOURNAL: Solvent Substitution, Annu. Int. Workshop Solvent Substitution,
1st  DATE: 1990  NUMBER: CONF-901285--DE92 003262  PAGES: 127-30  CODEN:
58FKA6  LANGUAGE: English  PUBLISHER: NTIS,Springfield, Va
  SECTION:
CA276000 Electric Phenomena
  IDENTIFIERS: review solvent ozone depleting replacement circuit,
trichloroethane replacement circuit board defluxing review,
trichlorotrifluoroethane replacement circuit board defluxing review
  DESCRIPTORS:
Electric circuits,printed, boards...
    defluxing of , replacement of ozone-depleting solvents in fabrication
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     of
   CAS REGISTRY NUMBERS:
  71-55-6  76-13-1  replacement of, in printed circuit board defluxing
  10028-15-6  uses, solvent depleting, replacement of, in printed circuit
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              $1.15  1 Types
              $1.00  View Fee
       $6.11  Estimated cost File399
       $0.40  SPRNTNET
       $6.51  Estimated cost this search
     $142.95  Estimated total session cost   0.496 Hrs.


  ### Status: Signed Off.
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  -- 1 -  AD NUMBER: B177501
  -- 2 -  FIELDS AND GROUPS: 7/3, 11/11
  -- 3 -  ENTRY CLASSIFICATION:   UNCLASSIFIED
  -- 5 -  CORPORATE AUTHOR: FOREIGN AEROSPACE SCIENCE AND TECHNOLOGY CENTER
  --      WRIGHT-PATTERSON AFB OH
  -- 6 -  UNCLASSIFIED TITLE:     PROJECT CFC/FREON REPLACEMENT AG-MEETING,
  --      PARTIAL REPORT.
  -- 8 -  TITLE CLASSIFICATION:   UNCLASSIFIED
  --11 -  REPORT DATE:       OCT 26, 1993
  --12 -  PAGINATION:     33P   MEDIA COST:  $  6.00
  --14 -  REPORT NUMBER:    FASTC-ID(RS)T-0438-93
  --18 -  MONITOR ACRONYM:  XC
  --19 -  MONITOR SERIES:   FASTC
  --20 -  REPORT CLASSIFICATION:  UNCLASSIFIED
  --21 -  SUPPLEMENTARY NOTE:     TRANS. OF PROJEKT CFC/FREON ERSATTNING AG-
  --      MOTE, DELRAPPORTERING (SWEDEN) NSFA20/90:26 P1-25, 11 SEP 90.
  --22 -  LIMITATIONS (ALPHA):    DISTRIBUTION AUTHORIZED TO U.S. GOV'T.
  --      AGENCIES AND THEIR CONTRACTORS; COPYRIGHT, SPECIFIC AUTHORITY; 26
  --      OCT 93. OTHER REQUESTS SHALL BE REFERRED TO FASTC/STINFO, WRIGHT-
  --      PATTERSON AFB, OH 45433.
  --23 -  DESCRIPTORS:       *HALOGENATED HYDROCARBONS, *CHLORINE, *FLUORINE,
  --      *HYDROGEN, *CARBON, *CLEANING, TRANSLATIONS, SWEDEN, SWEDISH

  -
  --      LANGUAGE, AROMATIC HYDROCARBONS, CIRCUITS, ALCOHOLS, CHLOROETHANES,
  --      CARDS, REPLACEMENT.
  --24 -  DESCRIPTOR CLASSIFICATION:    UNCLASSIFIED
  --25 -  IDENTIFIERS:       *FREON, *NAPHTHAS, TRICHLOROETHANE
  --26 -  IDENTIFIER CLASSIFICATION:    UNCLASSIFIED
  --27 -  ABSTRACT:  LARS-ERIK LARSSON POINTED OUT THAT NAPPAR IS A
  --      COMMERCIAL NAME FOR A LOW-AROMATIC NAPHTHAS. OTHER LOW-AROMATIC
  --      NAPHTHAS CAN ALSO BE CONSIDERED. MARCUS SUURKULA SAID THAT FMV HAS
  --      NOT YET DECIDED IF FFV MATERIAL TECHNOLOGY SHOULD BE GIVEN A
  --      REQUISITION TO INVESTIGATE REPLACEMENT PRODUCTS FOR 1,1,1-
  --      TRICHLOROETHANE. THE TEST-CLEANING RESULTS FOR CIRCUIT CARDS AND
  --      INSTRUMENTS NOT INCLUDED IN THE PRECEDING PROTOCOL ARE ENCLOSED
  --      HEREWITH IN APPENDIXES 1 AND 2
  --28 -  ABSTRACT CLASSIFICATION:      UNCLASSIFIED
  --29 -  INITIAL INVENTORY:     2
  --33 -  LIMITATION CODES:  2
  --35 -  SOURCE CODE:      425039
  --36 -  ITEM LOCATION:     DTIC
  --40 -  GEOPOLITICAL CODE:      3907
  --41 -  TYPE CODE:  F
  --43 -  IAC DOCUMENT TYPE:
  --******
  --     2   OF     3

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  -- 1 -  AD NUMBER: B083385
  -- 2 -  FIELDS AND GROUPS: 19/1
  -- 3 -  ENTRY CLASSIFICATION:   UNCLASSIFIED
  -- 5 -  CORPORATE AUTHOR: NAVAL WEAPONS STATION  YORKTOWN VA
  -- 6 -  UNCLASSIFIED TITLE:     SAFER MIXING AGENTS FOR PBXN-103 EXPLOSIVE,
  -- 8 -  TITLE CLASSIFICATION:   UNCLASSIFIED
  --10 -  PERSONAL AUTHORS: TEAL,W. B. , JR;
  --11 -  REPORT DATE:       APR   , 1984
  --12 -  PAGINATION:     15P   MEDIA COST:  $  6.00
  --14 -  REPORT NUMBER:    NWSY-TR-84-2
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--20 -  REPORT CLASSIFICATION:  UNCLASSIFIED
--22 -  LIMITATIONS (ALPHA):    DISTRIBUTION LIMITED TO U.S. GOV'T.
--      AGENCIES AND THEIR CONTRACTORS; ADMINISTRATIVE/OPERATIONAL USE; APR
--      84. OTHER REQUESTS MUST BE REFERRED TO NAVAL WEAPONS STATION,
--      YORKTOWN, VA 23691.
--23 -  DESCRIPTORS:       *EXPLOSIVES, *MIXING, *SLURRY EXPLOSIVES,
--      *CHEMICAL AGENTS, COMPARISON, HEPTANES, FLAMMABILITY, SAFETY,
--      NITROCELLULOSE, COSTS, THERMODYNAMIC PROPERTIES, TRICHLOROETHANES,
--      REPLACEMENT, SUBSTITUTES, ADDITIVES, HAZARDS
--24 -  DESCRIPTOR CLASSIFICATION:    UNCLASSIFIED
--25 -  IDENTIFIERS:       *PBXN-103 EXPLOSIVE, *STODDARD SOLVENT
--26 -  IDENTIFIER CLASSIFICATION:    UNCLASSIFIED
--27 -  ABSTRACT:   PBXN-103 IS A MILITARY EXPLOSIVE USED PRIMARILY IN

-
--      UNDERWATER ORDNANCE. THE CURRENT SPECIFICATION AND OPERATING
--      PROCEDURES REQUIRE THE USE OF N-HEPTANE AS A SLURRYING AGENT FOR
--      THE INGREDIENT NITROCELLULOSE, AND AS A MIXING AGENT FOR THE
--      EXPLOSIVE. THE USE OF HEPTANE IN THIS PROCESS IS A SAFETY HAZARD
--      BECAUSE IT IS FLAMMABLE. TWO ALTERNATE SLURRYING AND MIXING AGENTS
--      ARE COMPARED TO HEPTANE FOR USE IN PBXN-103 PRODUCTION. THE
--      ALTERNATES ARE STODDARD SOLVENT AND 1,1,1-TRICHLOROETHANE. THE
--      THREE ARE COMPARED ON THE BASIS OF THEIR SAFETY CHARACTERISTICS,
--      THERMODYNAMIC PROPERTIES, AND COST.
--28 -  ABSTRACT CLASSIFICATION:      UNCLASSIFIED
--29 -  INITIAL INVENTORY:    12
--33 -  LIMITATION CODES:  2
--35 -  SOURCE CODE:       253250
--36 -  ITEM LOCATION:      DTIC
--40 -  GEOPOLITICAL CODE:        5101
--41 -  TYPE CODE:  N
--43 -  IAC DOCUMENT TYPE:
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--     3   OF     3
-- 1 -  AD NUMBER: A275245
-- 2 -  FIELDS AND GROUPS: 7/3, 13/8, 20/1
-- 3 -  ENTRY CLASSIFICATION:   UNCLASSIFIED
-- 5 -  CORPORATE AUTHOR: ALLIED-SIGNAL AEROSPACE CO  KANSAS CITY MO

-
--      KANSAS CITY DIV
-- 6 -  UNCLASSIFIED TITLE:     DEVELOPMENT OF A REPLACEMENT FOR
--      TRICHLOROETHYLENE IN THE TWO-STAGE CLEANING PROCESS.
-- 8 -  TITLE CLASSIFICATION:   UNCLASSIFIED
--10 -  PERSONAL AUTHORS: HARDING, W. P.
--11 -  REPORT DATE:       DEC   , 1992
--12 -  PAGINATION:     16P   MEDIA COST:  $  6.00
--14 -  REPORT NUMBER:     KCP-613-4941
--18 -  MONITOR ACRONYM:  XF
--19 -  MONITOR SERIES:    DOE
--20 -  REPORT CLASSIFICATION:  UNCLASSIFIED
--23 -  DESCRIPTORS:       *CLEANING, *TRICHLOROETHYLENE, *ULTRASONIC
--      CLEANING, ALCOHOLS, MINERALS, REPLACEMENT.
--24 -  DESCRIPTOR CLASSIFICATION:    UNCLASSIFIED
--25 -  IDENTIFIERS:       *ISOPROPYL ALCOHOL, *D-LIMONENE, MINERAL SPIRITS
--26 -  IDENTIFIER CLASSIFICATION:    UNCLASSIFIED
--27 -  ABSTRACT:   ISOPROPYL ALCOHOL, D-LIMONENE, AND A SYNTHETIC MINERAL
--      SPIRITS WERE COMPARED FOR EFFECTIVENESS AS REPLACEMENTS FOR
--      TRICHLOROETHYLENE IN AN ULTRASONIC CLEANING PROCESS. ALL WERE FOUND
--      TO BE SUITABLE. ISOPROPYL ALCOHOL IS RECOMMENDED AS THE REPLACEMENT.
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--28 -  ABSTRACT CLASSIFICATION:      UNCLASSIFIED
--29 -  INITIAL INVENTORY:     1
--33 -  LIMITATION CODES:  1

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--35 -  SOURCE CODE:      420613
--36 -  ITEM LOCATION:     NTIS
--40 -  GEOPOLITICAL CODE:        2905
--41 -  TYPE CODE:  4
--43 -  IAC DOCUMENT TYPE:
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Appendix C:

Referenced ASTM Standards

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Designation: F 483 – 90 (Reapproved 1991)$^{\epsilon1}$

An American National Standard

Standard Test Method for Total Immersion Corrosion Test for Aircraft Maintenance Chemicals[1]

This standard is issued under the fixed designation F 483; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

$^{\epsilon1}$ NOTE—An editorial change was made in Section 1.2 in December 1991.

1. Scope

1.1 This test method covers the determination of the corrosiveness of aircraft maintenance chemicals on aircraft metals with time under conditions of total immersion by a combination of weight change measurements and visual qualitative determination of change.

1.2 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.3 The values stated in SI units are to be regarded as standard. The values in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1193 Specification for Reagent Water[2]

E 1 Specification of ASTM Thermometers[3]

3. Significance and Use

3.1 Many aircraft maintenance chemicals are used on components and structures which would be adversely affected by excessive dimensional change. This test method screens these chemicals to ensure compliance with specified weight change criteria.

4. Apparatus

4.1 *Wide-mouth Sealable Glass Jar or Stoppered Flask of Suitable Size*—The glass jar or flask should be so chosen so that the specimens will remain fully immersed in a vertical position during testing and the ratio of area of immersed metal to volume of solution will be in accordance with 7.1.

4.1.1 Caution—Some aircraft maintenance chemicals when heated have high vapor pressures or may produce gases during testing. Suitable precautions should be taken to prevent the containing vessel from exploding or the vessel should be so chosen as to withstand the resulting pressure.

4.2 *Specimen-Supporting Device*—A glass of fluorocarbon plastic supporting system designed to keep the specimen fully immersed while ensuring free contact with the solution, and designed to physically isolate the specimens from each other.

4.3 For materials containing low boiling point solvents, a means of preventing evaporation losses shall be used.

4.4 *Constant-Temperature Device*—Any suitable regulated heating device (mantle, hot plate, or bath) may be used to maintain the solution at the required temperature.

4.4 *Thermometer*, having a range from 0 to 302°F and conforming to requirements for Thermometer 1F in accordance with Specification E 1.

4.5 *Oven*, low temperature explosion-proof, capable of maintaining 38 ± 3°C (100 ± 5°F) through 120 ± 5°C (248 ± 5°F).

5. Reagents and Materials

5.1 *Acetone.*

5.2 *Methyl Ethyl Ketone.*

5.3 1,1,1-*Trichloroethane.*

6. Test Specimens

6.1 Take test specimens of a given alloy from the same sheet stock and measure 50.8 by 25.4 by 1.6 mm (2 by 1 by 0.06 in.) with a 3.2-mm (0.125-in.) diameter mounting hole suitably located at one end of the specimen. Test three replicate specimens in each concentration of maintenance chemical solution in accordance with 8.2.1. Take the total area of the specimen as 28.2 cm^2 (4.4 $in.^2$).

6.1.1 Identify each panel with numbers 1, 2, 3, or 4.

7. Precleaning Test Specimens

7.1 Immerse the test specimens in a beaker of 1,1,1-trichloroethane at room temperature and swab the surface of the individual specimen thoroughly using clean forceps to hold the test specimen and the cotton swab.

7.2 Shake off excess solvent. Transfer and immerse the test specimens separately several times in a beaker of methyl ethyl ketone.

7.3 Shake off excess methyl ethyl ketone and dry in a vacuum desiccator or in a low-temperature oven at 120 ± 5°C (248 ± 5°F) for 15 min. (If oven dried, remove to dessicator and cool to ambient.)

8. Conditioning

8.1 *Ratio of Area of Immersed Metal to Volume of Solution*—The ratio of area of immersed metal to volume of solution shall be 8 mL per cm^2. Use fresh solution for each set of replicates.

---

[1] This test method is under the jurisdiction of ASTM Committee F-7 on Aerospace and Aircraft and is the direct responsibility of Subcommittee F07.07 on Qualification Testing of Aircraft Cleaning Materials.

Current edition approved May 25, 1990. Published July 1990. Originally published as F 483 – 77. Last previous edition F 483 – 87.

[2] *Annual Book of ASTM Standards*, Vol 11.01.

[3] *Annual Book of ASTM Standards*, Vol 14.03.

8.2 *Solution Concentration:*

8.2.1 Unless otherwise specified, test the specimens in solutions of the maintenance chemical in the concentrated as-received condition and at the recommended use dilution using water that conforms to Specification D 1193, Type IV. In case the maintenance chemical is not soluble to the extent noted, record this fact and continue with the test.

8.2.2 If water is not used as the diluent, record the type and specification of diluent used in the test.

8.3 *Temperature*—Unless otherwise specified, the test temperature shall be 38 ± 3°C (100 ± 5°F).

9. Procedure

9.1 Weigh three of four specimens of the same alloy to the nearest 0.1 mg.

9.2 Immerse three weighed specimens of each alloy in the test solution at the prescribed temperature. Place only specimens of the same alloy in the containing vessel. Maintain at the required temperature for the prescribed exposure period. Retain the fourth specimen of each alloy for comparison purposes.

9.3 At the end of 24 h remove the test specimens and proceed as follows:

9.3.1 Rinse thoroughly under hot tap water, 49 to 60°C (120 to 140°F). Follow with a rinse in water conforming to Specification D 1193, Type IV at room temperature.

9.3.2 Rinse with a stream of acetone from a wash bottle and oven dry at 120°C (250°F), dessicate until cooled to ambient, weigh and record.

9.3.3 Then examine for and record on a form as illustrated in Appendix X1 in the 24-h column the following visible changes in comparison with the fourth virgin specimen of each alloy.

9.3.3.1 Discoloration and dulling,

9.3.3.2 Etching,

9.3.3.3 Presence of accretions and relative amounts,

9.3.3.4 Pitting, and

9.3.3.5 Presence of selective or localized attack.

9.4 Immerse the panels in the same test solution for a further 144 h, then repeat 9.3.1 through 9.3.3.5.

9.5 Reweigh specimens to nearest 0.1 g, calculate weight loss or gain, and record in 168-h column.

10. Report

10.1 Report the data for each test performed on a form as illustrated in Appendix X1.

11. Precision and Bias

11.1 The precision of the procedure in Test Method F 483 for measuring total immersion corrosion is being determined.

X1. RECOMMENDED REPORT FORM

X1.1 Report test results on a form as illustrated in Fig. X1.1.

TEST REPORT ACCORDING TO APPENDIX X1 FOR ASTM F 483

Client name ____________________

Address ____________________

Telephone ____________________

TESTING LABORATORY

Name ____________________

Address ____________________

Telephone ____________________

Name or reference of Maintenance

Chemical Tested ____________________

Alloy type ____________________

Surface treatment ____________________

Condition ____________________

Concentration ____________________

Diluent used ____________________

Temperature ____________________

Note here any conditions of test variations necessitated by peculiarity of maintenance chemical being tested ____________________

	Panel #	After 24 h		After 168 h	
Weight loss, mg	1				
Weight loss, mg	2				
Weight loss, mg	3				
Weight loss, mg	Control				
Average weight loss of panels 1, 2, 3 (after consideration of electrolytic cleaning constant), mg					
Above average divided by 28.2 expressed as loss in milligrams per square centimetre per 24 h					
		Before	After	Before	After
Discoloration or Dulling (9.3.3.1)	1				
	2				
	3				
Etching (9.3.3.2)	1				
	2				
	3				
Accretions Presence and Relative amounts (9.3.3.3)	1				
	2				
	3				
Pitting (9.3.3.4)	1				
	2				
	3				
Selective or localized attack (9.3.3.5)	1				
	2				
	3				

NOTE—Control panel weight loss is noted only to confirm its relevant loss as it affects the Test Panels. Before and After refers to the appearance of the panel before electrolytic cleaning and after electrolytic cleaning. Insert N.A. as not applicable if NO electrolytic cleaning operation was necessary.

FIG. X1.1 Report Form

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

Designation: F 945 – 85 (Reapproved 1993)

Standard Test Method for Stress-Corrosion of Titanium Alloys by Aircraft Engine Cleaning Materials[1]

This standard is issued under the fixed designation F 945; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Chemical solutions and compounds used for preinspection cleaning or for preservation of titanium alloy aircraft turbine engine parts shall be subject to qualification requirements of this test method.

1. Scope

1.1 This test method establishes a test procedure for determining the propensity of aircraft turbine engine cleaning and maintenance materials for causing stress corrosion cracking of titanium alloy parts.

1.2 The evaluation is conducted on representative titanium alloys by determining the effect of contact with cleaning and maintenance materials on tendency of prestressed titanium alloys to crack when subsequently heated to elevated temperatures.

1.3 Test conditions are based upon manufacturer's maximum recommended operating solution concentration.

1.4 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see 6.3 and 6.5.

2. Referenced Documents

2.1 *ASTM Standard:*

D 1193 Specification for Reagent Water[2]

2.2 *SAE Aerospace Material Specifications:*

AMS 4911 Sheet, Strip and Plate-6AL-4V Annealed[3]

AMS 4916 Sheet, Strip, and Plate-8AL 1MO 1V, Duplex Annealed[3]

3. Significance and Use

3.1 Due to the tendency of prestressed titanium alloy parts to crack if heated while in contact with certain chemical reagents, it is necessary to ensure that cleaning and maintenance materials will not initiate stress corrosion of titanium alloys under controlled conditions.

4. Apparatus

4.1 *Measuring Device* capable of linear measurement with a ±0.01-in. (±0.25-mm) tolerance.

4.2 *Press Forming Apparatus*[4] with 0.56-in. (14-mm) diameter mandrel capable of producing approximately 65° bends in 0.050-in. (1.25-mm) titanium alloy sheet specimens.

4.3 *Beakers or Small Tanks* for containment of cleaning, rinsing, and test solutions, appropriately lined to prevent contamination of the solutions by container materials.

4.4 *Vise,*[5] capable of precise manipulation at jaw opening of 0.65 in. (16.5-mm).

4.5 *Air Circulation Furnace*[6] capable of operating at 900°F (480°C) with control to ±20°F (10°C).

4.6 *Magnifier*[7] capable of 20-diameters magnification.

4.7 *Microscope*[8] capable of 500-diameters magnification.

4.8 *Bolt,* stainless steel, 0.25-in. (6-mm) diameter with stainless steel washers and nut.

4.9 *Test specimens, AMS 4911 and AMS 4916 Titanium Alloys* with specimens prepared from the same sheet stock for each alloy and cut parallel to the rolling direction to the dimensions of Fig. 1. The specimen edges shall not be deburred or otherwise relieved prior to testing.

4.10 *Cotton Gloves,* white.

5. Reagents and Materials

5.1 *Purity of Reagent*—Reagent grade chemicals shall be used in all cases. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[9] Other

---

[1] This test method is under the jurisdiction of ASTM Committee F-7 on Aerospace and Aircraft and is the direct responsibility of Subcommittee F07.07 on Qualification Testing of Aircraft Cleaning Materials.

Current edition approved July 26, 1985. Published September 1985.

[2] *Annual Book of ASTM Standards*, Vol 11.01.

[3] Available from Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

[4] A laboratory bench hydraulic press ENER PAC Model No. P-39 manufactured by Black Hawk Industrial Products, Butler, WI, has been found satisfactory.

[5] A standard sheet metal worker's vise with a 3-in. jaw has been found satisfactory.

[6] A Blue M Electric Co. POM-6680F-1 furnace has been found satisfactory.

[7] A Bausch and Lomb Stereo Zoom 4 Model KVB-73 has been found satisfactory.

[8] A Bausch and Lomb Micro Zoom Catalog No. 31-19-30-02 has been found satisfactory.

[9] *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmaceutical Convention, Inc. (USPC), Rockville, MD.

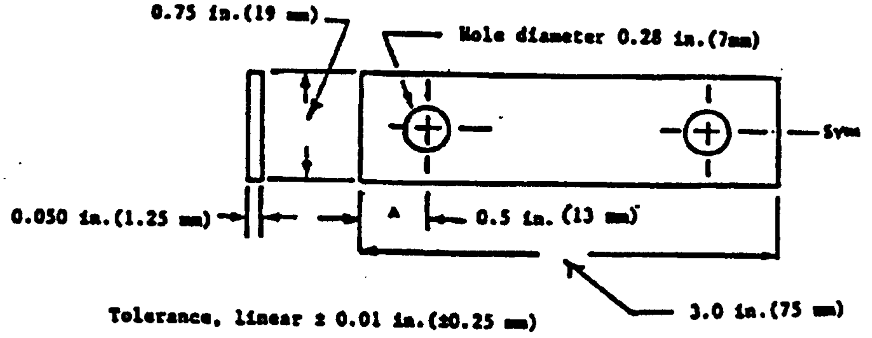

FIG. 1 U-Bend Specimen Dimensions

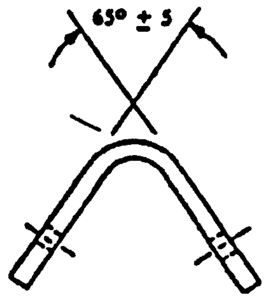

FIG. 2 Brake Formed U-Bend Specimen

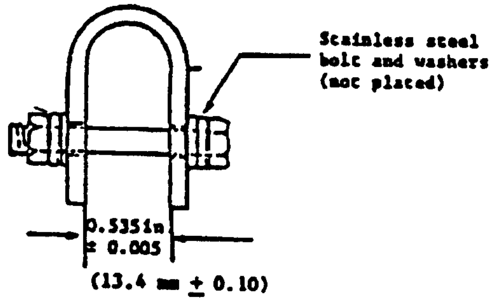

FIG. 3 Loaded U-Bend Specimen

grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of analysis.

5.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water conforming to Specification D 1193 Type IV.

5.3 *Cleaning Solution,* mix 35 volume % nitric acid (42 Be') (**Caution**—See Annex A1.2) and 3 volume % hydrofluoric acid (70 %) (**Caution**—See Annex A1.3) with reagent water.

5.4 *Salt Solution,* dissolve 3 weight % sodium chloride in distilled water.

5.5 *Solvent,* toluene or methyl ethyl ketone. (**Caution**—See Annex A1.1).

6. Precleaning Test Specimens

6.1 Handling contamination and shop soils may be removed by washing in a solvent. Dry thoroughly.

7. Specimen Fabrication

7.1 With the short specimen axis as the bend axis, press form the specimen around an approximately 0.45-in. (14-mm) diameter mandrel in one operation so that an unrestrained preform angle of approximately 65° is obtained. See Fig. 2.

7.2 Clean the specimen preform by immersing in cleaning solution of 5.3 for 15 ± 5 s. Rinse in clean water, then in reagent water. Air dry with the bend zone up. Use white cotton gloves when handling specimens, and do not touch the bend zone after cleaning.

7.3 Final U-bend configuration shall be accomplished by bending the free ends of the preform together in a vise until the distance between the free ends is reduced to 0.65 in. ± 0.05 (16.5 ± 1 mm). See Fig. 3.

7.4 Restrain the test specimen with sides approximately parallel by fastening the ends with a clean 0.25-in. (6-mm) diameter stainless steel bolt with washers. Unplated steel nuts may be used. See Fig. 1.

7.5 Load the specimen by tightening the bolt until the legs are 0.535 ± 0.005 in. (13.6 ± 0.10-mm) apart. See Fig. 3.

8. Procedure (See Fig. 4)

8.1 Test a minimum of nine specimens of each alloy using the following procedure.

8.1.1 To establish acceptability of the titanium alloy sheet materials for use in these tests, test three restrained test specimens of each alloy without contacting any test solution after acid cleaning.

8.1.2 To establish sensitivity of the titanium alloy sheet materials to stress corrosion attack, wet three restrained test specimens of each alloy by immersing in a solution of 3 weight % of sodium chloride in reagent water. Hang to dry with the bend zone down. Remove and test as in 8.2.

8.1.3 To evaluate the effect of the candidate solution, wet three restrained test specimens of each alloy by immersing in the candidate solution at the maximum recommended concentration. Hang to dry with the bend zone down, and test as in 8.2.

8.2 Heat the restrained specimens in an air circulation furnace in accordance with method(s) to be specified by the purchaser as follows:

- Preliminary Examination—20X
  - Examine Control Specimens:
    - If any are cracked, *repeat entire test.*
    - If none are cracked proceed to examine candidate solution treated specimens.
    - Hold uncracked NaCl treated specimens for metallographic examination.
  - Examine Candidate Solution Treated Specimens:
    - If all are cracked, *candidate cleaning compound is rejected.*
    - If some or none are cracked, proceed to clean specimens and perform metallographic examination.
- Metallographic Examination—500X
  - Examine Control Specimens:
    - If any are cracked, *repeat entire test.*
    - If none are cracked, proceed to examine NaCl and candidate solution treated specimens.
  - Examine NaCl Solution Treated Specimens:
    - If not all are cracked, *repeat entire test procedure.*
    - If all are cracked, proceed to examine candidate solution treated specimens.
  - Examine Candidate Solution Treated Specimens:
    - If none are cracked, *candidate cleaning compound is accepted.*
    - If all are cracked, *candidate cleaning compound is rejected.*
    - If some are cracked, *entire test procedure may be repeated at the tester's option.*

FIG. 4 Process Flow Chart

8.2.1 *Method A*—Heat at 900 ± 20°F (480 ± 10°C) for 8 ± 0.2 h.

8.2.2 *Method B*—Heat at 500 ± 20°F (260 ± 10°C) for 168 ± 4 h.

8.2.3 After heating, remove the specimens from the furnace, allow to cool, and inspect for cracks.

8.3 *Preliminary Evaluation*—Inspect all of the restrained specimens visually using 20-diameters magnification.

8.3.1 If cracks are found on the untreated (control) specimens, repeat the entire stress corrosion test using acceptable titanium alloy sheet material.

8.3.2 If cracks are found on all candidate solution treated specimens, this shall be cause for rejection of the candidate cleaning material.

8.3.3 All restrained specimens not found to be cracked during visual inspection at 20-diameters magnification prepare for further inspection as follows:

8.3.3.1 Remove the bolt restraints.

8.3.3.2 Rinse in warm tap water; do not permit to dry.

8.3.3.3 While wet, immerse in acid cleaning solution of 6.3 for 15 ± 5 s.

8.3.3.4 Rinse in tap water and air dry.

8.3.3.5 Inspect metallographically as in 8.4.1.

8.4 *Metallographic Inspection.*

8.4.1 Make a cross section of each specimen at the bend normal to the bend axis (parallel to the test panel long axis). Cut the specimens using a fine-tooth hacksaw or other apparatus capable of producing a smooth cut with minimal disturbance of specimen edges. Make the cut approximately at the center axis in line with the holes. The metallographic specimen shall encompass material from the bend to a point approximately 0.5 in. (13-mm) from the bend. Examine the cut surface over the 0.5-in. (13-mm) distance on both sides of the bend zone at 500-diameters following metallographic preparation appropriate to the specimen alloy composition.

8.5 For the Process Flow Chart, see Fig. 4.

9. Determination of Test Results

9.1 Detection of cracks on either the tension or compression surfaces of any of the untreated (control) specimens shall be cause to repeat the entire stress corrosion test using acceptable titanium alloy sheet material.

9.2 Failure to detect cracks on either the tension or compression surfaces of all of the sodium chloride solution treated specimens shall be cause to repeat the entire stress corrosion test using titanium alloy sheet having a demonstrated susceptibility to stress corrosion cracking.

9.3 Examine tension and compression surfaces of candidate solution treated specimens for cracks and make one of the following dispositions:

9.3.1 Failure to detect cracks on any specimen shall constitute an acceptance test for the candidate cleaning material.

9.3.2 Detection of cracks on all specimens shall be cause for rejection of the candidate cleaning material.

9.3.3 If some of the specimens do not exhibit cracks, the entire stress corrosion test may be repeated at the option of the testing facility.

10. Report

10.1 Report the name, type, source, and concentration of the candidate material.

10.2 Report the acceptance or rejection of the candidate material.

10.3 Report a description of any observed corrosion phenomena not considered in 9.3.

10.4 Report whether retesting was conducted in accordance with 8.3.1, 9.1, 9.2, or 9.3.3.

11. Precision and Bias

11.1 *Precision*—The precision of this test method has not been determined. A cooperative laboratory program is planned to obtain this data.

11.2 *Bias*—An estimate of the bias of this test is not possible.

ANNEX

(Mandatory Information)

A1. PRECAUTIONARY STATEMENTS

A1.1 Solvent (Typical for Toluene)

WARNING—Flammable. Vapor harmful.
Keep away from heat, sparks and open flame.
Keep container closed.
Use with adequate ventilation.
Avoid breathing of vapor or spray mist.
Avoid prolonged or repeated contact with skin.

A1.2 Nitric Acid (concentrated)

DANGER—Poison. Corrosive. Strong oxidizer.
Contact with organic material may cause fire.
May be fatal if swallowed.
Liquid and vapor cause severe burns.
Harmful if inhaled.
May cause delayed lung injury.
Spillage may cause fire or liberate dangerous gas, or both.
Do not get in eyes, on skin, or on clothing.
Do not breathe vapor, spray, or mist.
Dilute by adding acid to water.
Keep in tightly closed container in approved acid storage cabinet.
Keep cool.
Loosen closure carefully when opening.
Use with adequate ventilation.
Keep from contact with combustible materials.
Keep container closed when not in use.
Use protective clothing and goggles when handling.
Wash thoroughly after handling.

A1.3 Hydrofluoric Acid (concentrated)

DANGER—Poison. Corrosive. Strong oxidizer.
Contact with organic material may cause fire.
May be fatal if swallowed.
Liquid and vapor cause severe burns.
Harmful if inhaled.
May cause delayed lung injury.
Spillage may cause fire or liberate dangerous gas, or both.
Do not get in eyes, on skin, or on clothing.
Do not breathe vapor, spray, or mist.
Dilute by adding acid to water.
Keep in tightly closed container in approved acid storage cabinet.
Keep cool.
Loosen closure carefully when opening.
Use with adequate ventilation.
Keep from contact with combustible materials.
Keep container closed when not in use.
Use protective clothing and goggles when handling.
Wash thoroughly after handling.

Designation: F 1110 – 90

Standard Test Method for Sandwich Corrosion Test[1]

This standard is issued under the fixed designation F 1110; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method defines the procedure for evaluating the corrosivity of materials on aluminum alloys commonly used for aircraft structures. This test method is intended to be used in the qualification and approval of compounds employed in aircraft maintenance operations.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific hazard statements appear in Section 9.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1193 Specification for Reagent Water[2]

D 1748 Test Method for Rust Protection by Metal Preservatives in the Humidity Cabinet[3]

G 46 Practice for Examination and Evaluation of Pitting Corrosion[4]

2.2 *Federal Specifications:*

QQ-A-250/4 Al Alloy 2024 Plate and Sheet[4]

QQ-A-250/5 Al Alloy Alclad 2024 Plate and Sheet[4]

QQ-A-250/12 Al Alloy 7075 Plate and Sheet[4]

QQ-A-250/13 Al Alloy Alclad 7075 Plate and Sheet[4]

2.3 *Military Specification:*

MIL-A-8625 Anodic Coatings for Aluminum and Al Alloys[4]

3. Terminology

3.1 *Description of Term Specific to This Standard:*

3.1.1 *sandwich corrosion test*—a comparative accelerated environmental test of the corrosivity of liquid or solid materials on structural aluminum alloys commonly used in aerospace construction.

4. Summary of Test Method

4.1 Aluminum coupons having clad or anodized nonclad surfaces are sandwiched together with a filter paper saturated with the test material between the coupons. The sandwiched coupons are cycled between warm ambient air and warm humid air for 7 days. The coupons are then inspected to determine whether corrosion more severe than that caused by reagent water has occurred on the surfaces exposed to the test material. This test method may be used for solutions of dry granular material or for liquid materials.

5. Significance and Use

5.1 The data generated by this test method shall be used to determine whether aircraft structural aluminum alloys are liable to be corroded or damaged by application of the test material during routine maintenance operations.

5.2 Interpretation of the sandwich corrosion test results is based on a comparison of the appearance of faying surfaces of three sets of coupons. One set of test coupons is exposed with reagent water only in the faying surfaces, to establish the baseline (controls) against which the panels exposed to the test material are compared. Corrosion at cut edges of the test coupons should be disregarded.

5.3 The relative corrosion severity rating system is provided in order to allow a numerical classification of the test results and to eliminate the necessity for elaborate weight loss measurements. Pitting corrosion, which is rated 4—extensive (severe) corrosion, may involve only a negligible weight loss.

5.4 Relative corrosion severity rating system

0—No visible corrosion
1—Very slight corrosion or discoloration
2—Slight corrosion
3—Moderate corrosion
4—Extensive corrosion or pitting

0—No corrosion
1—Up to 5 % of the surface area corroded
2—5 to 10 %
3—10 to 25 %
4—25 % or more

6. Interferences

6.1 Tap water containing large amounts of dissolved solids, especially chlorides, may cause relative severe corrosion of the aluminum control panels. For this reason a reagent water is specified. For comparative purposes, a set of aluminum test panels, with the locally available tap water applied to the filter paper, may be run along with the reagent water panels.

6.2 Under certain conditions cellulose filter paper may react with the test aluminum alloy and change the test results. Filter paper made from glass fibers is available, and should be used, except for fluoride-containing compounds.

7. Apparatus

7.1 *Humidity Test Cabinet*, as specified in Test Method D 1748 or equal, capable of from 95 to 100 % relative

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[1] This test method is under the jurisdiction of ASTM Committee F-7 on Aerospace and Aircraft and is the direct responsibility of Subcommittee F07.07 on Qualification Testing of Aircraft Cleaning Materials.

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[2] *Annual Book of ASTM Standards*, Vol 11.01.

[3] *Annual Book of ASTM Standards*, Vol 05.01.

[4] *Annual Book of ASTM Standards*, Vol 03.02.

[5] Available from Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, PA 19120.

humidity at 37.7 ± 1°C (100 ± 2°F).

7.2 *Oven*, forced air circulation, capable of maintaining 37.7 ± 1°C (100 ± 2°F).

7.3 *Microscope*, binocular, 10× to 40×.

8. Reagents and Materials

8.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water as defined by Specification D 1193, Type IV.

8.2 *Aluminum Alloy Coupons:*

8.2.1 Aluminum alloy coupons shall conform to the following Federal Specifications:

QQ-A-250/4, 2024-T3 nonclad
QQ-A-250/5, 2024-T3 Alclad
QQ-A-250/12, 7075-T6 nonclad
QQ-A-250/13, 7075-T6 Alclad

8.2.2 *Coupon Size*—The recommended coupon size 50 by 100 by 1.0 to 1.5 mm (2 by 4 by 0.04 to 0.06 in.) has been found to provide suitable results for comparative tests. Smaller sizes are not recommended, because of the increased variations due to edge effects. Larger coupons are acceptable, but the space requirements for testing and storage should be considered.

8.3 Anodize the nonclad coupons in accordance with Military Specification MIL-A-8625C, Type 1 (Chromic Acid).

8.4 *Filter Paper*—Use Whatman GFA or equal filter paper made from glass fibers, 11 or 13 cms. Filter paper will not be required when the material being tested is a solid. Cellulose filter paper should be used with products containing fluorides.

9. Hazards

9.1 The materials used for aircraft maintenance may contain flammable solvents, strong acids or alkalis, or other toxic compounds. Take suitable precautions to prevent personal injury from these hazards. When the composition of the test material is not known, consult the manufacturer to determine whether any hazards exist.

9.2 Exercise special care in handling the chromic acid solution, specified in 8.3 for its etching properties.

10. Sampling

10.1 Agitate or thoroughly mix the test material to assure uniformity. Where dilution of the material is required, use reagent water or the solvent specified by the product manufacturer. Apply sufficient test material to saturate the area between the metal coupons.

11. Test Specimen

11.1 Prepare three sets of test panels. A test panel set shall consist of eight individual test coupons, sandwiched together in pairs of coupons of the same alloy and the same surface treatment, to provide four test coupon sandwiches for each test condition. Identify each coupon by impression stamping or other suitable permanent method.

11.2 Clean the panels by solvent wiping, or vapor degreasing. Do not use acid or caustic cleaners. Remove ink stamped markings from the panels. Do not use abrasive materials to clean the panels.

11.3 Prepare the test panel sets as follows for each alloy:

11.3.1 One set for the compound to be tested at use dilution,

11.3.2 One set for the compound to be tested in concentrated form and

11.3.3 One set for controls using reagent water.

12. Preparation of Apparatus

12.1 Verify that the humidity cabinet is operating at the specified temperature and humidity.

12.2 Verify that the air oven is operating at the specified temperature, with air circulation.

13. Calibration and Standardization

13.1 Since the test coupons include controls for comparative purposes, no special calibration or standardization procedures are required.

14. Conditioning

14.1 Conditioning of the test materials or the sets of prepared test coupons is not required. Thoroughly agitate the test sample before application to the test coupons.

14.2 Allow the anodized panels to age for a period of at least 48 h prior to exposure.

15. Procedure

15.1 Assemble the cleaned panels into three identical groups each having four different sets of panels suitably identified by permanent marking. Each panel set shall consist of two individual coupons of the same alloy and the same surface treatment.

15.2 Cut a piece of glass fiber filter paper to approximate 25 by 75 mm (1 by 3 in.). Fit this piece over one of the coupons. Add the test solution at the use concentration to the paper until saturated. Cover the wet paper with the second coupon of the sandwich pair. Repeat the operation for each of the coupon sets in the group. This test may be omitted if the test material is to be used in the concentrated form only. See 8.4 for deletion of the filter paper.

15.3 Prepare a second group of panels as outlined in 15.2 except apply the material to be treated in the concentrated as-received condition, without dilution by water or solvents. (Not applicable to dry granular materials.)

15.4 Prepare a third group of panels, as outlined in 15.2, except apply reagent water only to the filter paper between the panels.

15.5 During each test day, expose the panels in the air oven for 8 h followed immediately by exposure in the humidity cabinet. The alternating exposure periods should be started on a Monday morning with the initial exposure in the air oven. Over the following weekend the coupons should be left in the humidity cabinet. Maintain the humidity cabinet at 37.7 ± 1°C (100 ± 2°F) and 95 to 100 % relative humidity. Maintain the air oven at 37.7 ± 2.8°C (100 ± 5°F). Expose each set of panels individually, not stacked, in a horizontal position. After exposure, rinse the panels in warm tap water, and scrub lightly with a soft nonmetallic bristle brush. After drying, examine each panel under 10× magnification, and rate each set according to the scales in 5.4.

16. Interpretation of Results

16.1 Compare the corrosion rating on the set of panels from the first and second groups with those from the third, Reagent water, control group. Any corrosion in excess of that shown by group 3 shall be cause for rejection. Give pitting corrosion of any panel a severity rating of 4. Disregard any corrosion at the edges of the panel. Compare only those surfaces which were under the filter paper. Pitting is defined in Practice G 46.

17. Report

17.1 Prepare a report certifying that the test has been run in accordance with this test method and listing the exact conditions of the test as performed. Tabulate the corrosion rating of all test panels used in the test, and state whether the test compound is considered to be acceptable from a sandwich corrosion standpoint.

18. Precision and Bias

18.1 No statement is made about either the precision or bias of this test method since the result merely states whether there is conformance to the criteria for success specified in the accompanying material or process specification of the material being tested, or both.

APPENDIX

(Nonmandatory Information)

X1. RECOMMENDED PANEL IDENTIFICATION, TABULATION OF RESULTS, AND EXPOSURE SCHEDULE

X1.1 *Panel Identification:*

X1.1.1 *Test Material Diluted to Using Concentration:*

A-1 2024-T3 Nonclad Anodized
A-2 2024-T3 Alclad
A-3 7075-T6 Nonclad Anodized
A-4 7075-T6 Alclad

X1.1.2 *Test Material in Concentrated, As-Received Condition:*

B-1 2024-T3 Nonclad Anodized
B-2 2024-T3 Alclad
B-3 7075-T6 Nonclad Anodized
B-4 7075-T36 Alclad

X1.1.3 *Specification D 1193, Grade IV Control:*

C-1 2024-T3 Nonclad Anodized
C-2 2024-T3 Alclad
C-3 7075-T6 Nonclad Anodized
C-4 7075-T6 Alclad

X1.2 *Tabulation of Results:*

X1.2.1 See Fig. X1.1 for a recommended form for tabulation of results.

X1.3 *Exposure Schedule:*

X1.3.1 See Table X1.1 for a recommended exposure schedule.

NOTE—Record pitting corrosion separately, if present.

	Alloy			
Condition	1	2	3	4
A—Diluted				
B—Concentrate				
C—Specification D 1193, Type IV				

FIG. X1.1 Recommended Tabulation of Results

TABLE X1.1 Recommended Exposure Schedule[A]

Step	Exposure Time,[B] h ± ½	Conditions	
		Temperature °C (°F)	Relative Humidity, %
1	8	37.7 (100)	Ambient
2	16	37.7 (100)	95–100
3	8	37.7 (100)	Ambient
4	16	37.7 (100)	95–100
5	8	37.7 (100)	Ambient
6	16	37.7 (100)	95–100
7	8	37.7 (100)	Ambient
8	16	37.7 (100)	95–100
9	8	37.7 (100)	Ambient
10	64	37.7 (100)	95–100

[A] The sequence of steps is optional except tests shall be started on odd numbered steps.

[B] Total testing time is 168 h.

Designation: F 519 – 93

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If not listed in the current combined index, will appear in the next edition.

Standard Test Method for Mechanical Hydrogen Embrittlement Testing of Plating Processes and Aircraft Maintenance Chemicals[1]

This standard is issued under the fixed designation F 519; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers mechanical tests for the evaluation and control of the potential for hydrogen embrittlement that may arise from various sources of hydrogen as in plating processes, from fluids, cleaning treatments, maintenance chemicals, and gaseous environments that may contact the surface of steels.

1.2 The procedures and requirements are specified for five types of test specimens using a heat of AISI E4340 steel with demonstrated sensitivity. This test method is not intended to measure the relative susceptibility of other steels.

1.3 This test method assumes that AISI E4340 steel at 51HRC-54HRC, determined to be sensitive as specified in Table 1, is the worst case; that is, all other heat treated, high-hardness steels are less susceptible to hydrogen embrittlement.

1.4 For testing maintenance chemicals, the containment chamber must be isolated around the test specimen, as shown in Fig. 1 for Type 1a. If the test specimen and self-loading frame are to be immersed into the maintenance chemical, then the test fixture must be made from AISI E 4340 steel except that it can be vacuum melted and heat treated to a lower hardness by tempering at 482 ± 14°C (900 ± 25°F) to a hardness of 40HRC-43HRC. This is done in order to minimize any polarization effects of galvanic coupling that would influence the test results.

1.5 Specimen geometries, equivalent loading conditions, and the pass/fail requirements for each type are also specified.

1.6 *Classification*—Hydrogen embrittlement tests can be performed with specimens as specified in the following:

1.6.1 *Type 1—Notched:*

1.6.1.1 *Type 1a*—Round bar, loaded in tension, under constant load.

1.6.1.2 *Type 1b*—Round bar, loaded in tension, with self-loading ring.

1.6.1.3 *Type 1c*—Round bar loaded in bending with self-loading frame.

1.6.1.4 *Type 1d*—C-rings loaded in bending with self-loading bolt.

1.6.2 *Type 2*—Smooth (Unnotched).

1.6.2.1 *Type 2a*—Ring specimens loaded in bending with displacement bars.

1.7 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.8 This test method is limited to hydrogen embrittlement testing of steels that are exposed to the following:

1.8.1 An electrochemical plating process.

1.8.2 Maintenance chemicals, subsequent to cadmium plate.

1.9 The values stated in acceptable metric units shall be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[2]
D 1193 Specification for Reagent Water[3]
E 3 Methods of Preparation of Metallographic Specimens[4]
E 8 Test Methods for Tension Testing of Metallic Materials[4]
E 18 Test Methods of Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials[4]
E 30 Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron and Wrought Iron[5]
E 292 Practice for Conducting Time-for-Rupture Notch Tension Tests of Materials[4]
E 407 Test Methods for Microetching Metals and Alloys[4]
E 709 Guide for Magnetic Particle Examination[6]

2.2 *Military and Federal Standards:*[7]

MIL-H-6875 Heat Treatment of Steels, Process for
MIL-S-5000 Steel, Chrome-Nickel-Molybedenum (E 4340) Bars and Reforging Stock
MIL-S-13165 Shot Peening of Metals
MIL-S-851 Steel Grit, Shot and Cut Wire Shot; and Iron Grit and Shot Blast Cleaning and Peening
MIL-C-16173 Corrosion Preventive Compound, Solvent Cutback, Cold-Application
Federal Specification QQ-P-416 Plating, Cadmium (Electrodeposited)

3. Summary of Test Method

3.1 *Plating Processes*—Unstressed test specimens (see 6.1)

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[1] This test method is under the jurisdiction of ASTM Committee F-7 on Aerospace and Aircraft and is the direct responsibility of Subcommittee F07.04 on Hydrogen Embrittlement.

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[2] *Annual Book of ASTM Standards*, Vol 01.03.

[3] *Annual Book of ASTM Standards*, Vol 11.01.

[4] *Annual Book of ASTM Standards*, Vol 03.01.

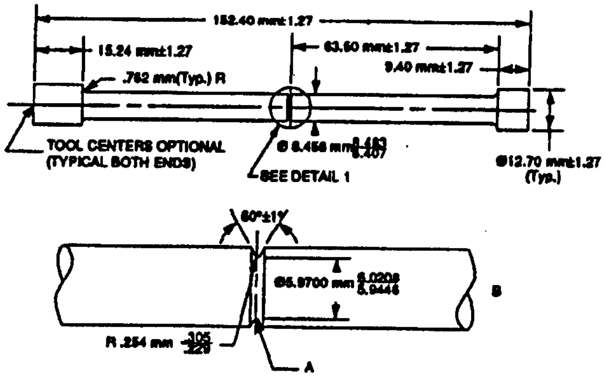
[5] *Annual Book of ASTM Standards*, Vol 03.05.

[6] *Annual Book of ASTM Standards*, Vol 03.03.

[7] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

TABLE 1 Electroplating Bath Compositions and Operating Conditions for Sensitivity Testing of Heats of AISI E4340 Steel

Bath Composition	Treatments	
	A	B
Cadmium (as CdO)	33.7 g/L (4.5 oz/gal)	33.7 g/L (4.5 oz/gal)
Sodium cyanide (NaCN)	104 g/L (14 oz/gal)	104 g/L (14 oz/gal)
Ratio NaCN to CdO	3	3
pH	12	12
Temperature	21–32°C (70–90°F)	21–32°C (70–90°F)
Sodium hydroxide (NaOH)	18.7 g/L (2.5 oz/gal)	18.7 g/L (2.5 oz/gal)
Brightener, Rohco 20 × L	15.0 g/L (2.0 oz/gal)	
Electroplating current	108 A/m² (10 A/ft²)	645 A/m² (60 A/ft²)
Electroplating time	30 min	6 min
Baking temperature	190 ± 14°C (375 ± 25°F)	190 ±14°C (375 ± 25°F)
Baking time; Type 1 Specimens	Do Not Bake	23 h
Baking time; Type 2 Specimen	8 h	23 h



DETAIL 1
Scale: Four times size

A - Root radii, reduced section, and notch root radius must be concentric with centerline of specimen within .076 mm T.I.R. Transitional taper to blend and fair into the .229 to .305 mm(.009 to .012 in.) radius. All surfaces of the notch must have a 32 finish.

B - For alternative specimen geometries that have reduced tensile load requirements, it is essential that a stress concentration factor (K_t) of 2.9 to 3.3 be maintained. For the relationship between geometry and K_t, see Peterson, R. E., Stress Concentration Factors, John Wiley and Sons, 1974.

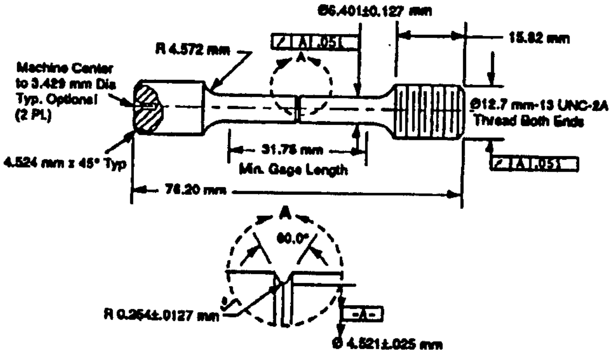


FIG. 1 Dimensional Requirements for Type 1a Specimens

are exposed to the same cleaning and plating procedure as will be used for the part, and baked for the same time and temperature as required for that plating process. After exposure and baking, test specimens are then maintained under a constant load in air, during the entire test period.

3.2 *Maintenance Chemicals*—Test specimens, prepared per Table 1, Treatment B, are loaded and then exposed to maintenance chemicals (see 8.2.3).

3.3 The sensitivity of each lot of AISI E 4340 steel is established by exposing six trial specimens to two different embrittling environments after manufacture and inspection in accordance with 7.3 and 7.4. Three specimens shall be electroplated under the highly embrittling conditions produced in a cadmium cyanide bath by Treatment A (Table 1) and the remaining three specimens shall be electroplated under the less embrittling conditions of Treatment B. A lot of the steel will be of suitable sensitivity only if, after loading to the equivalent loads specified in 8.1, all three specimens plated by Treatment A fail within 24 h and all three specimens plated by Treatment B do not fail within 200 h. When Type 1 specimens are plated in Treatment A, DO NOT BAKE.

4. Significance and Use

4.1 *Plating*—This test method establishes tests that are useful where strict controls must be maintained during production operations such as surface preparation and plating to prevent hydrogen embrittlement of high-strength steel parts during manufacture.

4.2 *Maintenance Chemicals*—These tests are also required to determine the hydrogen embrittlement potential of chemicals that may contact cadmium plated, high-strength, Type 4340 steel parts during manufacturing, overhaul, and service life.

5. Apparatus

5.1 *Loading Device.*

5.1.1 *Sustained Loading Device* (see 8.1.1).

5.1.2 *Self-Loading Fixtures*—All materials in the test fixtures shall be in accordance with the corresponding drawings with the exception that for maintenance chemicals when the test environment is an aqueous environment, the fixture shall be made of AISI E 4340 steel which shall be vacuum melted, heat treated, and tempered to 482 ± 14°C (900 ± 25°F) to a hardness of 40HRC to 43HRC.

5.2 Clean nonconductive and inert immersion container.

6. Readings and Materials

6.1 Sensitive heat of AISI E 4340 steel as defined in Table 1.

6.2 Aluminum oxide (150 grit or finer), and 180-grit silicon carbide paper.

6.3 Clean shot, size in accordance with MIL-S-13165.

6.4 *Corrosion*—Preventive compound, meeting the requirements of MIL-C-16173, Grade 2.

6.5 *Cadmium*—Cyanide electroplating bath (Federal Specification QQ-P-416). (Reference Table 1.)

6.6 Cleaners and paint strippers.

6.7 Chromic acid.

6.8 *Water*—Specification D 1193 Type IV.

7. Mechanical Test Specimens

7.1 *Number*—A minimum of three specimens shall be used for each test.

7.2 *Test Specimen*—AISI E 4340 steel at 51HRC to

54HRC is assumed to be the worst case; that is, all other heat-treated, high-hardness steels are less susceptible to hydrogen embrittlement. AISI E 4340 steel produced in accordance with MIL-S-5000, shall be used and heat treated to a hardness of 51HRC to 54HRC, reference tensile strength of 1800 to 1930 MPa (260 to 280 ksi) in accordance with MIL-H-6875. The 0.2 % offset yield strength shall be at least 80 % of the ultimate tensile strength.

7.3 *Dimensions*—Each test specimen shall conform to the following dimensions:

Type 1a—In accordance with Fig. 1
Type 1b—In accordance with Fig. 2
Type 1c—In accordance with Fig. 3
Type 1d—In accordance with Fig. 4
Type 2a—In accordance with Fig. 5

7.4 *Manufacture:*

7.4.1 All Type 1 specimens shall be ground to size after heat treatment. Continuous shaping of the grinding wheel (crush grinding) is used to produce all notches. Stress relief bake at 190 ± 14°C (375° ± 25°F) for 3 h.

7.4.2 Type 2a smooth ring specimens are machined to size from normalized and stress-relieved tubing or bar stock.

7.4.2.1 Specimens shall be deburred by hand, using silicon-carbide paper, prior to heat treat.

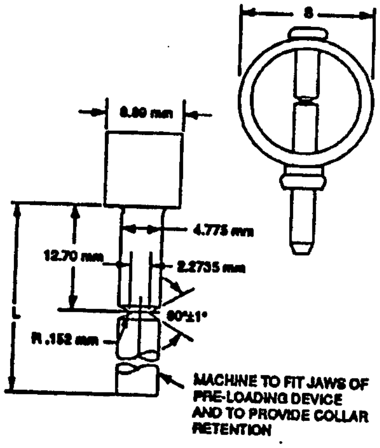
7.4.2.2 Specimens shall be heat treated from 51HRC to 54HRC. One specimen per lot shall be microstructurally examined to determine evidence of decarburization.

7.4.2.3 Specimens shall receive a light aluminum oxide blast (see 7.4.3) after final heat treat.

7.4.2.4 All surfaces of specimens shall be shot peened using conditioned shot. The shot intensity shall be Almen "A" 0.15 to 0.25 mm (0.006 to 0.010 in.) in accordance with MIL-S-13165.

Assembly of Type 1b Specimens with Type 1b Stress Ring with Locking Collar.

A flexible Plastic Collar is inserted over loaded specimen for protection. See Figure 7.

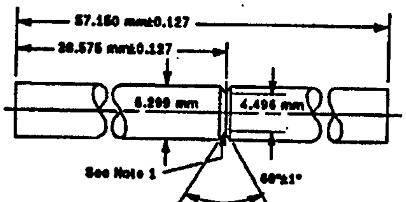


Note 1-"L" to be 38.1 mm (1.5 in.) or greater.
Note 2-Tolerance (unless otherwise specified):

XXX ±1.27 mm (.05 in.)
X.XXX ±.025 mm (.001 in.)
X.XXXX ±.0051 mm (.0002 in.)

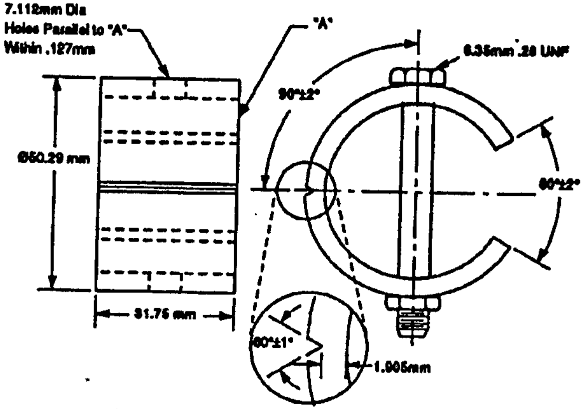
Note 3-Specimens and loading device that have been found to meet the standard are available from Stapleton Co., 1350 W 12th St., Long Beach, Calif. 90813.

FIG. 2 Dimensional Requirements of Type 1b Tension Specimen



Note 1- Notch root radius to be .127±.013 mm(.0050±.0005 in.).
Note 2- Notch surface must have a 8 finish or better.
Note 3- Tolerances (unless otherwise specified):
X.XXX ± .025 mm(.001 in.)

FIG. 3 Dimensional Requirements of Type 1c Bend Specimens



Note 1-Notch root radius to be .0762 ±.0127 mm(.0030±.0005 in.).
Note 2-Notch surface must have a 8 finish or better.
Note 3-Tolerances (unless otherwise specified):
X.XX ± .25 mm (.01 in.)
X.XXX ± .025 mm (.001 in.)

FIG. 4 Dimensional Requirements of Type 1d Ring Bend Specimens with Loading Bolt

7.4.2.5 Specimens shall receive a light aluminum oxide blast (see 7.4.3) after shot peening.

7.4.3 Clean all surfaces by blasting lightly with 150 grit or finer aluminum oxide after final heat treatment and again after shot peening. Use a 9.5 to 12.7-mm (0.375 to 0.5-in.) nozzle, 210 to 345-kPa (30 to 50-psi) pressure, approximately 250 mm (10 in.) from part surface and move continuously.

7.4.4 Acid or cathodic electrolytic cleaning is prohibited.

7.4.5 Straightening after final heat treatment is prohibited.

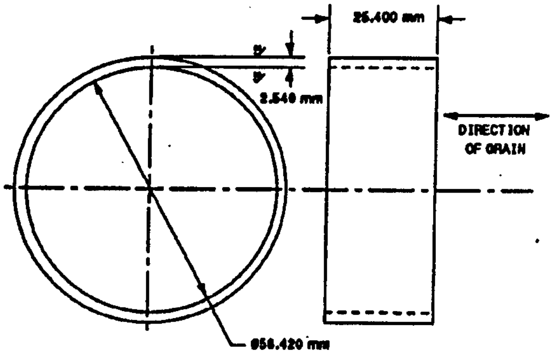
7.4.6 Grinding after final heat treatment is prohibited for Type 2a.

7.5 *Inspection:*

7.5.1 A lot shall consist of only those specimens cut from the same heat of steel in the same orientation, heat treated together in the same furnace, quenched together in the same bath, and subjected to the same additional manufacturing processes at the same time.

7.5.2 Type 1 specimens shall be suitable for test purposes if a sampling and inspection is in conformance to the requirements of Table 2.

7.5.3 Type 2a smooth rings specimens shall be suitable for test purposes if each specimen is inspected and found to be in



Note 1- Surface finish 8√ to be held prior to shot peening.
Note 2- Ovality of ring must be within tolerance before and after heat treatment and shot peening.
Note 3- Ovality of ring is determined by measuring the diameter of the ring at three locations oriented 60 Degrees apart.
Note 4- Tolerances (unless otherwise specified):

X.XX	± .25 mm (.01 in.)
X.XXX	± .051 mm (.002 in.)

FIG. 5 Dimensional Requirements of Type 2a Smooth Ring Specimens

conformance with the requirements of Table 3.

7.6 *Storage*—All specimens shall be stored in such a manner as to prevent corrosion.

8. Test Procedures

8.1 *Plating Process:*

8.1.1 *Type 1a*—For specimens shown in Fig. 1, the load carrying capacity of the sustained loading device must meet or exceed 8170 kg (18 000 lb) for loading to 75 % of the notched ultimate tensile strength. The capacity of the testing machine for determination of the notched ultimate tensile strength in accordance with Table 1 must exceed 10 890 kg (24 000 lb). The load requirements may be reduced by using a smaller diameter round bar if a K_t of 2.9 to 3.3 is maintained.

8.1.2 *Type 1b*—The method of spring-loading notched round bars in tension uses a precalibrated ring as detailed in Fig. 6. The ring manufacturer calibrates each ring by determining the change in diameter of the ring when subjected to a load equivalent to that required to stress a test specimen to 75 % of its notched ultimate strength.

8.1.2.1 Mechanisms used to load a test specimen in a stressed ring must be able to hold the test specimen at a stress level of 90 % of the maximum load applied to the specimen. A method that allows loading and locking test specimens at stress levels as high as 75 % of their notched tensile strength is described as follows. No torsional loads shall be introduced during loading.

TABLE 3 Acceptance Criteria for Type 2A O-Ring Specimens

Property	Requirement/Method
Hardness[A]	51HRC to 54HRC (Test Method E 18)
Dimensions[A]	Conformance to Fig. 5
Surface quality[A]	No magnetic indications >0.8 mm (0.03125 in.) Guide E 709
Scratches	Not allowed

[A] Only specimens meeting listed criteria shall be acceptable for testing.

8.1.2.2 Insert the test specimen in a calibrated ring. Fit the end of the specimen extending through the ring with a stainless steel retaining collar and insert it into the jaws of a hydraulic loading device. As the load is applied, the collar is swaged to the shaft of the specimen. The change in ring diameter after removal from the hydraulic loading device indicates the actual stress level obtained (test load), and this must be at least 90 % of the change in ring diameter produced during initial loading. If the specimen has not failed by the end of the test period, the measured ring diameter must be within 0.025 mm (0.001 in.) of that measured after initiating the test.

8.1.2.3 **Warning**—To prevent possible injury from a premature failure of a loaded specimen, mount a protective collar over the specimen and ring immediately after loading as shown in Fig. 7.

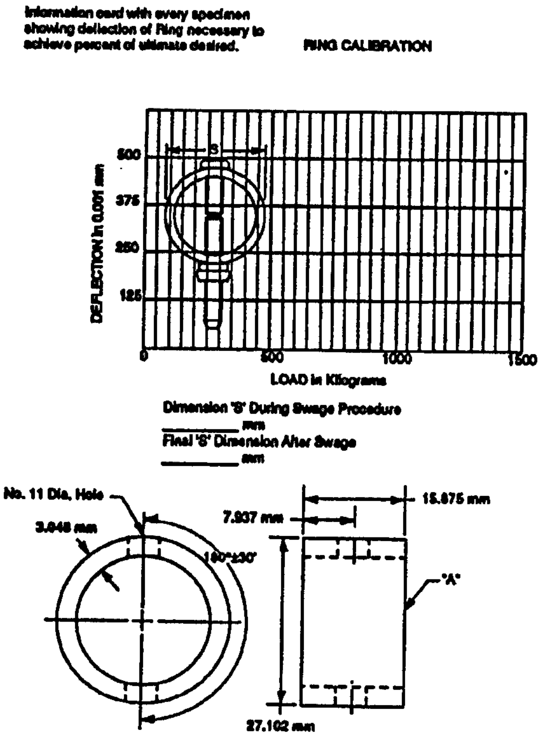
8.1.3 *Type 1c*—For specimens shown in Fig. 3, the device used to subject notched round bars to bending loads is shown in Fig. 8. Calibrate each device by counting the number of turns of the loading bolt required to fracture the specimen. Start the counting at the point where the tightening of the loading bolt first eliminates all slack in the mechanism. Note this position of the loading bolt and measure the distance between the loading bars at each end to ensure that the same starting point is used for each loading. Stress levels are then indicated as a percentage of the average number of turns required to cause failure in the calibration process.

8.1.4 *Type 1d*—Place the specimen under a sustained load and using a loading bolt oriented across the diameter of the specimen opposite the notch as shown in Fig. 4. Determine the average diameter of the notched C-ring at fracture with unexposed specimens (see Table 1) with the

TABLE 2 Lot Acceptance Criteria for Notched Specimens

Type	Property	Sampling of Each Lot	Requirement/Method
1a, 1b, 1c, 1d	Hardness[A]	5 %	Between 51HRC and 54HRC, Test Methods E 18.
1a, 1b, 1c, 1d	Notched surface quality[A]	10 %	No grinding burns or untempered martensite (discoloration method or nital etch Methods E 3, E 407).
1a, 1b	Dimensions	100 %	Meet tolerances of corresponding 1c, 1d figures. Notch dimension verified with shadowgraphic projection at 50x–100x.
1a, 1b	Cracks	100 %	Nondestructive tests—No cracks 1c, 1d permitted in any location. Magnetic particle inspection according to Guide E 709.
1a, 1b	Notched tensile load	10 specimens	NTS of each specimen must be within 69 MPa (10 ksi) of the average.
1c	Notched bend load	10 specimens	Number of turns of the loading bolt to produce failure in each specimen must be within 5 percent of the average.
1d	C-Ring bend load	10 specimens	The change in diameter at failure for each specimen must be within 0.13 mm (0.005 in.) of the average.

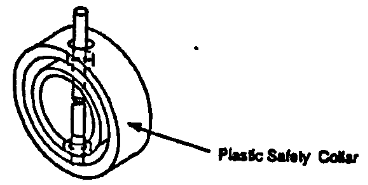
[A] If the hardness or notch surface quality requirements of any of the sampled specimens are not satisfied, only those specimens of the lot that are individually inspected for conformance to these requirements may be used for testing.



NOTE 1 - No. 11 diameter holes located at true position within .127 mm (.005 in.) diameter and drilled parallel to face "A" within .076 mm (.003 in.).
NOTE 2 - Material to be AISI 4130 steel heat treated in accordance with MIL-H-6875 to a tensile strenght between 1380 and 1520 MPa (200 and 220 ksi).
NOTE 3 - Tolerances (unless otherwise specified):

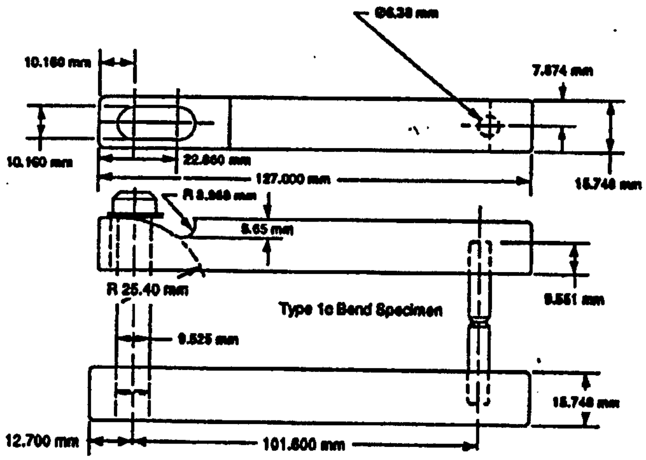
X.XXX ± .127 mm (.005 in.)
X.XXXX ± .0635 mm (.0025 in.)

FIG. 6 Dimensional Requirements of This Type 1b Stressing Ring



NOTE 1 - A flexible collar (44.45 mm outside diameter with 6.35 mm wall) is inserted over the specimen and stressing ring after loading to the required stress level.

FIG. 7 Protective Collar Installation on Type 1b Test Specimens and Stressing Ring



NOTE 1 - Loading bars shall be made from Type 304 stainless steel 15.875 mm square bar.
NOTE 2 - Tolerance (unless otherwise specified):

X.X ± 2.5 mm(.1 in.)
X.XX ± .25 mm(.01 in.)
X.XXX ± .051 mm(.002 in.)

FIG. 8 Dimensional Requirements of Type 1c Loading Bending Bars

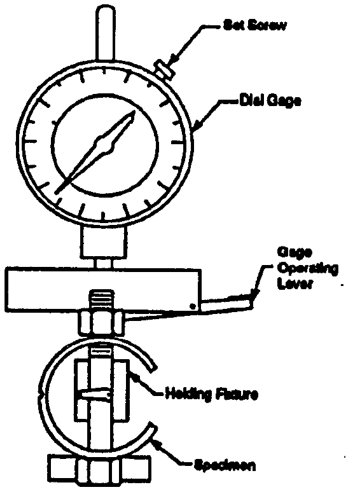


FIG. 9 Device for Measuring Deflection During Stressing of Type 1d C-Ring Bend Specimens

loading device in Fig. 9 or an equivalent method. Stress levels are indicated as percentages of the change in diameter required to fracture the specimens.

8.1.5 *Type 2a*—The specimen loading configuration involves the insertion of an oversized stressing bar into an O-ring, the dimension of the specimens are shown in Fig. 5, while the O-ring is compressed in a vise. The stressing bars are made in accordance with Fig. 10. The vise jaws should be faced with nonmarring material such as aluminum or rubber having a 60-shore A durometer hardness.

8.2 *Maintenance Chemicals:*

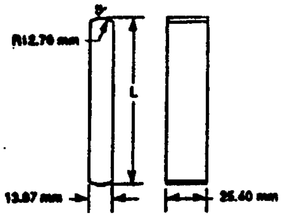
8.2.1 Test liquids in the concentrated condition and also at the maximum dilution at which the liquid maintenance chemicals can be used.

8.2.2 Test solids in the saturated condition and also at the minimum suggested concentration at which the dissolved solid maintenance chemicals can be used.

8.2.3 Conduct all tests at 20 to 30°C (68 to 86°F) or the operating service temperature of the maintenance chemicals and not exceed 66°C (150°F).

8.2.4 Degrease specimens and dry abrasive blast with alumina. Rinse the cleaned specimens free of abrasive with tap water; and while wet, immediately electroplate the specimens using the low-embrittlement cadmium cyanide bath (Treatment B, Table 1).

8.2.5 Rinse cadmium-electroplated specimens in tap



Note 1 - Bars should be made from plain carbon or low alloy steel.

Note 2 - Length "L" to be 61.341 ± .076 mm (2.415±.003 in.) to load Type 2a specimens to 80% of the yield strength. (Bars must be cadmium-electroplated with bright cadmium in accordance with QQ-P-416 prior to use.)

Note 3 - Length "L" to be 64.135 ± .051 mm (2.525 ± .002 in.) to load Type 2a specimens to 92% of the ultimate strength.

Note 4 - Tolerances (unless otherwise specified):
X.XX ± .25 mm (.01 in.)

FIG. 10 Dimensional Requirements of Type 2a Stressing Bars

water and then rinse by immersing and swirling for 15 s in a solution with a concentration equivalent to one containing 2.3 kg (5 lb) of chromic acid to 38 L (10 gal) of water. Remove the chromic acid from the specimens by rinsing in cold tap water followed by hot tap water, rinse, and dry. Place the cadmium-electroplated specimens in an oven at 191 ± 14°C (375 ± 25°F) for 23 h.

8.2.6 Each type of specimen for testing maintenance chemicals shall be loaded and then exposed as follows:

8.2.6.1 *Type 1a*—Assemble a minimum of three test specimens and place in tension (example shown in Fig. 11). Load specimens to 45 % of the notched ultimate tensile strength. Fill cups with the test solution and record the time to failure if less than 150 h. The test may be discontinued after 150 h (see 1.4).

8.2.6.2 *Type 1b*—A minimum of three test specimens shall be loaded to 55 % of the notch tensile strength as described in 8.1.2 to 8.1.2.3, Figs. 6 and 7. The loading rings shall also be cadmium-electroplated for fluid testing. Put the material to be tested into a clean plastic container, place the stressed specimens in the test solution, and record the time to failure if less than 150 h. The test may be discontinued after 150 h (see 1.4).

8.2.6.3 *Type 1c*—Load a minimum of three specimens to 45 % of the notched bend strength as described in 8.1.3 and Fig. 8. Put 800 mL of the test solution into a clean plastic container, place the stressed specimens in the test solution, and record the time to failure if less than 150 h. The test may be discontinued after 150 h (see 1.4).

8.2.6.4 *Type 1d*—Load a minimum of three test specimens to 65 % of the notch bend strength as described in 8.1.4 and Figs. 4 and 9. The loading bolt and nut shall also be cadmium plated. Put the maintenance chemical to be tested into a clean plastic container, place the stressed specimen into 800 mL of the test solution, and record the time to failure if less than 150 h. The test may be discontinued after 150 h (see 1.4).

8.2.6.5 *Type 2a*—Stress a minimum of three O-ring specimens to a deflection of 2.9 mm (0.115 in.) using a 61.34- mm (2.415-in.) cadmium-plated stress bar. (See 8.1.5 and Fig. 10.) Put the maintenance chemical to be tested in a proper container, immerse the stressed O-ring specimens in 800 mL of the maintenance chemical to be tested immediately after loading, and record the time to failure if it is less than 150 h. The test may be discontinued after 150 h.

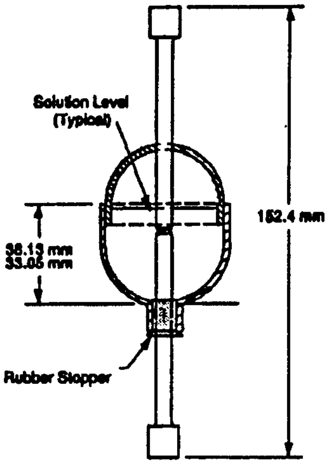


FIG. 11 Wet Notch

9. Interpretation of Results

9.1 *Plating Process*—A plating process shall be considered non-embrittling if the cadmium plated specimens do not fail within 200 h after applying the following loads:

Type 1 (a,b,c,d) at 75 % of the notch tensile load or bend load.
Type 2a at 92 % of the ultimate tensile load.

9.2 *Maintenance Chemicals*—A cleaner, paint stripper, or other maintenance chemical shall be considered non-embrittling if all specimens do not fail within 150 h after immersion in the cleaner or maintenance chemical being evaluated at the following loads:

Type 1a, 1c—45 % notch tensile load/bend load.
Type 1b—55 % notch tensile load/bend load.
Type 1d—65 % notch bend load.
Type 2a—80 % of 0.2 % offset yield load.

9.3 Failure times of all specimen types can be visually detected or electronically monitored with a relay switch system.

9.4 *Acceptance/Rejection Criterion:*

9.4.1 If none of the specimens fracture within the exposure time, the material or process shall be considered non-embrittling.

9.4.2 If only one of a minimum of three specimens fractures within the exposure time, retest the material or process with three unused specimens and if no fracture occurs within the exposure time, the material or process shall be considered non-embrittling. If any specimen fractures during retest, the material or process shall be considered embrittling.

9.4.3 As an alternative for Type 1a specimens: when one of a minimum of three specimens fractures in less than 200 h, continue loading the remaining two specimens. Upon completion of 200 h, step load the two specimens every hour in 5 % increments to 90 % notch tensile load/bend load. Leave samples at 90 % for 24 h. This information can be used to evaluate the significance of the single failure.

9.4.4 If two or more specimens fracture within the exposure time, the material or process shall be considered as having excessive embrittling characteristics.

9.4.5 Another retest can only be reconsidered after a metallurgical examination of the failed specimens indicates some defect in the processing of the specimens.

10. Report

10.1 The report shall provide the following minimum information:

10.1.1 The type and number of the specimens tested.

10.1.2 A description of the test environment (concentration, temperature, and so forth).

10.1.3 The load level (percent of unexposed value notched tensile strength, notch bend strength, change in diameter or ultimate tensile strength, yield strength).

10.1.4 Results (failure or exposure time under load in the test environments).

11. Precision and Bias

11.1 The acceptance and rejection criteria in 9.4 are the judgments for precision, and may vary with the precision on applied stress and test specimen notch geometry.

11.2 An interlaboratory study has not been made, therefore, a bias statement cannot be made at this time.

Designation: F 485 – 90 (Reapproved 1991)$^{\epsilon 1}$

Standard Test Method for Effects of Cleaners on Unpainted Aircraft Surfaces[1]

This standard is issued under the fixed designation F 485; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

$^{\epsilon 1}$ NOTE—An editorial change was made in Section 1.2 in December 1991.

1. Scope

1.1 This test method describes the procedure used to determine the effect of cleaners on unpainted aircraft surfaces. Visual observation is used for determining streaking or permanent stains which require polishing to remove.

1.2 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Significance and Use

2.1 This test method is used to ensure that candidate aircraft surface cleaners do not leave a residue which, on drying, would leave a permanent *stain* requiring polishing to remove.

3. Referenced Documents

3.1 *ASTM Standard:*

D 1193 Specification for Reagent Water[2]

3.2 *Federal Specification:*

QQ-A-250/13 Aluminum Alloy, Alclad 7075, Plate and Sheet[3]

3.3 *Military Specification:*

MIL-T-9046, Type III, Titanium and Titanium Alloy, Sheet, Strip, and Plate[3]

4. Test Specimens

4.1 *Materials:*

4.1.1 Aluminum 7075-T6 Alclad conforming to Federal Specification QQ-A-250/13.

4.1.2 Titanium Alloy 6A14V conforming to Military Specification MIL-T-9046, Type III.

4.1.3 *Reagent Water* conforming to Specification D 1193, Type IV.

5. Preparation of Test Specimens

5.1 Prepare two panels, each 2 by 6 by 0.020 in. (or 50 by 152 by 0.51 mm), from alclad aluminum and titanium alloy and clean them with methyl ethyl ketone or any suitable chlorinated solvent.

5.1.1 When using a chlorinated solvent, be aware that contamination of the solvent with water at levels of 300 to 400 ppm can instigate hydrolysis which will produce staining of aluminum panels.

6. Preparation of Test Solution

6.1 Make the solutions of the cleaner to be tested in reagent water (see 4.1.3) in accordance with the dilutions recommended by the manufacturer.

7. Procedure

7.1 Immerse the cleaned test specimens for 3 to 5 min in a sufficient quantity of the cleaning solution to cover approximately one half of the panel. After removing from the test solution, immediately place the panels at 45° from the horizontal in a mechanical convection oven maintained at 150 ± 5°F (65.5 ± 2°C) for 30 min. At the end of the 30-min period, remove the panels from the oven, cool to room temperature, rinse on each side within 15 min under running tap water for 1 min without using mechanical agitation, then rinse on each side with distilled or deionized water from a squeeze bottle for 15 s and allow to air dry for 30 min. Visually examine and compare the treated and untreated areas of the panels for the presence of residue or stains.

8. Report

8.1 Report the following:

8.1.1 The appearance of the panel after completion of the test, and

8.1.2 The concentration at which the test was performed and the diluent with which the cleaner was mixed, if other than distilled or deionized water (see 4.1.3).

9. Precision and Bias

9.1 Committee F-7 has no plans to establish a Precision and Bias statement for this test method.

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[1] This test method is under the jurisdiction of ASTM Committee F-7 on Aerospace and Aircraft and is the direct responsibility of Subcommittee F07.07 on Qualification Testing of Aircraft Cleaning Materials.

Current edition approved May 25, 1990. Published August 1990. Originally published as F 485 – 76. Last previous edition F 485 – 83$^{\epsilon 2}$.

[2] *Annual Book of ASTM Standards*, Vol 11.01.

[3] Available from Naval Publications and Forms Center, (NPFC-105), 5801 Tabor Ave., Philadelphia, PA 19120.

Designation: G 30 – 94

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If not listed in the current combined index, will appear in the next edition.

Standard Practice for Making and Using U-Bend Stress-Corrosion Test Specimens[1]

This standard is issued under the fixed designation G 30; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes procedures for making and using U-bend specimens for the evaluation of stress-corrosion cracking in metals. The U-bend specimen is generally a rectangular strip which is bent 180° around a predetermined radius and maintained in this constant strain condition during the stress-corrosion test. Bends slightly less than or greater than 180° are sometimes used. Typical U-bend configurations showing several different methods of maintaining the applied stress are shown in Fig. 1.

1.2 U-bend specimens usually contain both elastic and plastic strain. In some cases (for example, very thin sheet or small diameter wire) it is possible to form a U-bend and produce only elastic strain. However, bent-beam (Practice G 39 or direct tension (Practice G 49)) specimens are normally used to study stress-corrosion cracking of strip or sheet under elastic strain only.

1.3 This practice is concerned only with the test specimen and not the environmental aspects of stress-corrosion testing which are discussed elsewhere (1),[2] in Practices G 35, G 36, G 37, G 41, and G 44, and Test Method G 103.

1.4 The values stated in SI units are to be regarded as standard. The inch-pound units in parentheses are provided for information.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* (For more specific safety hazard information see Section 9.)

2. Referenced Documents

2.1 *ASTM Standards:*

G 1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens[3]

G 35 Practice for Determining the Susceptibility of Stainless Steels and Related Nickel-Chromium-Iron Alloys to Stress Corrosion Cracking in Polythionic Acids[3]

G 36 Practice for Performing Stress-Corrosion Cracking Tests in a Boiling Magnesium Chloride Solution[3]

G 37 Practice for Use of Mattsson's Solution of pH 7.2 to Evaluate the Stress-Corrosion Cracking Susceptibility of Copper-Zinc Alloys[3]

G 39 Practice for Preparation and Use of Bent-Beam Stress-Corrosion Specimens[3]

G 41 Practice for Determining Cracking Susceptibility of Metals Exposed Under Stress to a Hot Salt Environment[3]

G 44 Practice for Evaluating Stress Corrosion Cracking Resistance of Metals and Alloys by Alternate Immersion in 3.5 % Sodium Chloride Solution[3]

G 49 Practice for Preparation and Use of Direct Tension Stress-Corrosion Test Specimens[3]

G 103 Test Method for Performing a Stress-Corrosion Cracking Test of Low Copper Containing Al-Zn-Mg Alloys in Boiling 6 % Sodium Chloride Solution[3]

3. Summary of Practice

3.1 This practice involves the stressing of a specimen bent to a U shape. The applied strain is estimated from the bend conditions. The stressed specimens are then exposed to the test environment and the time required for cracks to develop is determined. This cracking time is used as an estimate of the stress corrosion resistance of the material in the test environment.

4. Significance and Use

4.1 The U-bend specimen may be used for any metal alloy sufficiently ductile to be formed into the U-shape without mechanically cracking. The specimen is most easily made from strip or sheet but can be machined from plate, bar, castings, or weldments; wire specimens may be used also.

4.2 Since the U-bend usually contains large amounts of elastic and plastic strain, it provides one of the most severe tests available for smooth (as opposed to notched or precracked) stress-corrosion test specimens. The stress conditions are not usually known and a wide range of stresses exist in a single stressed specimen. The specimen is therefore unsuitable for studying the effects of different applied stresses on stress-corrosion cracking or for studying variables which have only a minor effect on cracking. The advantage of the U-bend specimen is that it is simple and economical to make and use. It is most useful for detecting *large differences* between the stress-corrosion cracking resistance of (*1*) different metals in the same environment, (*2*) one metal in different metallurgical conditions in the same environment, or (*3*) one metal in several environments.

5. Test Specimen

5.1 *Specimen Orientation*—When specimens are cut from sheet or plate and in some cases strip or bar, it is possible to cut them transverse or longitudinal to the direction of rolling. In many cases the stress-corrosion cracking resistance in these two directions is quite different so it is important to

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[1] This practice is under the jurisdiction of ASTM Committee G-1 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.06 on Stress-Corrosion Cracking and Corrosion Fatigue.

Current edition approved Feb. 15, 1994. Published April 1994. Originally published as G 30 – 72. Last previous edition G 30 – 90.

[2] The boldface numbers in parentheses refer to the list of references at the end of this practice.

[3] *Annual Book of ASTM Standards*, Vol 03.02.

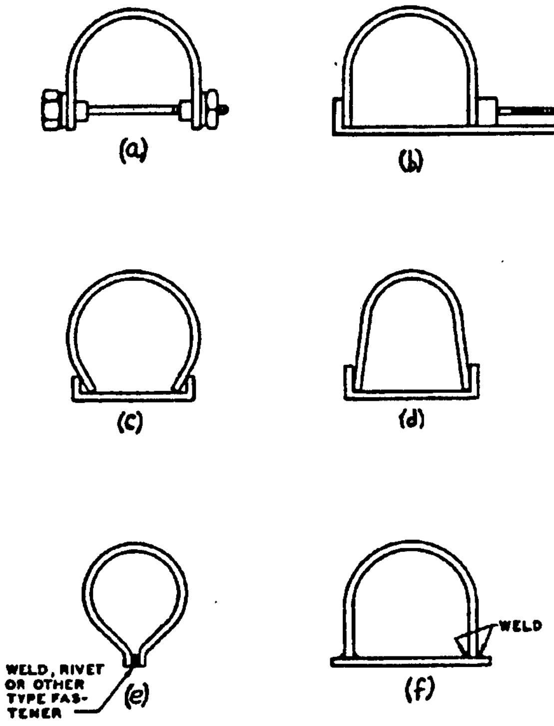
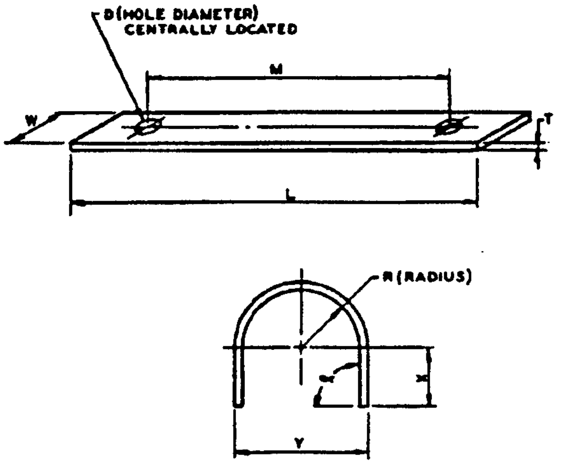


FIG. 1 Typical Stressed U-bends



Examples of Typical Dimensions (SI Units)

Example	L, mm	M, mm	W, mm	T, mm	D, mm	X, mm	Y, mm	R, mm	α, rad
a	80	50	20	2.5	10	32	14	5	1.57
b	100	90	9	3.0	7	25	38	16	1.57
c	120	90	20	1.5	8	35	35	16	1.57
d	130	100	15	3.0	6	45	32	13	1.57
e	150	140	15	0.8	3	61	20	9	1.57
f	310	250	25	13.0	13	105	90	32	1.57
g	510	460	25	6.5	13	136	165	76	1.57
h	102	83	19	3.2	9.5	40	16	4.8	1.57

FIG. 2 Typical U-Bend Specimen Dimensions (Examples only, not for specification.)

define the orientation of the test specimen.

5.2 *Specimen Dimensions*—Figure 2 shows a typical test specimen and lists, by way of example, several dimension combinations that have been used successfully to test a wide range of materials. Other dimensional characteristics may be used as necessary. For example, some special types of U-bend configuration have been used for simulating exposure conditions encountered in high temperature water environments relative to the nuclear power industry. These include double U-bend (2) and split tube U-bend (or reverse U-bend) (3) specimens.

5.2.1 Whether or not the specimen contains holes is dependent upon the method of maintaining the applied stress (see Fig. 1).

5.2.2 The length (L) and width (W) of the specimen are determined by the amount and form of the material available, the stressing method used, and the size of the test environment container.

5.2.3 The thickness (T) is usually dependent upon the form of the material, its strength and ductility, and the means available to perform the bending. For example, it is difficult to manually form U-bends of thickness greater than approximately 3 mm (0.125 in.) if the yield strength exceeds about 1379 MPa (200 ksi).

5.2.4 For comparison purposes, it is desirable to keep the specimen dimensions, especially the ratio of thickness to bend radius, constant. This produces approximately the same maximum strain in the materials being compared (see 7.3). However, it does not necessarily provide tests of equal severity if the mechanical properties of the materials being compared are widely different.

5.2.5 When wire is to be evaluated, the specimen is simply a wire of a length suitable for the restraining jig. It may be desirable to loop the wire rather than use just a simple U-shape (4).

5.3 *Surface Finish:*

5.3.1 Any necessary heat treatment should be performed before the final surface preparation.

5.3.2 Surface preparation is generally a mechanical process but in some cases it may be more convenient and acceptable to chemically finish (see 5.3.4).

5.3.3 Grinding or machining should be done in stages so that the final cut leaves the surface with a finish of 762 nm (30 μin.) or better. Care must be taken to avoid excessive heating during preparation because this may induce undesirable residual stresses and in some cases cause metallurgical or chemical changes, or both, at the surface. The edges of the specimen should receive the same finish as the faces.

5.3.4 When the final surface preparation involves chemical dissolution, care must be taken to ensure that the solution used does not induce hydrogen embrittlement, selectively attack constituents in the metal, or leave undesirable residues on the surface.

5.3.5 It may be desirable to test a surface (for example, cold rolled or cold rolled, annealed, and pickled) without surface metal removal. In such cases the edges of the specimen should be milled. Sheared edges should be avoided.

5.3.6 The final stage of surface preparation is degreasing. Depending upon the method of stressing, this may be done before or after stressing.

5.4 *Identification* of the specimen is best achieved by stamping or scribing near one of the ends of the test specimen, well away from the area to be stressed. Alternatively, nonmetallic tags may be attached to the bolt or fixture used to maintain the specimen in a stressed condition during the test.

6. Sampling

6.1 Specimens shall be taken from a location in the bulk sample so that they are representative of the material to be tested; however, the bulk sampling of mill products is outside the scope of this standard.

6.2 In performing tests to simulate a service condition it is essential that the thickness of the test specimen, its orientation with respect to the direction of metal working and the surface finish, etc., be relevant to the anticipated application.

7. Stress Considerations

7.1 The stress of principal interest in the U-bend specimen is circumferential. It is nonuniform because (*1*) there is a stress gradient through the thickness varying from a maximum tension on the outer surface to a maximum compression on the inner surface, (*2*) the stress varies from zero at the ends of the specimen to a maximum at the center of the bend, and (*3*) the stress may vary across the width of the bend. The stress distribution has been studied (5).

7.2 When a U-bend specimen is stressed, the material in the outer fibers of the bend is strained into the plastic portion of the true stress-true strain curve; for example, into Section *AB* in Fig. 3(*a*). Figures 3(*b–e*) show several stress-strain relationships that can exist in the outer fibers of the U-bend test specimen; the actual relationship obtained will depend upon the method of stressing (see Section 8). For the conditions shown in Fig. 3(*d*), a quantitative measure of the maximum test stress can be made (6).

7.3 The total strain (ϵ) on the outside of the bend can be closely approximated to the equation:

$$\epsilon = T/2R \text{ when } T \ll R$$

where:

T = specimen thickness, and

R = radius of bend curvature.

8. Stressing the Specimen

8.1 Stressing is usually achieved by either a one- or a two-stage operation.

8.2 Single-stage stressing is accomplished by bending the specimen into shape and maintaining it in that shape without allowing relaxation of the tensile elastic strain. Typical stressing sequences are shown in Fig. 4. The method shown in Fig. 4(*a*) may be performed in a tension testing machine and is often the most suitable method for stressing U-bends that are difficult to form manually due to large thickness or high-strength material or both. The techniques shown in Fig. 4(*b* and *c*) may be suitable for thin or low-strength material, or both, but are generally inferior to the method shown in Fig. 4(*a*). The method shown in Fig. 4(*b*) results in a more complex strain system in the outer surface and may cause scratching. The technique shown in Fig. 4(*c*) suffers from greater lack of control of the bend radius. The two types of stress conditions that can be obtained by the single-stage stressing method are defined by

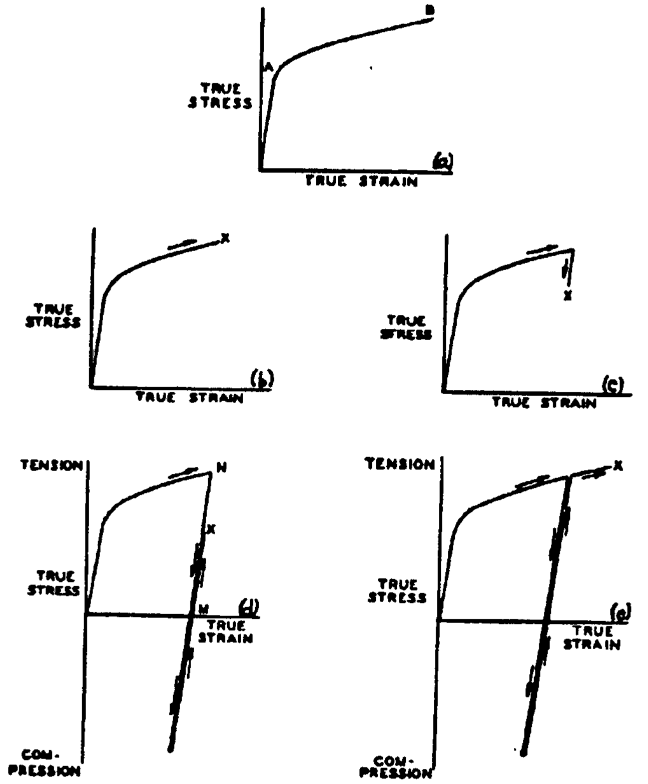


FIG. 3 True Stress-True Strain Relationships for Stressed U-Bends

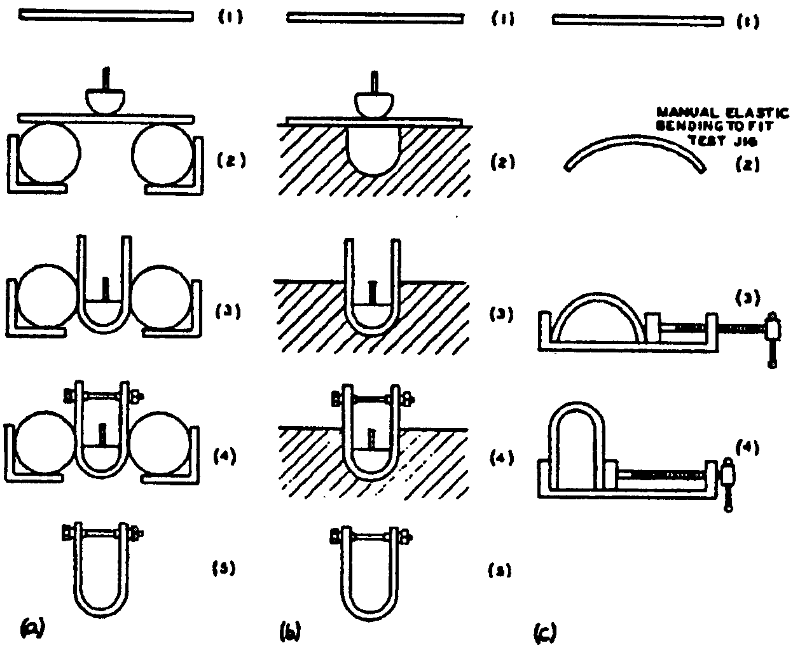


FIG. 4 Methods of Stressing U-Bend Specimens—Single-Stage Stressing

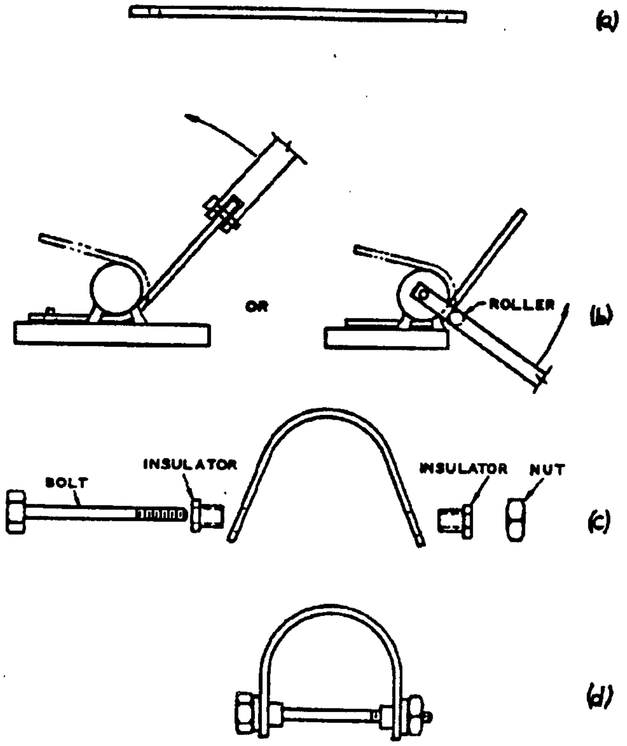


FIG. 5 Method of Stressing U-Bend—Two-Stage Method

point *X* in Fig. 3(*b* and *c*). In the latter case, some elastic strain relaxation has occurred as a result of allowing the U-bend legs to spring back slightly at the end of the stressing sequence.

8.3 Two-stage stressing involves first forming the approximate U-shape, then allowing the elastic strain to relax completely before the second stage of applying the test stress. A typical sequence of operations is shown in Fig. 5. The type of equipment shown in Fig. 4(*a* and *b*) can also be used to preform the U-shape. The test strain applied may be a percentage of the tensile elastic strain that occurred during preforming (Fig. 3(*d*)) or may involve additional plastic strain (Fig. 3(*e*)).

8.4 The slope, *MN*, of the curve shown in Fig. 3(*d*) is steep (equal to Young's modulus). Therefore, it is often difficult to reproducibly apply a constant percentage of the total elastic prestrain and there is a danger of leaving the specimen surface under compressive stress. For this reason and also because it results in a more severe test (that is, higher applied stress), *it is recommended that the stress conditions shown in Fig. 3(b or e) be achieved.* Hence, the final applied strain prior to testing consists of plastic and elastic strain. To achieve the conditions shown in Fig. 3(*b* and *e*), it is necessary (*1*) to avoid prestraining a greater amount than the final test strain and (*2*) to avoid "springback" of the U-bend legs after achieving the final plastic strain.

8.5 The bolt or restraining jig used to maintain the stress should be insulated from the test specimen to avoid galvanic corrosion effects. The insulators should have mechanical strength adequate to stand the stressing pressure, should not creep significantly during the test, and should be inert to the test environment. In some cases the use of insulators can be avoided by using a restraining jig made from a metal similar or the same as that being tested, provided it does not fail by stress-corrosion cracking in the test environment.

8.6 Some tests require that the U-bend specimen fit through a 45/50 ground glass joint for exposure in an Erlenmeyer flask. Examples a, e and perhaps d from Fig. 2 will accomplish this, assuming any insulator between the specimen and fastener is not too large. Larger insulators can be desirable so that a ceramic material (does not allow stress relaxation by compression during the test) can be used without breaking. Example h in Fig. 2 provides a U-bend which can be bent around a 9.6 mm (0.375 in.) diameter mandrel as in Fig. 4a. This specimen can then be stressed using substantial ceramic insulators (which fit into 9.6 mm (0.375 in.) diameter holes) and inserted through a 45/50 ground glass joint. This specimen is fabricated to provide plastic and elastic strain (position of X as shown in Figs. 3b or 3e) as follows.

8.6.1 Set the gap in the die at the mandrel diameter (9.6 mm or 0.0375 in.) plus two times the sample thickness. Mark the centerline on the sample to aid in aligning.

8.6.2 First depress the mandrel (hydraulic) until the apex of the U-bend is approximately level with the bottom of the die. Continue stressing until the legs of the U-bend are nearly parallel. Final stressing is preferably done with the fastener. The sample may be stressed in the die or it may be removed and re-stressed outside the die.

8.6.3 Insert the stressing fastener. Use ceramic insulators (zirconia or other non-compressible, corrosion resistant, non-conductive material). Flat washers should be used between the ceramic insulator and fastener to extend the life of the insulator. The bolt, nut and flat washer must resist corrosion in the test environment. UNS N10276 is useful in many environments, although other materials are superior in more highly oxidizing environments.

8.6.4 Stress the U-bend so that the legs are parallel, that is, the U-bend is more severely bent than it was due to the die pressure.

9. Hazards

9.1 U-bends made from high strength material may be susceptible to high rates of crack propagation and a specimen containing more than one crack may splinter into two or more pieces. Due to the highly stressed condition in a U-bend specimen, these pieces may leave the specimen at high velocity and can be dangerous.

10. Exposure of the Test Specimen

10.1 Prior to exposure the stressed specimen should be degreased in a solution known to be chemically inert to the metal being tested. In some cases, it may be more convenient and satisfactory to degrease prior to stressing. After degreasing, the specimens should be handled with clean gloves or tongs.

10.2 The stressed specimen should be examined for mechanical cracking prior to testing. A similar or more stringent inspection technique to that which will be used in the subsequent test should be applied. For example, if test specimens will be examined at 20× during the test, then they should be inspected at 20× or higher magnification prior to testing, to confirm the absence of cracks.

10.3 As soon as possible after degreasing, stressing, and inspecting the specimen should be put in test. Periodic checks should be made to ensure that the stress is not grossly relieved during the test. The latter most commonly occurs as a result of poor material selection in the restraining jig, insulators, etc., and can be corrected by redesign.

11. Inspection

11.1 Determination of cracking time is a subjective procedure involving visual examination that under some conditions can be very difficult, as noted in 11.4 to 11.6, and depends on the skill and experience of the inspector.

11.2 Examination procedures will depend upon convenience and the purpose of the test. In most laboratory tests, it is convenient and satisfactory to remove specimens from the environment (with clean gloves or tongs) and examine with the naked eye or at low magnification, for example, 20× (see 9.1). After inspection for cracks, the specimens can then be returned to the test. When working with a new system, it is advisable to confirm that this removal during the test does not influence the stress-corrosion cracking susceptibility. If the aim of the test is solely to determine whether the specimen can be made to crack, it is quite common practice to draw the legs of the U-bend together after a predetermined time in test and then return it to the test media.

11.3 Alternative methods are to view the specimen through the test chamber or to remove samples at intervals during the test but not return them to the test chamber. The latter is suitable if one wishes to detect cracking on a microscopic scale because sections from each U-bend can be metallographically examined.

11.4 Corrosion products may obscure cracking. Techniques for cleaning specimens are discussed in Practice G 1. Cleaned specimens should not be returned to test unless it is the intention of the test to evaluate this variable. If chemical cleaning techniques are used, then a stressed, clean, crack-free specimen should be given the same cleaning cycle to confirm that the cleaning agent does not itself cause cracking.

11.5 If specimens inspected at low magnification on completion of the test show no cracking, it is advisable to examine metallographically at higher magnifications, for example, 500×. Overstressing the bend to open up any cracks may aid inspection provided a control sample, which has not been stress-corrosion tested, can be overstressed without cracking.

11.6 Removal of the applied stress and comparison of the amount of relaxation in the tested versus an unexposed specimen can also be used to detect and measure the progress of cracking (7). If this method is used, then the specimen should be inspected to ensure that the loss of relaxation is due to crack propagation and not to general corrosion or pitting.

11.7 Fracture of specimens of relatively notch-sensitive materials can occur as a result of pitting corrosion and consequent mechanical fracture. Careful examination or fractography, or both, should be used to eliminate from evaluation any failures that did not result from stress-corrosion cracking.

12. Reporting

12.1 The time at which cracks are visible at a stated magnification should be reported. The specimens may remain in test after cracks have initiated and crack depths can be measured metallographically after a predetermined time in test.

12.2 When several specimens are tested it may be more meaningful to report the percentage cracked.

12.3 The orientation of the specimen (for example, transverse or longitudinal to the rolling direction), the dimensions of the stressed U-bend, its surface finish method of cleaning, and the method of stressing should be reported in addition to complete details concerning the material and test environment.

13. Keywords

13.1 plastic strain; stress corrosion cracking; stress-corrosion test specimen; U-bends

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Standard Practice for
Making and Using C-Ring Stress-Corrosion Test Specimens[1]

This standard is issued under the fixed designation G 38; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

$^{\epsilon 1}$ NOTE—Section 14 was added editorially in October 1995.

1. Scope

1.1 This practice describes the essential features of the design and machining, and procedures for stressing, exposing, and inspecting C-ring type of stress-corrosion test specimens. An analysis is given of the state and distribution of stress in the C-ring.

1.2 Specific considerations relating to the sampling process and to the selection of appropriate test environments are outside the scope of this practice.

1.3 The values stated in SI units are to be regarded as standard. The inch-pound units are provided for information.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Summary of Practice

2.1 This practice involves the preparation of and the quantitative stressing of a C-ring stress-corrosion test specimen by application of a bending load. Characteristics of the stress system and the distribution of stresses are discussed. Guidance is given for methods of exposure and inspection.

3. Significance and Use

3.1 The C-ring is a versatile, economical specimen for quantitatively determining the susceptibility to stress-corrosion cracking of all types of alloys in a wide variety of product forms. It is particularly suitable for making transverse tests of tubing and rod and for making short-transverse tests of various products as illustrated for plate in Fig. 1.

4. Sampling

4.1 Test specimens shall be taken from a location and with an orientation so that they adequately represent the material to be tested.

4.2 In testing thick sections that have a directional grain structure, it is essential that the C-ring be oriented in the section so that the direction of principal stress (parallel to the stressing bolt) is in the direction of minimum resistance to stress-corrosion cracking. For example, in the case of aluminum alloys (**1**),[2] this is the short-transverse direction relative to the grain structure. If the ring is not so oriented it will tend to crack off-center at a location where the stress is unknown.

5. Specimen Design

5.1 Sizes for C-rings may be varied over a wide range, but C-rings with an outside diameter less than about 16 mm (⅝ in.) are not recommended because of increased difficulties in machining and decreased precision in stressing. The dimensions of the ring can affect the stress state, and these considerations are discussed in Section 6. A typical shop drawing for the manufacture of a C-ring is shown in Fig. 2.

6. Stress Considerations

6.1 The stress of principal interest in the C-ring specimen is the circumferential stress. It should be recognized that this stress is not uniform (**2, 3**). First, there is a gradient through the thickness, varying from a maximum tension on one surface to a maximum compression on the opposite surface. Secondly, the stress varies around the circumference of the C-ring from zero at each bolt hole to a maximum at the middle of the arc opposite the stressing bolt; the nominal stress is present only along a line across the ring at the middle of the arc. Thus, when the specimen is stressed by measuring the strain on the tension surface of the C-ring, the strain gage should be positioned at the middle of the arc in order to indicate the maximum strain. Thirdly, the circumferential stress may vary across the width of the ring, the extent of the variation depending on the width-to-thickness and diameter-to-thickness ratios of the C-ring. In general, when loaded as shown in Fig. 3 (*a, b*), the tensile stress on the outer surface will be greater at the extreme edge than at the center, while when loaded as shown in Fig. 3 (*c*), the tensile stress on the inner surface will be less at the edge than at the center (**4**).

6.2 Another characteristic of the stress system in the C-ring is the presence of biaxial stresses; that is, transverse as well as circumferential stresses are developed on the critical test section. The transverse stress will vary from a maximum at the mid-width to zero at the edges, and will be the same sign as the circumferential stress. In general, the transverse stress may be expected to decrease with decreasing width to thickness and increasing diameter to thickness ratios. An

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[1] This practice is under the jurisdiction of ASTM Committee G-1 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.06 on Stress-Corrosion Cracking and Corrosion Fatigue.

Current edition approved Sept. 27, 1973. Published November 1973.

[2] The boldface numbers in parentheses refer to the list of references at the end of this practice.

example is shown in Fig. 4 where the transverse tensile stress at the mid-width of a 19.00 mm (0.748 in.) outside diameter by 1.537 mm (0.0605 in.) thick by 19.0 mm (0.75 in.) wide C-ring of aluminum alloy 7075-T6 was equal to about one third of the circumferential tensile stress. In this example the circumferential stress was uniform over most of the width of the C-ring; measurements were not made at the extreme edge.

6.3 In the case of the notched C-ring (Fig. 3(*d*)) a triaxial stress state is present adjacent to the root of the notch (5). In addition, the circumferential stress at the root of the notch will be greater than the nominal stress and generally may be expected to be in the plastic range.

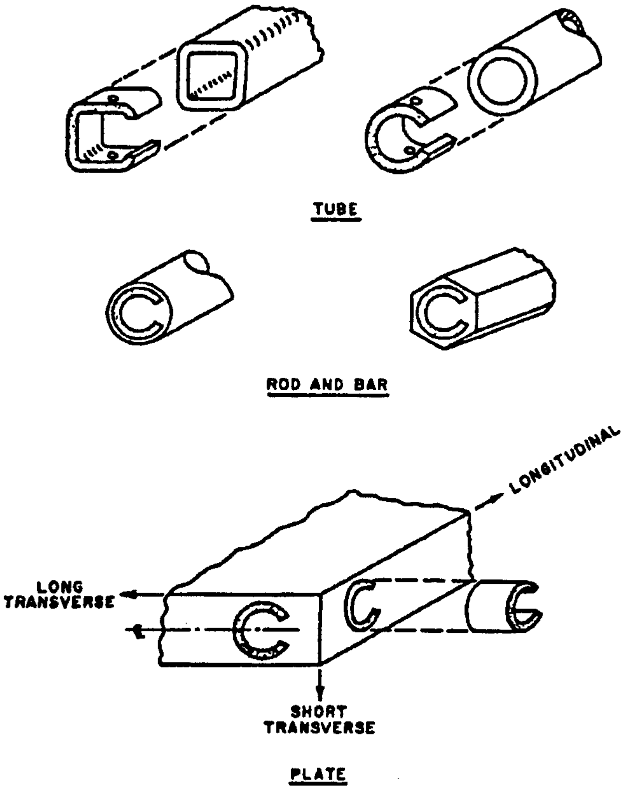


FIG. 1 Sampling Procedure for Testing Various Products

6.4 The possibility of residual stress should always be considered, especially when C-rings are machined from products that contain appreciable residual stress or when C-rings over about 6.35 mm (¼ in.) thick are heat treated after being machined. It is generally not advisable to heat treat finish-machined C-rings because of the likelihood of developing residual stresses in the ring.

NOTE 1—When specimens are exposed to corrosive media at elevated temperatures, the possibility of relaxation of stress during the exposure period should be investigated. Relaxation can be estimated from known creep data for both the ring and the stressing bolt.

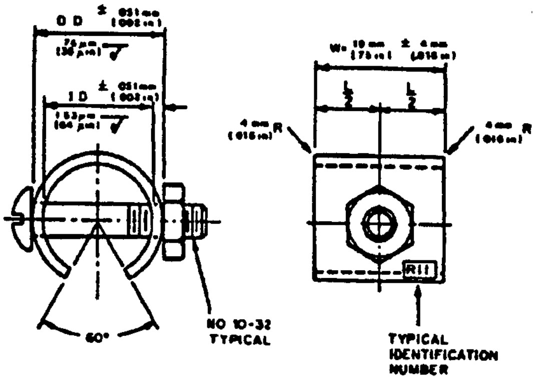
6.5 An advantage of the C-ring is that it can be stressed with high precision and bias by application of a measured deflection. The sources of error in stressing are those that are inherent with the use of measuring instruments (micrometers, strain gages, etc.) as discussed in 6.2 through 6.4 and Annex A1.

6.6 The calculated stress applies only to the state of stress *before* initiation of cracks. Once cracking has initiated the stress at the tip of the crack, as well as in uncracked areas, has changed.

7. Stressing Methods

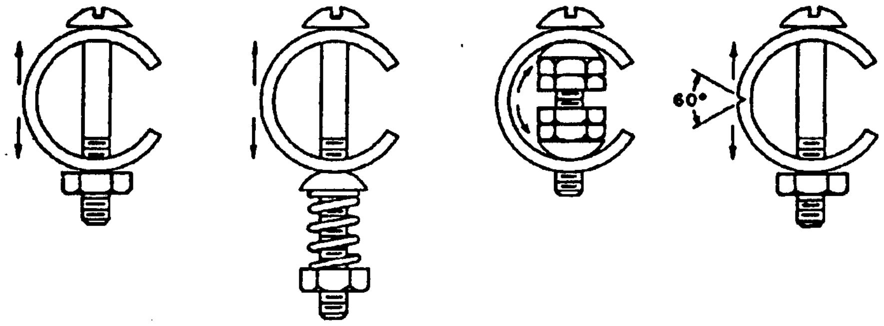
7.1 The C-ring, as generally used, is a constant-strain specimen with tensile stress produced on the exterior of the ring by tightening a bolt centered on the diameter of the ring. However, a nearly constant load can be developed by the use of a calibrated spring placed on the loading bolt. C-rings also can be stressed in the reverse direction by spreading the ring and creating a tensile stress on the inside surface. These methods of stressing are illustrated in Fig. 3. Proper choice of a minimum bolt diameter or a spring constant is, of course, required to assure achieving true constant strain or constant load stressing.

7.2 The most accurate stressing procedure is to attach circumferential and transverse electrical strain gages to the surface stressed in tension and to tighten the bolt until the strain measurements indicate the desired circumferential stress. The circumferential (σ_C) and transverse (σ_T), stresses are calculated as follows:



NOTE—If stock is undersize or tube stock is used dimensions can be varied to suit size of section from which the specimen must be cut.

FIG. 2 C-Ring Type of Stress-Corrosion Specimen



(a) CONSTANT STRAIN

(b) CONSTANT LOAD

(c) CONSTANT STRAIN

(d) NOTCHED C-RING

NOTE—For Fig 3 (d) a similar notch could be used on the tension side of (b) or (c).

FIG. 3 Methods of Stressing C-Rings

$$\sigma_C = E/(1 - \mu^2)\cdot(\epsilon_C + \mu\epsilon_T), \text{ and}$$

$$\sigma_T = E/(1 - \mu^2)\cdot(\epsilon_T + \mu\epsilon_C)$$

where:

E = Young's modulus of elasticity,

μ = Poisson's ratio,

ϵ_C = circumferential strain, and

ϵ_T = transverse strain.

NOTE 2—When using electrical strain gages with thin-walled C-rings, a correction should be allowed for the displacement of the gage from the surface of the ring. All traces of the gage and the adhesive must be removed from the C-ring before it is exposed.

NOTE 3—Stresses may be calculated from measured strains using the modulus of elasticity, *provided the stresses and strains do not exceed the proportional limit.*

7.3 When several rings of the same alloy and dimensions are to be loaded, it is convenient to determine a calibration curve of circumferential stress versus ring deflection as in Fig. 4 to avoid the inconvenience of strain gaging each ring.

7.4 The amount of compression required on the C-ring to produce elastic straining only, and the degree of elastic strains can be predicted theoretically (2, 3). Therefore, C-rings may be stressed by calculating the deflection required to develop a desired elastic stress by using the individual ring dimensions in a modified curved beam equation as shown in Table A1.1. The accuracy of calculated stresses is shown in Fig. 4 by the agreement of the calculated curve and the actual data points. See Annex A1 for the equation for stressing C-ring specimens.

7.5 In the case of notched specimens a nominal stress is assumed using the ring outside diameter measured at the root of the notch. Consideration then should be given to the stress concentration factor (K_T) for the specific notch when calculating the Δ required to develop the intended stress.

8. Machining

8.1 When rings are machined from solid stock, precautions should be taken to avoid practices that overheat, plastically deform, or develop residual stress in the metal surface. Machining should be done in stages so that the final cut leaves the principal surface with a clean finish of 0.7 μm (30 μin.) rms or better. Necessary machining sequences, type of tool, feed rate, etc., depend upon the alloy and temper of the test piece. Lapping, mechanical polishing, and similar operations that produce flow of the metal should be avoided.

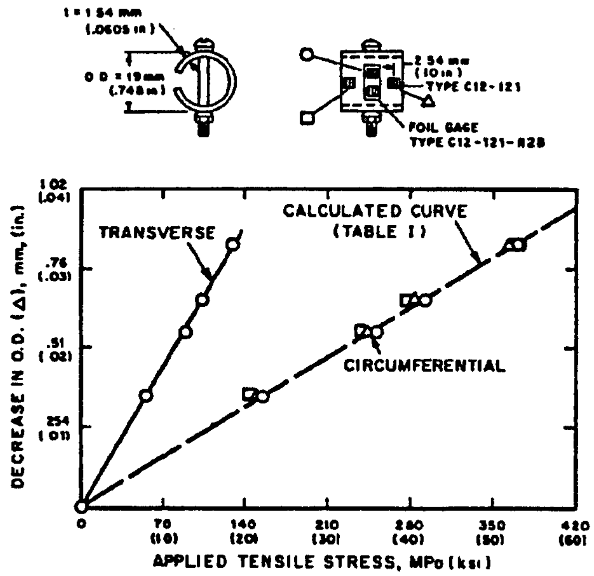


FIG. 4 Stresses in 7075-T6 Aluminum Alloy C-Ring Stress-Corrosion Specimen (4)

9. Surface Preparation

9.1 A high-quality machined surface is the most desirable for corrosion test purposes unless one wants to test the as-fabricated surface of a tube or bar; it should, of course, be degreased before exposing the specimen. In order to remove heat treat films or thin layers of surface metal that may have become distorted during machining, chemical or electrochemical etches may be used. The choice of such a treatment will depend upon the alloy of the test piece. Care should be exercised to choose an etchant that will not selectively attack constituents in the metal or will not deposit undesirable residues on the surface. Etching or pickling should not be used for alloys that may undergo hydrogen embrittlement.

9.2 It is generally the best procedure to complete the surface preparation before the C-ring is stressed except for a possible final degreasing of the critically stressed area.

9.3 Every precaution should be taken to maintain the integrity of the surface after the final preparation; that is, avoid finger printing and any rough handling that could mar the finish.

10. Specimen Identification

10.1 Specimen numbers may be scribed on one of the tips adjacent to the cut-away segment of the C-ring. No markings of any kind should be made on the critically stressed arc between the bolt holes. Nonmetallic tags may be attached to the stressing bolt by means of a second nut.

11. Exposure Methods

11.1 The C-ring, because of its small size and the simple methods of stressing, can be exposed to almost any kind of corrosive environment (6). The specimens should be supported in such a way that nothing except the corrosive medium comes in contact with the critically stressed area. No part of an exposure rack should be allowed to touch the surface or the edges of the critically stressed region.

11.2 Care must be exercised to avoid galvanic effects between the C-ring, the stressing bolt, and exposure racks. It is essential also to prevent crevice corrosion that could develop corrosion products between ring and bolt and alter the stress in the C-ring. Protection can readily be applied by means of suitable coatings or by insulating bushing as shown in Fig. 5. Consideration must be given to the selection of coatings or insulators that will neither contaminate the corroding medium nor be deteriorated by it. An insulating bushing, for example, that would deteriorate or creep, and thus allow the stress in the specimen to decrease, would be unsatisfactory.

NOTE 4—Specimens should be placed in the intended corrosive environment as soon as possible after being stressed, as some alloys may crack in moderately humid air.

NOTE 5—Hemispheric glazed ceramic insulators (S-151 Steatite) that are excellent for use outdoors and in neutral aqueous solutions can be obtained from Saxonburg Ceramics, Inc., P. O. Box 157, Saxonburg, PA 16056. Beeswax, and other adherent wax-type coatings, are suitable for room temperature tests in aqueous solutions. For tests in acidic or alkaline solutions, fast drying vinyl-type lacquers have been used successfully; an example is an electroplaters stop-off, "Micro Shield", available from the Michigan Chrome and Chemical Co., Dept. T-R, 8615 Grinnell Ave., Detroit, MI 48213.

11.3 Determination of cracking time is a subjective procedure involving visual examination that under some conditions can be very difficult, as noted in Section 12, and depends on the skill and experience of the inspector.

12. Inspection

12.1 Highly stressed C-rings of alloys that are appreciably susceptible to stress-corrosion cracking tend to fracture through the entire thickness or to crack in a way that is conspicuous. Frequently, however, with lower applied stresses, or with more stress-corrosion-resistant alloys, cracking begins slowly and is difficult to detect. Small cracks may initiate at multiple sites and be obscured by corrosion products, and an arbitrary decision must be made to declare a specimen "failed." Inasmuch as C-rings do not always fracture, it is preferable to report the first crack as the criterion of failure. It is common practice to make this inspection with the naked eye or at a low magnification. If there are indications noted that cannot be established definitely as a crack by this type of examination, the investigator should either (*a*) note the date of this first suspicion of cracking and continue the exposure of the specimen, watching for further growth that will confirm the first indication as the failure date, or (*b*) discontinue exposure of the specimen and perform a metallographic examination of a cross section taken through the suspected crack to establish whether there is cracking. Metallographic examination of fractured or cracked C-rings can also be helpful in determining whether the failure was caused by stress-corrosion cracking or by some other form of localized corrosion.

13. Report

13.1 In addition to reporting the number of specimens failed and the time to "failure" of each specimen, particulars should be reported concerning the following:

13.1.1 Stressing methods,
13.1.2 Magnitude of applied stress,
13.1.3 Specimen orientation,
13.1.4 Dimensions and surface preparation,
13.1.5 Test medium,
13.1.6 Test duration, and
13.1.7 Criterion of failure.

13.2 Full information should also be reported about the alloy(s) being tested, including the following:

13.2.1 Alloy designation or specification number,

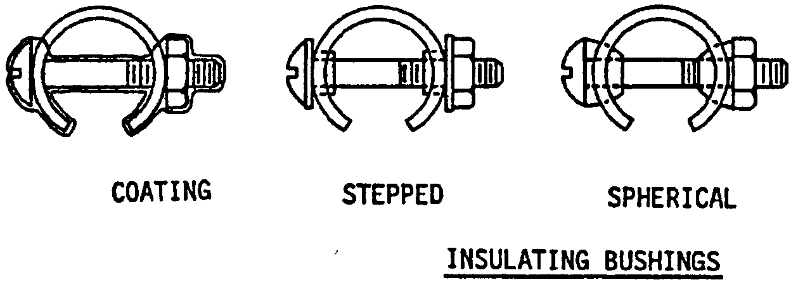


FIG. 5 Protection Against Galvanic Effects

13.2.2 Composition of the test lot,
13.2.3 Fabrication history,
13.2.4 Heat treatment, and
13.2.5 Mechanical properties.

14. Keywords

14.1 constant load; constant strain; C-rings; notches; quantitative stress; stress-corrosion cracking; stress-corrosion test specimen

ANNEX

(Mandatory Information)

A1. EQUATION FOR STRESSING C-RING SPECIMENS

A1.1 Calculate the final diameter (OD_f) required to give the desired stress using the following equations:

$$OD_f = OD - \Delta, \text{ and}$$
$$\Delta = f\pi D^2/4EtZ$$

where:

OD = outside diameter of C-ring before stressing, in. (or mm),
OD_f = outside diameter of stressed C-ring, in. (or mm),
f = desired stress, MPa (or psi) (within the proportional limit),
Δ = change of OD giving desired stress, mm (or in.),
D = mean diameter ($OD - t$), mm (or in.),
t = wall thickness, mm (or in.),
E = modulus of elasticity, MPa (or psi), and
Z = a correction factor for curved beams (see Fig. A1.1).

NOTE A1.1—Tables such as Table A1.1 can be developed to avoid repetitive calculations for investigations involving many tests of a given nominal size C-ring.

NOTE A1.2—The main source of error in this procedure lies in the measurements of the C-ring dimensions. If in a typical example of a 19.05 mm (0.750 in.) OD by 1.52 mm (0.060 in.) wall thickness C-ring the measurements are made to the nearest 0.03 mm (0.001 in.), the random error in the calculated value of Δ should not exceed about 3 %; and the error would be less for larger and thicker rings. An error of 0.001 in. in measuring OD and OD_f, however, will have a variable effect upon the stress actually developed, depending upon the magnitudes of the desired stress and the OD of the ring. For the size of ring mentioned the percent error in applying Δ would be ±3 % for f = 345 MPa (50 ksi) ranging to ±30 % for f = 34 MPa (5 ksi).

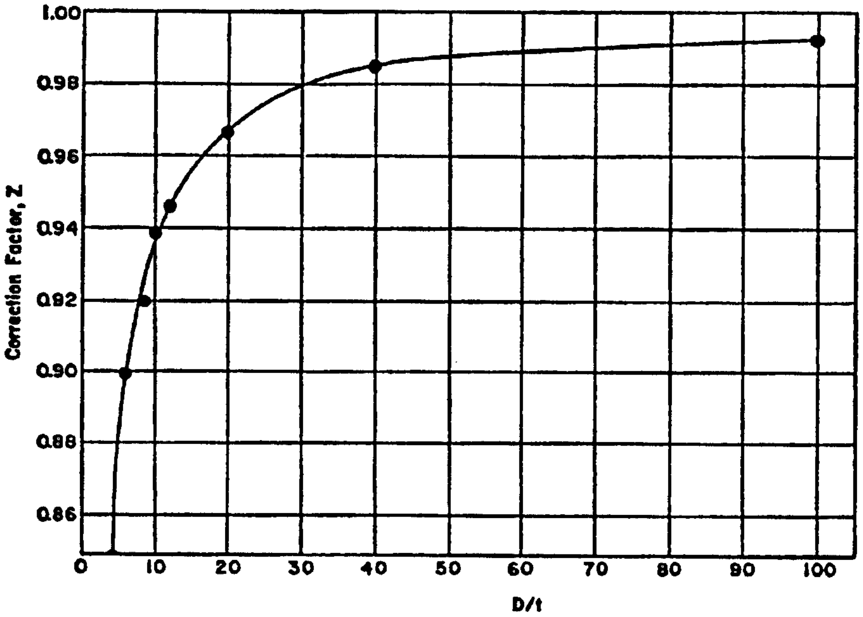


FIG. A1.1 Correction Factor for Curved Beams

TABLE A1.1 Deflections for a C-Ring of Nominal 0.750 in. OD by 0.060 in. Wall Thickness and Alloy with a Modulus of Elasticity of 68 900 MPa (10 000 ksi) for Stressing to 689 MPa (100 ksi)

NOTE 1—To obtain the deflection required to develop the intended stress, *f*, in a particular C-ring, locate the number corresponding to the actual OD and *t* for that particular C-ring and multiply it by $f \times 10^{-6}$; for example, for a C-ring with an OD of 0.7520 in. and a *t* of 0.0620 in., multiply 0.0642 by $f/1000 \times 1/100$.

NOTE 2—For alloys with a different modulus of elasticity another table could be calculated, or divide the calculated value of Δ by $E \times 10^{-7}$.

Actual *t*, mm	Actual OD, mm									
	18.974	18.999	19.025	19.050	19.075	19.101	19.126	19.152	19.177	19.202
1.422	1.808	1.816	1.819	1.826	1.831	1.836	1.841	1.846	1.852	1.857
1.435	1.791	1.796	1.801	1.806	1.811	1.816	1.821	1.826	1.834	1.839
1.448	1.773	1.778	1.783	1.788	1.793	1.798	1.803	1.808	1.814	1.819
1.460	1.755	1.760	1.765	1.770	1.775	1.780	1.786	1.791	1.796	1.801
1.473	1.737	1.742	1.748	1.753	1.758	1.763	1.768	1.773	1.778	1.783
1.486	1.720	1.725	1.730	1.735	1.740	1.745	1.750	1.755	1.760	1.765
1.499	1.702	1.707	1.712	1.717	1.722	1.727	1.732	1.737	1.742	1.747
1.511	1.687	1.692	1.697	1.702	1.707	1.709	1.714	1.720	1.725	1.730
1.524	1.669	1.674	1.679	1.684	1.689	1.694	1.699	1.704	1.709	1.714
1.537	1.653	1.659	1.664	1.669	1.671	1.676	1.681	1.687	1.692	1.697
1.549	1.636	1.643	1.646	1.651	1.656	1.661	1.666	1.671	1.676	1.681
1.562	1.620	1.626	1.631	1.636	1.641	1.646	1.650	1.656	1.659	1.664
1.575	1.605	1.610	1.615	1.620	1.626	1.631	1.633	1.638	1.643	1.648
1.587	1.590	1.595	1.600	1.605	1.610	1.615	1.618	1.623	1.628	1.633
1.600	1.577	1.580	1.585	1.590	1.595	1.600	1.603	1.608	1.613	1.618
1.613	1.562	1.565	1.570	1.575	1.580	1.585	1.590	1.593	1.598	1.603
1.626	1.647	1.552	1.557	1.560	1.565	1.570	1.575	1.580	1.582	1.588

Actual *t*, in.	Actual OD, in.									
	0.7470	0.7480	0.7490	0.7500	0.7610	0.7520	0.7530	0.7540	0.7550	0.7560
0.0560	0.0712	0.0715	0.0716	0.0719	0.0721	0.0723	0.0725	0.0727	0.0729	0.0731
0.0565	0.0706	0.0707	0.0709	0.0711	0.0713	0.0715	0.0717	0.0719	0.0722	0.0724
0.0570	0.0698	0.0700	0.0702	0.0704	0.0706	0.0708	0.0710	0.0712	0.0714	0.0716
0.0575	0.0691	0.0693	0.0695	0.0697	0.0699	0.0701	0.0703	0.0705	0.0707	0.0709
0.0580	0.0684	0.0686	0.0688	0.0690	0.0692	0.0694	0.0696	0.0698	0.0700	0.0702
0.0585	0.0677	0.0679	0.0681	0.0683	0.0685	0.0687	0.0689	0.0691	0.0693	0.0695
0.0590	0.0670	0.0672	0.0674	0.0676	0.0678	0.0680	0.0682	0.0684	0.0686	0.0688
0.0595	0.0664	0.0666	0.0668	0.0670	0.0672	0.0673	0.0675	0.0677	0.0679	0.0681
0.0600	0.0657	0.0659	0.0661	0.0663	0.0665	0.0667	0.0669	0.0671	0.0673	0.0675
0.0605	0.0651	0.0653	0.0655	0.0657	0.0658	0.0660	0.0662	0.0664	0.0666	0.0668
0.0610	0.0645	0.0647	0.0648	0.0650	0.0652	0.0654	0.0656	0.0658	0.0660	0.0662
0.0615	0.0638	0.0640	0.0642	0.0644	0.0646	0.0648	0.0650	0.0652	0.0653	0.0655
0.0620	0.0632	0.0634	0.0636	0.0638	0.0640	0.0642	0.0643	0.0645	0.0647	0.0649
0.0625	0.0626	0.0628	0.0630	0.0632	0.0634	0.0636	0.0637	0.0639	0.0641	0.0643
0.0630	0.0621	0.0622	0.0624	0.0626	0.0628	0.0630	0.0631	0.0633	0.0635	0.0637
0.0635	0.0615	0.0616	0.0618	0.0620	0.0622	0.0624	0.0626	0.0627	0.0629	0.0631
0.0640	0.0609	0.0611	0.0613	0.0614	0.0616	0.0618	0.0620	0.0622	0.0623	0.0625

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Standard Practice for Preparation and Use of Bent-Beam Stress-Corrosion Test Specimens[1]

This standard is issued under the fixed designation G 39; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

$^{\epsilon 1}$ NOTE—Section 15 was added editorially in October 1994.

1. Scope

1.1 This practice covers procedures for designing, preparing, and using bent-beam stress-corrosion specimens.

1.2 Different specimen configurations are given for use with different product forms, such as sheet or plate. This practice applicable to specimens of any metal that are stressed to levels less than the elastic limit of the material, and therefore the applied stress can be accurately calculated or measured (Note 1). Stress calculations by this practice are not applicable to plastically stressed specimens.

NOTE 1—It is the nature of these methods that only the applied stress can be calculated. Since stress-corrosion cracking is a function of the total stress, for critical applications and proper interpretation of results, the residual stress (before applying external stress) or the total elastic stress (after applying external stress) should be determined by appropriate nondestructive methods, such as X-ray diffraction (1).[2]

1.3 Test procedures are given for stress-corrosion testing by exposure to gaseous and liquid environments.

1.4 The bent-beam test is best suited for flat product forms such as sheet, strip, and plate. For plate material the bent-beam specimen is more difficult to use, because more rugged specimen holders must be built to accommodate the specimens. A double-beam modification of a four-point specimen to utilize heavier materials is described in 10.5.

1.5 The exposure of specimens in a corrosive environment is treated only briefly, since other methods deal with this aspect, for example, Specification D 1141, Practices G 30, G 36, G 44, and G 50, and Method G 43. The experimenter is referred to ASTM Special Technical Publication 425 (2).

1.6 The bent-beam method generally constitutes a constant strain (deflection) test. Once cracking has initiated, the state of stress at the tip of the crack as well as in uncracked areas has changed, and therefore the known or calculated stress or strain values discussed in this method apply *only* to the state of stress existing *before* initiation of cracks.

1.7 The values stated in SI units are to be regarded as standard. The inch-pound equivalents in parentheses are provided for information.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* (For more specific safety hazard information see Section 8 and 12.1.)

2. Referenced Documents

2.1 *ASTM Standards:*

D 1141 Specification for Substitute Ocean Water[3]

G 30 Practice for Making and Using U-Bend Stress Corrosion Test Specimens[4]

G 36 Practice for Performing Stress-Corrosion Cracking Tests in a Boiling Magnesium Chloride Solution[4]

G 43 Method of Acidified Synthetic Seawater (Fog) Testing[5]

G 44 Practice for Evaluating Stress Corrosion Cracking Resistance of Metals and Alloys by Alternate Immersion in 3.5 % Sodium Chloride Solution[4]

G 50 Practice for Conducting Atmospheric Corrosion Tests on Metals[4]

3. Terminology

3.1 *Description of Terms Specific to This Standard:*

3.1.1 *stress-corrosion cracking*—a cracking process requiring the simultaneous action of a corrodent and sustained tensile stress. This excludes corrosion-reduced sections that fail by fast fracture. It also excludes intercrystalline or transcrystalline corrosion which can disintegrate an alloy without either applied or residual stress.

3.1.2 *cracking time*—the time elapsed from the inception of test until the appearance of cracking.

DISCUSSION 1—The test begins when the stress is applied and the stressed specimen is exposed to the corrosive environment, whichever occurs later.

DISCUSSION 2—The specimen is considered to have failed when cracks are detected. Presence of cracks can be determined with or without optical, mechanical, or electronic aids. However, for meaningful interpretation, comparisons should be made only among tests employing crack detection methods of equivalent sensitivity.

4. Summary of Practice

4.1 This practice involves the quantitative stressing of a

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[1] This practice is under the jurisdiction of ASTM Committee G-1 on Corrosion of Metals, and is the direct responsibility of Subcommittee G01.06 on Stress Corrosion Cracking and Corrosion Fatigue.

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[2] The boldface numbers in parentheses refer to the list of references appended to this practice.

[3] *Annual Book of ASTM Standards*, Vol 11.02.

[4] *Annual Book of ASTM Standards*, Vol 03.02.

[5] Discontinued—See 1987 *Annual Book of ASTM Standards*, Vol 03.02.

beam specimen by application of a bending stress. The applied stress is determined from the size of the specimen and the bending deflection. The stress specimens then are exposed to the test environment and the time required for cracks to develop is determined. This cracking time is used as a measure of the stress-corrosion resistance of the material in the test environment at the stress level utilized.

5. Significance and Use

5.1 The bent-beam specimen is designed for determining the stress-corrosion behavior of alloy sheets and plates in a variety of environments. The bent-beam specimens are designed for testing at stress levels below the elastic limit of the alloy. For testing in the plastic range U-bend specimens should be employed (see Practice G 30). Although it is possible to stress bent-beam specimens into the plastic range, the stress level cannot be calculated for plastically stressed three- and four-point loaded specimens as well as the double-beam specimens. Therefore, the use of bent-beam specimens in the plastic range is not recommended.

6. Apparatus

6.1 *Specimen Holders*—Bent-beam specimens require a specimen holder for each specimen, designed to retain the applied stress on the specimen. Typical specimen holder configurations are shown schematically in Fig. 1 (Notes 2 and 3).

6.1.1 The holder shall be made of a material that would withstand the influence of the environment without deterioration or change in shape (Note 4).

6.1.2 When the stress-corrosion test is conducted by immersion in an electrolyte, galvanic action between specimen and holder (or spacer) shall be prevented (see Note 5). This is accomplished by (*1*) making the holder of the same material as the individual specimens, (*2*) inserting electrically insulating materials between specimen and holder at all points of contact (Note 4), (*3*) making the entire holder out of a nonmetallic material (Note 4), or (*4*) coating the holder with a coating that effectively prevents contact between holder and electrolyte.

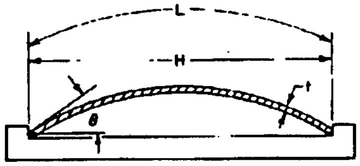
6.1.3 Crevice corrosion may occur in an electrolyte at contact points between specimen and holder (or spacer). In these instances the critical areas should be packed with a hydrophobic filler (such as grease or wax) (Note 5).

NOTE 2—The double-beam specimen, more fully described in 10.5, is self-contained and does not require a holder.

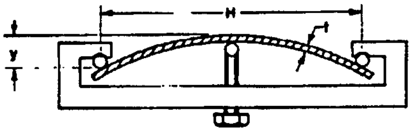
NOTE 3—Specimen holders can be modified from the constant deformation type shown in Fig. 1 to give a constant-load type of stressing. For instance, the loading bolt can be supplanted by a spring or dead-weight arrangement to change the mode of loading.

NOTE 4—It should be recognized that many plastics tend to creep when subjected to sustained loads. If specimen holders or insulators are made of such materials, the applied stress on the specimen may change appreciably with time. By proper choice of holder and insulator materials, however, many plastics can be used, especially in short-time tests.

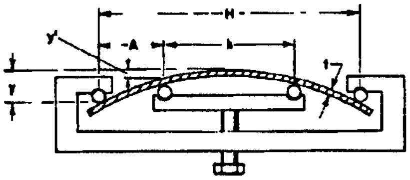
NOTE 5—In atmospheres (gas) galvanic action between specimen and holder either does not exist or is confined to a very small area as experienced in outdoor exposure tests.



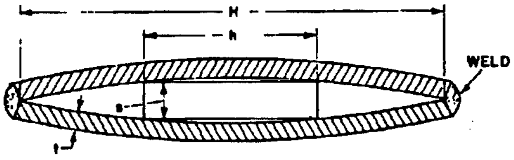
(a) TWO-POINT LOADED SPECIMEN



(b) THREE-POINT LOADED SPECIMEN



(c) FOUR-POINT LOADED SPECIMEN



(d) DOUBLE-BEAM SPECIMEN

FIG. 1 Schematic Specimen and Holder Configurations

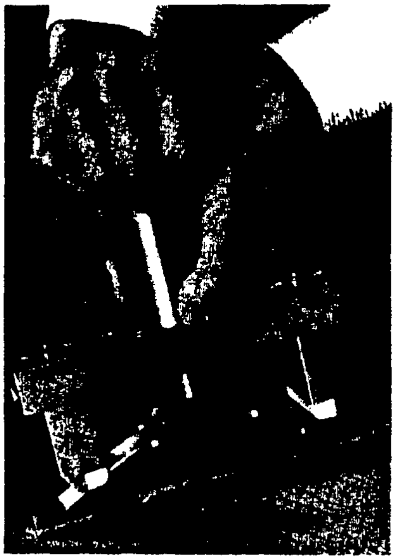


FIG. 2 Stressing Jig and Two-Point Loaded Specimen with Holder (approximately ¼ actual size)

6.2 *Stressing Jigs*—Three-point and four-point loaded specimen holders, Fig. 1 (*b* and *c*), contain a stressing feature in the form of a loading screw. To stress two-point loaded specimens (Fig. 1(*a*)), a separate stressing jig shall be used. A

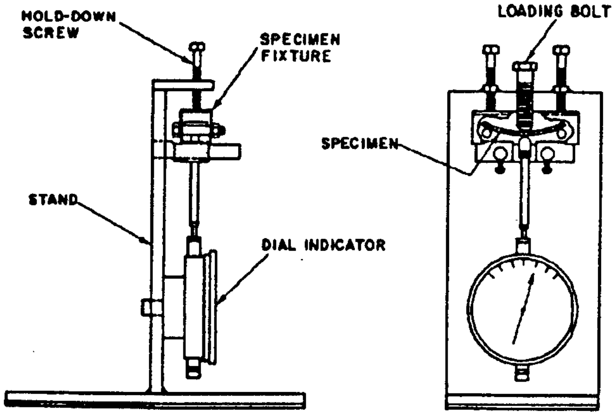


FIG. 3 Specimen Loading Apparatus for Three-Point Loaded Beam Specimens with Integral Deflection Gage

convenient stressing jig is shown in Fig. 2.

NOTE 6—The double-beam specimen, described in 10.5, requires a mechanical or hydraulic stressing frame (a universal tension testing machine can also be used) as well as welding equipment.

6.3 *Deflection Gages*—Deflection of specimens is determined by separate gages or by gages incorporated in a loading apparatus as shown in Fig. 3. In designing a deflection gage to suit individual circumstances care must be taken to reference the deflection to the proper support distance as defined in 10.2 to 10.5.

7. Test Specimen

7.1 The bent-beam stress-corrosion specimens shall be flat strips of metal of uniform, rectangular cross section and uniform thickness.

7.2 The identification of individual specimens should be permanently inscribed at each end of the specimen because this is the area of lowest stress and cracking is not expected to be initiated by the identification markings. If stenciling is used for identification, this shall be done only on softened material before any hardening heat treatments to prevent cracking in the stenciled area. Care must be taken to prevent the identification from being obliterated by corrosion.

7.3 Mechanical properties should be determined on the same heat-treatment lot from which stress-corrosion specimens are obtained.

7.4 The specimens can be cut from sheet or plate in such a fashion that the original material surface is retained. This procedure is recommended when it is desired to include the effect of surface condition in the test.

7.5 If, however, it is desired that surface conditions should not influence the test results of several materials with different surface conditions, the surfaces of all specimens must be prepared in the same way. It is recommended that grinding or machining to a surface finish of at least 0.7 µm (30 µin.) and to a depth of at least 0.25 mm (0.01 in.) be utilized for surface preparation. It is desirable to remove the required amount of metal in several steps by alternately grinding opposite surfaces. This practice minimizes warpage due to residual stresses caused by machining. All edges should be similarly ground or machined to remove cold-worked material from previous shearing. Chemical or electrochemical treatments that produce hydrogen on the specimen surface must not be used on materials that may be subject to embrittlement by hydrogen or that react with hydrogen to form a hydride.

7.6 Immediately before stressing the specimens should be degreased and cleaned to remove contamination that occurred during specimen preparation. Only chemicals appropriate for the given metal or alloy should be used. Care must be exercised not to contaminate cleaned specimens. Also, it is suggested that specimens be examined for cracks before exposure to the test environment.

8. Hazards

8.1 Bent-beam specimens made from high-strength materials may exhibit high rates of crack propagation and a specimen may splinter into several pieces. Due to high stresses in a specimen, these pieces may leave the specimen at high velocity and can be dangerous. Personnel installing and examining specimens should be cognizant of this possibility and be protected against injury.

9. Sampling

9.1 Test specimens shall be selected so that they represent the material to be tested. In simulating a service condition, the direction of load application in the specimen shall represent the anticipated loading direction in service with respect to processing conditions, for example, rolling direction.

9.2 Sections 7.4 and 7.5 deal specifically with specimen selection as related to the original material surface.

10. Stress Calculations

10.1 The equations given in this section are valid only for stresses below the elastic limit of the material. At stresses above the elastic limit but below the engineering yield strength (0.2 % offset) only a small error results from use of the equations (see Note 1). The equations must not be used above the yield strength of the material. The following paragraphs give relationships used to calculate the maximum longitudinal stress in the outer fibers of the specimen convex surface. Calculations for transverse stress or edge-to-edge variation of longitudinal stress are not given; the specimen dimensions are chosen to minimize these stresses consistent with convenient use of the specimens. The specimen dimensions given here can be modified to suit specific needs. How- ever, if this is done the approximate specimen proportions should be preserved to give a similar stress distribution (for instance, if the length is doubled the width should be doubled also).

10.1.1 When specimens are tested at elevated temperatures, the possibility of stress relaxation should be investigated. Relaxation can be estimated from known creep data for the specimen, holder, and insulating materials. Differences in thermal expansion also should be considered.

10.1.2 The applied stress is determined by specimen dimensions and the amount of bending deflection. Thus, the errors in the applied stress are related to those inherent in the use of measuring instruments (micrometers, deflection gages, strain gages, etc.). For the two-point loaded specimens most measured values lie within 5 % of the values calculated in accordance with the procedures given in 10.2.1 through 10.2.3, as reported by Haaijer and Loginow (4). The calculated stress applies only to the state of stress before initiation of cracks. Once cracking is initiated, the stress at the tip of the crack, as well as in uncracked areas, has changed.

10.2 *Two-Point Loaded Specimens*—This specimen can be used for materials that do not deform plastically when bent to $(L - H)/H = 0.01$ (see 10.2.4). The specimens shall be approximately 25 by 254-mm (1 by 10-in.) flat strips cut to appropriate lengths to produce the desired stress after bending as shown in Fig. 1(*a*).

10.2.1 Calculate the elastic stress in the outer fiber at midlength of the two-point loaded specimens from relationships derived from a theoretically exact large-deflection analysis (4), as follows:

$$\epsilon = 4(2E - K)\left[\frac{k}{2} - \frac{2E - K}{12}\left(\frac{t}{H}\right)\right]\frac{t}{H} \qquad (1)$$

and

$$(L - H)/H = [K/2E - K)] - 1 \qquad (2)$$

where:

L = length of specimen,
H = distance between supports (holder span),
t = thickness of specimen,
ϵ = maximum tensile strain,
K = $\int_0^{\pi/2} (1 - k^2 \sin^2 z)^{-1/2}\, dz$ (complete elliptic integral of the first kind),
E = $\int_0^{\pi/2} (1 - k^2 \sin^2 z)^{1/2}\, dz$ (complete elliptic integral of the second kind),
k = $\sin \theta/2$,
θ = maximum slope of the specimen, that is, at the end of the specimen, and
z = integration parameter (4).

10.2.2 The mathematical analysis establishes that Eqs 1 and 2 define the relationship between the strain ϵ and $(L - H)/H$ in parameter form. The common parameter in these equations is the modulus k of the elliptic integrals. Thus, the following procedure can be used to determine the specimen length L that is required to produce a given maximum stress σ:

10.2.2.1 Divide the stress σ by the modulus of elasticity E_m to determine the strain ϵ.

$$\epsilon = \sigma/E_m$$

10.2.2.2 From Eq 1 determine the value of k corresponding to the required value of ϵ.

10.2.2.3 By using appropriate values of k evaluate Eq 2 for L. To facilitate calculations a computer can be used to generate a table for a range of strain ϵ and H/t with resultant values of $(L - H)/H$.

10.2.3 Calculate the deflection of the specimen as follows:

$$y/H = k/(2E - K) \qquad (3)$$

where:

y = maximum deflection.

The other quantities are given in 10.2.1.

This relationship can be used as a simple check to ensure that the maximum stress does not exceed the proportional limit. If it should exceed the proportional limit, the measured deflection will be greater than that calculated from Eq 3.

10.2.4 As an alternative method the following approximate relationship can be used for calculating specimen length:

$$L = (ktE/\sigma)\sin^{-1}(H\sigma/ktE) \qquad (4)$$

where:

L = specimen length,
σ = maximum stress,
E = modulus of elasticity,
H = holder span,
t = thickness of specimen, and
k = 1.280, an empirical constant.

This equation can be solved by computer, by trial and error, or by using a series expansion of the sine function. Equation 4 shall be used only when the quantity $(H\sigma/ktE)$ is less than 1.0.

10.2.5 Choose specimen thickness and length, and holder span, to obtain a value for $(L - H)/H$ of between 0.01 and 0.50, thus keeping the error of stress within acceptable limits. A specimen thickness of about 0.8 to 1.8 mm (0.03 to 0.07 in.) and a holder span of 177.8 to 215.9 mm (7.00 to 8.50 in.) has been very convenient when working with very high strength steels and aluminum alloys with applied stresses ranging from about 205 MPa (30 ksi) for aluminum to 1380 MPa (200 ksi) for steel. The specimen dimensions given here can be modified to suit specific needs. However, if this is done, approximate dimensional proportions shall be preserved.

10.2.6 In two-point loaded specimens the maximum stress occurs at midlength of the specimen and decreases to zero at specimen ends.

10.2.7 The two-point loaded specimen is preferred to three-point loaded specimens, because in many instances crevice corrosion of the specimen occurs at the central support of the three-point loaded specimen. Since this corrosion site is very close to the point of highest tension stress, it may cathodically protect the specimen and prevent possible crack formation or cause hydrogen embrittlement. Furthermore, the pressure of the central support at the point of highest load introduces biaxial stresses at the area of contact and could introduce tension stresses where normally compression stresses are present.

NOTE 7—Occasionally two-point loaded specimens having a nonuniform cross section are used for special purposes. A description of such a specimen is given by Wilson and Spier (5).

10.3 *Three-Point Loaded Specimens*—The specimen shall be a flat strip typically 25 to 51 mm (1 to 2 in.) wide and 127 to 254 mm (5 to 10 in.) long. The thickness of the specimen is usually dictated by the mechanical properties of the material and the product form available. Support the specimen at the ends and bend the specimen by forcing a screw (equipped with a ball or knife-edge tip) against it at the point halfway between the end supports in a fashion shown in Fig. 1(*b*). The specimen dimensions given here can be modified to suit specific needs. However, if this is done, approximate dimensional proportions shall be preserved.

10.3.1 Calculate the elastic stress at midspan in the outer fibers of three-point loaded specimens from the relationship:

$$\sigma = 6Ety/H^2$$

where:

σ = maximum tensile stress,
E = modulus of elasticity,
t = thickness of specimen,
y = maximum deflection, and
H = distance between outer supports.

10.3.2 The above relationship is based on small deflections (y/H less than 0.1). In sheet gage bent-beam specimens the deflections are usually large, and thus, the relationship is only approximate. To obtain more accurate stress values, use for calibration a prototype specimen equipped with strain gages. This prototype should have the same dimensions as the test specimens, and should be stressed in the same way.

10.3.3 In three-point loaded specimens the maximum stress occurs at midlength of the specimen and decreases linearly to zero at the outer supports.

10.3.4 For limitation in the use of three-point loaded specimens see 10.2.7.

10.4 *Four-Point Loaded Specimens*—The specimen shall be a flat strip typically 25 to 51 mm (1 to 2 in.) wide and 127 to 254 mm (5 to 10 in.) long. The thickness of the specimen is usually dictated by the mechanical properties of the material and the product form available. Support the specimen at the ends and bend the specimen by forcing two inner supports against it in a fashion shown in Fig. 1(*c*). The two inner supports shall be located symmetrically around the midpoint between the outer supports. The specimen dimensions given here can be modified to suit specific needs. However, if this is done, approximate dimensional proportions shall be preserved.

10.4.1 Calculate the elastic stress for the midportion of the specimen (between contact points of the inner support) in the outer fibers of four-point loaded specimens from the following relationship:

$$\sigma = 12Ety/(3H^2 - 4A^2)$$

where:

σ = maximum tensile stress,
E = modulus of elasticity,
t = thickness of specimen,
y = maximum deflection (between outer supports),
H = distance between outer supports, and
A = distance between inner and outer supports.

The dimensions are often chosen so that $A = H/4$.

10.4.2 An alternative method of calculating the elastic stress between the inner supports is as follows:

$$\sigma = 4Ety'/h^2$$

where:

h = distance between inner supports, and
y' = deflection between inner supports.

(This equation is a special case of 10.4.1 when $A = 0$.)

10.4.3 The above relationships are based on small deflections (y/H less than 0.1). In sheet-gage bent-beam specimens the deflections are usually large, and thus, the relationships are only approximate. To obtain more accurate stress values, use for calibration a prototype specimen equipped with strain gages. This prototype specimen should have the same dimensions as the test specimens, and should be stressed in the same way.

10.4.4 In four-point loaded specimens the maximum stress occurs between the contact points with the inner supports; in this area the stress is constant. From the inner supports the stress decreases linearly toward zero at the outer supports.

10.5 *Double-Beam Specimen*—The specimen shall consist of two flat strips 25 to 51 mm (1 to 2 in.) wide and 127 to 254 mm (5 to 10 in.) long. Bend the strips against each other over a centrally located spacer until both ends of the specimens touch. Hold them in this position by welding the ends together as shown in Fig. 1(*d*) (Note 8). An equivalent procedure for bolted specimens is described on pp. 319–321 of Ref (2).

10.5.1 Calculate the elastic stress for the midportion of the specimen (between contact points of the spacer) in the outer fibers of the doublebeam specimens from the following relationship:

$$\sigma = \frac{3Ets}{H^2[1 - (h/H)][1 + (2h/H)]}$$

where:

σ = maximum tensile stress,
E = modulus of elasticity,
t = thickness of specimen strip,
s = thickness of spacer,
H = see Fig. 1(*d*), and
h = length of spacer.

10.5.2 When the length of the spacer h is chosen so that $H = 2h$ the equation in 10.5.1 is simplified to:

$$\sigma = 3Ets/H^2$$

10.5.3 The above relationships are based on small deflections (s/H being less than 0.2). In sheet-gage bent-beam specimens the deflections are usually large, and thus, the relationships are only approximate. To obtain more accurate stress values, use for calibration a prototype specimen equipped with strain gages. The prototype specimen should have the same dimensions as the test specimens, and should be stressed in the same way.

10.5.4 In double-beam specimens the maximum stress occurs between the contact points with the spacer; in this area the stress is constant. From the contact with the spacer the stress decreases linearly toward zero at the ends of specimens.

NOTE 8—If the test is to be conducted in an electrolyte, the spacer shall be made of the same material as the specimen (or of an electrically nonconducting material such as glass, ceramic, etc.) to prevent galvanic action between specimen and spacer. See also 6.1.2 and Notes 4 and 5.

11. Choice of Test Conditions

11.1 The purpose of stress-corrosion testing is to simulate on a small scale the conditions (materials, stress, and environment) that exist in an engineering application. The stresses in an engineering structure can be varied: operational (design) stresses and residual stresses (from heat treatment or fabrication). Residual stresses are frequently the more important, primarily because current design practices and close control of processes have kept operational stresses well below the yield strength of the metal in use. On the other hand, magnitude and direction of residual stresses frequently are difficult to predict and also difficult to measure. Depending on the degree of restraint, residual stresses may even exceed the initial yield strength of the material.

11.2 Generally stress-corrosion testing falls into two broad categories: (*1*) evaluation of materials for a specific application, and (*2*) comparison of the relative behavior of several materials or environments.

11.2.1 To evaluate materials for specific applications the testing conditions should be representative of the most severe conditions to which the materials would be subjected in

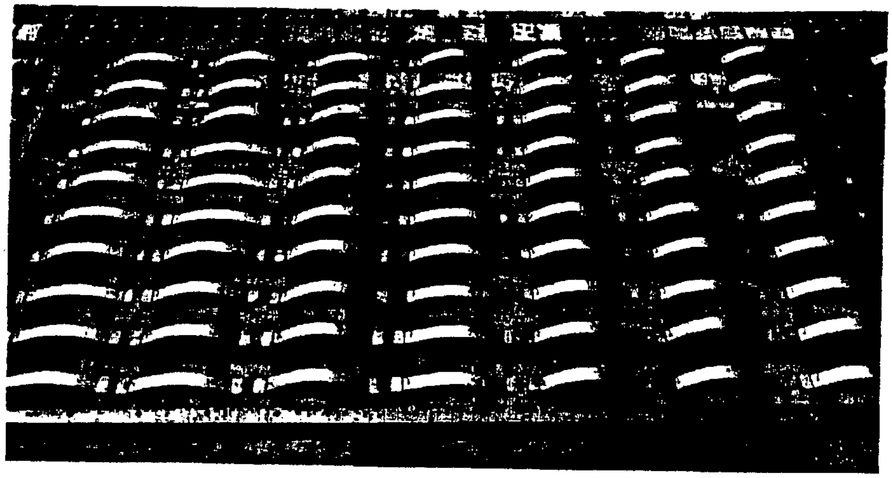


FIG. 4 Bent-Beam Specimens on Atmospheric Exposure Rack

service. Testing at nominal or design conditions could be misleading. An engineering structure, because of residual stresses, is expected to be stressed to its yield strength at some points even if the design stress for that structure is appreciably below yield strength. Thus, the use of the elastically stressed bent-beam specimens for materials evaluation is of limited value.

11.2.2 To compare materials or environments for relative stress-corrosion behavior the test conditions may be only severe enough to produce varying degrees of cracking in the alloys of interest, in mechanical or thermal treatments used, or in sensitivity to specific environments investigated. By testing a set of specimens at a series of stress levels the stress dependence of alloys can be assessed. The bent-beam specimen is very well suited for establishing the relative merits of several alloys for the relative severity of several environments.

11.3 Ideally, the environmental test conditions should be the same that would prevail in the intended use of the alloys. In choosing a set of test conditions, it is important that they (environment and stress) be well defined and reproducible. A detailed discussion is given by Loginow (6).

12. Specimen Exposure

12.1 Expose the stressed specimens to the environment (gaseous or liquid) of interest. This can be accomplished by mounting the specimen holders on appropriate racks and exposing the entire rack to the environment. A typical atmospheric exposure rack is shown in Fig. 4. As noted in 8.1 bent-beam specimens may break violently and thus cause injury. To protect personnel and to prevent specimen loss, drill holes in specimen ends and holders, and secure the specimens by wires to their holders.

12.2 Determination of cracking time is a subjective procedure involving visual examination that under some conditions can be very difficult, as noted in Section 13, and depends on the skill and experience of the inspector.

12.3 *Laboratory Exposure of Bent Beams*—In both alternate and sustained immersion of bent beams, avoid galvanic corrosion between fixtures and specimens as discussed in 6.1.2 and Notes 4 and 5. It should be recognized that, at points of contact between specimen and fixture, crevice corrosion may occur on some materials, which in turn may result in galvanic protection of the stressed area. If this condition occurs, either eliminate the crevice or consider a different kind of specimen. In alternate immersion expose the specimen to allow complete drainage and drying of the surface. In immersion tests arrange the specimens so as to prevent contact with each other. In both sustained and alternate immersion, the solution volume should be large enough to prevent depletion of corrosive agents. In elevated-temperature tests, make arrangements to reflux the solution to maintain a constant concentration.

12.4 *Atmospheric Exposure of Bent Beams*—Expose the specimens in an area that is representative of the atmospheric conditions of interest.

13. Inspection of Specimens

13.1 As continuous observation of specimens is usually impractical, inspect specimens for appearance of cracks at predetermined time intervals. These intervals are usually increased as the test progresses, because the logarithms of observed cracking times are often normally distributed as described by Loginow (6) and by Booth et al (7).

13.2 Determine presence of cracks by visual observation, usually with the aid of a 5 to 10 power magnifying glass. If the specimen contains only one or a few cracks, the shape of the bend can be considerably changed, predominantly by kinking; this feature helps in identifying cracked specimens. However, if many cracks are present a change in shape may not be apparent. It should also be noted that presence of voluminous corrosion products may obscure cracks, thus making a careful examination mandatory. In these instances metallographic sectioning of the specimen may be necessary to detect cracks.

14. Report

14.1 Results of stress-corrosion tests with bent-beam specimens are expressed as the time to produce failure by cracking or as the fraction of specimens that have cracked in a fixed time. In addition to the cracking time the following data shall be reported:

14.1.1 Specimen identification,

14.1.2 Material name or specification code,

14.1.3 Chemical composition,

14.1.4 Heat treatment,

14.1.5 Mechanical properties,

14.1.6 Type and orientation of specimen used and surface condition (hot rolled, cold rolled, machined, surface ground, etc.),

14.1.7 Applied stress (and residual stress, if known),

14.1.8 Details of specimen preparation if different from those specified here (or if not specified),

14.1.9 Detailed description of test environment, and

14.1.10 Remarks concerning the size and appearance of cracks may be included.

15. Keywords

15.1 bent-beam; constant deformation; constant load; elastic strain; quantitative stress; stress-corrosion cracking; stress-corrosion test specimen

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Standard Practice for Evaluating Stress Corrosion Cracking Resistance of Metals and Alloys by Alternate Immersion in 3.5 % Sodium Chloride Solution[1]

1. Scope

1.1 This practice covers procedures for making alternate immersion stress corrosion tests in 3.5 % sodium chloride (NaCl) (Note 1). It is primarily for tests of aluminum alloys (Test Method G 47) and ferrous alloys, but may be used for other metals. It sets forth the environmental conditions of the test and the means for controlling them.

NOTE 1—Alternate immersion stress corrosion exposures are sometimes made in substitute ocean water (without heavy metals) prepared in accordance with Specification D 1141. The general requirements of this present practice are also applicable to such exposures except that the reagents used, the solution concentration, and the solution pH should be as specified in Specification D 1141.

1.2 This practice applies only to tests in which the specimens are accessible to the surrounding air under conditions that permit drying. It does not cover tests in which specimens are placed in closed containers into which the solution is periodically pumped and the specimens not permitted to dry.

1.3 This practice is intended for alloy development and for applications where the alternate immersion test is to serve as a control test on the quality of successive lots of the same material. Therefore, strict test conditions are stipulated for maximum assurance that variations in results are attributable to variations in the material being tested.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1141 Specification for Substitute Ocean Water[2]
D 1193 Specification for Reagent Water[3]
E 3 Methods of Preparation of Metallographic Specimens[4]
G 1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens[5]
G 16 Guide for Applying Statistics to Analysis of Corrosion Data[5]
G 47 Test Method for Determining Susceptibility to Stress-Corrosion Cracking of High-Strength Aluminum Alloy Products[5]

3. Summary of Practice

3.1 The alternate immersion test utilizes a 1-h cycle that includes a 10-min period in an aqueous solution of 3.5 % sodium chloride (NaCl) followed by a 50-min period out of the solution, during which the specimens are allowed to dry. This 1-h cycle is continued 24 h/day for the total number of days recommended for the particular alloy being tested. Typically, aluminum and ferrous alloys are exposed from 20 to 90 days or longer, depending upon the resistance of the alloy to corrosion by saltwater.

4. Significance and Use

4.1 The 3.5 % NaCl alternate immersion procedure is a general, all-purpose procedure that produces valid comparisons for most metals, particularly when specimens are exposed at high levels of applied stress or stress intensity.

4.2 While the alternate immersion test is an accelerated test and is considered to be representative of certain natural conditions, it is not intended to predict performance in specialized chemical environments in which a different mode of cracking may be operative. For example, it does not predict the performance of aluminum alloys in highly acidic environments such as heated inhibited red fuming nitric acid (IRFNA). For such cases, the results of the alternate immersion test are of doubtful significance until a relationship has been established between it and anticipated service environments.

4.3 While the test is applicable in some degree to all metals, it is not equally discriminative of all alloys, even within the same metal system. Consequently, information should be established to allow comparisons of performances of the alloy of interest in the alternate immersion test and in natural environments.

5. Interferences

5.1 A disadvantage of the 3.5 % NaCl alternate immersion test for certain high-strength aluminum alloys is the severe pitting that develops in the specimens. Such pitting can interfere with the initiation of stress-corrosion cracks and may cause mechanical failures that complicate the interpretation of the stress corrosion test results. This is particularly a problem with copper-bearing aluminum alloys when tested

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[1] This recommended practice is under the jurisdiction of ASTM Committee G-1 on Corrosion of Metals, and is the direct responsibility of Subcommittee G01.06 on Stress-Corrosion Cracking and Corrosion Fatigue.

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[2] *Annual Book of ASTM Standards*, Vol 11.02.

[3] *Annual Book of ASTM Standards*, Vol 11.01.

[4] *Annual Book of ASTM Standards*, Vol 03.01.

[5] *Annual Book of ASTM Standards*, Vol 03.02.

with specimens of small cross section. Thorough metallographic examination of the specimens is necessary for proper diagnosis of the cause of failure and separation of stress corrosion failures from those caused by mechanical overload.

5.2 An advantage of the substitute ocean water (Note 1) is that it causes less pitting corrosion of aluminum alloys than the 3.5 % NaCl solution.

6. Apparatus

6.1 *Method of Cycling*—Any suitable mechanism may be used to accomplish the immersion portion of the cycle provided that: *(1)* it achieves the specified rate of immersion and removal, and *(2)* the apparatus is constructed of suitable inert materials. The usual methods of immersion are:

6.1.1 Specimens placed on a movable rack that is periodically lowered into a stationary tank containing the solution.

6.1.2 Specimens placed on a hexagonal Ferris wheel arrangement which rotates every 10 min through 60° and, thereby, passes the specimens through a stationary tank of solution. Use of a Ferris wheel continuously rotating at a rate of 1 revolution per hour is not recommended for very large specimens for which the rate of immersion would be slower than that specified in 6.2.

6.1.3 Specimens placed in a stationary tray open to the atmosphere and having the solution moved by air pressure, nonmetallic pump, or gravity drain from a reservoir to the tray.

6.2 *Rate of Immersion*—The rate of immersion and removal of the specimens from the solution should be as rapid as possible without jarring them. For purposes of standardization, an arbitrary limit shall be adopted such that no more than 2 min elapse from the time the first portion of any specimen is covered (or uncovered) until it is fully covered (or uncovered) by solution.

6.3 *Materials of Construction:*

6.3.1 Materials of construction that come in contact with the salt solution shall be such that they are not affected by the corrodent to an extent that they can cause contamination of the solution and change its corrosiveness.

6.3.2 Use of inert plastics or glass is recommended where feasible.

6.3.3 Metallic materials of construction should be selected from alloys that are recommended for marine use and of the same general type as the metals being tested. Preferably, all metal parts should be protected with a suitable corrosion-resistant coating that also satisfies paragraph 6.3.1.

6.4 *Specimen Holders:*

6.4.1 Specimen holders should be designed to electrically insulate the specimens from each other and from any other bare metal. When this is not possible, as in the case of certain stressing bolts or jigs, the bare metal contacting the specimen should be isolated from the corrodent by a suitable coating. Protective coatings should be of a type that will not leach inhibiting or accelerating ions or protective oils over the noncoated portions of the specimen. Coatings containing chromates are to be particularly avoided.

NOTE 2—Coatings that have been satisfactorily used by several laboratories are described in Appendix X1.

6.4.2 The shape and form of specimen supports and holders should be such that:

6.4.2.1 They avoid, as much as possible, any interference of free contact of the specimen with the salt solution.

6.4.2.2 They do not obstruct air flow over the specimen, thereby retarding the drying rate.

6.4.2.3 They do not retain a pool of solution in contact with the specimen after the immersion period.

6.4.2.4 Drainage from one specimen does not directly contact any other specimen.

7. Reagents

7.1 Reagent grade sodium chloride (NaCl) shall be used conforming to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are applicable (see Note 1).[6]

7.2 The solution shall be prepared using distilled or deionized water conforming to the purity requirements of Specification D 1193, Type IV reagent water except that for this practice the values for chloride and sodium shall be disregarded.

8. Solution Conditions

8.1 *Concentration*—The salt solution shall be prepared by dissolving 3.5 ± 0.1 parts by weight of NaCl in 96.5 parts of water.

8.2 *Solution pH:*

8.2.1 The pH of the salt solution, when freshly prepared, shall be within the range from 6.4 to 7.2. Only diluted, reagent grade hydrochloric acid (HCl) or reagent grade sodium hydroxide (NaOH) shall be used to adjust the pH.

8.2.2 Experience has shown that periodic adjustment of pH is not necessary when the minimum volume of solution is met and the solution is replaced at the specified interval. For a new testing facility, however, it is recommended that daily pH measurements be made for one week to verify stable operation and adjustments made if required. If the solution is used longer than the recommended interval (8.6), a pH measurement and any necessary adjustment should be made at least weekly.

8.3 *Temperature*—A freshly prepared solution should be allowed to come to within 3°C of the specified room temperature before being used (9.1.1). Thereafter, no control is required on the solution temperature per se. Instead, the room air temperature is controlled and the solution is allowed to reach temperature equilibrium.

8.4 *Minimum Volume*—The volume of the test solution should be large enough to avoid any appreciable change in its corrosiveness either through exhaustion of corrosive constituents, or the accumulation of corrosion products or other constituents that might significantly affect further corrosion. An arbitrary minimum ratio between the volume of test solution and area of specimen (including any uncoated accessories) of 32 mL/cm^2 (200 mL/in.^{2}) of specimen area is recommended.

8.5 *Replenishment of Water Lost by Evaporation*—Evap-

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[6] *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmaceutical Convention, Inc. (USPC), Rockville, MD.

oration losses should be made up by frequent, at least daily, additions of water of the required purity (7.2). Evaporation losses must NOT be replenished with the salt solution. The simplest and recommended procedure is to initially fill the solution to a liquid level line and refill to that line daily. Automatic constant liquid level devices may be used, but are not required. An alternative method is to check the solution with a hydrometer and add the necessary amount of water to bring the salt concentration to 3.5 %.

8.6 *Replacement of Solution*—Fresh solution shall be prepared weekly. At such time, the portions of the apparatus that contact the solution should be cleansed by flushing with water. More frequent replacement of solution may be required for certain steels if severe rusting occurs.

9. Air Conditions

NOTE 3—Other than temperature and humidity, the gaseous and particulate makeup of the laboratory atmosphere is beyond the scope of this recommended practice. However, testers are cautioned not to expose specimens in the vicinity of obvious fumes or airborne contamination, and to consider the possibility of such contamination if unusual results are obtained.

9.1 *Temperature:*

9.1.1 The air temperature shall be maintained at 27 ± 1°C (80 ± 2°F) throughout the entire test cycle.

NOTE 4—When a large Ferris wheel apparatus is used such that the specimens travel through several feet of height, care must be taken to ensure that the air temperatures at all height levels are within the prescribed limits.

9.2 *Relative Humidity*—The percent relative humidity of the air shall be controlled at 45 ± 10 % throughout the entire test cycle..

NOTE 5—Care should be taken to avoid overnight and weekend changes in the operation of the laboratory heating, ventilating, and air conditioning equipment which could result in systematic excursions outside the temperature and humidity control ranges. Occasional excursions related to power outage, mechanical failure, or weather conditions shall be recorded.

9.3 *Air Circulation:*

9.3.1 Air circulation is recognized to be an important consideration because it affects both the rate at which specimens dry and the loss of water by evaporation. Optimum conditions for air circulation have not been established, but the recommendations described in 9.3.2 should be followed.

9.3.2 The most important consideration is to achieve the moderate specimen drying conditions stipulated in 11.2. Because various testing facilities use different immersion apparatus and room sizes, individual experimentation is required to achieve adequate circulation. A mild circulation of air is recommended with two precautionary considerations:

9.3.2.1 Drying by forced air blasts on the specimens is not recommended because of difficulty in maintaining uniform drying of large groups of specimens.

9.3.2.2 Stagnant air conditions should be avoided.

10. Calibration and Standardization

10.1 When a new test facility is established, calibration stress corrosion tests should be conducted to determine how the results obtained compare with published data on well established alloys. Such tests are best made on products of simple geometry with uniform grain structure, such as rolled bar stock or plate.

10.2 It is recommended that each testing facility maintain a supply of a control lot of stress corrosion-susceptible material that can be exposed periodically to demonstrate the reproducibility of its test procedure. Preferably this should be material for which a history of performance in natural environments is available.

11. Procedure

11.1 *Period of Cycle*—Totally immerse specimens in the salt solution for 10 min of each hour and then remove from the solution and allow to dry for 50 min. Continue cycle 24 h/day for the specified period or until failure occurs, with interruptions only for changing solution or examining specimens.

NOTE 6—To some extent this is an arbitrary cycle, but it has considerable historical usage and correlation with exposures to natural atmospheres.[7]

11.2 *Specimen Drying*—As with air circulation (9.3), no fixed procedure has been established, and probably cannot be unless a standardized immersion apparatus and test chamber are adopted. The objective, however, is to ensure that all specimens dry slowly during the 50-min period. Because they drain differently, specimens with different accrued corrosion films will dry at different rates. New specimens with little accumulated corrosion products become dry in about 15 min, while other specimens with an accumulation of corrosion product and salt should be allowed about 40 min to dry.

NOTE 7—Use of heated air to promote drying is not permitted because elevated temperatures can have effects other than acceleration of the drying process.

11.3 *Concurrent Exposure of Various Alloys*—Do not expose specimens of different base metals, aluminum, copper, iron, magnesium, etc., concurrently in the same salt solution. For maximum assurance of reproducibility, do not expose specimens of low alloy content to the same solution used for specimens of high alloy content if the alloying element differs appreciably from the base metal in the galvanic series in salt water. For example, specimens of copper-free aluminum alloys should not be exposed with specimens from alloys containing copper greater than about 0.5 %.

11.4 *Test Duration:*

11.4.1 The duration of test shall be determined by the inherent resistance to corrosion of the alloy, the configuration of the test specimen, and the object of the test. Appropriate exposure periods are determined by correlation with service environments with caution to avoid interference effects described in Section 4. Termination of a test run with nonfailed "run-out" specimens should be governed by a statistical significance test between the final exposure time and longest failure times observed on susceptible items in accordance with Guide G 16.

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[7] Romans, H. B., "Stress Corrosion Test Environments and Test Durations," *Symposium on Stress Corrosion Testing, ASTM STP 425*, Am. Soc. Testing Mats., 1967, pp. 182–208.

11.4.2 When the purpose of the test is control of the quality of production lots, the test duration shall be as required in pertinent specifications or standards.

12. Cleaning Specimens

12.1 After exposure, specimens should be rinsed with water and then cleaned as soon as possible; otherwise, they will continue to corrode because the accumulated salt and corrosion products are hygroscopic. It is important that the specimens be cleaned as thoroughly as possible by recommended methods of cleaning, such as Practice G 1.

NOTE 8—Certain post-test appraisals, such as fractographic examination at high magnification, may require special cleaning methods.

13. Interpretation of Results

13.1 Interpretation of the test results will vary with the type of specimen used and the alloy being tested. Considerations that are common to all stress corrosion tests include:

13.1.1 Stress corrosion test specimens that do not show obvious cracks should be examined at low-power magnification (10 to 30×) for incipient cracks. In some cases, metallographic examination (see Method E 3) may be required to verify freedom from cracking.

13.1.2 Representative failed specimens should be examined metallographically to verify failure was caused by stress-corrosion cracking. Stress-corrosion cracking in aluminum alloys and certain other alloys is typically intergranular.

13.1.3 Any isolated or unusual failures should be closely scrutinized to determine whether such data should be included in the analyses of the data or discarded.

14. Report

14.1 Report the following essential information:

14.1.1 Identification of alloy (or composition if not conforming to registered alloy designation),

14.1.2 Product, temper, and section thickness of material tested, including reference to applicable product specification,

14.1.3 Sampling procedure: size and location of sample with respect to the as-fabricated material, if available,

14.1.4 Specimen details: type, size, and grain orientation of test specimen, and number of replicates,

14.1.5 Level(s) of stress or stress-intensity and method of loading,

14.1.6 Duration of test, and

14.1.7 Notation of any deviation in test procedure from that set forth in preceding paragraphs.

14.2 Other information that may be desirable in certain types of reports includes:

14.2.1 Surface condition of the specimens, including any protective coatings or surface working treatments,

14.2.2 Volume of solution to metal surface area ratio,

14.2.3 Description of the type of alternate immersion apparatus,

14.2.4 Methods used to clean specimens both before and after exposure, and

14.2.5 Listing of individual tabular data for each specimen, plus results of supporting metallographic examinations.

15. Keywords

15.1 accelerated corrosion test; alternate immersion test; aluminum alloys; ferrous alloys; quality control test; sodium chloride solution; stress corrosion cracking

APPENDIX

(Nonmandatory Information)

X1. SATISFACTORY PROTECTIVE COATINGS FOR USE IN ALTERNATE IMMERSION TESTS

X1.1 The following list of coatings is merely a suggested guide and is not intended to be mandatory or exclusive:

X1.1.1 *Maskcoat No. 2* manufactured by Western Coating Co., Box 598, Oakridge Station, Royal Oak, MI 48073. This is a cellulose acetate butyrate base with plasticizers added. It is obtained in bricks which must be melted, 177 to 188°C (350 to 370°F). The portions to be coated are dipped in the melt and allowed to air cool, usually less than 5 min required. Use of *Maskcoat Primer*, by the same company, is recommended for better adhesion at the edges of the coating. The coating is tough, resilient, and transparent and can be stripped without solvents. It may darken when heated for long periods, so it is advisable not to heat longer than necessary. If darkening has not occurred and the coating is clean, it can be recycled. Care should be taken during application to avoid contact with the skin, as severe burns can result.

X1.1.2 *Gaco N-700A* (black) produced by Gates Engineering Div. of Glidden Co., Wilmington, DE 19898. This is a solvent base, liquid neoprene. Thinned with *Gaco Neoprene Thinner N-450-11*, it can be applied by any conventional paint technique and air dries in a few hours or overnight depending on the film thickness applied. It is removed by dissolving in the above thinner or other suitable solvent, such as acetone.

X1.1.3 *Turco Form Mask 544* produced by Turco Products, 24600 South Main St., Wilmington, CA 90745. Good stripping characteristics.

G-01-01

Designation: G 47 – 90

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Standard Test Method for Determining Susceptibility to Stress-Corrosion Cracking of High-Strength Aluminum Alloy Products[1]

This standard is issued under the fixed designation G 47; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This test method covers a uniform procedure for characterizing the resistance to stress-corrosion cracking (SCC) of high-strength aluminum alloy wrought products for the guidance of those who perform stress-corrosion tests, for those who prepare stress-corrosion specifications, and for materials engineers.

1.2 This test method covers method of sampling, type of specimen, specimen preparation, test environment, and method of exposure for determining the susceptibility to SCC of high-strength 2XXX (with 1.8 to 7.0 % copper) and 7XXX (with 0.4 to 2.8 % copper) aluminum alloy products, particularly when stressed in the short-transverse direction relative to the grain structure.

1.3 The values stated in SI units are to be regarded as standard. The inch-pound units in parentheses are provided for information.

1.4 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

G 38 Practice for Making and Using the C-Ring Stress-Corrosion Cracking Test Specimen[3]

G 44 Practice for Evaluating Stress Corrosion Cracking Resistance of Metals and Alloys by Alternate Immersion in 3.5% Sodium Chloride Solution[3]

G 49 Practice for Preparation and Use of Direct Tension Stress Corrosion Specimens[3]

3. Summary of Test Method

3.1 This test method provides a comprehensive procedure for accelerated stress-corrosion testing high-strength aluminum alloy product forms, particularly when stressed in the short-transverse grain direction. It specifies tests of constant-strain-loaded, 3.18-mm (0.125-in.) tension specimens or C-rings exposed to 3.5 % sodium chloride (NaCl) solution by alternate immersion, and includes procedures for sampling various manufactured product forms, examination of exposed test specimens, and interpretation of test results.

4. Significance and Use

4.1 The 3.5 % NaCl solution alternate immersion test provides a test environment for detecting materials that would be likely to be susceptible to SCC in natural outdoor environments, especially environments with marine influences.[4,5,6] For determining actual serviceability of a material, other stress-corrosion tests should be performed in the intended service environment under conditions relating to the end use, including protective measures.

4.2 Although this test method is intended for certain alloy types and for testing products primarily in the short-transverse stressing direction, this method is useful for some other types of alloys and stressing directions.

5. Interferences

5.1 A disadvantage of the 3.5 % NaCl solution alternate immersion test is that severe pitting may develop in the specimens. Such pitting in tension specimens with relatively small cross section can markedly reduce the effective cross-sectional area and produce a net section stress greater than the nominal gross section stress, resulting in either: (*a*) fracture by mechanical overload of a material that is not susceptible to SCC; or (*b*) SCC of a material at an actual stress higher than the intended nominal test stress. The occurrence of either of these phenomena might then interfere with a valid evaluation of materials with relatively high resistance to stress corrosion.

6. Test Specimen

6.1 *Type and Size*—No single configuration of test specimen is applicable for the many complex shapes and sizes of

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[1] This test method, which was developed by a joint task group with the Aluminum Association, Inc., is under the jurisdiction of ASTM Committee G-1 on Corrosion of Metals, and is the direct responsibility of Subcommittee G01.06 on Stress Corrosion Cracking and Corrosion Fatigue.

Current edition approved March 30, 1990. Published May 1990. Originally published as G 47 – 76. Last previous edition G 47 – 79 (1984)$^{\epsilon1}$.

[2] *Annual Book of ASTM Standards*, Vol 03.03.

[3] *Annual Book of ASTM Standards*, Vol 03.02.

[4] Romans, H. B., *Stress Corrosion Testing, ASTM STP 425*, ASTM, 1967, pp. 182–208.

[5] Brown, R. H., Sprowls, D. O., and Shumaker, M. B., "The Resistance of Wrought High Strength Aluminum Alloys to Stress Corrosion Cracking," *Stress Corrosion Cracking of Metals—A State of the Art, ASTM STP 518*, ASTM, 1972, pp. 87–118.

[6] Sprowls, D. O., Summerson, T. J., Ugiansky, G. M., Epstein, S. G., and Craig, H. L., Jr., "Evaluation of a Proposed Standard Method of Testing for Susceptibility to Stress-Corrosion Cracking of High-Strength 7XXX Series Aluminum Alloy Products," *Stress Corrosion-New Approaches, ASTM STP 610*, ASTM, 1976, pp. 3–31.

products that must be evaluated. A tension specimen is preferred because it more consistently provides definite evidence of cracking and should be used whenever the size and shape of the product permits; it also provides a more severe test.[6]

6.1.1 *Tension Specimen*—The diameter of the reduced section shall be 3.17 ± 0.03 mm (0.125 ± 0.001 in.).

6.1.2 *C-Ring (see Practices G 38)*—The use of C-rings permits short-transverse tests to be made of sections that are too thin or complex for practical tests with a tension specimen. C-rings may be of various sizes as required for the product to be tested, but in no case less than 15.88 ± 0.05 mm (0.625 ± 0.002 in.) in outside diameter. The ratio of diameter to wall thickness shall be kept in the range from 11:1 to 16:1.

6.2 *Stressing Direction:*

6.2.1 *Short-Transverse Tests:*

6.2.1.1 For specified material thicknesses of 38.10 mm (1.500 in.) and over, the tension specimen shall be used.

6.2.1.2 For specified material thicknesses of 17.78 through 38.08 mm (0.700 through 1.499 in.), a C-ring shall be used. A tension specimen may be used if consistent with the provisions of Practice G 49.

6.2.2 For other stress directions in materials of 6.35 mm (0.250 in.) and over, the tension specimen shall be used.

6.3 *Surface Preparation*—Test specimens shall be degreased prior to exposure.

7. Sampling and Number of Tests

7.1 Unless otherwise specified, tests shall be performed in the short-transverse direction; the intention is to orient the specimen so that the applied tensile stress is perpendicular to the metal flow lines and in the short-transverse direction relative to the grain structure. In rolled or extruded sections that are approximately round or square, there is no true short-transverse direction because in a transverse plane the grains tend to be equiaxial; and, in such cases, the stress should be directed simply in the transverse direction. If, in certain unusual cases, the grain structure is or tends to be equiaxial also in the longitudinal direction, the stress shall be applied in a direction parallel to the smallest dimension of the product.

7.2 *Location of Specimens:*

7.2.1 For products stress relieved by stretching (TX51, TX510, TX511, TXX51, TXX510, TXX511), samples shall not be taken from the portion under the stretcher grips.

7.2.2 *Rolled Plate*—Short-transverse specimens shall be taken so that the region of maximum stress is centered on the mid-plane of the plate and at least 2½ plate thicknesses away from a side of the plate. (The side of the plate is defined as the edge parallel to the rolling direction.)

7.2.3 *Hand Forgings*—Short-transverse specimens shall be taken so that the stress is applied in a direction perpendicular to the forging flow lines. The region of maximum stress shall be centered in the forging thickness and approximately on the longitudinal center line of the forging, no less than ½ the section thickness away from "as-heat treated" edges of the forging.

7.2.4 *Die Forgings*—Because of the wide variety of configurations of die forgings, guidelines are provided for only certain common types of shapes that are widely used. Short-transverse specimens shall be taken so that the stress is applied in a direction perpendicular to the forging flow lines and, if possible, with the region of maximum stress centered on the parting plane. The metal flow pattern in die forgings cannot always be predicted, so only a few general rules are given, and they are illustrated in Fig. 1. Departures from these rules should be made only on the basis of a study of forging flow lines indicating that the intended type of test would not be obtained. In every case, a diagram should be filed with the test results to illustrate specimen locations and orientations.

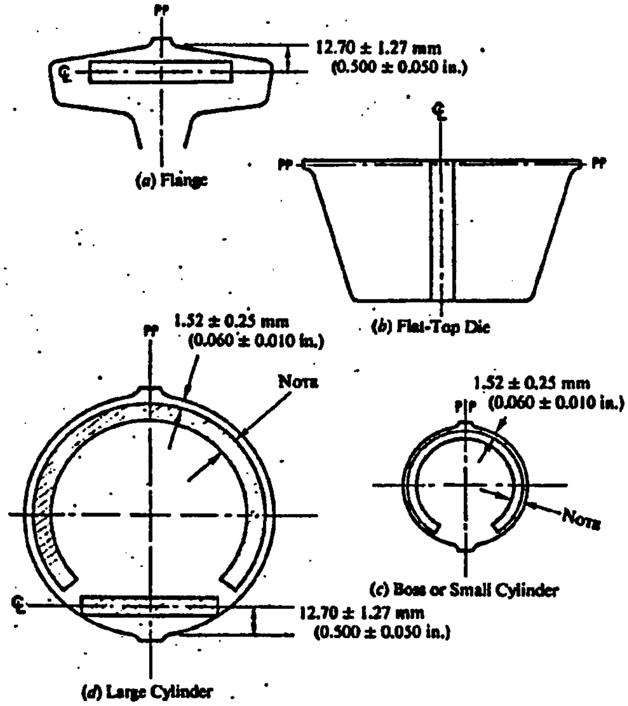
7.2.4.1 *Flanges*—The centerline of the specimen shall be 12.70 ± 1.27 mm (0.500 ± 0.050 in.) from the base of the fillet of the flash except for flanges that are too thin, in which case, the specimen should be centered.

7.2.4.2 *Flat-Top Die*—The tension specimen should be perpendicular to the parting plane and, if possible, centered in the width.

7.2.4.3 *Boss or Small Cylinder*—The C-ring specimen should be centered on the parting plane and with the outside diameter of the ring being 1.52 ± 0.25 mm (0.060 ± 0.010 in.) from the forging surface (see Fig. 1).

7.2.4.4 *Large Cylinder*—The centerline of tension specimens shall be 12.70 ± 1.27 mm (0.500 ± 0.050 in.) from the base of the flash. If a C-ring is required, its outside diameter shall be 1.52 ± 0.25 mm (0.060 ± 0.010 in.) from the forging surface (see Fig. 1).

7.2.5 *Extruded, Rolled, or Cold Finished Rod, Bar, and Shapes:*



(*a*) Flange

(*b*) Flat-Top Die

(*c*) Boss or Small Cylinder

(*d*) Large Cylinder

Note—Similar to that of typical machined part.

FIG. 1 Recommended Specimen Type and Location for Various Configurations of Die Forgings

7.2.5.1 *Width-to-Thickness Ratio Greater than 2*—Short-transverse specimens shall be taken so that the region of maximum stress is centered in the section thickness, at least one section thickness away from the sides of the product. In the case of complex configurations for which the grain directionality cannot be predicted, specimen location shall be determined by means of macroetched transverse sections to ensure a short-transverse specimen and to avoid regions of nearly equiaxial (transverse) grain flow.

7.2.5.2 *Width-to-Thickness Ratio of 2 or Less*—Specimens shall be centered in the section thickness so that the region of maximum stress application will be at least one half the section thickness away from a fabricated surface, if possible. These specimens shall be considered to have a "transverse" orientation to the grain structure. When C-rings are required, they shall be taken so that the region of maximum tensile stress is 3.18 ± 0.25 mm (0.125 ± 0.010 in.) from the product surface.

7.3 *Number of Specimens*—For each sample, which shall be uniform in thickness and grain structure, a minimum of three adjacent replicate specimens shall be tested.

8. Test Environment

8.1 *Corrosion Test Environment*—Specimens shall be exposed to the alternate 10-min immersion—50-min drying cycle in accordance with Practice G 44.

8.2 *Length of Exposure*—The test duration for 3.18-mm (0.125-in.) tension specimens and C-rings shall be 10 days for 2XXX alloys or 20 days for 7XXX alloys, unless cracking occurs sooner. For specimens to be tested in the long transverse direction, the test duration should be 40 days. Longer nonstandard test durations are likely to cause failures of the 3.18-mm tension specimens as a result of severe pitting as described in 5.1. There shall be no interruptions except as required for periodic inspection of specimens or changing of the solution.

9. Procedure

9.1 *Method of Loading:*

9.1.1 *Tension Specimens*—Stress tension specimens in "constant strain"-type fixtures, as in Fig. 3 of Practice G 49.

9.1.2 *C-rings*—Stress C-rings by a method that provides constant strain and produces a tensile stress on the ring outside diameter in accordance with Practice G 38.

9.2 *Magnitude of Applied Stress*—Stress specimens to one or more levels as specified or as required to determine comparative stress corrosion resistance. The application of a stress less than about 103 MPa (15 ksi) is not practicable.

9.3 *Examination of Specimens:*

9.3.1 *Interim Inspection:* Visually inspect specimens each working day for evidence of cracking without removal of corrosion products. Inspection may be facilitated by wetting the specimen with the test solution and by examination at low magnifications.

9.3.2 *Final Examination*—Perform final examination at a magnification of at least 10X on all surviving specimens after cleaning them in concentrated (70%) nitric acid (HNO_3) at room temperature followed by a water rinse. Section and metallographically examine any C-ring that is considered suspect, as evidenced by linear pitting, to determine whether or not SCC is present. Similar examination of fractured or cracked tension specimens also can be useful to verify SCC as the cause of failure.

10. Interpretation of Results

10.1 *Criterion of Failure:*

10.1.1 A sample shall be considered to have failed the test if one or more of the specimens fail, except that the retest provisions of Section 11 shall apply.

10.1.2 A specimen that has fractured or which exhibits cracking shall be considered as a stress corrosion failure unless proved otherwise by the provisions of 10.2 and 10.3.

10.2 *Macroscopic Examination*—Cracking should be clearly differentiated from lined-up pitting. If the presence of SCC is questionable, metallographic examinations should be performed to determine whether or not SCC is present.

NOTE 1—When a specimen fractures within a relatively short time after exposure (ten days or less), metallographic examination is not necessary because such rapid failures are characteristically due to SCC.

10.3 *Metallographic Examination:*

10.3.1 A specimen that reveals intergranular cracking, even when accompanied by transgranular cracking, shall be considered as an SCC failure. Intergranular fissures that are no deeper than the width of localized areas of intergranular corrosion or, in the case of C-rings, not deeper than those in unstressed or compressively stressed surfaces, shall not be considered as an SCC failure. In the case of tension specimens, the depth of intergranular fissures may be compared to those in an unstressed specimen when available.

10.3.2 A specimen that reveals only pitting corrosion (that is, no intergranular attack), or pitting plus transgranular cracking, shall not be considered as an SCC failure.

NOTE 2—Transgranular cracking in the absence of intergranular attack only occurs in pitted specimens under extremely high stress (intensity) and, for the purpose of this recommended practice, is not considered as a criterion of SCC.

11. Retesting and Resampling

11.1 Retesting shall be permitted only if a single specimen fails by SCC, in which case three replicate specimens shall be tested. If any retest specimen fails, the sample shall be considered to have failed the test.

11.2 If any failure is due to improper preparation of the specimen or to incorrect testing technique, or if the specimen is found to be not representative of the material, the specimen shall be discarded and another specimen substituted.

11.3 When resampling, the required specimens shall be taken from the original sample if possible, or from another sample of the same lot of material.

12. Report

12.1 Report the following information:

12.1.1 Results of all tests, including type and size of specimen, orientation of specimen and number of replicates, stress level, and times to failure.

12.1.2 Identification of alloy, temper, product form, and thickness of materials tested, including reference to applicable specifications.

12.1.3 Any deviation from the procedures outlined above.

13. Precision and Bias

13.1 Data on the precision of test results obtained by this test method were derived from interlaboratory tests of 2124 and 7075 alloys. The repeatability and reproducibility of the test results were good for specimens with either a high (rapid failures) or a very low susceptibility (no failures) to SCC. However, the variability was considerable for tests of specimens with intermediate susceptibility. This is shown in Fig. 2 by the increase in repeatability standard deviation of times to failure as a function of the arithmetic mean.

13.2 The alternate immersion test results obtained by this test method closely paralleled the results of atmospheric exposures, especially at the seacoast. Specific comparisons varied, however, depending on the condition of the alloy, the level of applied stress, and the type of atmospheric environment.[5,6]

13.3 Information relating to the precision and bias of the methods of stressing the test specimens is given in Practices G 38 and G 49.

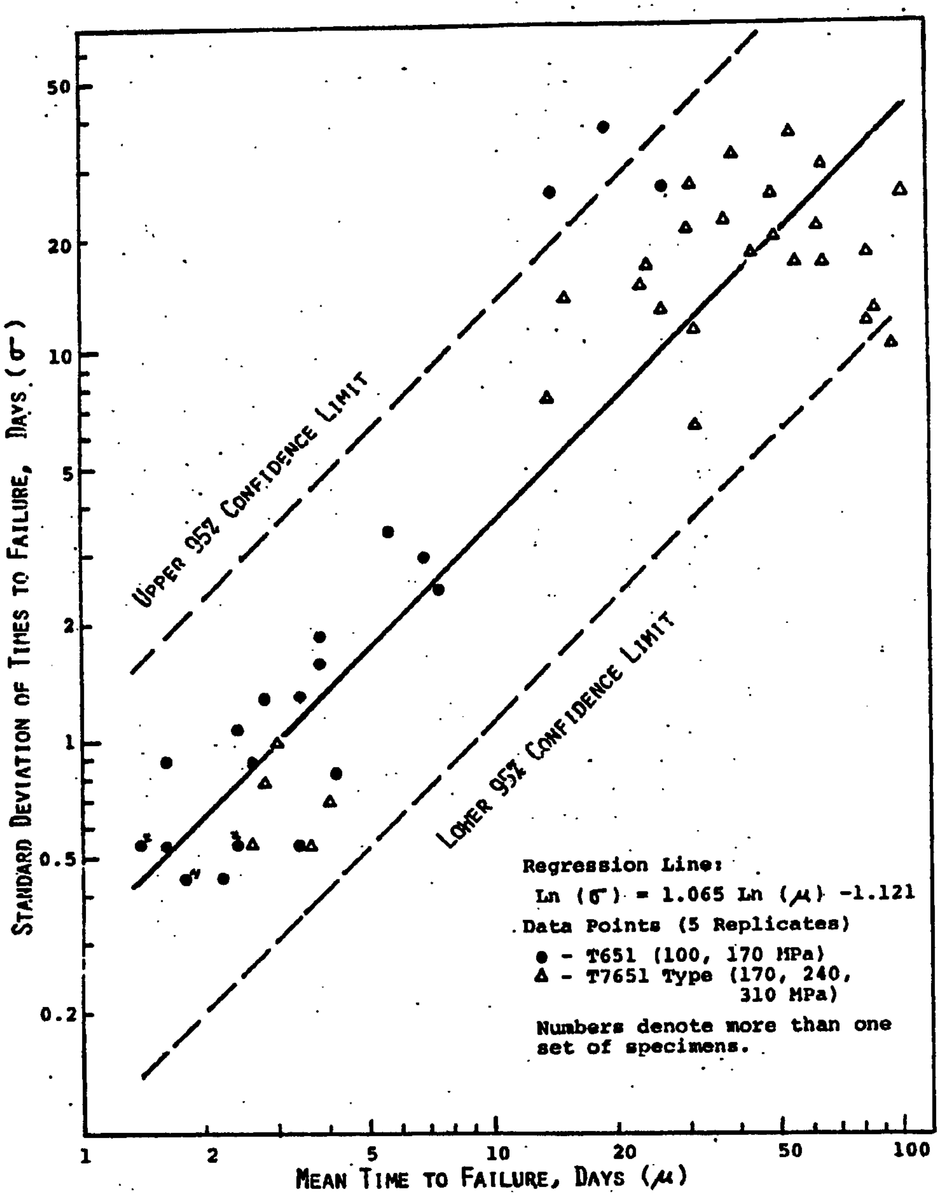


FIG. 2 7075 Alloy Short Transverse 3.18 mm Tension Specimens Stressed at Various Levels and Exposed in Quintuplicate to 3.5 % NaCl Solution by Alternate Immersion per Practice G 44

Designation: G 103 – 89$^{\epsilon1}$

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Standard Test Method for Performing a Stress-Corrosion Cracking Test of Low Copper Containing Al-Zn-Mg Alloys in Boiling 6 % Sodium Chloride Solution[1]

This standard is issued under the fixed designation G 103; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Continuous immersion in boiling 6 % sodium chloride solution historically was considered to be an effective accelerated SCC testing medium for Al-Zn-Mg-Cu alloys (**1, 2**),[2] but in more recent years, the 3.5 % sodium chloride alternate immersion test (Practice G 44) has become the favored test medium for the high copper (1.0–2.6 % Cu) 7XXX series alloys (**3, 4**). Evidence to date shows, however, that the boiling 6 % sodium chloride stress corrosion test correlates better with outdoor atmospheric exposure than the Practice G 44 test for the 7XXX series alloys containing little or no copper (**5, 6, 7, 8**).

$^{\epsilon1}$ Note—This test method was editorially renumbered in April 1994.

1. Scope

1.1 This stress corrosion test method is intended for statically loaded smooth non-welded or welded specimen tests of 7XXX series Al-Zn-Mg alloys containing less than 0.25 % copper.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* See Section 9 for additional precautions.

2. Referenced Documents

2.1 *ASTM Standards:*

B 580 Specification for Anodic Oxide Coatings on Aluminum[3]
D 1193 Specifications for Reagent Water[4]
G 1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens[5]
G 15 Terminology Relating to Corrosion and Corrosion Testing[5]
G 30 Practice for Making and Using U-Bend Stress-Corrosion Test Specimens[5]
G 38 Practice for Making and Using C-Ring Stress-Corrosion Test Specimens[5]
G 39 Practice for Preparation and Use of Bent-Beam Stress-Corrosion Test Specimens[5]
G 44 Practice for Evaluating Stress Corrosion Cracking Resistance of Metals and Alloys by Alternate Immersion in 3.5 % Sodium Chloride Solution[5]
G 47 Test Method for Determining Susceptibility to Stress-Corrosion Cracking of High-Strength Aluminum Alloy Products[5]
G 49 Practice for Preparation and Use of Direct Tension Stress Corrosion Test Specimens[5]
G 58 Practice for Preparation of Stress Corrosion Test Specimens for Weldments[5]

3. Summary of Test Method

3.1 Stressed specimens of Al-Zn-Mg alloys are totally immersed in boiling 6 % sodium chloride solution for up to 168 h. Various types of smooth test specimens and methods of stressing may be used. Performance is based on time to visual cracking.

4. Significance and Use

4.1 This test method is normally used as a stress corrosion screening test for the development of Al-Zn-Mg alloys containing less than 0.25 % copper. Generally, effects on stress corrosion resistance due to variables such as composition, thermo-mechanical processing, other fabrication variables and magnitude of applied stress may be compared.

4.2 For a given mechanical method of stressing, the relative stress corrosion resistance of the low copper containing Al-Zn-Mg alloys in atmospheric exposure correlates better with performance in boiling salt test than with other accelerated corrosion tests (**7**). In addition, this is a faster test than other laboratory SCC test methods.

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[1] This test method is under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.06 on Stress Corrosion Cracking and Corrosion Fatigue.

Current edition approved Feb. 24, 1989. Published May 1989.

[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[3] *Annual Book of ASTM Standards*, Vol 02.05.

[4] *Annual Book of ASTM Standards*, Vol 11.01.

[5] *Annual Book of ASTM Standards*, Vol 03.02.

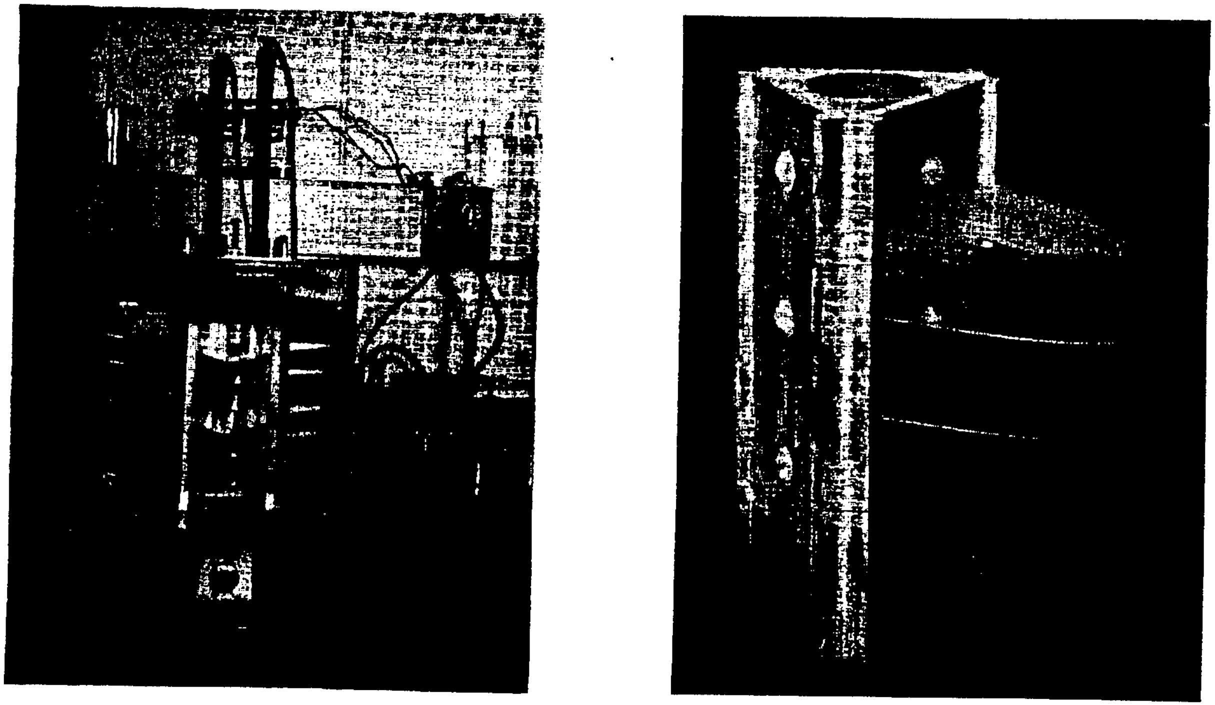

FIG. 1 Boiling 6 % NaCl—Stress Corrosion Test

U bend samples (ASTM G 39) were placed into an anodized aluminum fixture (right photo) and then placed into the pyrex battery jar (left photo). Pyrex jar is placed over a magnetic stirrer. The 6 % salt solution is heated to boiling by means of two quartz immersion heaters. A powerstat controls the heat output of the quartz heaters. A cold water circulating aluminum condenser tube is placed just below the aluminum cover. This prevents evaporation losses. Stressed specimens are placed in the jar, after the solution comes to a boil. Specimens are examined in place for visual evidence of cracking. The time to cracking is used to measure stress corrosion resistance.

4.3 This test is not applicable to 2XXX (Al-Cu), 5XXX (Al-Mg), and the 7XXX series alloys containing more than 1.2 % copper.

4.3.1 for 7XXX series alloys containing between 0.25 % and 1.2 % copper, there is no general agreement as to whether this method or Practice G 44 correlates better with stress corrosion resistance in service (5–9).

5. Apparatus

5.1 Figure 1 illustrates one type of apparatus that has been used.

5.2 *Materials of Construction:*

5.2.1 Materials of construction that come in contact with the boiling salt solution shall be such that they are not affected by the corrodent to an extent that they can cause contamination of the solution and change its corrosiveness.

5.2.2 Use of glass or aluminum containers and condensers is recommended.

5.2.3 Metallic materials of construction should be limited to copper free aluminum alloys, which may be anodized to provide electrical contact resistance.

5.3 *Specimen Holders*—The specimen holders should be designed to electrically insulate the specimens from each other and from other bare metal. An anodized aluminum holder has been found to be appropriate. (Satisfactory anodic coating may be Type A or B, Specification B 580.) Periodic ohmeter checks may be made to confirm electrical isolation of specimen and anodized holder.

5.4 *Heater for Solution:*

5.4.1 Heaters must be of sufficient capacity that boiling temperature can be maintained and solution can be brought back up to a boil within 10 min after the introduction of test specimens.

5.4.1.1 Quartz immersion heaters may be used.

5.4.1.2 Hot plate resistance heaters may be used.

6. Reagents and Solution Conditions

6.1 Reagent grade sodium chloride (NaCl) shall be used. It shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are applicable.

6.2 The 6 % NaCl solution shall be prepared using water conforming to the purity requirements of Specification D 1193, Type IV reagent water.

6.3 *Concentration*—The salt solutions shall be prepared by dissolving 6.0 ± 0.1 parts by weight of NaCl in 94.0 parts of water.

6.4 *Solution pH*, shall be between 6.4 and 7.2. The pH may be adjusted by the addition of dilute reagent grade HCl or NaOH solutions. (See Practice G 44.)

6.5 *Minimum Volume*—The volume of solution should be large enough to avoid any appreciable change in its corrosiveness through exhaustion of corrosive constituents, or the accumulation of corrosion products or other constituents that might significantly affect further corrosion. A minimum ratio between the volume of solution and area of specimen of 20 mL/in^2 (0.32 L/dm^2) is recommended.

6.6 Reflux condensers are required in order to prevent evaporation losses. Condenser material can be glass or copper-free aluminum alloy.

6.7 Solution should be boiling throughout the test, except for the first few minutes after specimens are immersed into the solution.

6.8 *Replacement of Solution*—New solution should be used for each test. Solution should not be changed during testing.

7. Test Specimens

7.1 *Type and Size*—No single configuration of test specimen is applicable for the many complex shapes and sizes of products that can be evaluated. Bent beam (G 39) and U bend (G 30) are useful for thin products while C-rings (G 38) or tension specimen (G 49) are more suitable for heavier products and for short transverse testing.

7.2 *Stressing Direction and Magnitude of Stress*—Any of the three primary grain directions may be used. The magnitude of stress can be either within the elastic range or beyond. The method of stressing the specimens should be reproducible and in accordance to standard procedures for the type of specimen selected.

7.3 *Surface Preparation*—The specimen surface should be free of oil, grease, and dirt. This usually entails washing with organic solvents such as alcohol or acetone and/or the use of chemical deoxidizing solutions.

7.4 There is no need to provide compensation for thermal expansion effects on applied stress.

7.5 *Number of Specimens*—A minimum of three replicate specimens shall be tested for each sample variable.

8. Safety Precautions

8.1 Care should be taken in order to avoid burns from hot surfaces.

8.2 Appropriate eye protection equipment should be used.

9. Procedure

9.1 Allow solution to boil for a minimum of 10 min before specimens are immersed.

9.2 Stress specimens shortly before immersion. (Long delays between stressing and testing should be avoided unless the stressed specimens are kept in a desiccator at a relative humidity less than 5 %.)

9.3 *Inspection Method and Frequency:*

9.3.1 Specimen surfaces should be examined for visual evidence of cracking or the initiation of gas evolution from the surface in areas of highest stress. (Usually gassing is noted before cracking.) It is preferred that these inspections be done in situ, which can be accomplished with glass reaction vessels. If the specimens have to be removed from the boiling salt solution, then the time out of solution should be kept to a minimum, no more than 5 min.

9.3.2 In research and development studies, the recommended frequency of inspection is every 15 min for the first 2 h. The examinations can be reduced to hourly intervals for the next 6 h. After 24 h, the inspection period can be reduced to four daily inspections. This would consist of 2-h intervals during the normal 8-h working day. (Alternate: For Quality Assurance Testing purposes, after the first two hours of the test, periodic inspections can be made at 2-h intervals during the first working day. Thereafter, inspections can be reduced to twice daily for the balance of the test.)

9.4 Time to first visual evidence of cracking and the first gassing shall be recorded.

9.5 *Test Duration*—A maximum of 168 h is recommended.

9.6 *Final Examination*—Give all specimens a final inspection for evidence of cracking at the termination of the test.

10. Interpretation of Results

10.1 *Criterion of Failure*—A specimen shall be considered to have failed when there is visual evidence of cracking. This is frequently preceded by evidence of gas (H2) emission at the point of crack initiation. (Usually all specimens are left in the test solution until test termination.)

10.2 *Macroscopic Examination*—Cracking should be clearly distinguishable from pit-fissures. If the presence of SCC is questionable, metallographic examinations should be performed to determine whether or not SCC is present.

10.3 *Metallographic Examination*—At least one of the replicate specimens of each variable should be cross sectioned and examined at test termination. This may be optional for routine study, but should be mandatory in development work.

10.3.1 A specimen that reveals intergranular cracking, even when accompanied by transgranular cracking, shall be considered a SCC failure.

10.3.2 A specimen that reveals only pitting corrosion or pitting plus transgranular cracking, shall not be considered a SCC failure. Additionally, in the absence of intergranular attack, transgranular cracking is not considered to be a SCC failure in this standard method. (See G47.)

11. Reporting Results

11.1 Report the following information:

11.1.1 Results of all tests, including type and size of specimen, orientation of specimen and number of replicates, solution volume to surface area ratio, stress level, and time to failure.

11.1.2 Identification of alloy, temper, product form, thickness of materials tested and reference to applicable specifications.

11.1.3 Any deviation from the procedures outlined above.

12. Precision and Bias

12.1 The precision of this test method for performing stress corrosion cracking tests of low copper containing Al-Zn-Mg alloys is being determined.

12.2 No justifiable statement can be made on the bias of this test method because the reference environment, outdoor atmospheric exposure, is not sufficiently defined to allow a quantitative assessment of bias. However, this method ranks materials according to their performance in marine atmospheres, as shown in Refs (**5**, **6**, **7**, **8**, **10**).

REFERENCES

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(2) Dix, E. H., Jr., "Aluminum-Zinc-Magnesium Alloys: Their Development and Commercial Production," *Trans.* ASM 42 (1950), pp. 1057–1127.

(3) Sprowls, D. O. and Brown, R. H., "What Every Engineer Should Know About Stress Corrosion of Aluminum," Metal Progress 81, 4, (1962), pp. 79–85 and 81, 5, (1962), pp. 77–83.

(4) Sprowls, D. O., Summerson, T. J., Ugiansky, G. M., Epstein, S. G., and Craig, H. L., Jr., "Evaluation of a Proposed Standard Method of Testing for Susceptibility to Stress-Corrosion Cracking of High Strength 7XXX Series Aluminum Alloy Products," *Stress Corrosion—New Approaches, ASTM STP 610* (1976), pp. 3–31.

(5) Romans, H. B., "Stress Corrosion Test Environments and Test Durations," ASTM STP 425 (1967), pp. 182–208.

(6) Lifka, B. W. and Sprowls, D. O., "Stress Corrosion Testing of Aluminum Alloy 7079-T6 in Various Environments," Stress Corrosion Testing, *ASTM STP 425* (1967), pp. 342–362.

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(9) King, W. L., "Boiling Salt Tests of 7016 and 7029 Alloy Bumpers," Alcoa Research Laboratory Report, September 9, 1981.

(10) Helfrich, W. J., "Influence of Stress and Temperature on the Short Transverse Stress Corrosion Resistance of Al-4.2Zn-2.5Mg Alloy." *ASTM STP 425*, (1967).

Designation: G 123 – 96

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Standard Test Method for Evaluating Stress-Corrosion Cracking of Stainless Alloys with Different Nickel Content in Boiling Acidified Sodium Chloride Solution[1]

This standard is issued under the fixed designation G 123; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method describes a procedure for conducting stress-corrosion cracking tests in an acidified boiling sodium chloride solution. This test method is performed in 25 % (by *mass*) sodium chloride acidified to pH 1.5 with phosphoric acid. This test method is concerned primarily with the test solution and glassware, although a specific style of U-bend test specimen is suggested.

1.2 This test method is designed to provide better correlation with chemical process industry experience for stainless steels than the more severe boiling magnesium chloride test of Practice G 36. Some stainless steels which have provided satisfactory service in many environments readily crack in Practice G 36, but have not cracked during interlaboratory testing[2] using this sodium chloride test method.

1.3 This boiling sodium chloride test method was used in an interlaboratory test program to evaluate wrought stainless steels, including duplex (ferrite-austenite) stainless and an alloy with up to about 33 % nickel. It may also be employed to evaluate these types of materials in the cast or welded conditions.

1.4 This test method detects major effects of composition, heat treatment, microstructure, and stress on the susceptibility of materials to chloride stress-corrosion cracking. Small differences between samples such as heat-to-heat variations of the same grade are not likely to be detected.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statements, see Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1193 Specification for Reagent Water[3]

E 8 Test Methods for Tension Testing of Metallic Materials[4]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[5]

G 15 Terminology Relating to Corrosion and Corrosion Testing[6]

G 16 Guide for Applying Statistics to Analysis of Corrosion Data[6]

G 30 Practice for Making and Using U-Bend Stress Corrosion Test Specimens[6]

G 36 Practice for Evaluating Stress-Corrosion-Cracking Resistance of Metals and Alloys in a Boiling Magnesium Chloride Solution[6]

G 49 Practice for Preparation and Use of Direct Tension Stress Corrosion Test Specimens[6]

G 107 Guide for Formats for Collection and Compilation of Corrosion Data for Metals for Computerized Database Input[6]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of corrosion-related terms used in this test method, see Terminology G 15.

4. Summary of Test Method

4.1 A solution of 25 % sodium chloride (by *mass*) in reagent water is mixed, and the pH is adjusted to 1.5 with phosphoric acid. The solution is boiled and U-bends (or other stressed specimens) are exposed in fresh solution for successive one-week periods.

4.2 The test may be continued for as many weeks as necessary, but six weeks (about 1000 h) or less are expected to be sufficient to crack susceptible materials. Longer exposures provide greater assurance of resistance for those materials which do not crack.

4.3 It is recommended that samples of a susceptible material, for example, UNS S30400 or S31600 (Type 304 or Type 316 stainless, respectively), be included as a control when more resistant materials are evaluated.

5. Significance and Use

5.1 This test method is designed to compare alloys and may be used as one method of screening materials prior to service. In general, this test method is more useful for

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[1] This test method is under the jurisdiction of ASTM Committee G-1 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.06 on Stress Corrosion Cracking and Corrosion Fatigue.

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[2] Interlaboratory test program including UNS S30400, S31600, S32550, and N08020. These data are available at ASTM Headquarters, 1916 Race St., Philadelphia, PA 19103. Request RR G01-1013.

[3] *Annual Book of ASTM Standards*, Vol 11.01.

[4] *Annual Book of ASTM Standards*, Vol 03.01.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

[6] *Annual Book of ASTM Standards*, Vol 03.02.

stainless steels than the boiling magnesium chloride test of Practice G 36. The boiling magnesium chloride test cracks materials with the nickel levels found in relatively resistant austenitic and duplex stainless steels, thus making comparisons and evaluations for many service environments difficult.

5.2 This test method is intended to simulate cracking in water, especially cooling waters that contain chloride. It is not intended to simulate cracking that occurs at high temperatures (greater than 200°C or 390°F) with chloride or hydroxide.

5.3 Correlation with service experience should be obtained when possible. Different chloride environments may rank materials in a different order.

5.4 In interlaboratory testing, this test method cracked annealed UNS S30400 and S31600 but not more resistant materials, such as annealed duplex stainless steels or higher nickel alloys, for example, UNS N08020 (for example 20Cb-3[7] stainless). These more resistant materials are expected to crack when exposed to Practice G 36 as U-bends. Materials which withstand this sodium chloride test for a longer period than UNS S30400 or S31600 may be candidates for more severe service applications.

5.5 The repeatability and reproducibility data from Section 11 and Appendix X1 must be considered prior to use. Interlaboratory variation in results may be expected as occurs with many corrosion tests. Acceptance criteria are not part of this test method and if needed are to be negotiated by the user and the producer.

6. Apparatus

6.1 The glassware used for this test method is shown in Fig. 1 and is as follows:

6.1.1 *Flask*—1000-mL Erlenmeyer flask with a 45/50 ground-glass joint.

6.1.2 *Condenser*, a four-bulb Allihn condenser with a 45/50 ground glass joint (water-cooled joint suggested), a water jacket at least 20 cm (8 in.) long and a 1 to 2.5 cm (0.4 to 0.95 in.) long drip tip is used. (Modified Allihn condensers with no drip tip and condensers with longer drip tips may produce different results. These alternate Allihn condenser designs may be used if control samples of susceptible (for example, UNS S31600) and resistant (for example, UNS N08020) materials are included in the study.)

6.1.3 *Hot Plate*, capable of maintaining the solution at its boiling point.

7. Reagents

7.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[8] Other grades may be used provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without affecting results.

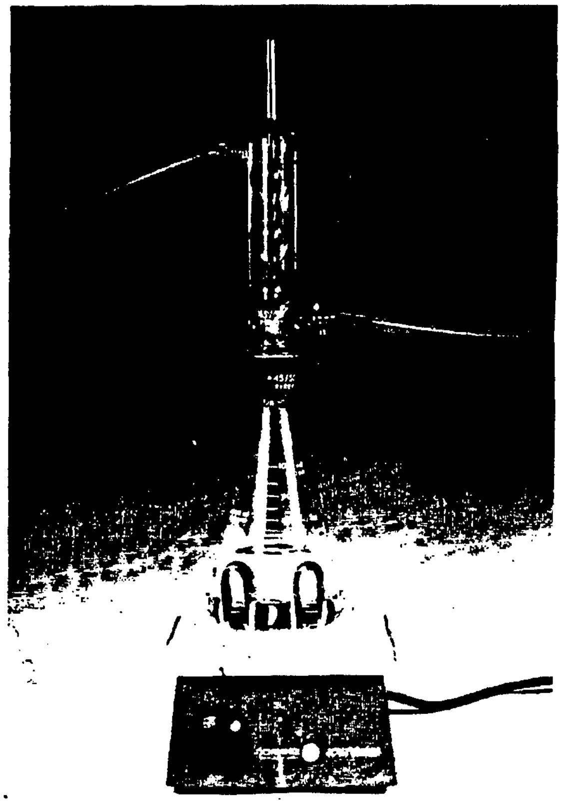

FIG. 1 Apparatus Used for Stress-Corrosion Cracking Test

7.2 *Purity of Water*—Solutions shall be made with water of purity conforming to at least Type IV reagent water as specified in Specification D 1193 (except that for this method limits for chlorides and sodium may be ignored).

7.3 *Sodium Chloride (NaCl)*—A solution of 25 % NaCl (by mass) acidified to pH 1.5 with phosphoric acid (H_3PO_4) is used. The solution may be prepared by adding 750 g H_2O (750 mL) to 250 g NaCl, and adjusting to pH 1.5 with H_3PO_4. Varying quantities of solution may be prepared and larger amounts may be stored indefinitely in appropriate glassware. The pH must be determined prior to each use.

8. Hazards

8.1 Normal precautions for handling boiling liquid should be observed.

8.2 All heating or boiling of the NaCl solution should be done in an area where personnel are not likely to accidentally bump the flask. A hooded area is preferred.

8.3 Minimum personal protective equipment for handling boiling sodium chloride should include safety glasses or goggles, face shield, laboratory coat, and rubber gloves.

NOTE 1: **Caution**—U-bends (and other highly stressed test specimens) may be susceptible to high rates of crack propagation and a specimen containing more than one crack may splinter into two or more

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[7] 20Cb-3 is a registered trademark of Carpenter Technology Corp., Reading, PA.

[8] *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmaceutical Convention, Inc. (USPC), Rockville, MD.

pieces. This may also occur due to a cracked restraining bolt. Due to the highly stressed condition in a U-bend specimen, these pieces may leave the specimen at high velocity and can be dangerous.

9. Test Specimens

9.1 U-bends are preferred but other stress corrosion cracking specimens may be used with this test solution. The specimen style chosen should provide sufficient stress to crack less resistant materials (for example, UNS S30400 or S31600) in 1000 h or less). (See Annex A1.) Regardless of the specimen style, it is recommended that UNS S30400 or UNS S31600, or both, be included as controls.

9.2 The test specimen must be thick enough so that the applied stress does not cause mechanical rupture of less resistant materials if the cross section is reduced by pitting or general corrosion.

9.3 The size of alternate specimens (other than those in Annex A1) must allow a solution volume to specimen surface area ratio of at least 5:1 mL/cm^2 (33 mL/in.^{2}).

9.4 A minimum of four replicates (two per flask) is required because of the variability typical in stress-corrosion testing.

9.5 Methods of fabricating U-bend specimens are provided in Annex A1. These procedures are based on Practice G 30, but in addition provide a specimen that fits through a 45/50 ground-glass joint. Assurance that the legs are stressed sufficiently by the bolt is also provided.

9.5.1 Other methods of producing U-bends described in Practice G 30 may be used; however, during exposure the U-bends must be (*a*) in the plastic range and (*b*) stressed to the maximum applied tensile load experienced during fabrication. The same method must be used to fabricate all the U-bends in a given study.

9.5.2 The bolt, nut, and flat washer must be made of a material resistant to general corrosion, pitting, and stress corrosion cracking in the environment. UNS N10276 (Alloy C-276) is recommended because some other materials (for example, titanium or UNS N06600 [Alloy 600]) may be attacked resulting in an increase in solution pH.

9.5.3 The metallic fastener must be electrically isolated from the specimen by a rigid shoulder washer, (that is, zirconia or another material that will not be compressed during the test).

9.5.4 The extended end of the bolt may require cutting to fit into the test vessel.

10. Procedure

10.1 Stress the specimens, examine at 20×, and replace any specimens with cracks or other defects.

NOTE 2—The direction and intensity of the incident light may affect crack detection during the 20× examination.

10.2 Degrease in a halogen-free solvent or laboratory detergent, rinse as necessary, and dry. It is best practice to stress the specimens immediately before the beginning of the test. Any storage of the specimens should be in a clean enclosure. A desiccant such as silica gel may be used. The specific level of relative humidity is not important for the alloys of interest.

10.3 Place duplicate specimens in each 1000-mL Erlenmeyer flask. Duplicate flasks (four specimens) are necessary to evaluate a given sample of the specific material, material condition, etc. (The specimens may be placed in the flasks after the solution has been added, if convenient.)

10.4 The specimens in each flask must be kept separate and completely submerged. Tight crevices between the stressed (bend) area and any means of specimen support should be avoided. The stressed area should be free from direct contact with heated surfaces. Specimens may be supported on glass rods or tubes or by glass fixtures.

10.5 Drop boiling chips[9] into the flasks.

10.6 Add 600 mL of 25 % NaCl solution, pH 1.5 to each flask. When each flask contains two U-bends as described in Annex A1, the solution volume to sample surface area ratio is 5:1 mL/cm^2 (33 mL/in^2).

10.7 Place the flasks on a hot plate and insert the condenser. Begin recording the test duration when the solution begins boiling. The boiling point during interlaboratory testing was 106 to 110°C (223 to 230°F).

10.8 After one week remove the flask from the hot plate, determine the final pH of the solution at room temperature, and discard the remaining solution. A final pH over about 2.5 suggests that general corrosion or pitting of the specimen or fastening device has occurred. A pH at this level is expected to reduce the test severity and may delay or preclude failures of UNS S31600. More rapid cracking of UNS S31600 appears likely with a final pH of about 2 or less.

10.9 Rinse and dry the specimens. Examine the bend area, legs, and area adjacent to the crevice (at the fastener) at 20× for cracking. See Note 3. Record location of cracks. Additional exposures or metallographic evaluation may be used to determine if questionable indications are, in fact, stress-corrosion cracks.

NOTE 3—Any cracking at the fastener is very likely due to residual stresses and more aggressive solution which may be formed in crevices. If crevices are expected in service (due to design of service equipment or deposits), a U-bend specimen employing a crevice on the bend may be evaluated.

10.10 Periodic removal of the specimens from the solution may be necessary during the first-week to determine the time when cracks first appear. Removal of the specimens is expected to disturb local corrosion cells and may influence test results. All specimens in a given test program should have the same removal/examination schedule. When the time-to-crack is recorded, the test duration at the previous examination (no cracks) should also be noted.

10.11 Expose for additional one-week periods as necessary. Fresh solution must be used for each exposure and the initial and final pH (at room temperature) must be recorded weekly. See 10.8 regarding the effect of the final pH.

10.12 After the final 20× examination (following the last test period) remove the fastener and examine the crevice areas at 20× for cracking.

10.13 A final examination for cracks may be performed by additionally bending the specimens until the ends of the legs touch. This may expose tight cracks which were not previously detected. The additional bending may not be appropriate for materials which are susceptible to hydrogen embrittlement in this environment. Do not re-expose speci-

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[9] Amphoteric alundum granules, such as Hengar Granules, from the Hengar Co., Philadelphia, PA have been found satisfactory for this purpose. An equivalent may be used.

mens after this additional bending.

10.14 Ruptured specimens should also be examined for evidence of mechanical failure resulting from the action of applied stress on specimens whose cross sections have been reduced by general or pitting corrosion, or both. Such failures usually show evidence of ductility. Repeat tests with thicker specimens should be made in case of doubt.

11. Report

11.1 Report the type of specimen used, method of specimen fabrication, times to cracking (including maximum time without cracks), location of cracks, final pH of each exposure, and details regarding the Allihn condenser drip tip. Note whether or not metallographic techniques or additional bending of the specimen (see 9.13) were employed. Electronic data exchange can be facilitated by using the fields suggested in Appendix X2. (excerpted from Guide G 107).

11.2 Data for resistant materials shall be accompanied by data for at least four susceptible control specimens for example, UNS S30400 or UNS S31600.

12. Precision and Bias[10]

12.1 *Precision*—Variability occurred in both repeatability and reproducibility for time-to-fail data developed using UNS S30400 and S31600 in an interlaboratory test program (Appendix X1). Such variability is typical in time-to-fail data for stress-corrosion cracking tests, and is expected to preclude detection of small differences between samples.

12.1.1 Histograms of the time-to-crack for UNS S30400 and S31600 tested in accordance with this test method appear in Appendix X1 along with data from each laboratory. The time-to-crack values in Appendix X1 are not necessarily the maximum or minimum values which could be obtained in other testing.

12.1.2 Every specimen of UNS S30400 and S31600 cracked within the 1000-h interlaboratory test duration while no cracking occurred for more resistant materials, UNS S32550 (Ferralium[11] Alloy 225) and N08020.

12.1.3 It has been observed in stress-corrosion tests of various metal-alloy systems that the precision is best for tests of specimens that have either a very low probability of stress-corrosion cracking (few, if any, failures in the prescribed test duration) or a high probability (short failure times). The precision is least for groups of test specimens with an intermediate probability. This was observed in the interlaboratory test program. There were no failures of the more resistant materials, (UNS S32550 and UNS N08020), generally rapid failure of the least resistant material (UNS S30400, see Fig. X1.3) and greater variation in failure times for the material expected to have intermediate resistance (UNS S31600, see Fig. X1.4).

12.1.4 Reproducibility between laboratories frequently varied more widely than repeatability within each laboratory. Although this variation is substantial, it is within what may be expected for a stress-corrosion cracking test. The effects of interlaboratory variation must be considered if data from multiple laboratories are used.

12.1.5 Analysis of the interlaboratory test data using a log normal distribution appears in Appendix X1.

12.2 *Bias*—The procedure in this test method for measuring time-to-cracking of specimens in acidified sodium chloride solution has no bias because the time-to-cracking is defined only in terms of this test method, and there is no absolute standard for reference. Time-to-cracking is a function of specimen type as well as stress and material composition.

13. Keywords

13.1 boiling acidified sodium chloride (NaCl); glassware; histograms; stress corrosion cracking; U-bend specimens; UNS N08020

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[10] The data used to evaluate precision are filed at ASTM Headquarters. Request RR G01-1013.

[11] Ferralium is a registered trademark of Langley Alloys, Ltd. of Slough, United Kingdom.

ANNEX

(Mandatory Information)

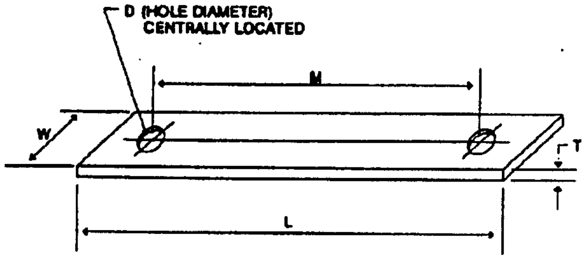
A1. SUGGESTED TEST SPECIMEN

A1.1 Using the procedure described in this test method, the U-bend specimen described in A1.2 has produced cracking of UNS S30400 and S31600 in less than 1000 h, without cracking more resistant duplex stainless and higher nickel (for example, about 33 %) materials.

A1.2 Suggested specimen dimensions appear in Fig. A1.1. The specimen differs slightly from those suggested in Practice G 30 to allow the completed U-bend to pass through a 45/50 ground-glass joint while being large enough to accommodate ceramic insulators of sufficient size to resist cracking during use.

A1.3 If surface finish is not the subject of the evaluation, prepare the specimens to produce a 120-grit finish or its equivalent with machining techniques.

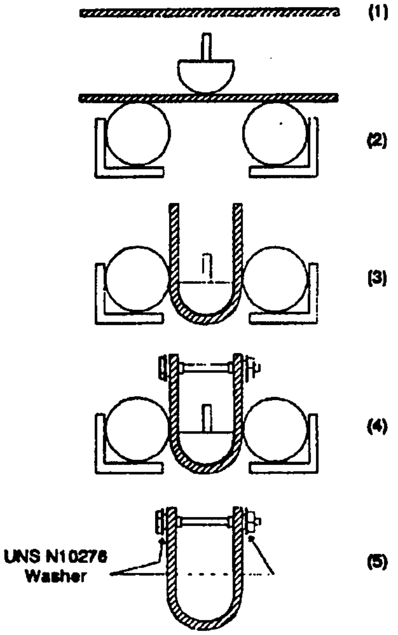
A1.4 Bend the specimens around a 9.5 mm (0.375-in.) diameter mandrel using an adjustable die similar to that in Fig. A1.2 as follows. (This figure is the same as Fig. 4a in Practice G 30.)



NOTE :

L, mm (in)	M, mm (in)	W, mm (in)	T, mm (in)	D, mm (in)
101.6 (4)	82.6 (3¼)	19.0 (¾)	~ 3.2 (~ ⅛)	9.5 (⅜)

FIG. A1.1 Suggested U-Bend Specimen Dimensions



NOTE—Mandrel has 9.5 mm (0.375-in.) diameter. Dimension Z is mandrel diameter plus two times the specimen thickness.

FIG. A1.2 Suggested Stressing Fixture
(fastener inserted while specimen in die)

A1.4.1 Mark the centerline on the specimen to aid aligning.

A1.4.2 Set the gap in the die at the mandrel diameter plus two times the specimen thickness.

A1.4.3 First, depress the mandrel (hydraulic) until the apex of the U-bend is approximately level with the bottom of the die. Continue stressing until the legs of the U-bend are nearly parallel. Final stressing is preferably done with the fastener. The specimen may be stressed in the die or it may be removed and restressed outside the die. Partial stressing in the die followed by final stressing outside the die may be optimum.

A1.4.4 Insert the stressing fastener. Use ceramic insulators (zirconia or other non-compressible, corrosion resistant, nonconductive material). Flat washers should be used between the ceramic insulator and fastener to extend the life of the insulator. The bolt, nut, and flat washer must resist corrosion in the NaCl environment. UNS N10276 is recommended for all three items.

A1.4.5 Stress the U-bend so that the legs are parallel, that is, the U-bend is more severely bent than it was due to the die pressure. The inside dimension between the legs will be about 11.4 mm (about 0.450 in.).

APPENDIX

(Nonmandatory Information)

X1. SUMMARY OF INTERLABORATORY TEST DATA ANALYSIS

X1.1 Test Method

X1.1.1 Testing in accordance with this test method was performed by seven laboratories and included UNS S30400, S31600, S32550, and N08020. Each laboratory exposed a series of duplicate flasks, each containing two U-bends of each grade. UNS N10276 fasteners were used by most laboratories and the solution was replaced weekly. Examinations were scheduled after 6 h, daily for one week, and weekly for six weeks. Concerns of Practice E 691 and Guide G 16 were considered as possible and appropriate.

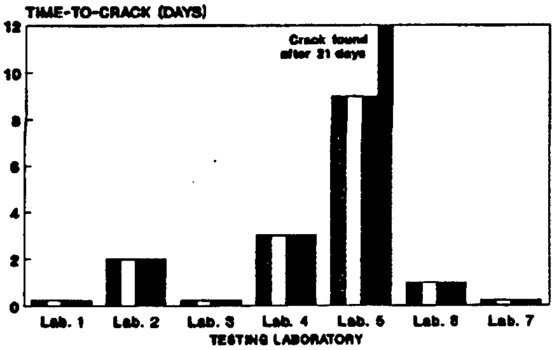
X1.1.2 The pH was recorded before and after each exposure. The initial pH was specified as 1.5. The change in pH during all the one-week periods for all laboratories ranged from +0.6 to +2.8 for UNS S30400 and −0.1 to +2.72 for UNS S31600. Only one of the laboratories experienced a pH increase greater than 0.55 for UNS S31600 and this increase may have been related to attack of the fasteners.

X1.2 Interlaboratory Test Data Analysis Using Histograms

X1.2.1 Figures X1.1 and X1.2 present the time-to-crack data for all U-bends of susceptible materials, UNS S30400 and UNS S31600, respectively. The within-laboratory repeatability was often better than the between-laboratory reproducibility. This could occur if different operators had different ability to detect cracks or tended to find cracks in all samples after cracks in one sample were noticed.

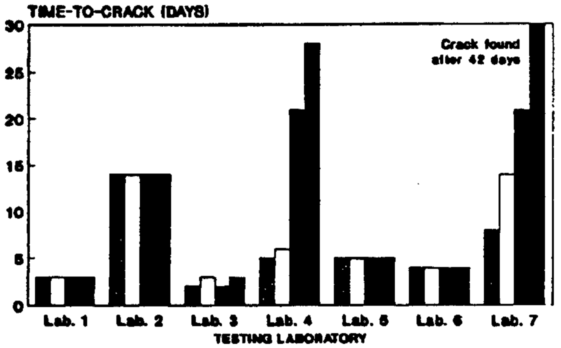
X1.2.2 The nature of the data suggest that analysis by histogram is superior to attempting to calculate mean and standard deviation values.

X1.2.3 Figures X1.3 and X1.4 present histograms of the time-to-crack data for UNS S30400 and UNS S31600, respectively. All but one of the failures occurred in 28 days or



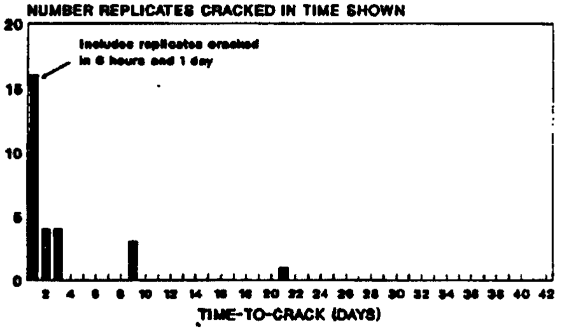
NOTE—Four replicates tested per laboratory. Examinations scheduled after 6 h, daily for one week, and weekly for six weeks.

FIG. X1.1 Time-To-Crack for UNS S30400 U-Bends in pH 1.5 NaCl Test



NOTE—Four replicates tested per laboratory. Examinations scheduled after 6 h, daily for one week, and weekly for six weeks.

FIG. X1.2 Time-To-Crack for UNS S31600 U-Bends in pH 1.5 NaCl Test

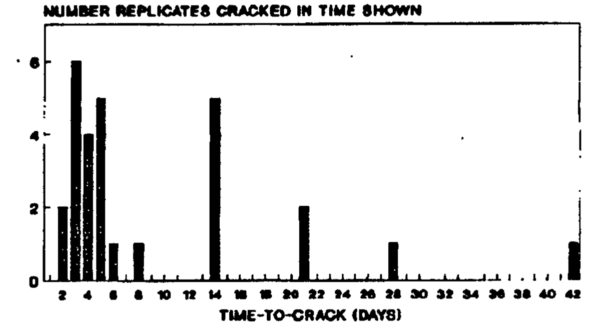


NOTE—Seven laboratories, each tested four replicates. Examinations scheduled after 6 h, daily for one week, and weekly for six weeks.

FIG. X1.3 Histogram of Time-To-Crack Data for UNS S30400 Stainless U-Bends in pH 1.5 NaCl Test

less. Cracks in one sample of UNS S31600 were found after 42 days (1000 h). An increase in pH due to attack of the UNS N06600 fasteners may have delayed this cracking for at least one week.

X1.2.4 Four U-bends of UNS S32550 and N08020 were exposed by each laboratory. These materials have demonstrated good resistance to stress-corrosion cracking in service and none of the U-bends cracked in the 42-day test.



NOTE—Seven laboratories, each tested four replicates. Examinations scheduled after 6 h, daily for one week, and weekly for six weeks.

FIG. X1.4 Histogram of Time-To-Crack Data for UNS S31600 Stainless U-Bends in pH 1.5 NaCl Test

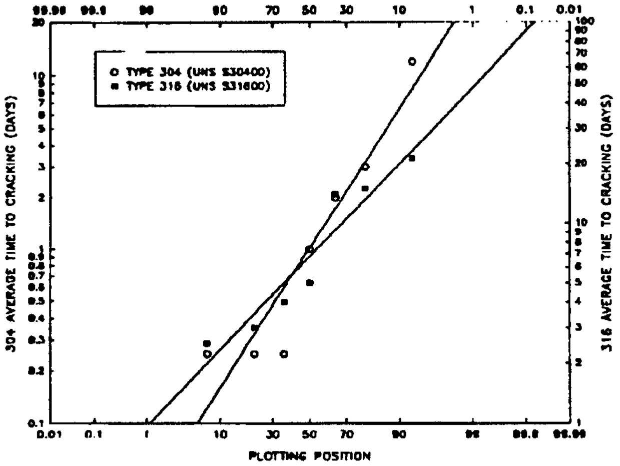


FIG. X1.5 Distribution of Average Cracking Time

X1.2.5 Analysis of the interlaboratory test data indicates that materials which withstand this 42-day test without cracks are more resistant to stress-corrosion cracking than UNS S30400 and UNS S31600. This statement is based upon use of the sampling and testing procedures employed in this interlaboratory test program.

X1.3 Interlaboratory Test Data Analysis Using a Log Normal Distribution

X1.3.1 The average time to cracking for the four replicates of each grade tested at each laboratory are plotted in Fig. X1.5. The tendency to follow straight line relationships suggests these data approximate a log normal distribution.

X1.3.2 The log average time to cracking is 1.0 day for UNS S30400 and 6.4 days for UNS S31600. The intralaboratory variation (95 % confidence interval) is 0.685 to 1.46 times this average for UNS S30400 and 0.36 to 2.79 times the average for UNS S31600. The interlaboratory variation (95 % confidence interval) is 0.029 to 35.6 times the average for UNS S30400 and 0.15 to 6.6 times this average for UNS S31600. All calculations are based on the seven participating laboratories and the assumption that the data follow a log normal distribution.

X2. STANDARD DATA ENTRY FORMAT

X2.1 Table X2.1 defines the data categories and specific data elements (fields) considered necessary for searching and comparing data using computerized databases. Pertinent items from Guide G 107 have been included along with additional items specific to evaluation of stress-corrosion cracking using this test method.

X2.2 The Guide G 107 Reference Number is shown in Table X2.1 . Reference numbers not pertinent for this test method have been omitted from the table.

X2.3 Items in Table X2.1 which are not pertinent for a specific test series (for example, details for wrought-annealed specimens) may simply be omitted from the report.

TABLE X2.1 Standard Data Entry Format for Corrosion Database Development

Field	Guide G 107 Reference Number	Field Name/Description	Category Sets/Fields Type/Units[A]
1	5.1.1	Individual test number to identify grouping of specimens tested concurrently. See subsequent entries for test method	alphanumeric
Type of Test			
2	5.1.2.1	Standard test specification	alphanumeric
3	5.1.2.2	Laboratory test	L = laboratory
4	5.1.2.3	Date test started	YYYYMMDD
Test Emphasis			
5	5.1.3.1	Type(s) of corrosion evaluated[B]	stress corrosion
Chemistry of Environment[C]			
6	5.1.4.1	Generic description of environment	25 % NaCl (by mass) acidified to pH 1.5 with H_3PO_4
7	5.1.4.2	Component, common name	sodium chloride, phosphoric acid
8	5.1.4.3	Chemical abstracts registry number	NaCl-7647-14-5 H_3PO_4-7664-38-2
9	5.1.4.4	Concentration (liquids)	g/L
10	5.1.4.6	Component form	(1) solid (2) liquid
11	5.1.4.7	Ionic species	Na^+, Cl^-, H^+, PO_4^{-3}
Exposure Conditions			
12	5.1.5.1	Exposure duration	days
13	5.1.5.4	Temperature, average	boiling
14	5.1.5.7	pH, min	real number
15	5.1.5.8	pH, max	real number
16	5.1.5.9	pH, average	real number
17	5.1.5.16	Flow	none
18	5.1.5.18	Sparging	none-less than saturated (open to air)
19	5.1.5.20	Exposure zone	continuous immersion
20	5.1.5.24	Ratio of specimen surface area to corrodent volume	mm^2/L, $in.^2/L$
21	. . .	Allihn condenser drip tip	(1) none (2) length in mm
Material Identification[D]			
22	5.1.6.1	Material class	alphanumeric
23	5.1.6.2	Subdivision of class	alphanumeric
24	5.1.6.3	Finer subdivision of class	alphanumeric
25	5.1.6.4	Common name/trade name (include owner of trade name)	alphanumeric
26	5.1.6.5	Material Designation—UNS No.	alphanumeric
27	5.1.6.6	Specification/standard	alphanumeric
28	5.1.6.7	Product shape	(1) pipe/tube (2) plate (3) sheet/strip (4) wire/rod/bar (5) other—describe in 5.1.6.8
29	5.1.6.8	Description for (5) in 5.1.6.7	alphanumeric
30	5.1.6.9	Product production method	(1) extrusion (2) forging (3) casting (4) rolling (5) powder compaction (6) other—describe in 5.1.6.10
31	5.1.6.10	Description of (6) in 5.1.6.9	alphanumeric
32	5.1.6.11	Heat/lot identification	alphanumeric
33	5.1.6.12	Heat/lot chemical analysis	alphanumeric
Specimen Identification			
34	5.1.7.1	Specimen thickness	mm, in.
35	5.1.7.2	Specimen width/diameter	mm, in.
36	5.1.7.3	Specimen length	mm, in.

TABLE X2.1 *Continued*

Field	Guide G 107 Reference Number	Field Name/Description	Category Sets/Fields Type/Units[A]
		Specimen Identification	
37	5.1.7.4	Specimen surface area	mm², in.²
38	5.1.7.5	Density	kg/mm³, lb/in.³
39	5.1.7.6	Welded specimen	(1) Y = yes (2) N = no
40	5.1.7.7	Type of weld (see 5.1.7.8 for additional detail)	(1) autogenous (2) matching filler (3) dissimilar metal weld
41	5.1.7.8	Weld details[E]	alphanumeric
42	5.1.7.9	Welds ground or machined	(1) ground (2) machined (3) as deposited (4) glass bead blasted
43	5.1.7.10	Thermomechanical condition	(1) standard temper—describe in 5.1.7.11 (2) annealed (3) normalized (4) sensitized (5) as-cold-worked (6) as-hot-worked (7) aged (8) other H.T./processing—describe in 5.1.7.11
44	5.1.7.11	Description for (1) or (7) in 5.1.7.10	alphanumeric
45	5.1.7.12	Final reduction step	(1) cold-worked—give percent reduction in 5.1.7.13 (2) hot-worked (includes extrusion and forging)
46	5.1.7.13	Percent cold reduction	%
47	5.1.7.14	Ultimate tensile strength	MPa, ksi
48	5.1.7.15	Yield strength	MPa, ksi
49	5.1.7.16	Percent offset for yield strength	%
50	5.1.7.17	Fracture ductility (strain)	%
51	5.1.7.18	Hardness	real number
52	5.1.7.19	Hardness scale	alphanumeric
53	5.1.7.20	Surface condition	(1) as produced (2) scaled (3) machined/ground (4) chemically cleaned (5) sand/grit blasted (6) other
54	5.1.7.21	Surface treatment	(1) none (2) nitrided (3) carburized (4) plated (5) clad (6) other
55	5.1.7.22	If (4), (5), or (6) in 5.1.6.21, plating or cladding material or other surface treatment	alphanumeric
56	5.1.7.23	Condition of edges	(1) as cut (2) as sheared (3) ground (4) machined (5) other—describe in 5.1.7.24
57	5.1.7.24	Description of other edge condition	alphanumeric
58	5.1.7.25	Sample orientation relative to working direction	(1) longitudinal (2) transverse (3) short transverse
59	5.1.7.26	Stress-corrosion cracking (SCC) specimen type	(1) double cantilever beam (DCB) (2) wedge open loaded (WOL)—see 5.1.7.27 (3) bent beam—2 loaded (4) bent beam—3 loaded (5) bent beam—4 loaded (6) standard tension specimen (Test Methods E 8) (7) subsize tension specimen (Test Methods E 8) (8) C ring (9) stressed ring (10) U-bend (11) other
60	5.1.7.27	Material used for wedge in WOL specimen	alphanumeric
61	5.1.7.28	Was stressing device insulated from specimen?	alphanumeric
62	5.1.7.29	Stress-corrosion cracking specimen test area	(1) smooth (2) notched (3) precracked
63	5.1.7.30	Direct tension stress-corrosion cracking specimen-applied stress (Practice G 49)	(1) constant load (2) slowly increasing strain rate (3) constant deflection
64	5.1.7.31	Stress-corrosion cracking specimen—stress level (absolute)	MPa, ksi

TABLE X2.1 *Continued*

Field	Guide G 107 Reference Number	Field Name/Description	Category Sets/Fields Type/Units[A]
65	5.1.7.32	Stress-corrosion cracking specimen—stress level (percent of yield strength at test temperature)	%
66	. . .	If U-bend used, note stressing method	(1) single stage as in Practice G 30, Fig. 4a, b, or c (2) Two stage as in Practice G 30, Fig. 5
67	. . .	Diameter of mandrel (if used for stressing U-bend)	mm
68	. . .	Outside of diameter of U-bend	mm
		Specimen Performance	
69	5.1.8.6	Reduction in elongation	%
70	5.1.8.7	Reduction in fracture ductility (strain)	%
71	5.1.8.8	Reduction in tensile strength	%
72	5.1.8.9	Reduction in yield strength	%
73	5.1.8.10	Nature of corrosion products	alphanumeric
74	-5.1.8.11	Visible corrosion?	(1) corroded (2) no visible corrosion
75	5.1.8.17	Weld related corrosion	(1) fusion line (2) base metal (3) weld metal (4) heat-affected zone
76	5.1.8.19	Stress-corrosion cracking (SCC) test—severity of attack	(1) no cracking (2) microcracks (3) total fracture (complete separation)
77	5.1.8.20	SCC cracking mode	(1) transgranular (2) intergranular (3) mixed mode (4) ductile
78	5.1.8.31	Time to initial crack detection	hours
79	5.1.8.32	Measured crack length at time of first detection	mm, in.
80	5.1.8.33	Method used to detect initial cracking	alphanumeric (naked eye, 5× to 40×, metallographic section [mag.] or additional bending)
81	5.1.8.37	Threshold stress intensity range, K	MPa $\sqrt{m}$, ksi $\sqrt{in.}$
82	. . .	Maximum time without stress-corrosion cracking	hours
83	. . .	Stress-corrosion threshold stress intensity	MPa $\sqrt{m}$, ksi $\sqrt{in.}$
84	. . .	Location of cracking	alphanumeric
		Documentation	
85	5.1.9.1	Test number	alphanumeric
86	5.1.9.2	Published reference	alphanumeric
87	5.1.9.3	Unpublished data—location	alphanumeric
88	5.1.9.4	Technical committee report/file	alphanumeric
89	5.1.9.5	Other documentation	alphanumeric
		Supplementary Notes	
90	5.2.0.1	Supplementary notes	alphanumeric

[A] Data should be reported in the units in which the original measurements were made. Subsequent conversions are at the discretion of data base developers. Units listed are nonmandatory examples.

[B] For example, general corrosion, stress corrosion, pitting, crevice corrosion, hot or cold wall effects, fretting, stray current, weld corrosion, corrosion-fatigue, galvanic corrosion, and microbiological corrosion.

[C] Many environments contain multiple components. Reference numbers 5.1.4.1 through 5.1.4.7 should be repeated for each component and no restrictions should be placed on the number of components to be described for any given environment.

[D] Reference numbers 5.1.6.1 through 5.1.6.6 are basic fields for use in material identification in database. Refer to Committee E 49 guidelines for material identification in computerized material property databases.

[E] For example, preheat, welding process, number of passes, heat input, joint shape, cover gas, etc.

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

Designation: D 3167 – 93

AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Floating Roller Peel Resistance of Adhesives[1]

This standard is issued under the fixed designation D 3167; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

The purpose of this test method is to provide for the determination of the metal-to-metal peel strength of adhesives by a method that will provide good reproducibility at low-, as well as at high-strength levels and yet allow for a simple method of test specimen preparation and testing.

The accuracy of the results of strength tests of adhesive bonds will depend on the conditions under which the bonding process is carried out. Unless otherwise agreed upon between the manufacturer and the purchaser, the bonding conditions shall be prescribed by the manufacturer of the adhesive. In order to ensure that complete information is available to the individual conducting the tests, the manufacturer of the adhesive shall furnish numerical values and other specific information for each of the following variables:

(*1*) Procedure for preparation of the surfaces prior to application of the adhesive, the cleaning and drying of metal surfaces, and special surface treatments such as sanding, which are not specifically limited by the pertinent test method.

(*2*) Complete mixing directions for the adhesive.

(*3*) Conditions for application of the adhesive, including the rate of spread or thickness of film, number of coats to be applied whether to be applied to one or both surfaces, and the conditions of drying where more than one coat is required.

(*4*) Assembly conditions before application of pressure, including the room temperature and length of time.

(*5*) Curing conditions, including the amount of pressure to be applied, the length of time under pressure, and the temperature of the assembly when under pressure. It should be stated whether this temperature is that of the glue line, or of the atmosphere at which the assembly is to be maintained.

(*6*) Conditioning procedure before testing, unless a standard procedure is specified, including the length of time, temperature, and relative humidity.

A range may be prescribed for any variable by the manufacturer of the adhesive, if it can be assumed by the test operator that any arbitrarily chosen value within such a range or any combination of such values for several variables will be acceptable to both the manufacturer and the purchaser of the adhesive.

1. Scope

1.1 This test method covers the determination of the relative peel resistance of adhesive bonds between one rigid adherend and one flexible adherend when tested under specified conditions of preparation and testing.

1.2 A variation in thickness of the adherends will generally influence the test values. For this reason, the thickness of the sheets used to make the test specimens shall be specified in the material specification. When no thickness is specified, the flexible adherend shall be 0.63 mm (0.025 in.) thick and the rigid adherend shall be 1.63 mm (0.064 in.) thick.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

B 209 Specification for Aluminum and Aluminum-Alloy Sheet and Plate[2]

D 1781 Method for Climbing Drum Peel Test for Adhesives[3]

E 4 Practices for Load Verification of Testing Machines[4]

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[1] This test method is under the jurisdiction of ASTM Committee D-14 on Adhesive and is under the jurisdiction of Subcommitte D14.80 on Metal Bonding Adhesives.

Current edition approved Dec. 15, 1993. Published February 1994. Originally published as D 3167 – 73 T. Last previous edition D 3167 – 76 (1986).

[2] *Annual Book of ASTM Standards*, Vol 02.02.

[3] *Annual Book of ASTM Standards*, Vol 15.06.

[4] *Annual Book of ASTM Standards*, Vol 03.01.

3. Summary of Test Method

3.1 This test method consists of testing laminated or bonded adherends, where one adherend is made to be rigid and the other adherend is made to be flexible, by peeling of the flexible adherend from the rigid adherend at a controlled angle of peel using the test fixture shown in Fig. 1.

4. Significance and Use

4.1 This test method is of value for acceptance and process control testing. This test method may be used as an alternative to Method D 1781 when that facility is not available. This test method should be considered more severe since the angle of peel is greater.

5. Apparatus

5.1 *Testing Machine*, conforming to the requirements of Practices E 4. The testing machine shall be so selected that the breaking load of the specimens falls between 15 and 85 % of the full-scale capacity. The machine shall be capable of maintaining a constant crosshead rate of 152 mm/min (6 in./min), unless otherwise specified. It shall be provided with a suitable self-aligning grip to hold the specimen. It is recommended that the jaws of this grip shall engage the outer 25.4 mm (1 in.) of the end of the flexible adherend firmly. The grip and attachments shall be so constructed that they will move into alignment with the test specimen as soon as the load is applied, so that the flexible member of the test specimen will coincide with the direction of the applied pull through the center line of the grip assembly. The machine shall be autographic, giving a chart that can be read in terms of millimetres (or inches) of separation as one coordinate and applied load as the other coordinate. The applied load as measured and recorded shall be accurate within ±1 %.

5.2 A fixture as shown in Fig. 1 for support of the test specimen shall be attached to one of the testing machine cross arms. The 1-in. diameter rollers on this test fixture shall roll freely.

6. Sample Preparation

6.1 Laminated test panels (see Fig. 2) shall consist of two adherends properly prepared and bonded together in accordance with the adhesive manufacturer's recommendations.

6.2 Unless otherwise specified, clad alluminum alloy conforming to the specification for aluminum-alloy sheet and plate (Specification B 209) Alloy 2024-T3 shall be used.

6.3 The bonded panels shall be cut into 12.7-mm (0.5-in.) wide test specimens (see Fig. 2) by a means that is not deleterious to the bond. Edge members may or may not be discarded, depending on desire to measure peel strength in this area. The method of cutting test specimens is controlled by adherend and adhesive compositions and the accuracy desired. Shearing, milling, and band-saws can all be used successfully. The unbonded end of the flexible adherend shall be bent, perpendicular to the rigid adherend, for clamping in the grip of the testing machine. Specimens shall be two in number for each temperature tested from each of three bonded panels.

NOTE 1—Direct comparison of different adhesives may be made only when specimen construction and test conditions are identical.

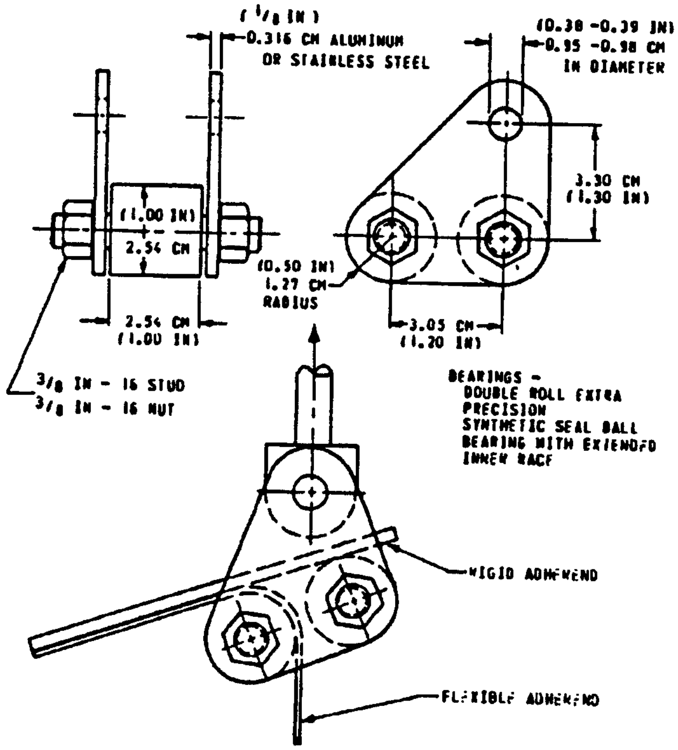
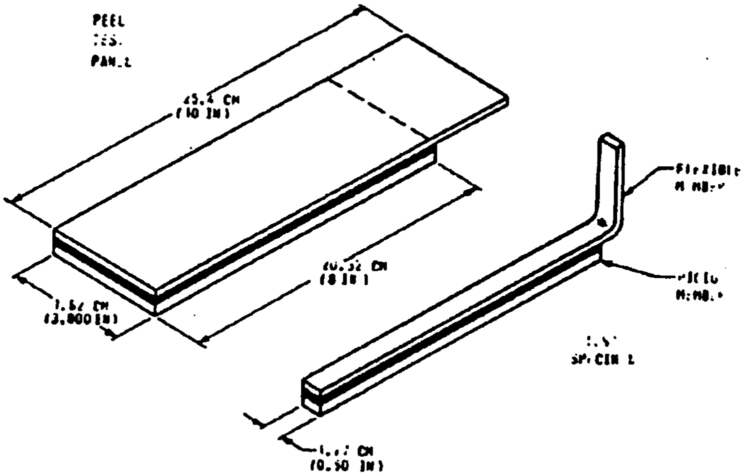


FIG. 1 Roller Drum Peel Test Fixture



NOTE—A 1.5 to 3.0-in. (38.1 to 74.2-mm) shim can be used to facilitate the start of peel.

FIG. 2 Test Panel and Test Specimen

NOTE 2—Within the limitations imposed by 5.3, other specimen widths may be used, provided the test machine grip and peel test fixtures are of ample width to apply the load uniformly across the width of the adherends.

NOTE 3—Direct comparison of different adhesives may be made only when the angle of peel is identical. The operator must ascertain that the flexible adherend is bending over the mandrel and not at some irregular angle.

7. Test Method

7.1 Insert the test specimen into the peel test fixture as shown in Fig. 1, with the unbonded end of the flexible adherend gripped in the test machine jaw. Peel the specimen at 152-mm/min (6-in./min) bond separation rate by applying the load at a constant head speed of 152 mm/min. If the backup plate bends or is distorted during the test, it is recommended that the specimen be redesigned with a backup member stiff enough to ensure even peel.

6.2 During the peel test, make an autographic recording of load versus head movement (load versus distance peeled).

6.3 Record the load over at least a 7.6-mm (3-in.) length of the bond line, disregarding the first 2.54 mm (1 in.) of peel.

8. Calculation

8.1 Determine from the autographic curve, or at least 7.6 mm (3 in.) of peeling (disregarding the first 25.4 mm (1 in.)), the average peeling load in pounds-force per inch (or kilonewtons per metre) of the specimen width required to separate the adherends. It is preferred that the average load be determined from the curve by means of a planimeter.

NOTE 4—In case a planimeter is not used, the average may be calculated as the average of load readings taken at fixed increments of crosshead motion. For example, the load may be recorded at each 12.7-mm (½-in.) interval of heat motion (discarding the first inch) until at least six readings have been attained.

9. Report

9.1 Report the following information:

9.1.1 Complete identification of the adhesive tested including type, source, manufacturer's code number, batch or lot number, form, etc.

9.1.2 Complete identification of adherends used, including material thickness, surface preparation, and orientation.

9.1.3 Description of bonding process, including method of application of adhesive, glueline thickness, drying or precuring conditions (where applicable), curing time, temperature, and pressure.

9.1.4 The average thickness of adhesive layer after formation of the joint shall be reported within 0.0127 mm (0.0005 in.). The method of obtaining the thickness of adhesive layer shall be described including procedure, location of measurements, and range of measurements.

9.1.5 Complete description of the test specimen, including dimensions and construction of the test specimen, conditions used for cutting individual test specimens, number of test panels represented, and number of individual test specimens.

9.1.6 Conditioning procedure prior to testing.

9.1.7 Testing temperature.

9.1.8 Type of test machine and crosshead separation rate used.

9.1.9 Method of recording load and determining average load.

9.1.10 Average, maximum, and minimum peeling load values for each individual specimen.

9.1.11 Average peel strength in pounds-force per inch (or kilonewtons per metre) of width for each combination of materials and constructions under test.

9.1.12 Type of failure, that is, cohesive failure within the adhesive or adherend or adhesion to the adherend, or combination thereof, for each individual specimen.

10. Precision and Bias

10.1 At the present time, there is no basis for a statement of precision and bias concerning the reproducibility of results among laboratories.

10.2 The precision and bias of this test method is a function of the properties of the cured bondline. Precision shall be reported in terms of standard deviation of the data and the standard error of the mean.

11. Keywords

11.1 adhesives; assemblies; bonds; laminates; metal; peel; roller

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Appendix D:

Referenced Military Specifications and Standards

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MIL-C-87937A
16 Oct 1991
Superseding
MIL-C-87937
29 Oct 1990

MILITARY SPECIFICATION

CLEANING COMPOUND, AEROSPACE EQUIPMENT

This specification is approved for use by all
Departments and Agencies of the Department of Defense

1. SCOPE

1.1 Scope. This specification establishes the requirements for biodegradable, water dilutable, environmentally safe cleaning compounds for use on aerospace equipment to include aircraft, engines and aerospace ground equipment (AGE).

1.2 Classification. The cleaning compounds covered by this specification shall be of the following types.

Type I - Terpene Based, Solvent Emulsion, Water Dilutable Cleaning Compound

Type II - Water Dilutable Cleaning Compound

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards and handbooks form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, noted in the solicitation.

SPECIFICATIONS

Federal

O-S-642	Sodium Phosphate, Tribasic, Anhydrous, Dodecahydrate, & Monohydrate, Technical
QQ-A-250/4	Aluminum Alloy 2024, Plate and Sheet
QQ-A-250/5	Aluminum Alloy Alclad 2024, Plate and Sheet
QQ-A-250/12	Aluminum Alloy 7075, Plate and Sheet

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Code (68) SA-ALC/SFRT, Kelly AFB TX 78241-5000, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A
DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

FSC 6850

QQ-A-250/13	Aluminum Alloy Alclad 7075 Plate and Sheet
QQ-M-44	Magnesium Alloy Plate and Sheet (AZ31B)
QQ-P-416	Plating, Cadmium (Electrodeposited)
TT-E-529	Enamel, Alkyd, Semi-gloss, Low VOC Content
TT-E-781	Ethylene Glycol Monoethyl Ether, Technical
TT-I-735	Isopropyl Alcohol
TT-L-32	Lacquer, Cellulose Nitrate, Gloss, For Aircraft Use
TT-P-1757	Primer Coating, Zinc Chromate, Low Moisture Sensitivity
PPP-D-729	Drums, Shipping and Storage, Steel, 55 Gallon (208 Liters)
PPP-P-704	Pails, Metal: (Shipping, Steel, 1 through 12 gallons)

Military

MIL-L-2104	Lubricating Oil, Internal Combustion Engine, Tactical Service
MIL-M-3171	Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion on
MIL-S-7952	Steel, Sheet and Strip, Uncoated, Carbon (1020 and 1025) (Aircraft Quality)(ASG)
MIL-P-7962	Primer Coating, Cellulose-Nitrate Modified Alkyl Type, Corrosion Inhibiting, Fast-Drying (For Spray Application Over Pretreatment Coating)
MIL-C-8514	Coating Compound, Metal Pretreatment, Resin-Acid (ASG)
MIL-A-8625	Anodic Coatings, For Aluminum and Aluminum Alloys
MIL-S-8802	Sealing Compound, Temperature Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High Adhesion
MIL-T-9046	Titanium and Titanium Alloy, Sheet, Strip and Plate
MIL-G-21164	Grease, Molybdenum Disulfide, For Low and High Temperatures
MIL-C-22750	Coating, Epoxy Polyamide
MIL-P-23236	Paint Coating System, Fuel Salt Water Ballast Tanks
MIL-P-23377	Primer Coating, Epoxy Polyamide, Chemical and Solvent Resistant
MIL-S-81733	Sealing and Coating Compound, Corrosion Inhibitive
MIL-H-83282	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft
MIL-C-83286	Coating Urethane, Aliphatic Isocyanate, for Aerospace Application
MIL-P-83310	Plastic Sheet, Polycarbonate, Transparent
MIL-C-83957	Cleaning and Polishing Pad, Non-metallic (For Aircraft)
MIL-C-85285	Coating: Polyurethane, High Solids

STANDARDS

Federal

FED-STD-141	Paint, Varnish, Lacquer and Related Materials Methods of Inspection, Sampling and Testing
FED-STD-313	Material Safety Data Sheets, Preparation and the Submission of

Military

MIL-STD-109	Quality Assurance Terms and Definitions
MIL-STD-129	Marking For Shipment And Storage
MIL-STD-147	Palletized Unit Loads

(Copies of specifications, standards, handbooks, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094)

2.1.2 Other Government documents, drawings, and publications. The following other Government documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issue shall be that in effect on the date of the solicitation.

CODE OF FEDERAL REGULATIONS

29 CFR - Labor
40 CFR - Protection of Environment
49 CFR - Transportation

2.2 Other publications. The following non-government documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issue of the non-government documents which is current on the date of the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM Standards

A 153	Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
D 56	Test Method for Flash Point by Tag Closed Tester
D 92	Test Method for Flash and Fire Points by Cleveland Open Cup
D 460	Method for Sampling and Chemical Analysis of Soaps and Soap Products
D 846	Specification for Ten-Degree Xylene
D 1193	Specification for Reagent Water
D 2240	Test Method for Rubber Property - Durometer Hardness
D 3951	Practice for Commercial Packaging
E 70	Test Method for pH of Aqueous Solutions with the Glass Electrode
F 483	Method For Total Immersion Corrosion Test for Aircraft Maintenance Chemicals
F 484	Test Method for Stress Crazing of Acrylic Plastics in Contact with Liquid or Semi-Liquid Compounds
F 485	Test Method for Effects of Cleaners on Unpainted Aircraft Surfaces
F 502	Test Method for Effects of Cleaning and Chemical Maintenance Materials on Painted Aircraft Surfaces

F 519	Method for Mechanical Hydrogen Embrittlement Testing of Plating Processes and Aircraft Maintenance Chemicals
F 1104	Test Method for Preparing Aircraft Cleaning Compounds, Liquid Type, Water Base, for Storage Stability Testing
F 1110	Test Method for Sandwich Corrosion Test
F 1111	Test Method for Corrosion of Low Embrittling Cadmium Plate by Aircraft Maintenance Chemicals

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia PA 19103.)

SOCIETY OF AUTOMOTIVE ENGINEERS

SAE Standards

AMS 3204	Synthetic Rubber, Low-Temperature Resistant 25-35
AMS 3209	Chloroprene Rubber, Weather Resistant, 65-75

(Application for copies should be addressed to the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale PA 15096.)

UNIFORM FREIGHT CLASSIFICATION RULES (Current Issue)

(Application for copies should be addressed to the Uniform Classification Committee, Room 1106, 222 South Riverside Plaza, Chicago, IL 60606.)

ALUMINUM ASSOCIATION INCORPORATED

AA Standards

2090-T-83	Aluminum-Lithium Alloy

AMERICAN IRON AND STEEL INSTITUTE

AISI Standards

AISI 4340	High Strength, Low Alloy Steel

INTERNATIONAL CIVIL AIR ORGANIZATION (ICAO)

Technical Instructions for the Safe Transport of Dangerous Goods by Air

INTERNATIONAL AIR TRANSPORT ASSOCIATION (IATA)

Dangerous Goods Regulations

INTERNATIONAL MARITIME ORGANIZATION (IMO)

International Maritime Dangerous Goods Code

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and a reference cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 Initial qualification. The cleaning compound furnished under this specification shall be a product which has been tested and has passed the qualification tests specified herein and has been listed or approved for listing on the applicable Qualified Products List (QPL) at the time of award of contract.

3.1.2 Retention of qualification. In order to retain qualification approval of a cleaning compound furnished under this specification, the manufacturer will be required to certify, at least every three years, that the cleaning compound is still available from the same plant, can be produced under the same conditions as originally qualified, and meet the requirements of the current issue of the specification. Re-examination and retest of the cleaning compound shall be required by the qualifying activity when the manufacturer has modified the product in any way, the specification is revised to affect the characteristics of the product, or when deemed necessary by the qualifying activity to determine that the product continues to meet all of the specification requirements. Any product which does not conform to all of the qualification retention requirements specified herein will be removed from the qualified products list.

3.2 Materials. The composition and formulation of the cleaning compound shall be optional with the manufacturer within the restrictions specified herein.

3.2.1 Acceptable materials.

3.2.1.1 Type I. Type I shall contain d-limonene as specified in Table I and will consist of a combination of one or more of the following: surfactants, alkaline builders, water conditioning agents, corrosion inhibitors, and/or synthetic detergents to produce a stable, homogeneous product, conforming to the requirements of this specification. Certification from the manufacturer is required on the percentage of total terpenes contained in the cleaning compound. The d-limonene used shall be of a high grade with no extraneous materials.

3.2.1.2 Type II. Type II compound will consist of one or more of the following: surfactants, alkaline builders, water conditioning agents and/or corrosion inhibitors.

3.2.2 Unacceptable materials. The cleaning compounds shall not contain detectable amounts of any of the following: aliphatic and aromatic hydrocarbons, abrasives, chromates, cadmium, lead, mercury, phenols, cresols, ketones, or chlorinated compounds, except where specified within this specification. The following materials are unacceptable unless they are being used as an essential active ingredient in the cleaner: sodium chloride, urea, sodium sulfate, nitrites, nitrates, sucrose or any sugars. They shall not contain any chemical listed by the current report of known carcinogens of the National Toxicology Program (NTP). The cleaning compounds shall not contain any hazardous compounds as defined in 40 CFR 261 (see para 4.8).

3.3 Toxicity. The cleaning compound shall have no adverse effect on the health of personnel when used for its intended purpose and with proper personal protective equipment (when required). The cleaner must be evaluated and approved for toxicity prior to listing on the QPL.

3.3.1 Formulation. The manufacturer shall submit to the qualifying activity, SA-ALC/SFTT, Kelly AFB TX 78241: (1) written certification that the cleaning compound contains no substance known to be above toxic limits (as defined in 29 CFR and 40 CFR), and (2) a complete formulation including the chemical name and weight percent of each ingredient. Trade names alone will not be considered satisfactory. If this information is proprietary in nature, it will be protected as such.

3.3.2 Material safety data sheet. The manufacturer shall submit a material safety data sheet (MSDS) for each component of the product and for the finished product to the qualifying activity, and to the procuring activity. The MSDS shall be prepared in accordance with the latest revision of FED-STD-313.

3.3.3 Toxicological data. The manufacturer shall submit a copy of pertinent toxicological data/information on their product to the qualifying activity.

3.3.4 Biodegradability. The supplier of the cleaning compound shall furnish certification from the surfactant manufacturers that the surfactants are readily biodegradable in accordance with 40 CFR, Part 796, Subpart D. Biodegradability testing shall be accomplished as specified in paragraph 4.6.24 on the finished product. Biodegradability on the finished product shall be determined over 28 days by the Shake Flask Method monitored by analysis of Total Organic Carbon (TOC). The type I compound shall meet the requirement of a minimum of 75% biodegradable and the type II compound shall meet the requirement of a minimum of 85% biodegradable at the end of the 28 day period.

3.4 Compositional assurance. The cleaning compound shall be tested for nonvolatile matter as specified in paragraph 4.6.1. The concentrated cleaning compound and a 10% solution of the cleaning compound in distilled water shall be tested for pH as specified in paragraph 4.6.3. Results of these tests as well as an infrared spectrogram of the nonvolatile matter (see 4.9) shall be recorded by the qualifying activity for use in quality conformance inspections (see 4.4). Quality conformance inspection results for nonvolatile matter shall not differ by more than 2 percent absolute from the recorded value. Quality conformance inspection results for pH shall not differ by more than 1 pH unit from the recorded value. Quality conformance inspection infrared spectrograms shall show no significant difference when compared to the original qualifying spectrogram.

3.5 Chemical properties.

3.5.1 Chemical requirements. The cleaning compound shall meet the requirements listed in Table I.

TABLE I. Quantitative Requirements

REQUIREMENT	TYPE I		TYPE II		TEST METHOD
	MIN	MAX	MIN	MAX	
Insoluble Matter (WT%)	—	0.05	—	0.05	4.6.2
Flash Point (°F)					
10% Solution	200	—	—	—	4.6.8
Concentrated Solution	120	—	None \1	—	
Emulsion Characteristics (ml free water)					
15 min	—	1.0	—	—	4.6.9
8 hours	15.0	—	—	1.0	
24 hours	—	—	15.0	—	
Hard Water Stability (ppm silica)	—	20.0	—	20.0	4.6.10
d-Limonene Content (% vol)	25	40	—	—	4.6.25

\1 No flash point should be observed up to the boiling point of the compound.

3.5.2 Volatility. For both types, the volatility of a 10% solution in distilled water shall be less than or equal to the volatility of distilled water when tested in accordance with 4.6.4.

3.5.3 Residue rinsibility. For both types, when a freshly prepared solution of the cleaning compound is tested in accordance with 4.6.5, it shall not leave any residue or stains. A freshly prepared solution is defined as one being prepared no longer than 30 minutes prior to testing. Weight change shall be no greater than that obtained with standard hard water tested under the same conditions.

3.6 Physical properties (all types unless noted).

3.6.1 Heat stability (type II only). The concentrated cleaning compound, when tested in accordance with 4.6.6, will show no marked color change or precipitation and shall not corrode or stain the low carbon test strip (a slight darkening of the steel strip shall not be objectionable). Layering or separation will constitute failure if it does not return to its original homogeneous state upon cooling.

3.6.2 Cold stability. The concentrated cleaning compound shall return to its original homogeneous condition when tested in accordance with 4.6.7.

3.7 Effect on metals.

3.7.1 Hydrogen embrittlement. When tested in accordance with 4.6.11, the concentrated cleaner and a 10% solution of the cleaner in distilled water shall not cause hydrogen embrittlement of cadmium plated AISI 4340 steel.

3.7.2 Total immersion corrosion. When tested in accordance with 4.6.12, the concentrated cleaning compound and a 10% solution of the cleaning compound in distilled water shall not show any indication of staining, etching, pitting, or localized attack on any of the panels, or cause a weight change of an average of three (3) test panels greater than shown in Table II. A slight discoloration of the panels shall not be objectionable.

TABLE II. Total Immersion Corrosion Requirements

Alloy	Average of 3 Panels Weight Loss, Max (mg/cm²/168 hrs) \1
Magnesium (AZ 31B-H24) QQ-M-44 surface treated in accordance with Type II of MIL-M-3171	0.21
Aluminum, QQ-A-250/4, T3 surface treated in accordance with Type I, Class I of MIL-A-8625	0.49
Aluminum, QQ-A-250/4, Bare T3 Alloy	0.49
Aluminum, QQ-A-250/12, Bare T6 Alloy	0.49
Titanium, MIL-T-9046, 6A1-4V Class III, Composition C	0.35
Steel, MIL-S-7952, Grade 1020	1.40
Steel, MIL-S-7952, Grade 1020, Hot Dip Galvanized per ASTM A 153	0.50
Aluminum-Lithium, AA 2090-T-83	0.21
Steel, 410 SS, Silver Plated	0.14

\1 Requirements listed is for weight loss after 168 hours. The weight loss after 24 hours should be reported only

3.7.3 Low-embrittling cadmium plate corrosion. Steel panels coated with low-embrittling cadmium plate immersed in the concentrated cleaning compound and a 10% solution of the cleaning compound in distilled water shall not show a weight change greater than 0.14 mg/cm^2 for 24 hours when tested in accordance with 4.6.13.

3.7.4 Effects on unpainted metal surfaces. A 10% solution of the cleaning compound in distilled water shall not cause streaking, stains or other deposits that cannot be easily removed with water when tested in accordance with 4.6.14.

3.7.5 Sandwich corrosion. When tested in accordance with 4.6.19, the cleaning compound shall not cause a corrosion rating greater than two (2) on any test panel.

3.8 Effect on painted surfaces. A 25% solution of the cleaning compound in distilled water shall not cause streaking, blistering, discoloration or a permanent decrease in film hardness of more than one (1) pencil hardness level when tested in accordance with 4.6.15. The Type I material shall be tested using only the (F) Enamel and (P) Polyurethane Paint Systems.

3.9 Stress crazing of stretched (type A and C) acrylic plastics. The concentrated cleaning compound and a 10% solution in distilled water shall not cause stress crazing or staining of acrylic plastics when tested in accordance with 4.6.16.

3.10 Stress crazing of polycarbonate plastic. The concentrated cleaning compound and a 10% solution in distilled water shall not cause stress crazing or staining of polycarbonate plastic conforming to MIL-P-83310 when tested in accordance with 4.6.17.

3.11 Long-term storage stability. After being stored for a period of 12 months, in accordance with 4.6.18, the cleaning compound shall not cause corrosion of the shipping container and shall meet all requirements of this specification.

3.12 Foaming properties.

3.12.1 Type I. The cleaning compound, when tested as specified in 4.6.20, shall produce a stabilized foam which shall not break down nor produce more than 80 ml of liquid after standing for 4 minutes.

3.12.2 Type II. The cleaning compound, when tested as specified in 4.6.20, shall produce a stabilized foam which shall not break down nor produce more than 80 ml of liquid after standing for 6 minutes. The foam produced with foam generating equipment shall cling to the underside of panel surfaces held at 60 degrees to the horizontal and shall remain on all panels tested for not less than 60 seconds.

3.13 Workmanship. The cleaning compound shall be a liquid having a uniform and homogenous appearance. The cleaning compound shall be manufactured from materials entirely suitable for the purpose intended and shall be processed in a manner that will produce a product harmless to metal surfaces and humans when used as directed.

3.14 Effect on polysulfide sealants. A 25% solution of the cleaning compound in distilled water shall not change the durometer hardness of the polysulfide sealant by more than 5 units when tested in accordance with 4.6.21.

3.15 Rubber compatibility. A 25% solution of the cleaning compound in distilled water shall not change the durometer hardness more than 5 units when tested in accordance with 4.6.22.

3.16 Cleaning efficiency. When evaluated in accordance with paragraph 4.6.23, the cleaning compound shall exhibit a cleaning efficiency equal to or better than the control formula.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification when such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of tests. The inspection and testing of the cleaning compound shall be as follows. The inspection terms used herein are as defined in MIL-STD-109.

a. Qualification inspection (4.3).

b. Quality conformance inspection (4.4).

4.3 Qualification inspection. Qualification inspection shall consist of all inspections and tests specified herein.

4.3.1 Qualification samples. The initial qualification samples shall consist of 8 liters (2 gallons) of the cleaning compound. The cleaning compound shall be furnished in containers of the type to be used in filling contract orders. Samples shall be identified as follows and forwarded to the activity responsible for testing, as designated in the letter of authorization from the activity responsible for qualification (See 6.4):

- Samples for Qualification Tests.
- Cleaning Compound, Aerospace Equipment, Type (I or II),
- MIL-C-87937.
- (Manufacturers Product and Code Number)
- (Name and Address of Contractor)
- Submitted by (Name), (Date) for Qualification Testing in Accordance with the Requirements of MIL-C-87937 Under Authorization (Reference Authority Letter).
- (Mixing and Other Important Instructions.)
- (Safety Information and Precautions.)

4.3.2 Test reports. In addition to the qualification test samples, the contractor shall furnish a certified test report showing that the material conforms to all the requirements of this specification with the exception of the storage stability test. Additionally, a certified statement shall be furnished to the qualifying activity that specifically identifies each ingredient including solvent, in the cleaning compound by a readily recognizable chemical name, source and the percentage by weight contained in the compound. Trade names alone will not be considered satisfactory.

4.3.3 Qualification required. Prior to actual procurement, the cleaning compound shall pass the qualification inspections and requirements specified herein. If the product is later modified in any way, the modified form shall be subjected to and shall pass the same qualification inspections (see 3.1). Any changes or modifications from the formulation used at the initial qualification shall be approved by the qualifying activity and may require requalification. All qualifications will be granted contingent upon compliance with the long term storage stability requirement specified in paragraph 3.11.

4.4 Quality conformance tests. Quality conformance tests for acceptance of the cleaning compound shall consist of the following tests.

A. Cold Stability
B. Insoluble Matter
C. Immersion Corrosion*
D. Emulsion Characteristics
E. Nonvolatile Matter
F. Hard Water Stability
G. pH
H. Flash Point
I. Infrared Spectrogram

*Immersion Corrosion Quality Conformance Test ran on Aluminum QQ-250/4, Bare T3 alloy panel only.

If during quality conformance testing a lot fails any of the above acceptance tests, all tests required for qualification will be reinstituted. These qualification tests will be required until two successive lots meet all requirements of the specification, after which quality conformance testing will again be authorized. (See paragraph 4.4.6)

4.4.1 Sampling. Unless otherwise specified, not less than a 3.8 liter (1 gal) container of the cleaning compound shall be selected at random from each lot and subjected to the tests specified in 4.4.

4.4.2 Lot. A lot shall consist of one of the following:

a. The cleaning compound produced in not more than 24 consecutive hours from a continuous process which is used to fill shipping containers directly from the process output. A continuous process shall be the production of product by continuous input of raw materials and output of finished product by one manufacturer in one plant with no change in manufacturing conditions or materials.

b. The cleaning compound from individual runs of a batch process which is used to fill shipping containers directly from the process output. A batch process shall be the production of product by runs from single additions of raw materials which are mixed, reacted, and/or purified forming the product.

c. The cleaning compound from either or both the continuous and batch processes which is held in a single storage tank and subsequently withdrawn to fill shipping containers. The product will be homogeneous at the time of withdrawal and shall not be added to while being withdrawn. After each addition to the storage tank, the contents shall constitute a separate lot.

4.4.3 Sampling of product. Unless otherwise specified, quality conformance tests shall be made on the sample of product taken directly from the filled containers. The number of filled containers selected for sampling from each lot shall be in accordance with Table III. The first and last containers to be filled within a given lot shall be sampled. Other containers will be selected at random. The contents of each selected container for sampling shall be thoroughly mixed by rolling and inverting immediately prior to sampling. The samples may be obtained in any convenient manner that does not compromise the integrity of the sample. The sampled containers shall be subjected to the inspections specified in 4.4.5.

TABLE III. Sampling for Tests

Number of Containers in lot	Number of Containers to be sampled
2 to 15	2
16 to 25	3
26 to 90	5
91 to 150	8
151 to 280	13
281 to 500	20
501 to 1200	32
1201 to 3200	50
3201 to 10000	80
10001 to 35000	125
35001 to 150000	200
150001 to 500000	315
500001 and over	500

4.4.4 Inspection of materials. The contractor is responsible for insuring that materials and components used are manufactured, tested and inspected in accordance with the requirements of referenced subsidiary specifications and standards to the extent specified, or, if none, in accordance with this specification. (See 2.3)

4.4.5 Inspection of the end item. Examination of the end item shall be made in accordance with the following classification of defects. The lot size, for purposes of determining the sample size in accordance with Table III, shall be expressed in units of filled primary containers for the examination specified in 4.4.5.1, and 4.4.5.2, and in units of shipping containers for the examinations specified in 4.4.5.3.

4.4.5.1 Examination for container defects. The end item containers shall be examined for defects in appearance, closure, construction, workmanship, and markings in accordance with Table IV.

TABLE IV. Examination for Container Defects

EXAMINATION	DEFECT
-Appearance, construction, and workmanship	Not in container specified, cracked, crushed, or any defect affecting serviceability. Not clean; evidence of dirt, rust, or foreign matter.
-Closure	Any leakage or seepage of contents in either an upright or horizontal position. Closure not as specified.
-Markings	Omitted, illegible, incorrect, or not in accordance with contract requirements.

4.4.5.2 Examination for net contents. The quality of the batch shall be unacceptable if the average net content is less than the specified or indicated quantity.

4.4.5.3 Examination of preparation for delivery. An examination shall be made to determine the packing, palletization, and markings comply with Section 5 and Table V.

TABLE V. Examination of Preparation for Delivery

EXAMINATION	DEFECT
-Packing	Container not as specified. Arrangement or number of unit containers per pallet (as applicable) not in accordance with contract requirements. Loose or inadequate strappings, bulged or distorted containers.
-Palletization	Palletization not in accordance with requirements.
-Markings	Data illegible, incorrect, incomplete or not in accordance with contract.

4.4.6 Rejection and retest. When any sample of the product examined and tested in accordance with this specification fails to conform to the requirements specified herein, the entire lot represented by the sample shall be rejected. Rejected material shall not be resubmitted for acceptance without prior approval of the qualifying activity. The application for resubmission shall contain full particulars concerning previous rejections and all measures taken to correct those defects. Samples for retest shall be taken from previously unopened product containers.

4.5 Testing standards. All laboratory tests shall be conducted at standard conditions unless otherwise specified herein. Standard conditions are defined by FED-STD-141, Section 9. Unless otherwise specified, all chemical tests shall be made with ACS specification reagent grade chemicals. Unless otherwise specified, all product dilutions will be made with distilled water which conforms to the requirements of ASTM D 1193, Type IV, reagent water.

4.6 Test methods.

4.6.1 Nonvolatile matter. Weigh 5 ± 0.01 g of the sample in a porcelain or glass dish about 6 to 8 cm in diameter and about 2 to 4 cm in depth. Dry to constant weight in an air oven at a temperature of 105 ± 2°C. Constant weight is attained when successive heating for 1-hour periods shows a loss (or gain) of not more than 0.1%. Nonvolatile matter determinations shall be made on a minimum of two samples and the average shall be reported. If the two weights differ by more than 0.5% the procedure shall be repeated. The nonvolatile content of the each sample shall be calculated as follows.

$$\%NVM = \left(\frac{A}{B}\right) \times 100$$

Where: A = Weight of residue

B = Weight of sample

%NVM = Percent nonvolatile matter

4.6.2 Insoluble matter. The concentrated cleaning compound shall be thoroughly agitated and a 200 ml test sample withdrawn. The insoluble matter shall be collected with the aid of a vacuum filtering apparatus consisting of a water tap filter pump, a 2,000 ml Erlenmeyer flask, a size 4 (126 mm ID) Buchner funnel and a piece of 126 mm diameter Whatman No 5 filter paper, or equivalent. The filter paper shall be dried at 60°C (140°F) for 30 minutes in a gravity convection oven, cooled for 3 minutes in a desiccator, and weighed to the nearest 0.1 mg. The filter paper shall be placed in the Buchner funnel so that its circumference coincides with the circumference of the funnel. The vacuum shall be started and the filter paper wetted with approximately 10 ml of distilled water in order to secure it properly in place. The test sample shall be filtered. The sides of the beaker which contained the test sample shall be rinsed with 25 ml of distilled water from a wash bottle, and the rinse transferred to the funnel, insuring that any remaining insoluble matter is completely transferred with the rinse. When all the initial liquid and the rinse have been transferred through the filter, the sides of the funnel shall be washed with 25 ml of distilled water from a wash bottle and the rinse allowed to filter. The vacuum on the flask shall be relieved and the filter paper removed from the funnel. The filter paper shall be dried for 1 hour at 60°C (140°F) in a gravity convection oven, cooled for 3 minutes in a desiccator, and weighed to the nearest 0.1 mg. The percent insolubles shall be calculated as follows:

$$I = \left[\frac{A - B}{W}\right] X\ 100$$

Where:
A = Final filter paper weight
B = Initial filter paper weight
W = Weight of sample
I = % wt insoluble matter

Care should be exercised throughout the final drying and weighing cycle to maintain the flat surface of the filter paper in a horizontal position in order that none of the insoluble matter will be lost. Insoluble matter determinations shall be made on a minimum of two samples and the average shall be reported. If the two results differ by more than 0.5% the procedure shall be repeated.

4.6.3 pH value. The pH value of the concentrated cleaning compound and a 10 percent solution of the cleaning compound in freshly boiled distilled water shall be measured in accordance with ASTM E 70.

4.6.4 Volatility. A petri dish, 9 centimeters in diameter and 1.5 centimeters deep shall be placed on each pan of a two-pan beam balance with a minimum of a ± 0.5 gram precision. A sufficient amount of a 10% solution of the compound in distilled water shall be added to cover the entire bottom of one of the dishes. Distilled water shall be carefully poured in the other dish until the dish containing the compound is counterbalanced. The balance with filled dishes on the pans shall be exposed for 60 minutes in a draft free atmosphere having a temperature of 25 ± 3 °C (75 ± 5 °F). At the end of the exposure period, the comparative weight loss will be determined.

4.6.5 Residue rinsibility. Six smooth aluminum dishes, containing no creases or crevices, shall be cleaned in a solution of Brite-Boy, (from 3D Inc., or equivalent), rinsed, dried, and weighed. Ten ml of a 25% by volume solution of the cleaning compound in standard hard water (See 4.6.10.1) shall be placed in three of the precleaned dishes and tested as follows:

Dry for 7 1/2 hours in a circulating oven at 68 ± 2 °C with full draft. Cool in desiccator overnight and weigh. Rinse with running distilled water for 1 minute. Brush with a sash-type brush containing long-fiber bristles (2.5 cm diameter by 3.8 cm to 6.4 cm long) for 1 minute using distilled water. Rinse for 30 seconds with running distilled water. Dry in oven, cool and reweigh. Standard hard water, prepared as described in 4.6.10.1, shall be tested as control for weight change comparison in the remaining three precleaned dishes, using the same procedure as above.

4.6.6 Heat stability. A 141.75 g sample of the well mixed concentrated cleaning compound shall be placed into each of two clean 255 ml (12 oz) clear glass bottles having approximate dimensions of 24 cm in height by 6.35 cm in diameter (9.5 in x 2.5 in). One bottle containing the concentrated cleaning compound shall be sealed with a screw type cap and stored in a dark place at standard conditions for 6 days (144 hrs) for reference purposes. Place into the second bottle of concentrated cleaning compound a strip of steel, 15.24 cm by 1.27 cm by 0.05 cm (6 in x 0.5 in x 0.02 in) conforming to MIL-S-7952. Clean the steel strip by abrasively polishing to remove surface scale and corrosion followed by immersion for one minute in xylene (ASTM D 846) followed by immersion for one minute in isopropyl alcohol (TT-I-735, grade A) at standard conditions. Seal the bottle containing the concentrated cleaning compound and the cleaned steel strip with a screw type cover and shake thoroughly for 1 minute. Place the bottle in a bath maintained at 46 ± 2 °C (115 ± 3 °F) for 5 hours, then remove and allow to cool to ambient conditions for 19 hours. This heating/cooling cycle will be repeated 5 times. After completion of the test period, remove the test strip and inspect the portion of the strip which was immersed in the cleaning compound and the portion exposed to the vapor. Any corrosion, pitting or discoloration constitutes failure. The bottle is resealed and along with the control bottle, that has been maintained in the dark, is shaken thoroughly for 1 minute, then allowed to remain undisturbed for 1 hour at room temperature. The bottles are then examined. Any marked change in color, precipitation, layering or separation constitutes failure.

4.6.7 Cold stability. A 50 ml sample of the cleaning compound shall be poured into a suitable test tube and cooled to 0°C. This temperature shall be maintained for one hour. The compound shall then be allowed to reach room temperature. After 5 (five) complete temperature inversion cycles of the test tube, the compound shall be examined for homogeneity.

4.6.8 Flash point. The flash point of the concentrated cleaning compound (both types) shall be determined in accordance with ASTM D 56. The flash point of the 10% solution in distilled water (Type I only) shall be determined in accordance with ASTM D 92.

4.6.9 Emulsion characteristics. Twenty ml of a 25% by volume solution of the cleaning compound shall be placed in a 50 ml glass stoppered, graduated cylinder. Twenty ml of lubricating oil conforming to MIL-L-2104, grade 10W shall be added. An emulsion shall be formed by 10 inversions of the graduated cylinder followed by a vigorous 15 second shake. After the emulsion has stood for 5 minutes, the 15 second shake shall be repeated. At 15 minutes and 8 hours for the Type I cleaner, or at 15 minutes and 24 hours for the Type II cleaner, the amount of free water and cleaner which separates from the lubricating oil shall be recorded.

4.6.10 Hard-water stability.

4.6.10.1 Preparation of stock solution. A 20-grain (as $CaCO_3$) hard-water stock solution shall be prepared by dissolving 0.40 ± 0.005 g of reagent grade Calcium Acetate, $Ca(C_2H_3O_2)_2 \cdot 2H_2O$ and 0.28 ± 0.005 g of reagent grade Magnesium Sulfate, $MgSO_4 \cdot 7H_2O$, in 1 liter of boiled distilled water.

4.6.10.2 Procedure. Using a 5 ml volumetric pipet transfer 5 ml of a 25% by volume solution of cleaning compound into each of 3 clean 50 ml volumetric flasks. Add hard-water stock solution to each of 3 flasks to make 50 ml. Each solution shall be well mixed and allowed to stand undisturbed for 24 hours at 25 ± 1 °C. Each solution shall then be visually examined for precipitation. Agitate each solution by inverting the flask five times. The turbidity shall be measured with a Hellige turbidimeter or equivalent non-photometric instrument and calibrated as ppm silica.

4.6.11 Hydrogen embrittlement. The hydrogen embrittlement properties of the cleaning compound shall be determined in accordance with ASTM F 519 using Type 1a, Treatment B AISI 4340 steel specimens.

4.6.12 Total immersion corrosion. The total immersion corrosion effects of the cleaning compound on the new, unused metals and metal alloys listed in Table II shall be determined in accordance with ASTM F 483. In order to obtain the best results on test panels in this very low weight category, the panels must be handled with gloves, cleaned in a very careful manner and dried in an oven. They are cooled and dried in a desiccator both before and after each weighing.

4.6.13 <u>Low embrittling cadmium plate corrosion</u>. The cleaning compound shall be evaluated for corrosion on low-embrittling cadmium plate in accordance with ASTM F 1111.

4.6.14 <u>Effects on unpainted metal surfaces</u>. The cleaning compound shall be evaluated for effects on unpainted metal surfaces in accordance with ASTM F 485.

4.6.15 <u>Effect on painted surfaces</u>. Prepare a 25% solution of cleaning compound with distilled water. Test both the 25% solution and concentrate in accordance with ASTM F 502 except that the panels used for testing shall be coated with the paint systems listed in Table VI. For all paint systems tested, a separate panel will be required for both 25% solution and concentrate. For Type II compound, conduct the test on all paint systems listed in Table VI. For Type I compound, conduct the test only on the enamel (F) and polyurethane (P) paint systems.

4.6.16 <u>Stress crazing of stretched (type A and C) acrylic plastics</u>. The cleaning compound shall be evaluated for stress crazing of stretch (Type A and C) acrylic plastics in accordance with ASTM F 484.

4.6.17 <u>Stress crazing of polycarbonate plastic.</u> The cleaning compound shall be evaluated for stress crazing of polycarbonate plastics using the test procedure outlined in ASTM F 484 with the exception that the acrylic plastics called for in the procedure be replaced with polycarbonate plastic conforming to MIL-P-83310 of the same dimensions and the polycarbonate specimens shall be stressed for 30 ± 2 minutes to an outer fiber stress of 2000 psi.

4.6.18 <u>Long term storage stability</u>. The cleaning compound shall be prepared and stored for long term storage stability in accordance with ASTM F 1104 using two (2) 3.8 liter (one-gallon) cans conforming to PPP-P-704 or non-metallic DOT 34-5.

4.6.19 <u>Sandwich corrosion.</u> The cleaning compound shall be tested in accordance with ASTM F 1110 except that non-conformance shall be determined by the requirements specified in paragraph 3.7.5.

4.6.20 <u>Foaming properties.</u>

4.6.20.1 <u>Type I and type II</u>. One part of the concentrated cleaning compound will be mixed with 15 parts water. 100 ml of this mixture shall be placed in a 500 ml capacity blender with a maximum 9.5 cm (3.75 inch) outside diameter. The blender shall be turned on and run for 2 minutes at 8000 ± 1000 rpm. A stabilized foam is indicated by negligible agitation at the upper surface. The blender shall be turned off after 2 minutes and allowed to stand undisturbed for the time specified in paragraph 3.12.

4.6.20.2 <u>Type II only</u>. If the cleaning compound meets the requirements of 4.6.20.1 the test should be continued by spraying as a foam from a B&B Chemical Portafoamer 20 or equivalent, using tap water. The first application shall be made to an aluminum panel, 61 x 61 cm (24 x 24 in), from a hose having an inside diameter of 2.5 cm (1 in) and 15.2 to 22.9 m (50 to 75 ft) long at a dilution ratio set at 1 part compound to 9 parts water. The second application shall be made to a similar panel with a hose having an inside diameter of 1.9 cm (3/4 in) and 7.6 m (25 ft) in length with dilution set at 1 part compound to 9 parts water. The panels shall be held at an angle of 60 degrees to the horizontal.

TABLE VI. Test Panel Finishes

Primer Coatings				
Panel Set No.	Primer Material Specification	Dry Film Thickness Per Coat/ mm (inches)	No. of Coats	Drying Time Before Topcoating
L	MIL-C-8514, Coating Compound Metal Pretreatment Resin-Acid (First Coat)	0.0051 - 0.0102 (0.0002 - 0.0004)	1	2 - 8 hours
	MIL-P-7962, Lacquer Primer (Second Coat)	0.0076 - 0.0127 (0.0003 - 0.0005)	1	2 - 8 hours
EPH	MIL-P-23377, Primer, Coating Epoxy-Polyamide	0.0178 - 0.0229 (0.0007 - 0.0009)	1	2 - 8 hours
F	TT-P-1757 Primer Coating Zinc Chromate	0.0178 - 0.0203 (0.0007 - 0.0008)	1	2 - 8 hours

Top Coats, Color Number 17925 per FED-STD-595						
Panel Set	Topcoat Material	Dry Film Thickness Per Coat/ mm (inches)	No. of Coats	Drying Time Between Coats	Dry Film Thickness mm (inches)	Days to Dry Before Testing
L	TT-L-32 Lacquer, Acrylic Gloss	0.0102 - 0.0127 (0.0004 - 0.0005)	2	1 hour	0.0203 - 0.0254 (0.0008 - 0.0010)	7
E	MIL-C-22750 Coating, Epoxy Topcoat	0.0102 - 0.0127 (0.0004 - 0.0005)	2	1 hour	0.0203 - 0.0254 (0.0008 - 0.0010)	7
P	MIL-C-83286 Polyurethane	0.0203 - 0.0305 (0.0008 - 0.0012)	2	1 hour	0.0457 - 0.0610 (0.0018 - 0.0024)	7
H	MIL-C-85285	same as P				
F	TT-E-529 Enamel Semigloss	0.0203 - 0.0305 (0.0008 - 0.0012)	2	1 hour	0.0457 - 0.0610 (0.0018 - 0.0024)	7
D	DOD-P-23236 Paint Coating Requires No Primer	0.0457 - 0.0610 (0.0018 - 0.0024)	1	24 hours		

4.6.21 Effects on polysulfide sealant.

4.6.21.1 Preparation of test specimens. MIL-S-81733, Type I, and MIL-S-8802, Type I, sealants shall be mixed as specified by their respective manufacturers and each pressed into a 1/8 inch thick sheet mold until cured (this will be the sheet stock for each sealant). The sealants will be cured for 7 days at 49°C. The specimens shall be cut from the sheet stock.

4.6.21.2 Test procedures. Immerse two specimens of each sealant in a 25% solution of the cleaning compound at room temperature for 30 minutes. Remove from the solution, rinse with cool tap water, and test within 30 minutes for Shore A hardness in accordance with ASTM D 2240.

4.6.22 Test on rubber compatibility. Tests will be conducted on AMS 3204 and AMS 3209 rubbers for compatibility with the cleaning compounds.

4.6.22.1 Preparation of test specimens. Three (3) test specimens will be used for each type rubber specified. Test specimens will be cut from 1/8 inch sheet stock.

4.6.22.2 Test procedure. Test and record the Shore A hardness of each test specimen in accordance with ASTM D 2240. Immerse each specimen in 25% solution of the cleaning compound at room temperature for 30 minutes. Remove from the solution, rinse with cool tap water, and test within 30 minutes for a Shore A hardness in accordance with ASTM D 2240.

4.6.23 Cleaning efficiency.

4.6.23.1 Preparation of control formula. The control formula shall be prepared by the testing laboratory in accordance with Table VII and subjected to the cleaning test. The cleaning efficiency of the cleaning compound shall be compared to the cleaning efficiency of the corresponding control formula to determine if the cleaning compound meets the requirements of paragraph 3.16.

TABLE VII. Control Formulas for Cleaning Efficiency Test

Component	Composition (% by weight) \1	
	Control for Type I Cleaning Compounds	Control for Type II Cleaning Compounds
d-limonene	30.0	—
di-ethanolamine	5.0	—
non-ionic surfactant (Triton X-100)	5.0	2.0
sodium metasilicate pentahydrate	—	7.0
trisodium phosphate dodecahydrate (O-S-642)	—	5.0
ethylene glycol monoethyl ether (TT-E-781)	—	6.0
distilled water (ASTM D 1193, type IV)	60.0	80.0

\1. These formulations are corrosive and solely intended for use as the control for the cleaning efficiency test. They will not qualify to the other requirements listed in this specification.

4.6.23.2 Panel preparation. Aluminum alloy panels 15.2 x 6.4 x 0.05 cm (6 x 2.5 x 0.02 in) shall be finished in accordance with panel set no. P of Table VI. Panels shall then be conditioned for one week at 66°C (150°F). Only those panels having a 60-degree gloss not less than 2.0 and not more than 4.0 shall be used for this test. The lightness value (L-value in a L-a-b color system) shall be measured using a McBeth 1010S colorimeter (illuminant C) or equivalent prior to soil application (Lv), prior to cleaning (Ls), and following cleaning (Lc).

4.6.23.3 Soil preparation. Hydraulic fluid soil shall be prepared by blending 50 grams of carbon black and 500 grams of MIL-H-83282 fluid with a speed Cowles type dispersator for 15 minutes. Molybdenum disulfide grease soil shall be prepared by blending 50 grams of carbon black and 500 grams of MIL-G-21164 grease with a mechanical grease worker for 15 minutes. Wire rope lubricant (Sprayon No. 201) is applied from an aerosol spray can as received.

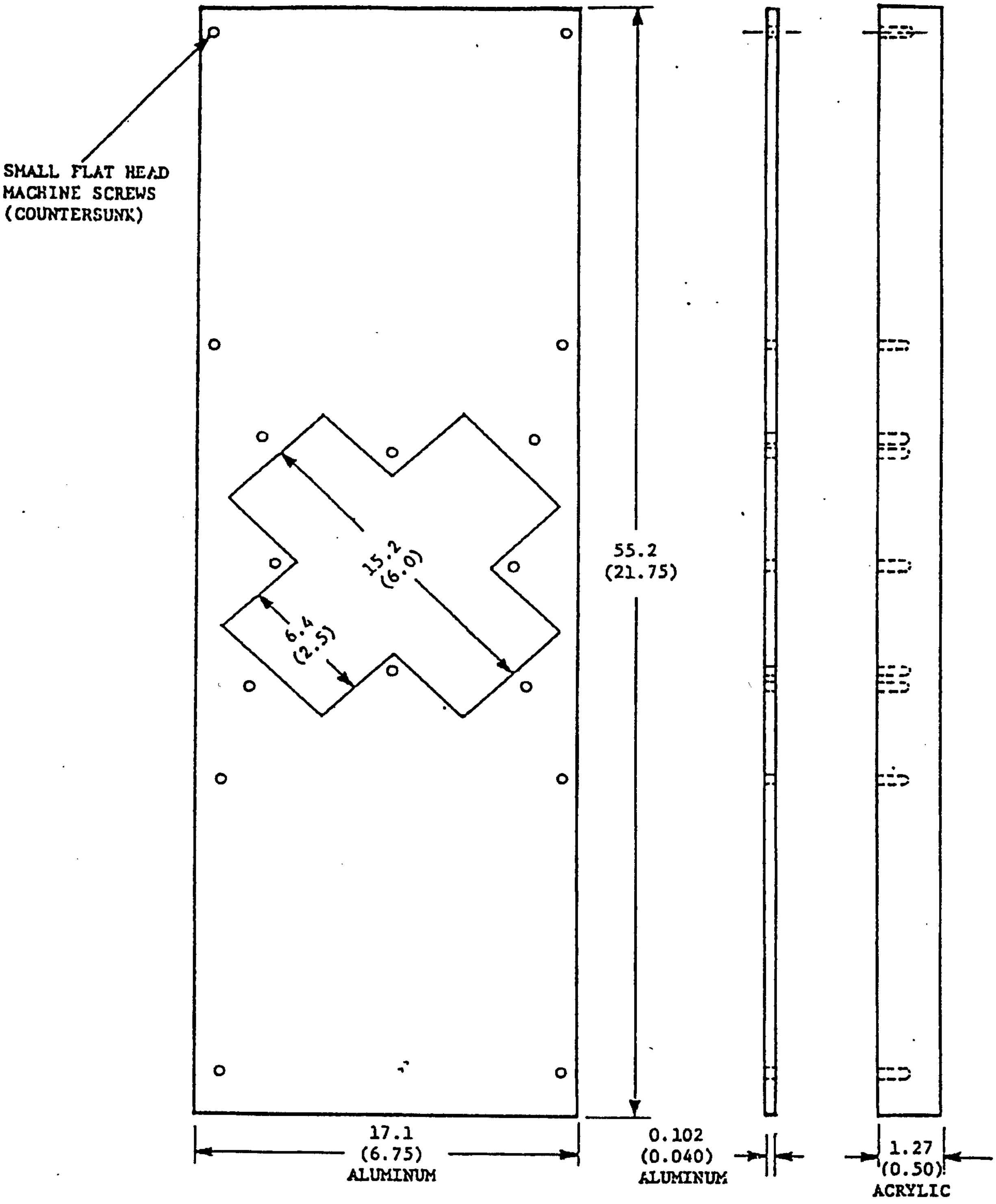
4.6.23.4 Application of hydraulic fluid and grease soils. Using a soft bristle brush, gently paint the coated surface of a test panel with the test soil. Remove excess hydraulic fluid soil by covering the test panel with folded absorbent tissue and exerting pressure by rolling over the tissue with a five pound rubber cylinder; Repeat this blotting procedure twice. Remove excess grease soil by stroking the test panel with a piece of MIL-C-83957 cleaning pad 5 times. Brush each test panel using ten strokes of a hog bristle brush (Pacific Scientific, Bethesda, MD; catalog no. WG2000B or equivalent). Each freshly soiled panel shall be baked at 105 ± 1°C (221 ± 2°F) for 60 minutes then cooled to room temperature and used within 4 hours.

4.6.23.5 Application of wire rope lubricant. Place wire rope lubricant (Sprayon No. 201) onto a test panel and immediately wipe back and forth using a piece of MIL-C-83957 cleaning pad (3/8 inch thickness) to achieve a uniform soil in the center of the panel. Color and uniformity of all test panels shall be similar. Bake the soiled test panels at 105 ± 1°C (221 ± 2°F) for 60 minutes then cool to room temperature prior to use.

4.6.23.6 Cleaning. The test panel shall be cleaned using a Gardner heavy duty wear tester, or equivalent, fitted with a cellulose sponge. The sponge shall be cut such that the dimension parallel to the cleaning stroke is 9 cm (3.5 in) and the width is 7 cm (2.75 in). The cleaning head with the dry sponge attached shall be weighed to a mass of 1370 to 1380 grams. The cleaning compound and the control formula shall be diluted 1 part cleaner with 9 parts distilled water. After placing a soiled test panel in the template at 45 degrees (see figure 1), the cleaning solution shall be applied to the sponge then applied to the soiled test panel so that it is completely covered. After allowing a 30 second dwell time, the test panel shall be cleaned using 5 cycles of the wear tester, then turned 90 degrees and cleaned for an additional 5 cycles. The panel shall then be rinsed under cold running tap water and allowed to dry.

4.6.23.7 Evaluation. The colorimeter L values for unsoiled panel (Lv), after soiling (Ls), and after cleaning (Lc) shall be used in determining the percent cleaning efficiency as follows:

$$\%\text{Cleaning Efficiency} = \left[\frac{Lc - Ls}{Lv - Ls}\right] \times 100$$



DIMENSIONS IN CENTIMETERS (INCHES).

Figure 1. Template

4.6.24 Biodegradability. Biodegradation will be determined by the "Shake Flask Biodegradation Tests" for measuring ultimate or ready degradation potential, as found in EPA Chemical Fate Test Guidelines 40 CFR Method 796.3100 (Aerobic Aquatic Biodegradation Test) or 40 CFR Method 796.3240 (OECD Screening Test for Ready Biodegradability). Biodegradability will be shown as carbon transformation by both soluble organic carbon reduction and CO_2 evolution.

4.6.25 d-Limonene content (Type I only). Test for d-limonene content of the concentrated cleaning compound shall be determined by the following procedure.

4.6.25.1 Gas chromatographic column. The column to be used for this analysis is the 6 foot Poropak P column, or equivalent, connected to a thermal conductivity detector.

4.6.25.2 Gas chromatographic parameters. Experimental parameters for analysis are as follows:

Sample size	1 µl
Carrier gas	Helium
Carrier gas flow rate	20 ml/min
Initial column temperature	150°C (302°F)
Initial isothermal hold time	10 min
Gradient heating rate	10°C/min (18°F/min)
Final temperature	230°C (446°F)
Final isothermal hold time	10 min

4.6.25.3 Calibration procedure. Obtain the normalization factors for d-limonene by observing the areas produced by a specially prepared mixture, designated the reference standard. Prepare the standard with all reagent grade components of known assay. The composition of the mixture should be approximately 10% butyl cellosolve and 90% d-limonene. Weigh each component to 0.1 milligram. Calculate the actual composition as follows:

$$\%Com_i = \frac{W_i \times \%P_i}{W}$$

Calculate the normalization factor for d-limonene as follows:

$$K_i = \frac{\%Com_i \times A_b}{A_i \times \%Com_b}$$

Where: W_i = Weight of d-limonene in standard (mg)

$\%P_i$ = Purity of d-limonene in standard (%)

W = Total weight of standard (mg)

$\%Com_i$ = Weight % of d-limonene in standard (%)

$\%Com_b$ = Weight % of butyl cellosolve in standard (%)

A_i = Area under peak for d-limonene

A_b = Area under peak for butyl cellosolve

K_i = Normalization factor for d-limonene

4.6.25.4 Test procedure. Weigh out 9.00 ± .01 g of the concentrated cleaning compound in a 15-20 ml screw top vial. Add 1.00 ± .01 g of butyl cellosolve to the vial. Screw the cap onto the vial tightly and invert several times to mix. Equilibrate the instrument and make at least one blank run. Insert a 1µl sample of the cleaning compound spiked with 10% butyl cellosolve at least five times. Take an average of the area counts for each component.

4.6.25.5 Calculation.

$$\%C_l = \frac{A_l \times K_l \times \%C_b}{A_b}$$

Where: $\%C_l$ = Weight % of d-limonene

$\%C_b$ = Weight % of butyl cellosolve

A_l = Average of areas under peak for d-limonene

A_b = Average of areas under peak for butyl cellosolve

K_l = Normalization factor for d-limonene

4.6.25.6 Reagents and equipment. The following equipment and reagents shall apply as test conditions for 4.6.25.

a. Equipment.

(1) Gas chromatograph: Incorporating a thermal conductivity detector.

(2) Column: Poropak P 6 foot (80/100 mesh), or equivalent.

b. Reagents.

(1) Butyl cellosolve (2-butoxy ethanol): Baker D648 or equivalent.

(2) d-Limonene: Fisher Scientific 1980 or equivalent.

4.7 Toxicity and waste disposal characteristics. The supplier shall furnish the toxicological data or formulations required (See 3.3) to evaluate the safety of the material proposed for use. The manufacturer will provide current procedures for disposal per federal EPA regulations. The supplier shall also furnish certification of the percent activity and percent biodegradability of the cleaner. The data will be forwarded to San Antonio Air Logistics Center, Attention SFTT, Kelly AFB, Texas 78241-5000.

4.8 Filler materials. The contractor shall furnish certification that the cleaning compound contains only the materials allowed and does not contain any filler materials disallowed per paragraph 3.2.

4.9 Infrared spectrograms graph. Infrared spectrograms of the nonvolatile matter shall be prepared by the Government approved qualification laboratory (See 3.4). The method of sample preparation of the spectra shall be provided with each graph to the qualifying activity by the qualification laboratory.

5. PACKAGING

5.1 Packing. Packing shall be Level A, or Industrial for required net fill, as specified.

5.1.1 Level A. The cleaning compound shall be furnished in 208 liter (55 gallon) drums conforming to PPP-D-729, Type II and UN 1A1 or in 18.9 liter (5 gallon) containers conforming to PPP-P-704, Type I, Class 4 and UN 1A1, or non-metallic DOT 34-5.

5.1.2 Industrial. The cleaning compound shall be packed in accordance with ASTM D 3951. Containers shall be in accordance with Uniform Freight Classification rules or regulations of other carriers applicable to the mode of transportation.

5.1.3 Compatibility of materials. The container, closure, lining, or sealing compound shall not interact physically or chemically with the contents so as to corrode, be altered, or to alter the strength, quality or purity of the contents.

5.2 Palletization. When specified, the cleaning compound, shall be palletized in accordance with Load Type III (strapped) of MIL-STD-147 except that for overseas shipment the overall height of the load shall not exceed 109.2 cm (43 inches.)

5.3 Marking. Containers shall be marked in accordance with MIL-STD-129 and 49 CFR. For international shipments, containers shall also be marked in accordance with ICAO, IATA, and IMO as applicable for mode of transportation. The shipment marking nomenclature shall be:

CLEANING COMPOUND, AEROSPACE EQUIPMENT, TYPE - (I OR II)

DIP TANK IMMERSION METHOD:

Dilute the concentrate with a minimum of two parts water unless otherwise specified in Technical Order (TO). Normal dilution ratios are 1:4 for heavy soils, 1:10 for light soils.

EXTERIOR CLEANING METHOD:

Aircraft and AGE: Dilute the concentrate 1:10 to 1:20 with water depending on the amount of soil to be removed. Dilute the concentrate with 4 to 10 parts water depending on the amount of soil to be removed for spot cleaning. Not recommended for cleaning canopies.

Engines: Dilute the concentrate with 3 to 10 parts water depending on the amount of soil to be removed. Not recommended as a spot cleaner for engines.

5.3.1 Storage temperature. The markings on the container shall include a caution statement stating the temperature range within which the product can be stored without compromising the performance of the product.

5.4 Material safety data sheet. Contractor shall comply with the requirements of the latest revision of FED-STD-313.

5.5 Hazardous material warning labels. A hazardous warning label shall be developed in accordance with the requirements of the OSHA Hazardous Communication Standard (29 CFR 1910.1200) and MIL-STD-129.

6. NOTES

6.1 Intended use. The two types of cleaning compound covered by this specification are intended to be used for cleaning Aerospace Equipment including aircraft, engines and aerospace ground equipment (AGE). The cleaners shall be used in place of other cleaners when approved by the System Program Manager of the equipment being cleaned. Type I should be used only on polyurethane and enamel coatings as it may attack acrylic nitrocellulose lacquer coatings. Type I material is intended for light to heavy duty removal of greases, oils, hydraulic fluid, and carbon. Type II is intended for medium to light cleaning and is not intended to remove heavy soils.

6.2 Material safety data sheets. Contracting officers will identify those activities requiring copies of completed Material Safety Data Sheets prepared in accordance with FED-STD-313. The pertinent Government mailing addresses for submission of data are listed in FED-STD-313.

6.3 Ordering data. Procurement documents should specify the following:

a. Title, number and date of this specification.
b. Type I or Type II.
c. Size containers required.
d. QPL reference or test number.
e. Level of packing required.
f. Palletization, when applicable.

6.4 Qualification. With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in the applicable Qualified Products List whether or not such products have actually been so listed by that date. The attention of the contractors is called to this requirement, and contractors are urged to arrange to have their products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the Qualified Products List is San Antonio Air Logistics Center, Attention SFTT, Kelly AFB Texas 78241-5000; and information pertaining to qualification of products may be obtained from that activity (See 4.3.1).

CUSTODIANS:
Air Force - 68

REVIEW ACTIVITIES:
Air Force - 11
Navy - AS

PREPARING ACTIVITY:
Air Force - 68

PROJECT NO. 6850-1100

INCH-POUND
MIL-C-87937B
27 Jan 94
Superseding
MIL-C-87937A
16 Oct 1991

MILITARY SPECIFICATION

CLEANING COMPOUND, AEROSPACE EQUIPMENT

This specification is approved for use by all
Departments and Agencies of the Department of Defense

1. SCOPE

1.1 Scope. This specification establishes the requirements for biodegradable, water dilutable, environmentally safe cleaning compounds for use on aerospace equipment to include aircraft, aerospace ground equipment (AGE) and AGE engines.

1.2 Classification. The cleaning compounds covered by this specification shall be of the following types.

Type I - Terpene Based, Solvent Emulsion, Water Dilutable Cleaning Compound

Type II - Water Dilutable Cleaning Compound

Type III - Gel-Type Cleaning Compound

Type IV - Heavy Duty, Water Dilutable Cleaning Compound

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards and handbooks form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, noted in the solicitation.

SPECIFICATIONS

Federal

O-S-642	Sodium Phosphate, Tribasic, Anhydrous, Dodecahydrate, & Monohydrate, Technical
P-D-680	Dry Cleaning and Degreasing Solvent
QQ-A-250/4	Aluminum Alloy 2024, Plate and Sheet
QQ-A-250/5	Aluminum Alloy Alclad 2024, Plate and Sheet
QQ-A-250/12	Aluminum Alloy 7075, Plate and Sheet

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Code (68) SA-ALC/SFSP, 1014 Andrews Rd STE 1, Kelly AFB TX 78241-5603, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A
FSC 6850

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

QQ-P-416	Plating. Cadmium (Electrodeposited)
QQ-S-365	Silver Plating, Electrodeposited: General Requirements for
TT-E-529	Enamel, Alkyd, Semi-gloss, Low VOC Content
TT-E-781	Ethylene Glycol Monoethyl Ether, Technical
TT-I-735	Isopropyl Alcohol
TT-L-32	Lacquer, Cellulose Nitrate, Gloss, For Aircraft Use
TT-P-1757	Primer Coating, Zinc Chromate, Low Moisture Sensitivity
PPP-D-729	Drums, Shipping and Storage, Steel, 55 Gallon (208 Liters)
PPP-P-704	Pails, Metal: (Shipping, Steel, 1 through 12 gallons)

Military

MIL-L-2104	Lubricating Oil, Internal Combustion Engine, Tactical Service
MIL-P-5425	Plastic, Sheet, Acrylic, Heat Resistant
MIL-M-3171	Magnesium Alloy, Processes for Pretreatment and Prevention of Corrosion on
MIL-S-7952	Steel, Sheet and Strip, Uncoated, Carbon (1020 and 1025) (Aircraft Quality)(ASG)
MIL-P-7962	Primer Coating, Cellulose-Nitrate Modified Alkyl Type, Corrosion Inhibiting, Fast-Drying (For Spray Application Over Pretreatment Coating)
MIL-C-8514	Coating Compound, Metal Pretreatment, Resin-Acid (ASG)
MIL-A-8625	Anodic Coatings, For Aluminum and Aluminum Alloys
MIL-S-8802	Sealing Compound, Temperature Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High Adhesion
MIL-T-9046	Titanium and Titanium Alloy, Sheet, Strip and Plate
MIL-G-21164	Grease, Molybdenum Disulfide, For Low and High Temperatures
MIL-C-22750	Coating, Epoxy Polyamide
MIL-P-23236	Paint Coating System, Fuel Salt Water Ballast Tanks
MIL-P-23377	Primer Coating, Epoxy Polyamide, Chemical and Solvent Resistant
MIL-P-25690	Plastic, Sheets And Parts, Modified Acrylic Base, Monolithic, Crack Propagation Resistant
MIL-W-81381	Wire, Electric, Polyimide-Insulated, Copper or Copper Alloy
MIL-S-81733	Sealing and Coating Compound, Corrosion Inhibitive
MIL-C-83286	Coating Urethane, Aliphatic Isocyanate, for Aerospace Application
MIL-P-83310	Plastic Sheet, Polycarbonate, Transparent
MIL-C-83957	Cleaning and Polishing Pad, Non-metallic (For Aircraft)
MIL-C-85285	Coating: Polyurethane, High Solids

STANDARDS

Federal

EPA-600-4-90-027	Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms
FED-STD-141	Paint, Varnish, Lacquer and Related Materials Methods of Inspection, Sampling and Testing
FED-STD-313	Material Safety Data Sheets, Preparation and the Submission of
FED-STD-595	Colors

Military

MIL-STD-109	Quality Assurance Terms and Definitions
MIL-STD-129	Marking For Shipment And Storage
MIL-STD-147	Palletized Unit Loads

(Copies of specifications, standards, handbooks, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094)

2.1.2 Other Government documents, drawings, and publications. The following other Government documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issue shall be that in effect on the date of the solicitation.

CODE OF FEDERAL REGULATIONS

29 CFR - Labor
40 CFR - Protection of Environment
49 CFR - Transportation

(Application for copies should be addressed to Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.)

2.2 Other publications. The following non-government documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issue of the non-government documents which is current on the date of the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM Standards

A 153	Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
D 56	Test Method for Flash Point by Tag Closed Tester
D 92	Test Method for Flash and Fire Points by Cleveland Open Cup
D 93	Standard Test Methods for Flash Point by Pensky-Closed Tester
D 460	Method for Sampling and Chemical Analysis of Soaps and Soap Products
D 1193	Specification for Reagent Water
D 2240	Test Method for Rubber Property - Durometer Hardness
D 3951	Practice for Commercial Packaging
E 70	Test Method for pH of Aqueous Solutions with the Glass Electrode
F 483	Method For Total Immersion Corrosion Test for Aircraft Maintenance Chemicals
F 484	Test Method for Stress Crazing of Acrylic Plastics in Contact with Liquid or Semi-Liquid Compounds
F 485	Test Method for Effects of Cleaners on Unpainted Aircraft Surfaces
F 502	Test Method for Effects of Cleaning and Chemical Maintenance Materials on Painted Aircraft Surfaces
F 519	Method for Mechanical Hydrogen Embrittlement Testing of Plating Processes and Aircraft Maintenance Chemicals
F 1104	Test Method for Preparing Aircraft Cleaning Compounds, Liquid Type, Water Base, for Storage Stability Testing
F 1110	Test Method for Sandwich Corrosion Test
F 1111	Test Method for Corrosion of Low Embrittling Cadmium Plate by Aircraft Maintenance Chemicals

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia PA 19103.)

SOCIETY OF AUTOMOTIVE ENGINEERS

SAE Standards

AMS 3204	Synthetic Rubber, Low-Temperature Resistant 25-35
AMS 3209	Chloroprene Rubber, Weather Resistant, 65-75
AMS 4375	Magnesium Alloy, Sheet & Plate, 3.01A-1.0ZN (AZ31B-O)
AMS 4376	Magnesium Alloy Plate, 3.01A-1.0ZN (AZ31B-H26)
AMS 4377	Magnesium Alloy, Sheet & Plate, 3.01A-1.0ZN (AZ31B-H24)

(Application for copies should be addressed to the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale PA 15096.)

UNIFORM FREIGHT CLASSIFICATION RULES (Current Issue)

(Application for copies should be addressed to the Uniform Classification Committee, Room 1106, 222 South Riverside Plaza, Chicago, IL 60606.)

ALUMINUM ASSOCIATION INCORPORATED

AA Standards

2090-T-83	Aluminum-Lithium Alloy

(Application for copies should be addressed to The Aluminum Association Inc., 900 19th St MW, Washington D.C. 20006.)

AMERICAN IRON AND STEEL INSTITUTE

AISI Standards

AISI 4340	High Strength, Low Alloy Steel

(Application for copies should be addressed to American Iron and Steel Institute, 1133 15th St N.W. Suite 300, Washington DC 20005.)

INTERNATIONAL CIVIL AIR ORGANIZATION (ICAO)

Technical Instructions for the Safe Transport of Dangerous Goods by Air

(Application for copies should be addressed to International Civil Aviation Organization, Place de l'Aviation Internationale, 1000 Sherbrooke St., W, Montreal, Quebec, Canada H3A 2R2.)

INTERNATIONAL AIR TRANSPORT ASSOCIATION (IATA)

Dangerous Goods Regulations

(Application for copies should be addressed to the International Air Transport Association, 2000 Peel St., Montreal, Quebec, Canada H3A 2R4.)

INTERNATIONAL MARITIME ORGANIZATION (IMO)

International Maritime Dangerous Goods Code

(Application for copies should be addressed to the International Maritime Organization, 4 Albert Embankment, London SE1 7SR United Kingdom.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and a reference cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 Qualification.

3.1.1 Qualification (Initial). The cleaning compound furnished under this specification shall be a product which has been tested and has passed the qualification tests specified herein and has been listed or approved for listing on the applicable Qualified Products List (QPL).

3.1.2 Qualification (Periodic). The cleaning compound furnished under this specification must be retested or recertified by the qualifying activity at least every three years for the product to remain listed on the QPL. Qualification retesting shall be accomplished on any qualified cleaning compound for which a using activity issues a valid deficiency report. The cleaning compound shall also be subject to qualification retesting for any change in chemical formulation, material, process, or procedure in manufacturing the cleaning compound. Any cleaning compound which does not conform to all the qualification tests specified herein on periodic requalification testing shall be removed from the QPL.

3.2 Materials. The composition and formulation of the cleaning compound shall be optional with the manufacturer within the restrictions specified herein.

3.2.1 Acceptable materials.

3.2.1.1 Type I. Type I shall contain terpene hydrocarbons as specified in Table I. Certification from the manufacturer is required on the percentage of total terpenes contained in the cleaning compound. The terpene hydrocarbons used shall be of a high grade with no extraneous materials.

3.2.1.2 Type II, Type III and Type IV. Type II, Type III, and Type IV compounds shall consist of one or more of the following: Surfactants, adjuvant solubilizers for organic soils such as greases and oils, alkaline builders, water conditioning agents and/or corrosion inhibitors.

3.2.2 Unacceptable materials. The cleaning compound shall not contain any hazardous compounds as defined in 40 CFR 261 (see para 4.7) nor shall it contain any chemical listed by the current report of known carcinogens of the National Toxicology Program (NTP). The cleaning compound shall not contain detectable amounts of any of the following: abrasives, chromates, cadmium, lead, mercury, phenols, cresols, ketones, chlorinated compounds or ozone depleting chemicals (ODC), except where specified within this specification. The following materials are unacceptable unless they are being used as an essential active ingredient in the cleaner: sodium chloride, urea, sodium sulfate, nitrites, nitrates, sucrose or any sugars.

3.3 Toxicity. The cleaning compound shall have no adverse effect on the health of personnel or the environment when used for its intended purpose and with proper personal protective equipment (when required). The product shall be evaluated for aquatic toxicity with a 96 hour Fathead minnow (pimephales promelas) bioassay and a 48 hour Ceriodaphnia dubia bioassay in accordance with Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, EPA/600/4-90/027. The percent survival at 1, 10, 50, and 100 ppm must be reported for both organisms.

3.3.1 Formulation. The manufacturer must submit to the qualifying activity, SA-ALC/SFTT, 1014 Andrews Rd STE 1, Kelly AFB TX 78241-5603, a complete formulation including the chemical name, CAS number, and weight percent of each ingredient. Trade names alone are not satisfactory. All proprietary information shall be protected as such.

3.3.1.1 Type I. The manufacturer shall submit to the qualifying activity the chemical name of each terpene used in the formulation including its CAS number and range of values in percent by weight of the formulation. The manufacturer shall also submit test procedures used to verify the terpene percentages within these ranges. All procedures shall be subject to approval by the qualifying activity.

3.3.2 Material safety data sheet. The manufacturer shall submit to the qualifying activity, and to the procuring activity a material safety data sheet (MSDS) for the finished product and for each component in the finished product. The MSDS shall be prepared in accordance with the latest revision of FED-STD-313.

3.3.3 Toxicological data. The manufacturer shall submit to the qualifying activity a copy of pertinent toxicological data/information (see para 4.7) for their product.

3.3.4 Biodegradability. The supplier of the cleaning compound shall furnish certification from the surfactant manufacturers that the surfactants are readily biodegradable in accordance with 40 CFR, Part 796, Subpart D. Biodegradability testing shall be accomplished as specified in paragraph 4.6.22 on the finished product. Biodegradability on the finished product shall be determined over 28 days by the Shake Flask Method monitored by analysis of Total Organic Carbon (TOC). The Type I compound shall meet the requirement of a minimum of 75% biodegradable and the Type II, Type III, and Type IV compound shall meet the requirement of a minimum of 85% biodegradable at the end of the 28 day period.

3.4 Compositional assurance. The cleaning compound shall be tested for nonvolatile matter as specified in paragraph 4.6.1. The concentrated cleaning compound and a 10% solution of the cleaning compound in distilled water shall be tested for pH as specified in paragraph 4.6.3. Results of these tests as well as an infrared spectrogram of the nonvolatile matter (See 4.9.2) and a gas chromatogram (See 4.9.1 for Type I only) shall be recorded by the qualifying activity for use in quality conformance inspections (see 4.4). Quality conformance inspection results for nonvolatile matter shall not differ by more than 2 percent absolute from the recorded value. Quality conformance inspection results for pH shall not differ by more than 1 pH unit from the recorded value. Quality conformance inspection infrared spectrograms and gas chromatograms shall show no significant difference when compared to the original qualifying spectrogram.

3.5 Chemical properties.

3.5.1 Chemical requirements. The cleaning compound shall meet the requirements listed in Table I.

3.5.2 Residue rinsibility. When a freshly prepared solution of the cleaning compound is tested in accordance with 4.6.4, it shall not leave any residue or stains. A freshly prepared solution is defined as one being prepared no longer than 30 minutes prior to testing. Weight change shall be no greater than that obtained with standard hard water tested under the same conditions.

3.6 Physical properties (Types I, II, III, and IV unless otherwise noted).

3.6.1 Heat stability (Types II, III, and IV only). The concentrated cleaning compound, when tested in accordance with 4.6.5, shall show no marked color change or precipitation and shall not corrode or stain the MIL-S-7952 (1020) steel strip (a slight darkening of the steel strip shall not be objectionable). Layering or separation will constitute failure if it does not return to its original homogeneous state upon cooling.

3.6.2 Cold stability. The concentrated cleaning compound shall return to its original homogeneous condition when tested in accordance with 4.6.6.

3.6.3 Rheology (Type III only)

3.6.3.1 Consistency . When tested as specified in 4.6.24, the concentrated cleaning compound shall flow between 10 and 20 centimeters in 10 seconds. The product shall also exhibit rheology which enables it to meet the sprayability requirement.

3.6.3.2 Sprayability. The concentrated cleaning compound, when dispensed at 45 psig and tested in accordance with 4.6.25, shall give satisfactory spray characteristics and deposit a uniform layer on a vertical surface 3 feet away from the nozzle. (See 4.6.25).

TABLE I. Quantitative Requirements

REQUIREMENT	TYPE I		TYPE II		TYPE III		TYPE IV		TEST METHOD
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
Insoluble Matter (WT%)	---	0.05	---	0.05	---	0.05	---	0.05	4.6.2
Flash Point (°F)									
10% Solution	200	---	---	---	---	---	--	---	4.6.7
Concentrated Solution	120	---	None 1/	---	None 1/	---	None 1/	---	
Emulsion Characteristics (ml free water)									
5 min	---	5.0	---	5.0	---	5.0	---	5.0	4.6.8
8 hours	13.0	---	---	---	---	---	---	---	4.6.8
24 hours	---	---	13.0	---	8.0	---	11.0	---	4.6.8
% Cleaning Efficiency	95	---	40	---	65	---	90	---	4.6.21
Terpene Hydrocarbons (% WT)	25	40	---	---	---	---	---	---	4.6.23

1/ No flash point should be observed up to the boiling point of the compound.

3.7 Effect on metals (Types I, II, III, and IV unless otherwise noted).

3.7.1 Hydrogen embrittlement. When tested in accordance with 4.6.9, the concentrated cleaner (Types I, II, III, and IV) and a 10% solution of the cleaner (Types I, II and IV only) in distilled water shall not cause hydrogen embrittlement of cadmium plated AISI 4340 steel.

3.7.2 Total immersion corrosion. When tested in accordance with 4.6.10 (ASTM F 483), the concentrated cleaning compound (all types) and a 10% solution of the cleaning compound (Types I, II, and IV only) in distilled water shall not show any indication of staining, etching, pitting, or localized attack on any of the panels, or cause a weight change of an average of three (3) test panels greater than that shown in Table II. A slight discoloration of the panels shall not be objectionable. The cleaning compound shall not layer or separate for the duration of the test.

3.7.3 Low-embrittling cadmium plate corrosion. Steel panels coated with low-embrittling cadmium plate immersed in the concentrated cleaning compound (all types) and a 10% solution of the cleaning compound (Types I, II and IV only) in distilled water shall not show a weight change greater than 0.14 mg/cm^2 for 24 hours when tested in accordance with 4.6.11.

3.7.4 Effects on unpainted metal surfaces. The concentrated cleaning compound (Type III only) and a 10% solution (Types I, II, and IV only) of the cleaning compound in distilled water shall not cause streaking, stains or other deposits that cannot be easily removed with water when tested in accordance with 4.6.12.

3.7.5 Sandwich corrosion. When tested in accordance with 4.6.16, the concentrated cleaner (all types) and a 10% solution (Types I, II, and IV only) shall not cause a corrosion rating greater than two (2) on any test panel.

3.8 Effect on painted surfaces. The concentrated cleaning compound (Type III only) and a 25% solution (Types I, II, and IV only) of the cleaning compound in distilled water shall not cause streaking, blistering, discoloration or a permanent decrease in film hardness of more than one (1) pencil hardness level when tested in accordance with 4.6.13. The Type I material shall be tested using only the (F) Enamel Semigloss and (P) Polyurethane Paint Systems.

3.9 Stress crazing of MIL-P-5425 and MIL-P-25690 (Type A and C) acrylic plastics. The concentrated product (Type III only) and a 10% solution (Types I, II, and IV) in distilled water shall not cause stress crazing or staining of acrylic plastics when tested in accordance with 4.6.14.

3.10 Stress crazing of polycarbonate plastic. The concentrated product (Type III only) and a 10% solution (Types I, II, and IV) in distilled water shall not cause stress crazing or staining of polycarbonate plastic conforming to MIL-P-83310 when tested in accordance with 4.6.15.

3.11 Long-term storage stability. After being stored for a period of 12 months, in accordance with 4.6.17, the cleaning compound shall not have corroded the shipping container and shall meet the requirements of paragraphs 3.5.1, 3.7.1, 3.7.2, 3.15, and 3.16 of this specification.

3.12 Hot Dip Galvanizing Corrosion. Steel panels conforming to MIL-S-7952, Grade 1020, Hot Dip Galvanized per ASTM A 153, immersed in the concentrated product (Type III only) and a 10% solution of the cleaning compound (Types I, II and IV) in distilled water shall not show a weight change of an average of three (3) test panels greater than 0.14 mg/cm^2 for 24 hrs when tested in accordance with 4.6.18.

3.13 Workmanship. The cleaning compound shall be a liquid having a uniform and homogenous appearance. The cleaning compound shall be manufactured from materials entirely suitable for the purpose intended and shall be processed in a manner that will produce a product harmless to metal surfaces and humans when used as directed.

3.14 Effect on polysulfide sealants. The concentrated cleaning compound (Type III only) and a 25% solution (Type I, Type II, and Type IV only) of the cleaning compound in distilled water shall not change the durometer hardness of the polysulfide sealant by more than 5 units when tested in accordance with 4.6.19.

3.15 Rubber compatibility. The concentrated cleaning compound (Type III only) and a 25% solution (Types I, II, and IV only) of the cleaning compound in distilled water shall not change the durometer hardness more than 5 units when tested in accordance with 4.6.20.

3.16 Effect on polyimide insulated wire. The cleaning compound, when tested according to 4.6.26, shall not cause dissolution, cracking, or dielectric breakdown (leakage) of the polyimide insulated wire in excess of that produced by distilled water.

TABLE II. Total Immersion Corrosion Requirements

Alloy	Average of 3 Panels Weight Loss, Max (mg/cm^2/168 hrs)
Magnesium (AZ 31B-H24) AMS 4377 surface treated in accordance with Type III of MIL-M-3171	0.70
Aluminum, QQ-A-250/4, T3 surface treated in accordance with Type I, Class I of MIL-A-8625	0.49
Aluminum, QQ-A-250/4, Bare T3 Alloy	0.49
Aluminum, QQ-A-250/12, Bare T6 Alloy	0.49
Titanium, MIL-T-9046, 6AL-4V Class III, Composition C	0.35
Steel, MIL-S-7952, Grade 1020	1.40
Aluminum-Lithium, AA 2090-T-83	0.21
Steel, 410 SS, Silver Plated QQ-S-365, Type II, Grade B.	0.14

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification when such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.2 Classification of tests. The inspection and testing of the cleaning compound shall be as follows. The inspection terms used herein are as defined in MIL-STD-109.

a. Qualification inspection (4.3).

b. Quality conformance inspection (4.4).

4.3 Qualification inspection. Qualification inspection shall consist of all inspections and tests specified herein.

4.3.1 Qualification samples. The initial qualification samples shall consist of 8 liters (2 gallons) of the cleaning compound. The cleaning compound shall be furnished in containers of the type to be used in filling contract orders. Samples shall be identified as follows and forwarded to the activity responsible for testing, as designated in the letter of authorization from the activity responsible for qualification (See 6.4):

- Samples for Qualification Tests.
- Cleaning Compound, Aerospace Equipment, (Types I, II, III, and IV).
- MIL-C-87937B.
- (Manufacturers Product and Code Number)
- (Name and Address of Contractor)
- Submitted by (Name), (Date) for Qualification Testing in Accordance with the Requirements of MIL-C-87937B Under Authorization (Reference Authority Letter).
- (Mixing and Other Important Instructions.)
- (Safety Information and Precautions.)

4.3.2 Test reports. In addition to the qualification test samples, the contractor shall furnish a certified test report showing that the material conforms to all the requirements of this specification with the exception of the storage stability test. Additionally, a certified statement shall be furnished to the qualifying activity that specifically identifies each ingredient including solvent, in the cleaning compound by a readily recognizable chemical name, CAS number, source and the percentage by weight contained in the compound. Trade names alone will not be considered satisfactory.

4.3.3 Qualification required. Prior to actual procurement, the cleaning compound shall pass the qualification inspections and requirements specified herein. If the product is later modified in any way, the modified form shall be subjected to and shall pass the same qualification inspections (see 3.1). Any changes or modifications from the formulation used at the initial qualification shall be approved by the qualifying activity and may require requalification. All qualifications will be granted contingent upon compliance with the long term storage stability requirement specified in paragraph 3.11.

4.4 Quality conformance tests. Quality conformance tests for acceptance of the cleaning compound shall consist of the following tests.

A. Workmanship
B. Cold Stability
C. Insoluble Matter
D. Consistency (Type III only)
E. Immersion Corrosion*
F. Emulsion Characteristics
G. Nonvolatile Matter
H. pH
I. Flash Point
J. Infrared Spectrogram (Types II, III, and IV)
K. Gas Chromatogram (Type I only)

*Immersion Corrosion Quality Conformance Test ran on Aluminum QQ-250/4, Bare T3 alloy panel only.

If during quality conformance testing a lot fails any of the above acceptance tests, all tests required for qualification will be reinstituted. These qualification tests will be required until two successive lots meet all requirements of the specification, after which quality conformance testing will again be authorized. (See paragraph 4.4.6)

4.4.1 Sampling. Unless otherwise specified, not less than a 3.8 liter (1 gal) container of the cleaning compound shall be selected at random from each lot and subjected to the tests specified in 4.4. The contents of each selected container for sampling shall be thoroughly mixed by rolling and inverting immediately prior to sampling.

4.4.2 Lot. A lot shall consist of one of the following:

a. The cleaning compound produced in not more than 24 consecutive hours from a continuous process which is used to fill shipping containers directly from the process output. A continuous process shall be the production of product by continuous input of raw materials and output of finished product by one manufacturer in one plant with no change in manufacturing conditions or materials.

b. The cleaning compound from individual runs of a batch process which is used to fill shipping containers directly from the process output. A batch process shall be the production of product by runs from single additions of raw materials which are mixed, reacted, and/or purified forming the product.

c. The cleaning compound from either or both the continuous and batch processes which is held in a single storage tank and subsequently withdrawn to fill shipping containers. The product will be homogeneous at the time of withdrawal and shall not be added to while being withdrawn. After each addition to the storage tank, the contents shall constitute a separate lot.

4.4.3 Sampling of product. Unless otherwise specified, quality conformance tests shall be made on the sample of product taken directly from the filled containers. The number of filled containers selected for sampling from each lot shall be in accordance with Table III. The first and last containers to be filled within a given lot shall be sampled. Other containers will be selected at random. The samples may be obtained in any convenient manner that does not compromise the integrity of the sample. The sampled containers shall be subjected to the inspections specified in 4.4.5.

TABLE III. Sampling for Tests

Number of Containers in lot	Number of Containers to be sampled
2 to 15	2
16 to 25	3
26 to 90	5
91 to 150	8
151 to 280	13
281 to 500	20
501 to 1200	32
1201 to 3200	50
3201 to 10000	80
10001 to 35000	125
35001 to 150000	200
150001 to 500000	315
500001 and over	500

4.4.4 Inspection of materials. The contractor is responsible for insuring that materials and components used are manufactured, tested and inspected in accordance with the requirements of referenced subsidiary specifications and standards to the extent specified, or, if none, in accordance with this specification. (See 2.3)

4.4.5 Inspection of the end item. Examination of the end item shall be made in accordance with the following classification of defects. The lot size, for purposes of determining the sample size in accordance with Table III, shall be expressed in units of filled primary containers for the examination specified in 4.4.5.1, and 4.4.5.2, and in units of shipping containers for the examinations specified in 4.4.5.3.

4.4.5.1 Examination for container defects. The end item containers shall be examined for defects in appearance, closure, construction, workmanship, and markings in accordance with Table IV.

4.4.5.2 Examination for net contents. The quality of the batch shall be unacceptable if the average net content is less than the specified or indicated quantity.

4.4.5.3 Examination of preparation for delivery. An examination shall be made to determine the packing, palletization, and markings comply with Section 5 and Table V.

4.4.6 Rejection and retest. When any sample of the product examined and tested in accordance with this specification fails to conform to the requirements specified herein, the entire lot represented by the sample shall be rejected. Rejected material shall not be resubmitted for acceptance without prior approval of the qualifying activity. The application for resubmission shall contain full particulars concerning previous rejections and all measures taken to correct those defects. Samples for retest shall be taken from previously unopened product containers.

TABLE IV. Examination for Container Defects

EXAMINATION	DEFECT
-Appearance, construction, and workmanship	Not in container specified, cracked, crushed, or any defect affecting serviceability. Not clean; evidence of dirt, rust, or foreign matter.
-Closure	Any leakage or seepage of contents in either an upright or horizontal position. Closure not as specified.
-Markings	Omitted, illegible, incorrect, or not in accordance with contract requirements.

TABLE V. Examination of Preparation for Delivery

EXAMINATION	DEFECT
-Packing	Container not as specified. Arrangement or number of unit containers per pallet (as applicable) not in accordance with contract requirements. Loose or inadequate strappings, bulged or distorted containers.
-Palletization	Palletization not in accordance with requirements.
-Markings	Data illegible, incorrect, incomplete or not in accordance with contract.

4.5 Testing standards. All laboratory tests shall be conducted at standard conditions unless otherwise specified herein. Standard conditions are defined by FED-STD-141, Section 9. Unless otherwise specified, all chemical tests shall be made with ACS specification reagent grade chemicals. Unless otherwise specified, all product dilutions will be made with distilled water which conforms to the requirements of ASTM D 1193, Type IV, reagent water. The term "concentrated" cleaner or compound refers to that concentration of the cleaner/compound as received from the manufacturer. No further dilution or concentration shall be performed on the product.

4.6 Test methods.

4.6.1 Nonvolatile matter. Weigh 5.00 ± 0.01 g of the sample in a porcelain or glass dish about 6 to 8 cm in diameter and about 2 to 4 cm in depth. Dry to constant weight in an air oven at a temperature of 105 ± 2°C. Constant weight is attained when successive heating for 1-hour periods shows a loss (or gain) of not more than 0.1%. Nonvolatile matter determinations shall be made on a minimum of two samples and the average shall be reported. If the two weights differ by more than 0.5% (absolute) the procedure shall be repeated. The nonvolatile content of the each sample shall be calculated as follows:

$$\%NVM = \left(\frac{A}{B} \right) X \ 100$$

Where: A = Weight of residue

B = Weight of sample

%NVM = Percent nonvolatile matter

4.6.2 Insoluble matter. The concentrated cleaning compound shall be thoroughly agitated and a 200 ml test sample withdrawn. The insoluble matter shall be collected with the aid of a vacuum filtering apparatus consisting of a water tap filter pump, a 2,000 ml Erlenmeyer flask, a size 4 (126 mm ID) Buchner funnel and a piece of 126 mm diameter Whatman No 5 filter paper, or equivalent. The filter paper shall be dried at 60°C (140°F) for 30 minutes in a gravity convection oven, cooled for 3 minutes in a desiccator, and weighed to the nearest 0.1 mg. The filter paper shall be placed in the Buchner funnel so that its circumference coincides with the circumference of the funnel. The vacuum shall be started and the filter paper wetted with approximately 10 ml of distilled water in order to secure it properly in place. The test sample shall be filtered. The sides of the beaker which contained the test sample shall be rinsed with 25 ml of distilled water from a wash bottle, and the rinse transferred to the funnel, insuring that any remaining insoluble matter is completely transferred with the rinse. When all the initial liquid and the rinse have been transferred through the filter, the sides of the funnel shall be washed with 25 ml of distilled water from a wash bottle and the rinse allowed to filter. The vacuum on the flask shall be relieved and the filter paper removed from the funnel. The filter paper shall be dried for 1 hour at 60°C (140°F) in a gravity convection oven, cooled for 3 minutes in a desiccator, and weighed to the nearest 0.1 mg. The percent insolubles shall be calculated as follows:

$$I = \left[\frac{A - B}{W} \right] X \ 100$$

Where: A = Final filter paper weight

B = Initial filter paper weight

W = Weight of sample

I = % wt Insoluble matter

Care should be exercised throughout the final drying and weighing cycle to maintain the flat surface of the filter paper in a horizontal position in order that none of the insoluble matter will be lost. Insoluble matter determinations shall be made on a minimum of two samples and the average shall be reported. If the two results differ by more than 0.5% (absolute) the procedure shall be repeated.

4.6.3 pH value. The pH value of the concentrated cleaning compound and a 10 percent solution of the cleaning compound in freshly boiled distilled water shall be measured in accordance with ASTM E 70.

4.6.4 Residue rinsibility. Six smooth aluminum dishes. containing no creases or crevices, shall be cleaned in a solution of Brite-Boy, (from 3D Inc., or equivalent), rinsed, and dried to constant weight. Ten ml of a 25% by volume solution of the cleaning compound in standard hard water (See 4.6.4.1) shall be placed in three of the precleaned dishes and tested according to the procedure in 4.6.4.2.

4.6.4.1 Preparation of standard hard water. A 20-grain (as $CaCO_3$) hard-water stock solution shall be prepared by dissolving 0.40 ± 0.005 g of reagent grade Calcium Acetate, $Ca(C_2H_3O_2)_2 \cdot 2H_2O$ and 0.28 ± 0.005 g of reagent grade Magnesium Sulfate, $MgSO_4 \cdot 7H_2O$, in 1 liter of boiled distilled water.

4.6.4.2 Procedure. Dry three dishes each containing 10.0 ml of a 25% cleaning solution for 7 1/2 hours in a circulating oven at 68 ± 2 °C with full draft. Cool in desiccator overnight and weigh. Rinse with running distilled water for 1 minute. Brush with a sash-type brush containing long-fiber bristles (2.5 cm diameter by 3.8 cm to 6.4 cm long) for 1 minute using distilled water. Rinse for 30 seconds with running distilled water. Dry in oven as before, cool and reweigh. Standard hard water (4.6.4.1) shall be tested as control for weight change comparison in the remaining three precleaned dishes, using the same procedure as above.

4.6.5 Heat stability. A 141.75 g sample of the well mixed concentrated cleaning compound shall be placed into each of two clean 255 ml (12 oz) clear glass bottles having approximate dimensions of 24 cm in height by 6.35 cm in diameter (9.5 in x 2.5 in). One bottle containing the concentrated cleaning compound shall be sealed with a screw type cap and stored in a dark place at standard conditions for 6 days (144 hrs) for reference purposes. Place into the second bottle of concentrated cleaning compound a strip of steel, 15.24 cm by 1.27 cm by 0.05 cm (6 in x 0.5 in x 0.02 in) conforming to MIL-S-7952. Clean the steel strip by abrasively polishing to remove surface scale and corrosion followed by immersion for one minute in P-D-680 followed by immersion for one minute in isopropyl alcohol (TT-I-735, grade A) at standard conditions. Seal the bottle containing the concentrated cleaning compound and the cleaned steel strip with a screw type cover and shake thoroughly for 1 minute. Place the bottle in a bath maintained at 46 ± 2 °C (115 ± 3 °F) for 5 hours, then remove and allow to cool to ambient conditions for 19 hours. This heating/cooling cycle will be repeated 5 times. After completion of the test period, remove the test strip and inspect the portion of the strip which was immersed in the cleaning compound and the portion exposed to the vapor. Any corrosion, pitting or discoloration constitutes failure. The bottle is resealed and along with the control bottle, that has been maintained in the dark, is shaken thoroughly for 1 minute, then allowed to remain undisturbed for 1 hour at room temperature. The bottles are then examined. Any marked change in color, precipitation, layering or separation constitutes failure.

4.6.6 Cold stability. A 50 ml sample of the cleaning compound shall be poured into a suitable test tube and cooled to 0°C. This temperature shall be maintained for one hour. The compound shall then be allowed to reach room temperature. After 5 (five) complete temperature inversion cycles of the test tube, the compound shall be examined for homogeneity. A slight turbidity shall not be objectionable provided no precipitation is present.

4.6.7 Flash point. The flash point of the concentrated cleaning compound (Type I, II, III, and IV) shall be determined in accordance with ASTM D 56 (Tag Closed Cup) and for materials that have a tendency to form a surface film under the test conditions, use ASTM D 93. The flash point of the 10% solution in distilled water (Type I only) shall be determined in accordance with ASTM D 92.

4.6.8 Emulsion characteristics. Twenty ml of a 25% by volume solution (Types I and II) of the cleaning compound (12.5% by volume solution for Types III and IV) shall be placed in a 50 ml glass stoppered graduated cylinder. Twenty ml of lubricating oil conforming to MIL-L-2104, grade 10W, shall be added. An emulsion shall be formed by 10 inversions of the graduated cylinder followed by a vigorous 15 second shake. After the emulsion has stood for 5 minutes, the 15 second shake shall be repeated. At 5 minutes and 8 hours for the Type I and at 5 minutes and 24 hours for the Types II, III and IV cleaner, the amount of free water and cleaner which separates from the lubricating oil shall conform to the requirements of Table I.

4.6.9 Hydrogen embrittlement. The hydrogen embrittlement properties of the cleaning compound shall be determined in accordance with ASTM F 519 using either Type 1a, 1b, or 1c, Treatment B AISI 4340 steel specimens.

4.6.10 Total immersion corrosion. The total immersion corrosion effects of the cleaning compound on the new, unused metals and metal alloys listed in Table II shall be determined in accordance with ASTM F 483. Conformance to the requirements in Table II shall be for weight loss after 168 hours. In order to obtain the best results on test panels in this very low weight category, the panels must be handled with gloves, cleaned in a very careful manner and dried in an oven. They are cooled and dried in a desiccator both before and after each weighing.

4.6.11 Low embrittling cadmium plate corrosion. The cleaning compound shall be evaluated for corrosion on low-embrittling cadmium plate in accordance with ASTM F 1111.

4.6.12 Effects on unpainted metal surfaces. The cleaning compound shall be evaluated for effects on unpainted metal surfaces in accordance with ASTM F 485.

4.6.13 Effect on painted surfaces. The concentrated cleaning compound (Type III only) and a 25% solution (Type I, II, and IV only) with distilled water shall be tested in accordance with ASTM F502 except that the panels used for testing shall be coated with the paint systems listed in Table VI. For all paint systems tested, a separate panel will be required for both 25% solution and concentrate. For Type II, Type III, and Type IV compound, conduct the test on all paint systems listed in Table VI. For Type I compound, conduct the test only on the enamel semigloss (F) and polyurethane (P) paint systems.

4.6.14 Stress crazing of MIL-P-5425 and MIL-P-25690 (type A and C) acrylic plastics. The cleaning compound shall be evaluated for stress crazing of stretch (Type A and C) acrylic plastics in accordance with ASTM F 484.

4.6.15 Stress crazing of polycarbonate plastic. The cleaning compound shall be evaluated for stress crazing of polycarbonate plastics using the test procedure outlined in ASTM F 484 with the exception that the acrylic plastics called for in the procedure be replaced with polycarbonate plastic conforming to MIL-P-83310 of the same dimensions and the polycarbonate specimens shall be stressed for 30 ± 2 minutes to an outer fiber stress of 2000 psi.

4.6.16 Sandwich corrosion. The cleaning compound shall be tested in accordance with ASTM F 1110 except that non-conformance shall be determined by the requirements specified in paragraph 3.7.5.

4.6.17 Long term storage stability. The cleaning compound shall be prepared and stored for long term storage stability in accordance with ASTM F 1104 using two (2) 3.8 liter (one-gallon) DOT Specification cans conforming to PPP-P-704; or the non-metallic specification DOT 34-1 (or the polyethylene UN 1H1 plastic container which may be substituted for the DOT 34-1). Manufacturers using both types material in production packaging shall test each type container with their product.

4.6.18 Hot Dip Galvanizing Corrosion. The total immersion corrosion effect of the concentrated product (Type III only) and a 10% solution of (Types I, II and IV) cleaning compound and distilled water on Steel, MIL-S-7952, Grade 1020, Hot Dip Galvanized per ASTM A 153 shall be evaluated per ASTM F 483.

4.6.19 Effects on polysulfide sealant.

4.6.19.1 Preparation of test specimens. MIL-S-81733, Type I, and MIL-S-8802, Type I, sealants shall be mixed as specified by their respective manufacturers and each pressed into a 1/8 inch thick sheet mold until cured (this will be the sheet stock for each sealant). The sealants will be cured for 7 days at 49°C. The specimens shall be cut from the sheet stock.

4.6.19.2 Test procedures. Immerse two specimens of each sealant in the concentrated product (Type III only) and a 25% solution of the cleaning compound (Types I, II, and IV) at room temperature for 30 minutes. Remove from the solution, rinse with cool tap water, and test within 30 minutes for Shore A hardness in accordance with ASTM D 2240.

4.6.20 Test on rubber compatibility. Tests will be conducted on AMS 3204 and AMS 3209 rubbers for compatibility with the cleaning compounds.

4.6.20.1 Preparation of test specimens. Three (3) test specimens will be used for each type rubber specified. Test specimens shall be cut from 1/8 inch sheet stock.

4.6.20.2 Test procedure. Test and record the Shore A hardness of each test specimen in accordance with ASTM D 2240. Immerse each specimen in the concentrated product (Type III only) and a 25% solution of the cleaning compound (Types I, II, and IV) at room temperature for 30 minutes. Remove from the solution, rinse with cool tap water, and test within 30 minutes for a Shore A hardness in accordance with ASTM D 2240.

4.6.21 Cleaning efficiency (all Types). The cleaning efficiency of the cleaning compound shall be reported as the average of three test results and shall conform to the Quantitative Requirements of Table I.

4.6.21.1 Preparation of control formula. The control formula shall be prepared by the testing laboratory in accordance with Table VII and subjected to the cleaning test (4.6.21.5) and evaluation (4.6.21.6). Valid control formula preparations shall produce denominator values greater than 0.95 during testing.

4.6.21.2 Panel preparation. Bare aluminum alloy panels 40.6 x 12.7 x 0.05 cm (16 x 5 x .02 in) shall be used.

4.6.21.3 Soil preparation. Molybdenum disulfide grease soil shall be prepared by blending 50 grams of carbon black and 500 grams MIL-G-21164 grease with a mechanical grease worker for 15 minutes.

TABLE VI. Test Panel Finishes

Primer Coatings				
Panel Set No.	Primer Material Specification	Dry Film Thickness Per Coat/ mm (inches)	No. of Coats	Drying Time Before Topcoating
L	MIL-C-8514, Coating Compound Metal Pretreatment Resin-Acid (First Coat)	0.0051 - 0.0102 (0.0002 - 0.0004)	1	2 - 8 hours
	MIL-P-7962, Lacquer Primer (Second Coat)	0.0076 - 0.0127 (0.0003 - 0.0005)	1	2 - 8 hours
FEPH	MIL-P-23377, Primer, Coating Epoxy-Polyamide	0.0178 - 0.0229 (0.0007 - 0.0009)	1	2 - 8 hours

Top Coats, Color Number 17925 per FED-STD-595						
Panel Set	Topcoat Material	Dry Film Thickness Per Coat/ mm (inches)	No. of Coats	Drying Time Between Coats	Dry Film Thickness mm (inches)	Days to Dry Before Testing
L	TT-L-32 Lacquer, Acrylic Gloss	0.0102 - 0.0127 (0.0004 - 0.0005)	2	1 hour	0.0203 - 0.0254 (0.0008 - 0.0010)	7
E	MIL-C-22750 Coating, Epoxy Topcoat	0.0102 - 0.0127 (0.0004 - 0.0005)	2	1 hour	0.0203 - 0.0254 (0.0008 - 0.0010)	7
P	MIL-C-83286 Polyurethane	0.0203 - 0.0305 (0.0008 - 0.0012)	2	1 hour	0.0457 - 0.0610 (0.0018 - 0.0024)	7
H	MIL-C-85285	same as P				
F	TT-E-529 Enamel Semigloss	0.0203 - 0.0305 (0.0008 - 0.0012)	2	1 hour	0.0457 - 0.0610 (0.0018 - 0.0024)	7
D	MIL-P-23236 Paint Coating Requires No Primer	0.0457 - 0.0610 (0.0018 - 0.0024)	1			7

4.6.21.4 Application of grease soil. Panels shall be wiped with clean tissue soaked in reagent grade acetone then dried to a constant weight. Record the weight to the nearest 0.1 mg. Apply approximately 200 mg grease soil using a soft bristle brush over an area approximately 2" x 7" in the center of the panel. Remove excess grease soil by covering the test panel with a folded absorbent tissue and exerting pressure by rolling a five pound rubber cylinder over the tissue. Repeat this blotting procedure twice. Each freshly soiled panel shall be baked at 105 ± 5 °C for 60 minutes then cooled to room temperature and weighed to the nearest 0.1 mg. Only use panels with more than 50 mg of grease soil. Panels shall be used within 4 hours.

TABLE VII. Control Formula for the Cleaning Efficiency Test

Component	Control Formula Composition (% by weight) 1/
d-limonene	30.0
diethanolamine	5.0
nonionic surfactant (Triton X-100)	5.0
distilled water (ASTM D 1193, type IV)	60.0

1/. This formulation is corrosive and intended solely for use as the control for the cleaning efficiency test. It will not qualify to the requirements in this specification.

4.6.21.5 Cleaning test. The test panels shall be cleaned using a Gardner heavy duty wear tester, or equivalent, fitted with a cellulose sponge. The sponge shall be cut such that the dimension parallel to the cleaning stroke is 9 cm (3.5 in) and the width is 7 cm (2.75 in). The cleaning head with the dry sponge attached shall be weighed to a mass of 495 to 505 grams. The cleaning stroke of the scrub tester shall be 12 inches. The cleaning compound (including Type III) and the control formula shall be diluted 1 part cleaner with 9 parts distilled water. After placing a soiled test panel in the template 100 ml of the cleaning solution shall be applied to the sponge then applied to the soiled test panel so that it is completely covered. After allowing a 30 seconds dwell time, the test panel shall be cleaned using 5 cycles of the wear tester. The panel shall then be adequately rinsed with sufficient amounts of distilled water.

4.6.21.6 Evaluation. The rinsed panel shall be heated to 105°C ± 5°C for 10 minutes, cooled to room temperature, then weigh to the nearest 0.1 mg. Report the % Cleaning Efficiency as the average of three (3) tests using the following:

$$\%\text{Cleaning Efficiency} = \frac{\left[\dfrac{A - B}{A - C}\right]}{\left[\dfrac{X - Y}{X - Z}\right]} \times 100$$

where: A = weight of the soiled panel before cleaning with product
B = weight of the soiled panel after cleaning with product
C = weight of the unsoiled panel used in the product cleaning test
X = weight of the soiled panel before cleaning with the control formula
Y = weight of the soiled panel after cleaning with the control formula
Z = weight of the unsoiled panel used in the control formula cleaning test

4.6.22 Biodegradability. Biodegradation will be determined by the "Shake Flask Biodegradation Tests" for measuring ultimate or ready degradation potential, as found in EPA Chemical Fate Test Guidelines 40 CFR Method 796.3100 (Aerobic Aquatic Biodegradation Test) or 40 CFR Method 796.3240 (OECD Screening Test for Ready Biodegradability). Biodegradability will be shown as carbon transformation by both soluble organic carbon reduction and CO_2 evolution.

4.6.23 Terpenes hydrocarbons (Type I only). An approved test procedure shall be used. See 3.3.1.1.

4.6.24 Consistency (Type III only). A consistometer (Central Scientific Company, Chicago, IL; Catalog No. 24925 or equivalent) shall be used as follows: Shake the container of cleaning compound by hand for 10 seconds. Pour the material into the well of the consistometer completely filling it. Release the gate and determine the extent of flow in ten seconds.

4.6.25 Sprayability (Type III only). Fill the reservoir of the application test equipment with Type III compound, as supplied. Release the compound flow valve and gradually increase the nozzle tip pressure to not more than 8 psi pressure , observing the discharge spray characteristics. Report the following:

a. The maximum pressure at which no bubbles are released into the surrounding air.

b. The distance the gel can be satisfactorily projected.

4.6.25.1 Technique: Under these optimized conditions apply with a sideways sweeping motion the compound to a vertical surface and examine the deposited film and record assessment. The product should display uniformity with absence of large and entrained air bubbles or a consistency which would not inhibit effective cleaning.

4.6.25.2 Application test equipment.

a. Reservoir: Hand pump pressure sprayer (modified), or pressure pot with air pressure applied from external compressor.

b. Nozzle: Fan jet with an equivalent orifice diameter 1.1 mm and spray angle 65°C. (Spraying Systems Co., Wheaton Illinois, Item Number H-VV 6503)

4.6.26 Effect on polyimide insulated wire. Coil two segments of MIL-W-81381/11-20 wire approximately 61 cm (24 in) and place into separate 118 ml (4 oz) wide mouth jars. To one jar add sufficient concentrate cleaning compound to completely cover the wire coil. To the other jar (control sample) add sufficient distilled water to cover the wire coil. Cap both jars and store at room temperature (20 - 25 °C) for 14 days. At the end of the storage period remove both coils, rinse thoroughly with distilled water and suspend to allow complete draining and drying. Uncoil the wires, examine each closely for dissolution, and report the results. The wire immersed in the cleaner shall perform as well as the wire immersed in distilled water. Both wires shall then be subjected to a double reverse wrap on a 0.3 cm (0.125 in) mandrel and examined for cracking. (Note: Failure of the control sample here voids the test and must be repeated using new MIL-W-81381/11-20 material). Wire immersed in the cleaner shall then be examined for cracking. If cracking occurs results shall be reported and the test ended. Passing wire shall then withstand a one minute dielectric test of 2,500 volts (rms). using a Hypot model number 4045 or equivalent, and examined for breakdown and/or leakage. Wire immersed in the cleaner shall perform equally well as the control wire immersed in distilled water.

4.7 Toxicity and waste disposal characteristics. The supplier shall furnish the toxicological data or formulations required (See 3.3) to evaluate the safety of the material proposed for use. The manufacturer will provide current procedures for disposal per federal EPA regulations. The supplier shall also furnish certification of the percent activity and percent biodegradability of the cleaner. The data will be forwarded to SA-ALC/SFTT 1014 Andrews Rd STE 1, Kelly AFB TX 78241-5603.

4.8 Filler materials. The contractor shall furnish certification that the cleaning compound contains only the materials allowed and does not contain any filler materials disallowed per paragraph 3.2.

4.9 Qualitative Identification of Components (Types I, II, III, and IV).

4.9.1 Gas Chromatogram (Type I only). A gas chromatogram of the Type I product shall be provided by the Government approved qualification laboratory (See 3.4). The chromatogram shall report all salient instrumental parameters (column type and dimensions, temperature(s), carrier gas and flow rate, detector type, sample dilution(s), etc.) required to produce it.

4.9.2 Infrared spectrogram. (Types II, III, and IV). Infrared spectrograms of the nonvolatile matter shall be prepared by the Government approved qualification laboratory (See 3.4). The spectrogram, including method for sample preparation, shall be provided to the qualifying activity by the qualification laboratory.

5. PACKAGING

5.1 Packing. Packing shall be Level A, or Industrial for required net fill, as specified.

5.1.1 Level A. The cleaning compound shall be furnished in following packages which shall, as a minimum, meet the specifications of 49 CFR Parts 100 - 190:

5.1.1.1 55 Gallon Drums. The cleaning compound shall be available in 208 liter (55 gallon) Specification DOT 17E drums conforming to PPP-D-729, Type II, or UN 1A1 drums qualified to the Packing Group II level and which meet the minimum specifications for a Type II drum in accordance wiht PPP-D-729.

5.1.1.2 5 Gallon Containers. The cleaning compound shall be available in 18.9 liter (5 gallon) DOT Specification metal containers conforming to PPP-P-704, Type I, Class 4, or non-metallic Specification DOT 34-5 (or the 18.9 liter capacity UN 1H1 polyethylene container which may be subsituted for the DOT 34-5).

5.1.2 Industrial. The cleaning compound shall be packed in accordance with ASTM D 3951. Containers shall be in accordance with Uniform Freight Classification rules or regulations of other carriers applicable to the mode of transportation.

5.1.3 Compatibility of materials. The container, closure, lining, or sealing compound shall not interact physically or chemically with the contents so as to corrode, be altered, or to alter the strength, quality or purity of the contents.

5.2 Palletization. When specified, the cleaning compound, shall be palletized in accordance with Load Type III (strapped) of MIL-STD-147 except that for overseas shipment the overall height of the load shall not exceed 109.2 cm (43 inches).

5.3 Marking. Containers shall be marked in accordance with MIL-STD-129 and 49 CFR. For international shipments, containers shall also be marked in accordance with ICAO, IATA, and IMO as applicable for mode of transportation. The shipment marking nomenclature for Type I, Type II and Type IV shall be:

CLEANING COMPOUND, AEROSPACE EQUIPMENT, TYPES (I, II, OR IV)

DIP TANK IMMERSION METHOD:

Dilute the concentrate with a minimum of two parts water unless otherwise specified in Technical Order (TO). Normal dilution ratios are 1:4 for heavy soils, 1:10 for light soils.

EXTERIOR CLEANING METHOD:

Aircraft : Dilute the concentrate 1:10 to 1:20 with water depending on the amount of soil to be removed. For spot cleaning, dilute the concentrate with 4 to 10 parts water depending on the amount of soil to be removed. After cleaning, rinse off with water. Ensure engines are properly blocked and sealed to preclude contact with internal jet engine components. Not recommended for cleaning canopies.

Aerospace Ground Equipment (AGE): Dilute the concentrate 1:10 to 1:20 with water depending on the amount of soil to be removed. For spot cleaning, dilute the concentrate with 4 to 10 parts water depending on the amount of soil to be removed. After cleaning, rinse off with water.

Motor Vehicle Engines: Dilute the concentrate with 3 to 10 parts water depending on the amount of soil to be removed. After cleaning, rinse off with water. Not recommended as a spot cleaner for engines.

The shipment marking nomenclature for Type III shall be:

CLEANING COMPOUND, AEROSPACE EQUIPMENT, TYPE III, GEL TYPE DEGREASER

Directions: Apply full strength with brush or pump spray. Allow 5 to 15 minutes dwell time. Brush, if necessary, then spray with fresh water to rinse. Brush then rinse again to completely remove the cleaner.

5.3.1 Storage temperature. The markings on the container shall include a caution statement stating the temperature range within which the product can be stored without compromising the performance of the product.

5.4 Material safety data sheet. Contractor shall comply with the requirements of the latest revision of FED-STD-313.

5.5 Hazardous material warning labels. A hazardous warning label shall be developed in accordance with the requirements of the OSHA Hazardous Communication Standard (29 CFR 1910.1200) and MIL-STD-129.

6. NOTES

6.1 Intended use. The four types of cleaning compound covered by this specification are intended to be used for cleaning Aerospace Equipment including aircraft, aerospace ground equipment (AGE) and AGE engines. The cleaners shall be used in place of other cleaners when approved by the System Program Manager of the equipment being cleaned. Type I should be used only on polyurethane and enamel coatings as it may attack acrylic nitrocellulose lacquer coatings found in numerous aircraft. Type I and IV materials are intended for light to heavy duty removal of greases, oils, hydraulic fluid, and carbon. Type II is intended for light to medium cleaning and is not intended to remove heavy soils. Type III is intended for light to heavy duty removal of greases, oils, hydraulic fluid, and carbon in wheel wells, wing butts and other areas where complete rinsing with water can be tolerated. After cleaning, rinse off with water. These cleaners are not intended to be used as canopy cleaners.

6.2 Material safety data sheets. Contracting officers will identify those activities requiring copies of completed Material Safety Data Sheets prepared in accordance with FED-STD-313. The pertinent Government mailing addresses for submission of data are listed in FED-STD-313.

6.3 Ordering data. Procurement documents should specify the following:

a. Title, number and date of this specification.
b. Type I, Type II, Type III or Type IV.
c. Size containers required.
d. QPL reference or test number.
e. Level of packing required.
f. Palletization, when applicable.

6.4 Qualification. With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in the applicable Qualified Products List whether or not such products have actually been so listed by that date. The attention of the contractors is called to this requirement, and contractors are urged to arrange to have their products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the Qualified Products List is San Antonio Air Logistics Center, Attention SFTT, 1014 Andrews Rd Suite 1, Kelly AFB TX 78241-5603; and information pertaining to qualification of products may be obtained from that activity (See 4.3.1).

6.5 Key words.

AGE

Biodegradable

Gel-type

QPL

Terpenes

CUSTODIANS:
Air Force - 68

REVIEW ACTIVITIES:
Air Force - 11
Navy - AS
DLA - GS

PREPARING ACTIVITY:
Air Force - 68

PROJECT NO. 6850-1121

METRIC

NOTICE OF VALIDATION

MIL-G-21164D
NOTICE 1
24 October 1991

MILITARY SPECIFICATION

GREASE, MOLYBDENUM DISULFIDE, FOR LOW AND HIGH TEMPERATURES, NATO CODE NUMBER G-353

MIL-G-21164D, dated 8 December 1981, has been reviewed and determined to be valid for use in acquisition.

Custodians:
Army – ME
Navy – AS
Air Force – 11

Preparing activity:
Navy – AS

AMSC N/A

FSC 9150

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

H-07-71

MIL-G-21164D
8 December 1981
SUPERSEDING
MIL-G-21164C
17 July 1968

MILITARY SPECIFICATION

GREASE, MOLYBDENUM DISULFIDE, FOR LOW AND HIGH TEMPERATURES, NATO CODE NUMBER G-353

This specification is approved for use by the Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the requirements for one grade of low and high temperature molybdenum disulfide grease for use as a lubricant on heavily loaded sliding steel surfaces. This grease is identified by NATO Symbol G-353 Military Symbol GMD.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this specification to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-M-7866 - Molybdenum Disulfide, Technical, Lubricant Grade.

STANDARDS

FEDERAL

FED-STD-313 - Material Safety Data Sheets Preparation and the Submission of.

FED-STD-791 - Lubricants, Liquid Fuels and Related Products, Methods of Testing.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Engineering Specifications and Standards Department (Code 93), Naval Air Engineering Center, Lakehurst, NJ 08733, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FSC 9150

M

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.

MIL-STD-290 - Packaging, Packing and Marking of Petroleum and Related Products.

(Copies of specifications, standards, handbooks, drawings, and publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 217 - Cone Penetration of Lubricating Grease.

ASTM D 942 - Oxidation Stability of Lubricating Greases by the Oxygen Bomb Method.

ASTM D 1264 - Water Washout Characteristics of Lubricating Greases.

ASTM D 1478 - Low-Temperature Torque of Ball Bearing Greases.

ASTM D 1743 - Corrosion Preventive Properties of Lubricating Greases.

ASTM D 2265 - Dropping Point of Lubricating Grease Over Wide Temperature Range.

ASTM D 2595 - Evaporation Loss of Lubricating Greases Over Wide Temperature Range.

ASTM D 2596 - Extreme-Pressure Properties of Lubricating Grease (Four-Ball Method), Measurement of.

ASTM D 3336 - Performance Characteristics of Lubricating Greases in Ball Bearings at Elevated Temperatures.

ASTM D 4048 - Detection of Copper Corrosion from Lubricating Grease by the Copper Strip Tarnish Test.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 Qualification. The molybdenum disulfide grease furnished under this specification shall be products which are qualified for listing on the applicable qualified products list at the time set for opening of bids (see 4.3 and 6.3).

3.2 First article. When specified (see 6.2.1), a sample shall be subjected to first article inspection (see 4.4 and 6.4).

3.3 Materials. The composition of the grease is not limited, except that it shall contain a diester liquid lubricant with a suitable gelling agent and molybdenum disulfide conforming to MIL-M-7866, (see 4.7.2).

3.4 Physical properties. The finished grease shall conform to the requirements specified in table I when tested in accordance with 4.7.2.

3.5 Chemical properties.

3.5.1 Molybdenum disulfide content. The grease shall contain not less than 4.5 percent and not more than 5.5 percent molybdenum disulfide when tested in accordance with 4.7.2.

3.6 Toxicity. The grease shall have no adverse effect on the health of personnel when used for its intended purpose. The grease shall contain no components which produce noxious vapors in such concentrations as to be an annoyance to personnel during formulation or use under conditions of adequate ventilation while exercising caution to avoid prolonged contact with the skin and while observing Occupational Safety and Health Administration (OSHA) guidelines. Questions pertaining to the toxic effects shall be referred by the contracting activity to the appropriate departmental medical service who will act as an advisor to the contracting agency (see 4.3.2).

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see 4.3).

b. First article inspection (see 4.4).

c. Quality conformance inspection (see 4.5).

4.3 Qualification inspection.

4.3.1 Qualification inspection sample. The qualification inspection sample shall consist of 10 pounds of grease. The sample shall be forwarded to the Aircraft and Crew Systems Technology Directorate, Code 60612, Naval Air Development Center, Warminster, PA 18974. The sample shall be plainly identified by a securely attached durable tag or label marked with the following information:

Sample for qualification inspection.
Grease, Molybdenum Disulfide, for Low and High Temperatures.
Name of manufacturer.
Product code number.
Batch number.
Date of manufacture.
Submitted by (name) (date) for qualification inspection in accordance with MIL-G-21164D under authorization of (reference authorizing letter) (see 6.3).

4.3.2 Test reports. Two copies of the manufacturer's test report, containing complete test data showing that material submitted for qualification conforms to the requirements of this specification, shall be submitted with qualification sample. Location and identity of the plant which produced the sample tested shall also be supplied. Material safety data sheets on toxicity shall be prepared and submitted to the qualifying laboratory (see 4.3.1) in accordance with FED-STD-313 (see 3.6).

4.3.3 Retention of qualification. In order to retain qualification of a product approved for listing on the Qualified Products List (QPL), the manufacturer shall verify by certification to the qualifying activity, that the manufacturer's product complies with the requirements of this specification. The time of periodic verification by certification shall be in two-year intervals from the date of original qualification. The Government reserves the right to re-examine the qualified product whenever deemed necessary to determine that the product continues to meet any or all of the specification requirements.

4.3.4 Qualification inspection tests. Qualification inspection tests shall be as specified in 4.7.2.

4.4 First article inspection. The manufacturer shall submit to the qualifying laboratory (see 4.3.1) a 10 pound sample of grease taken from the first production lot of grease processed under the first contract or order. After the product has passed the qualification inspection (see 6.3), the tests shall be limited to the requirements of 3.4 and 3.5 and the methods of 4.7.2. Delivery of the grease shall not be delayed pending completion of testing on the first article sample by the qualifying laboratory.

4.5 Quality conformance inspection. The quality conformance inspection of the grease samples from 4.5.2 shall consist of the examinations and tests specified in table II.

4.5.1 Lot formation. A lot shall consist of all the grease produced by one manufacturer, at one plant, from the same materials and under essentially the same conditions, provided the operation is continuous and does not exceed a 24 hour period. In the event the process is a batch operation, each batch shall constitute a lot (see 6.5).

4.5.2 Sampling.

4.5.2.1 For examination of filled containers. A random sample of filled containers, fully prepared for delivery, shall be selected from each lot of grease in accordance with MIL-STD-105, inspection level I and an acceptable quality level (AQL) of 2.5 percent defective.

4.5.2.2 For tests. The sample for tests shall consist of two 5 pound samples of grease taken at random from filled containers from each lot of grease. The lot shall be unacceptable if either sample fails to comply with any of the requirements for the tests specified in 4.7.2.

4.6 Test conditions. Test conditions shall be in accordance with 4.7 and the physical values specified in section 3 apply to the average of determinations made on the sample.

4.7 Methods of examinations and tests.

4.7.1 Examinations. Each of the filled containers, selected in accordance with 4.5.2.1, shall be examined for defects of the container and closure, for evidence of leakage and for unsatisfactory markings to determine conformance with 5.1. Each sample container shall also be weighed to determine the amount of contents. If the number of defective containers exceeds the acceptance number of the sampling plan specified in 4.5.2.1, the lot shall be rejected.

4.7.2 Tests. Tests shall be performed in accordance with table III to determine conformance with the requirements specified in 3.4 and 3.5.

5. PACKAGING

5.1 Packaging, packing and marking. The grease shall be packaged, packed and marked in accordance with MIL-STD-290. The type and size of the containers and the level of packaging and packing shall be as specified by the acquiring activity (see 6.2.1).

6. NOTES

6.1 Intended use. The grease covered by this specification is intended for use as a lubricant for accessory splines, heavily loaded sliding surfaces or for antifriction bearings carrying high loads and operating through wide temperature ranges where molybdenum disulfide will prevent or delay seizure in the event of inadequate lubrication. This grease should not be used for wheel bearings or for other than steel surfaces without prior performance evaluation.

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number and date of this specification.

b. Quantity desired.

c. Whether first article inspection is required (see 3.2 and 4.4).

d. Size and type of container for grease (see 5.1).

e. Applicable levels of packaging and packing and other options (see 5.1).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time set for opening of bids, qualified for inclusion in Qualified Products List (QPL-21164) whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. The activity responsible for the Qualified Products List is Commander, Naval Air Systems Command, Attn: AIR-5304, Washington, DC 20361; however, information pertaining to qualification of products and letter of authorization for submital of sample may be obtained from the Aircraft and Crew Systems Technology Directorate, Code 60612, Naval Air Development Center, Warminster, PA 18974.

6.4 First article. When a first article inspection is required, the item will be tested and should be a sample selected from the first production lot. The first article should consist of a 10 pound sample of grease. The contracting officer should include specific instructions for examinations, tests and approval of the first article.

6.5 Batch. A batch is defined as that quantity of material which has been manufactured by some unit chemical process and subjected to some physical mixing operation intended to make the final product substantially uniform.

6.6 International standardization agreements. Certain provisions of this specification (see 1.1) are the subject of international standardization agreement, ASCC Air Standard 15/1, NATO STANAG NAT-STD-1135. When amendment, revision, or cancellation of this specification is proposed, which will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels including departmental standardization offices to change the agreement or make other appropriate accomodations.

6.7 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:
Army - ME
Navy - AS
Air Force - 11

Preparing activity:
Navy - AS

(Project No. 9150-0602)

Review activities:
Army - AR, MI
Air Force - 85

International Interests:
NATO (see 6.6)

TABLE I. Physical properties.

Characteristics	Requirements
Penetration:	
Unworked, minimum	200
Worked	260 - 310
Dropping point, °C (°F), minimum	165 (329)
Bomb oxidation:	
Pressure drop, KPa (psi), maximum:	
in 100 hours	68.9 (10)
in 500 hours	103.4 (15)
Copper, corrosion:	
ASTM classification, maximum	1b 1/
Water resistance, percent grease loss at 40° ± 0.5°C (104° ± 1°F), maximum	20
Evaporation, percent weight loss in 22 hours at 100° ± 1°C (212° ± 2°F), maximum	2.0
Oil separation, percent weight loss in 30 hours, maximum	5
Low temperature torque, at -73°C (-100°F) Nm, maximum:	
Starting	0.98
Running after 1 hour	0.098
Extreme pressure properties load heat index, minimum	50
High temperature performance, hours at 121°C (250°F), minimum	1,000
Penetration after mechanical working 100,000 double strokes	260 - 375
Rust preventative properties	2/
Storage ability after 6 months at 40° ± 2°C (104° ± 4°F):	
Unworked penetration, minimum	200
Worked penetration, change in points from original, maximum	30

TABLE I. Physical properties. - Continued

1/ Should the strip appear to have a darker orange color then the ASTM standard strip 1b, consider the observed strip as still in ASTM classification 1b. If any evidence of red color is noticed, the observed strip belongs in ASTM classification 2.

2/ No pitting, etching, discoloration or corrosion in excess of three small spots.

TABLE II. Quality conformance tests.

Inspection	Paragraph	
	Requirement	Test method
Penetration	3.4	4.7.2
Dropping point	3.4	4.7.2
Copper corrosion	3.4	4.7.2
Evaporation	3.4	4.7.2
Oil separation	3.4	4.7.2
Low temperature torque	3.4	4.7.2
Extreme pressure properties	3.4	4.7.2
Penetration after mechanical working	3.4	4.7.2
Examination of filled containers	5.1	4.7.1

TABLE III. Methods of tests.

Tests	Method	
	FED-STD-791	ASTM
Dropping point	-	D 2265
Penetration	-	D 217
Bomb oxidation	-	D 942
Copper corrosion	-	D 4048
Water resistance	-	D 1264
Evaporation	-	D 2595
Oil separation	321	-
Low temperature torque 1/	-	D 1478
Extreme pressure properties	-	D 2596
High temperature performance	-	D 3336
Penetration after mechanical working	313	-
Rust preventive properties	-	D 1743
Molybdenum disulfide content 2/	3720	-
Storage stability 3/	3467	-

1/ Test shall be conducted at -73°C (-100°F). Observations for skidding or ball sliding shall be made during test run.

2/ For non-soap greases use method 3722 of FED-STD-791 or instrumental analytical test methods such as X-ray fluorescence techniques.

3/ Temperature of 40° ± 2°C (104° ± 4°F) to be maintained for 6 months.

| METRIC |

MIL-G-81322E
22 JANUARY 1992
SUPERSEDING
MIL-G-81322D
2 AUGUST 1982

MILITARY SPECIFICATION

GREASE, AIRCRAFT, GENERAL PURPOSE, WIDE TEMPERATURE RANGE

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the requirements for two grades of grease. Grade A is formulated for the lubrication of aircraft accessories and aircraft related equipment. Grade B grease is formulated for the lubrication of aircraft arresting gear and other equipment that operate under high contact loads and high sliding speeds. Both grades of grease are formulated to withstand operations at high speeds and temperatures of -54° to 177°C (-65° to 350°F) (see 6.1). Grade A grease is identified by NATO Code G-395 and Military Symbol WTR (see 6.7).

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

MILITARY

MIL-P-5431	Plastic, Phenolic, Graphited Sheets, Rods, Tubes, and Shapes
MIL-G-23549	Grease, General Purpose

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commanding Officer, Naval Air Warfare Center, Aircraft Division Lakehurst, Systems Requirements Department (Code SR3), Lakehurst, NJ 08733-5100, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A
FSC 9150

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

STANDARDS

FEDERAL

FED-STD-313	Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities
FED-STD-791	Lubricants, Liquid Fuels, and Related Products; Methods of Testing

MILITARY

MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-290	Packaging of Petroleum and Related Products

(Unless otherwise indicated, copies of federal and military specifications, standards and handbooks may be obtained from the Naval Publications and Printing Service, Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094).

2.1.2 Other Government documents and publications. The following other Government documents and publications form a part of this specification to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

Code of Federal Regulations (CFR):

29 CFR 1910.1200	Occupational Safety and Health Standards - Hazard Communications

(Application for copies of the above listed document should be addressed to the Superintendent of Documents, Government Printing Office, Washington, DC 20402).

Naval Air Engineering Center Document

Material and Process Requirement

MPR 400	Graphited Phenolic Material, MIL-P-5431A(AS): Modification of Requirements for Sheets Used in Arresting Gear and Catapult Applications

(Application for copies of the above listed document should be addressed to the Commanding Officer, Naval Air Warfare Center, Aircraft Division Lakehurst, Systems Requirements Department (Code SR46), Lakehurst, NJ 08733-5092).

2.2 Non-Government publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z129.1	American National Standard for Hazardous Industrial Chemicals - Precautionary Labeling

(Application for copies of the above listed document should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 150/B 150M	Aluminum Bronze, Rod, Bar, and Shapes
ASTM D 217	Cone Penetration of Lubricating Grease
ASTM D 235	Standard Specification for Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent)
ASTM D 740	Methyl Ethyl Ketone
ASTM D 942	Oxidation Stability of Lubricating Greases by the Oxygen Bomb Method
ASTM D 1264	Water Washout Characteristics of Lubricating Greases
ASTM D 1478	Low-Temperature Torque of Ball Bearing Greases
ASTM D 1743	Corrosion Preventive Properties of Lubricating Greases
ASTM D 2265	Dropping Point of Lubricating Grease Over Wide Temperature Range
ASTM D 2266	Wear Preventive Characteristics of Lubricating Grease (Four-Ball Method)
ASTM D 2595	Evaporation Loss of Lubricating Greases Over Wide Temperature Range
ASTM D 2596	Measurement of Extreme Pressure Properties of Lubricating Grease (Four-Ball Method)
ASTM D 2714	Calibration and Operation of the Falex Block-on-Ring Friction and Wear Testing Machine

ASTM D 3336	Performance Characteristics of Lubricating Greases in Ball Bearings at Elevated Temperatures
ASTM D 4048	Detection of Copper Corrosion from Lubricating Grease by the Copper Strip Tarnish Test
ASTM D 4057	Manual Sampling of Petroleum and Petroleum Products

(Applications for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-1187).

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

Aerospace Materials Specification (AMS)

AMS 6294	Steel Bars and Forgings, Carburizing 1.8Ni-0.25Mo(0.17-0.22C) (SAE 4620)

(Application for copies should be addressed to SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001).

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets or MS standards), the text of this document shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations, unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Qualification. The greases furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list at the time of award of contract (see 4.4 and 6.3). Any change in the formulation of a qualified product will necessitate its requalification. The material supplied under contract shall be identical, within manufacturing tolerances, to the product receiving qualification.

3.2 First article. When specified (see 6.2.1), a sample shall be subjected to first article inspection (see 4.5 and 6.4).

3.3 Materials. The grease shall consist essentially of a wide temperature range liquid lubricant and a jelling agent with a high melting point. Compositions containing base oils radically different from those in greases currently listed on the Qualified Products List shall be compatible with the listed greases (see 4.4.2).

3.4 Physical properties. Physical properties of the grease shall be in accordance with Table I, when tested as specified in Table II.

TABLE I. Physical properties.

Properties	Limits
Odor	No objectional odor of rancidity, perfume or free alcohol
Dirt particles per milliliter (ml) of grease, maximum (max.)	
25-74 microns (μm) diameter	1000
75 microns (μm) diameter or larger	None
Dropping point, minimum (min.)	232°C (450°F)
Worked penetration	
Grade A	265 - 320
Grade B	300 - 330
Corrosiveness (copper strip) 1/	1b, max.
Oxidation stability, at 99°C (210°F), pressure drop, max.:	
In 100 hours (hrs.)	0.083 MPa (12.0 psi)
In 500 hrs.	0.172 MPa (25.0 psi)
Water resistance, at 40° - 42°C (103° - 107°F), max.	20 percent
High temperature performance, at 174° - 180°C (345° - 355°F) 2/	400 hrs, min.
Evaporation, weight loss, in 22 hours, at 174° - 180°C (345° - 355°F), max.	12.0 percent
Oil separation, weight loss in 30 hours at 174° - 180°C (345° - 355°F), max.	10.0 percent
Load carrying capacity, (Load wear index), min.	30.0
Rubber swell, max.	10.0 percent
Low temperature torque, max.: (newton-meter (N-m) (inch-pound (in-lb))	
Starting	0.98 N-m (8.70 in-lb)
Running (after 60 minutes), at -54°C (-65°F)	0.098 N-m (0.87 in-lb)
Steel on steel wear, max 3/	1.3 mm (0.05 in.)

TABLE I. Physical properties - Continued.

Properties	Limits
Worked stability (penetration), max., after 100,000 double strokes	350
Rust preventative properties, ASTM rating	Pass 4/
Gear wear, mg/1000 cycles, max.:	
Under 2.27-kg (5 pound (lb.)) load	2.5
Under a 4.54-kg (10-lb.) load	3.5
Oscillation:	
Friction and wear after 35,000 cycles, width of wear scar, max.	6.35 mm (0.25 in.)
Storage stability, penetration, min.:	
Unworked	200
Separation of crystalline material	None
Worked, max.	
Grade A, change from original	± 30
Grade B, change from original	± 20
Friction coefficient (Grade B only)	
Initial, max.	0.23
Steady state	0.10
Frictional heating (Grade B only), max.	195°C (383°F)

1/ The grease shall show no green color in that portion contacting the copper strip. The copper strip shall not tarnish more than a classification of 1b when compared with the ASTM copper strip corrosion standards.
2/ Average of four test runs.
3/ Based on the average diameter of wear scars on the three steel balls.
4/ Based on the pass or fail rating as determined by at least two of three bearins.

3.5 Toxicity. The grease furnished under this specification shall have no adverse effect on the health of personnel when used for its intended purpose. Questions pertinent to the effects of this grease shall be referred by the contracting agency to the appropriate departmental medical service. The departmental medical service will act as advisor to the contracting agency (see 4.4.2 and 6.10). Material safety data sheets shall be prepared and submitted in accordance with 3.6.

3.6 Material safety data sheets. Material safety data sheets (MSDS) shall be prepared and submitted in accordance with FED-STD-313 and shall be in accordance with the requirements of 29 CFR 1910.1200. When FED-STD-313 is in variance with the CFR, 29 CFR 1910.1200 shall take precedence, modify, and supplement FED-STD-313. One copy of the MSDS shall accompany the samples being submitted to the qualifying activity for testing (see 4.4.2).

3.7 Workmanship. The grease, when examined visually, shall be a smooth and homogeneous mixture, free from lumps and extraneous materials.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspections set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of the manufacturing operation, is an acceptable practice to ascertain conformance to requirements; however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.2 Classification of inspection. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (4.4).

b. First article inspection (see 4.5).

c. Quality conformance inspection (4.6).

4.3 Inspection conditions. Unless otherwise specified, all test conditions shall be performed in accordance with 4.7 and the physical values specified in Table I apply to the average of determinations made on the sample. Unless otherwise specified, all tests shall be performed on unworked grease.

4.4 Qualification inspection. Qualification inspection shall consist of a review of the manufacturer's test report (see 4.4.2) to determine that the qualification inspection sample (see 4.4.1) complies with all the requirements for the physical properties specified in Table I when tested in accordance with the inspection methods specified in Table II. In order to determine the suitability of the grease for specific service applications, the qualifying activity reserves the right to conduct wheel bearing, actuator or compatibility tests.

4.4.1 Qualification inspection sample. The qualification inspection sample shall consist of 6.81-kg (15.0-lb.) of grease. The sample shall be forwarded to the Commander, Naval Air Warfare Center, Aircraft Division Warminster, Aircraft and Crew Systems Technology Directorate, Code 6061, Warminster, PA 18974. The sample shall be plainly identified by a securely attached, durable tag or label containing the information listed below:

- Qualification test sample.
- GREASE, AIRCRAFT, GENERAL PURPOSE, WIDE TEMPERATURE RANGE.
- Grade (A or B, as applicable).
- Manufacturer's name.
- Manufacturer's product number.
- Batch number.
- Date of manufacture.
- Submitted by (name and date), for qualification inspection in accordance with MIL-G-81322E, under authorization of (reference authorization letter).

The qualification test sample shall be forwarded to the laboratory designated in the letter of authorization (see 6.3).

4.4.2 Test reports. Two copies of the manufacturer's test report, containing complete test data showing that material submitted for qualification conforms to the requirements of this specification, shall be submitted with the qualification inspection sample. Location and identity of the plant which produced the qualification inspection sample shall be supplied. Material safety data sheets on toxicity shall be prepared and submitted to the qualifying laboratory (see 4.4.1) in accordance with 3.6.

4.4.3 Retention of qualification. In order to retain qualification of a product approved for listing on the Qualified Products List (QPL), the manufacturer shall verify by certification to the qualifying activity that the manufacturer's product complies with the requirements of this specification. The time of periodic verification by certification shall be in two-year intervals from the date of original qualification. The Government reserves the right to re-examine the qualified product whenever deemed necessary to ensure that the product continues to meet any or all of the specification requirements.

4.5 First article inspection. The manufacturer shall submit to the qualifying laboratory (see 4.4.1) a 4.54-kg (10.0-lb.) sample of grease taken from the first production lot of grease processed under the first contract or order, after the product has passed the qualification inspection (see 6.3). The tests shall be limited to the requirements of 3.4 and 3.7 and the test methods of 4.7.2. Delivery of the grease shall not be delayed pending completion of testing on the first article sample by the qualifying laboratory.

TABLE II. Inspection methods.

Tests	Method	
	FED-STD-791	ASTM
Dirt	3005	--
Dropping point	--	D 2265
Worked penetration	--	D 217
Corrosiveness (copper strip)		D 4048
Oxidation stability	--	D 942
Water resistance	--	D 1264
High temperature performance	--	D 3336
Evaporation	--	D 2595
Oil separation	321	--
Load carrying capacity	--	D 2596
Rubber swell 1/	3603	--
Low temperature torque 2/	--	D 1478
Steel on steel wear	--	D 2266
Worked stability	313	--
Rust preventive properties	--	D 1743
Gear wear	335	--
Oscillation: Friction and wear 3/	--	--
Storage stability 4/	3467	--
Friction coefficient 5/	--	--
Frictional heating 5/	--	--

1/ Use standard rubber NBR-L (see 6.5) within 6 months of date of manufacture.
2/ Observation for skidding or ball sliding shall be made during test run.
3/ Tests shall be conducted in accordance with 4.7.3 through 4.7.3.7.
4/ Temperature of 38° ± 3°C (100° ± 5°F) to be maintained for 6 months. After determination of unworked penetration, the unworked penetration sample shall be stored at 38° ± 3°C (100° ± 5°F) for an additional 6 months. The sample shall be covered in such fashion to provide an air space above the grease and to prevent the surface of the grease from being disturbed. The sample shall then be examined for presence of crystalline material.
5/ Tests shall be conducted in accordance with 4.8 through 4.8.2.1.

TABLE III. Quality conformance tests.

Inspection	Paragraph	
	Requirement	Test Method
Odor	3.4	---
Dirt	3.4	4.7.2
Dropping point	3.4	4.7.2
Worked penetration	3.4	4.7.2
Corrosiveness (copper strip)	3.4	4.7.2
Evaporation	3.4	4.7.2
Oil separation	3.4	4.7.2
Load carrying capacity	3.4	4.7.2
Low temperature torque	3.4	4.7.2
Steel on steel wear	3.4	4.7.2
Worked stability	3.4	4.7.2
Examination of filled containers	5.1	4.7.1
Workmanship	3.7	---

4.6 Quality conformance inspection. The quality conformance inspection of the grease shall consist of tests of samples from 4.6.2.2 in accordance with Table III and an examination of samples from 4.6.2.1 for conformance with 4.7.1. Samples shall be labeled completely with the information identifying the purpose of the sample, name of product, specification number, lot and batch number, date of sampling and contract number.

4.6.1 Lot formation. A lot shall consist of all the grease produced by one manufacturer, at one plant, from the same materials and under essentially the same conditions, provided the operation is continuous and does not exceed a 24-hour period. In the event the process is a batch operation, each batch shall constitute a lot (see 6.8).

4.6.2 Sampling.

4.6.2.1 For examination of filled containers. A random sample of filled containers, fully prepared for delivery, shall be selected from each lot of grease in accordance with MIL-STD-105, inspection level I with acceptable quality level (AQL) of 2.5 percent defective.

4.6.2.2 For tests. The sample for tests shall consist of two 2.27-kg (5.0-lb.) samples of grease, taken at random from filled containers of each lot of grease. For users who obtain grease in large containers, two 2.27-kg (5.0-lb.) samples shall be taken in accordance with ASTM D 4057. One sample shall be tested for all the tests specified in 4.7.2; the other sample shall be retained. If a test result does not comply with the requirements of any of the tests specified in 4.7.2, the test in question shall be repeated using the retained sample. The lot shall be unacceptable if the average of both test results fails to comply with requirements specified in 4.7.2.

4.7 Methods of examinations and tests.

4.7.1 Examinations. To ensure conformance with 5.1, each filled container, selected in accordance with 4.6.2.1, shall be examined for defects in the container, closure, and marking. Each sample container shall also be weighed to determine the amount of the contents. If the number of defective containers exceeds the acceptance number of the sampling plan specified in 4.6.2.1, the lot shall be rejected.

4.7.2 Tests. Tests shall be performed in accordance with Table II and 4.7.3 through 4.7.3.7 to determine conformance with the requirements specified in 3.4.

4.7.3 Oscillation - friction and wear test.

4.7.3.1 Apparatus. The apparatus used consists of the following:

a. Falex model number 1 ring and block test machine, or equivalent, equipped with an oscillatory drive mechanism, load cell transducer and a transducer amplifier/indicator (see 6.6).

b. Measuring magnifier glass, with metric calibration (precision of 0.05 mm).

c. Analytical balance, capable of weighing to the nearest 0.1 mg.

4.7.3.2 Test ring. The test ring shall be made of SAE/AISI 4620 alloy steel (AMS 6294) and have a hardness (Rockwell) of 58 to 63 HRC. The ring shall have a ground face width of 8.15 ± 0.13 mm (0.321 ± 0.005 in.) and a diameter of 35.0 mm (1.375 in.). The eccentricity between the inner and outer surface shall be no greater than 38 µm (1.5 mil). The outside diameter of the ring shall have a finished surface of 0.10 to 0.38 µm (5.0 to 15.0 µin.) root mean square (rms), in the direction of the motion.

4.7.3.3 Test block. The test block shall be made of copper alloy, conforming to ASTM B150/B150M, alloy 64200, with the test surface dimensions as follows: 6.35 mm (0.25 in.) wide and 15.70 ± 0.13 mm (0.620 ± 0.005 in.) long. The height of the block shall be 10.16 ± 0.05 mm (0.400 ± 0.002 in.). The block shall have a hardness (Rockwell) of 85 to 91 HRB. Each block shall have a test surface polished to a finish of 0.1 to 0.2 µm (4 to 8 µin.) rms, being perfectly square with all outside edges.

4.7.3.4 Calibration of apparatus. The apparatus shall be calibrated in accordance with ASTM D 2714.

4.7.3.5 Reagents. The reagents used are:

a. Heptane (ACS grade).
b. Methyl ethyl ketone conforming to ASTM D 740.
c. Petroleum spirits conforming to ASTM D 235.

4.7.3.6 Preparation of apparatus. Before each test, thoroughly clean the specimen holder, threaded section, locknut and lockwasher. The heptane shall be used as the cleaning agent and methyl ethyl ketone as the rinse. A new test ring and block shall be used for each test. Each test ring and block shall be cleaned for each test, using the following procedure:

a. Immerse in petroleum spirits and scrub with lint-free cloth.
b. Rinse in a second bath of petroleum spirits.
c. Suspend in the vapor of boiling heptane for 30 seconds.
d. Immerse in boiling methyl ethyl ketone for 30 seconds.
e. Allow part to drip dry.
f. When part has dried, suspend it in vapor of boiling heptane for 30 seconds.
g. Allow part to air dry.
h. Weigh each test ring and block to the nearest 0.1 mg.
i. Store specimens in desiccator until ready to use.

Lubricate the quarter segment of the specimen holder and the threaded section with grease conforming to MIL-G-23549. Apply the grease to be tested to the test ring surface, ensuring that the entire wear surface is completely covered with test grease. Mount the test block in the quarter segment (clean, lint-free, cotton gloves should be used in handling the specimens) and position both in the specimen holder, ensuring that the quarter segment and block are securely positioned in the cylindrical slot. While holding the test block mount, tighten to 28.2 N-m (250 in-lb), using a torque wrench. Apply additional test grease to the area of the test block which overlaps the ring on both sides of the block. Place a 454-g (1.0-lb.) weight in position on the bale rods. Align the two reference markers by adjusting the turnbuckle on the friction rod. Tighten locknuts on the turnbuckle. Position the friction force cut-off such that the level is set to 177.9 Newtons for a maximum coefficient of friction of 0.44. Adjust the amplitude of oscillation for a 90 degree arc.

4.7.3.7 Procedure. With the revolution counter set to zero, start machine and adjust the oscillating speed to 87.5 cycles per minute (cpm), ensuring that the reference markers are aligned. When 60 cycles is reached, add a 454-g (1.0-lb.) weight. When 120 cycles is reached, add another 454-g (1.0-lb.) weight. Run this test for 35,000 cycles or until failure, due to excessive friction (cut-off coefficient of friction of 0.44), is encountered. After reaching 35,000 cycles, dismount and clean test block. Measure wear scar width, in accordance with ASTM D 2714. The maximum width of wear scar shall be in accordance with Table I.

4.8 Friction coefficient and frictional heating.

4.8.1 Apparatus. The apparatus used for this test (see Figure 1) consists of the following:

a. The phenolic sample consists of material conforming to MIL-P-5431, with the modifications specified in MPR 400. The phenolic sample is affixed to a motor-driven table capable of rotating at 3600 revolutions per minute (rpm).
b. The aluminum specimen consists of material conforming to alloy 7075-T6, with a Brinnel hardness of 150 H_B. The aluminum specimen remains stationery and is fitted into a larger brass fixture. The aluminum specimen is diagramed in Figure 2. Grease grooves are cut into the surface of the aluminum specimen and the sides of the inner cavity of the phenolic disk are sloped toward the interface to ensure a flow of grease to the interface area of the aluminum and phenolic test pieces (see Figures 2 and 3).
c. A thermocouple, located 1.6 mm from the sliding interface within the aluminum specimen, is used to measure the near-interface temperatures.

4.8.2 Procedure. A constant volume of grease is to be packed into the cavity area (see Figure 1) and a light coating of grease is to be applied to the sliding surfaces of both the aluminum and phenolic test pieces prior to all testing. The test pieces are then brought together and the test begun. The test is initiated with the rotating table and phenolic test piece being rotated at 3600 rpm with no applied load. The load is then applied and incrementally increased every 60 seconds, 38.6-kilopascal (kPa) at a time, until a maximum load of 546-kPa is achieved. The sliding speed for the test is 5.54 meters per second and the average contact stress is 581 mm^2.

4.8.2.1 After the maximum contact load of 546-kPa is achieved, the rotation is stopped and the system is allowed to cool to room temperature. After cooling, a new supply of grease is injected into the cavity through the grease fitting and the test sequence is repeated. This sequence is repeated until the total number of test sequences is three (3). Using the thermocouple, the system temperature is to be continuously monitored during the test. The maximum allowable frictional heating value is listed in Table I. The friction coefficient is determined by measuring the friction force caused by the torque arm and dividing that by the normal load. The maximum allowable friction coefficient is listed in Table I.

5. PACKAGING

5.1 Packaging and packing. The grease shall be packaged and packed in accordance with MIL-STD-290. The type and size of the containers and the level of packaging and packing shall be as specified by the procuring activity (see 6.2).

5.1.1 Marking. All unit, intermediate and shipping containers shall be marked in accordance with MIL-STD-290. Any additional special marking shall be as specified by the procuring activity (see 6.2). All unit and intermediate packs of toxic and hazardous chemicals and materials shall also be labeled in accordance with the applicable laws, statutes, regulations, and ordinances, including federal, state, and municipal requirements. In addition, unit and intermediate containers, including unit containers that serve as shipping containers, such as pails and drums, shall be marked with the applicable precautionary information detailed in ANSI Z129.1.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory).

6.1 Intended use. The greases covered by this specification are intended for use as lubricating greases in applications where the operating temperatures fall between -54° and 177°C (-65° and 350°F). Grade A is specifically designed for aircraft wheel bearings in internal brake wheel assemblies, anti-friction bearings, gear boxes, and plain bearings. Grade B is specifically formulated for use in the lubrication of aircraft arresting gear sheave spacers and other equipment that operate under high contact loads and high sliding speeds.

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this specification.
b. Issue of DODISS to be cited in the solicitation and, if required, the specific issue of individual documents referenced (see 2.1 and 2.2).
c. Grade of grease desired (A or B)
d. Quantity desired (in kilograms).
e. Whether first article inspection is required (see 3.2 and 4.5).
f. Type and size of the container (see 5.1).
g. Applicable levels of packaging and packing (see 5.1).

6.3 Qualification. With respect to products requiring qualification, awards may be made only for products which are, at the time set for opening of bids, qualified for inclusion in the applicable Qualified Products List (QPL-81322), whether or not such products have actually been so listed by that date. The contractor's attention is called to this requirement. Manufacturers are urged to arrange having the products they propose to offer to the Government tested for qualification, so that they may be eligible for award of contract(s) or order(s) for material covered by this specification. The activity responsible for the Qualified Products List is the Commander, Naval Air Systems Command, AIR-5304, Department of the Navy, Washington, DC 20360; however, information pertaining to qualification of products and letter of authorization for submittal may be obtained from the Commander, Naval Air Warfare Center, Aircraft Division Warminster, Aircraft and Crew Systems Technology Directorate, Code 6061, Warminster, PA 18974. In the event that the grease furnished under contract is found to deviate from the composition of the approved product, or that the product fails to perform satisfactorily, approval of such products will be subject to immediate withdrawal from the Qualified Products List.

6.4 First article. When a first article inspection is required, the item will be tested and should be a sample selected from the first production lot. The first article should consist of a 4.54-kg (10.0-lb.) sample of grease. The contracting officer should include specific instructions for examinations, tests and approval of the first article.

6.5 Standard rubber samples. Samples of the standard synthetic rubber NBR-L for the test specified in Table II may be obtained from Wynn's Precision Company, 708 West 22nd Street, Tempe, AZ 85282.

6.6 Source for Falex test machine. The Falex model number 1 ring and block test machine (see 4.7.3.1) is available from Falex Corporation, 2055 Comprehensive Drive, Aurora, IL 60505.

6.7 International standardization agreements. Certain provisions of this specification (see 1.1) are the subject of international standardization agreement, ASCC Air Standard 15/1, and NATO STANAG NAT-STD-1135. When amendment, revision or cancellation of this specification is proposed, which will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accommodations.

6.8 Batch. A batch is defined as that quantity of material which has been manufactured by some unit chemical process and subjected to some physical mixing operation intended to make the final product substantially uniform.

6.9 Subject term (keyword) listing.

Lubricant
High melt point
Wide temperature range

6.10 Part numbers. Part numbers for cataloging purposes under this specification are coded as follows:

M81322E - X

M81322E: Specification identifier

X:
A = Grade A
B = Grade B

6.11 Material safety data sheets (MSDS). Contracting officers will identify those activities requiring copies of completed MSDS (see 3.6). The pertinent government mailing addresses for submission of data are listed in Appendix B of FED-STD-313.

6.12 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:
Army - ME
Navy - AS
Air Force - 11

Preparing Activity:
Navy - AS
Project No. 9150-1002

Review activities:
Army - AR, AV, EA, MI
Navy - OS, SH
Air Force - 68
DLA - GS

International interest:
NATO (see 6.7)

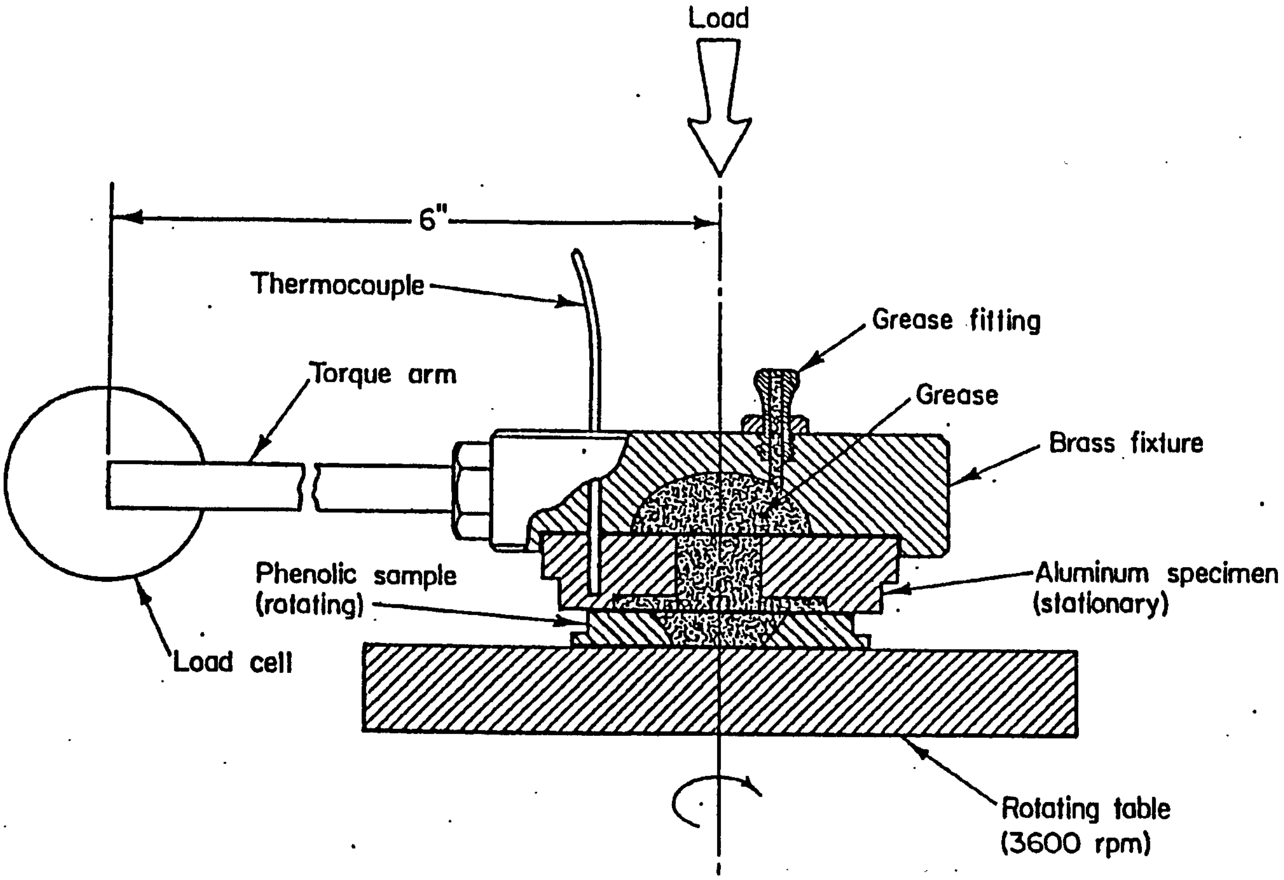
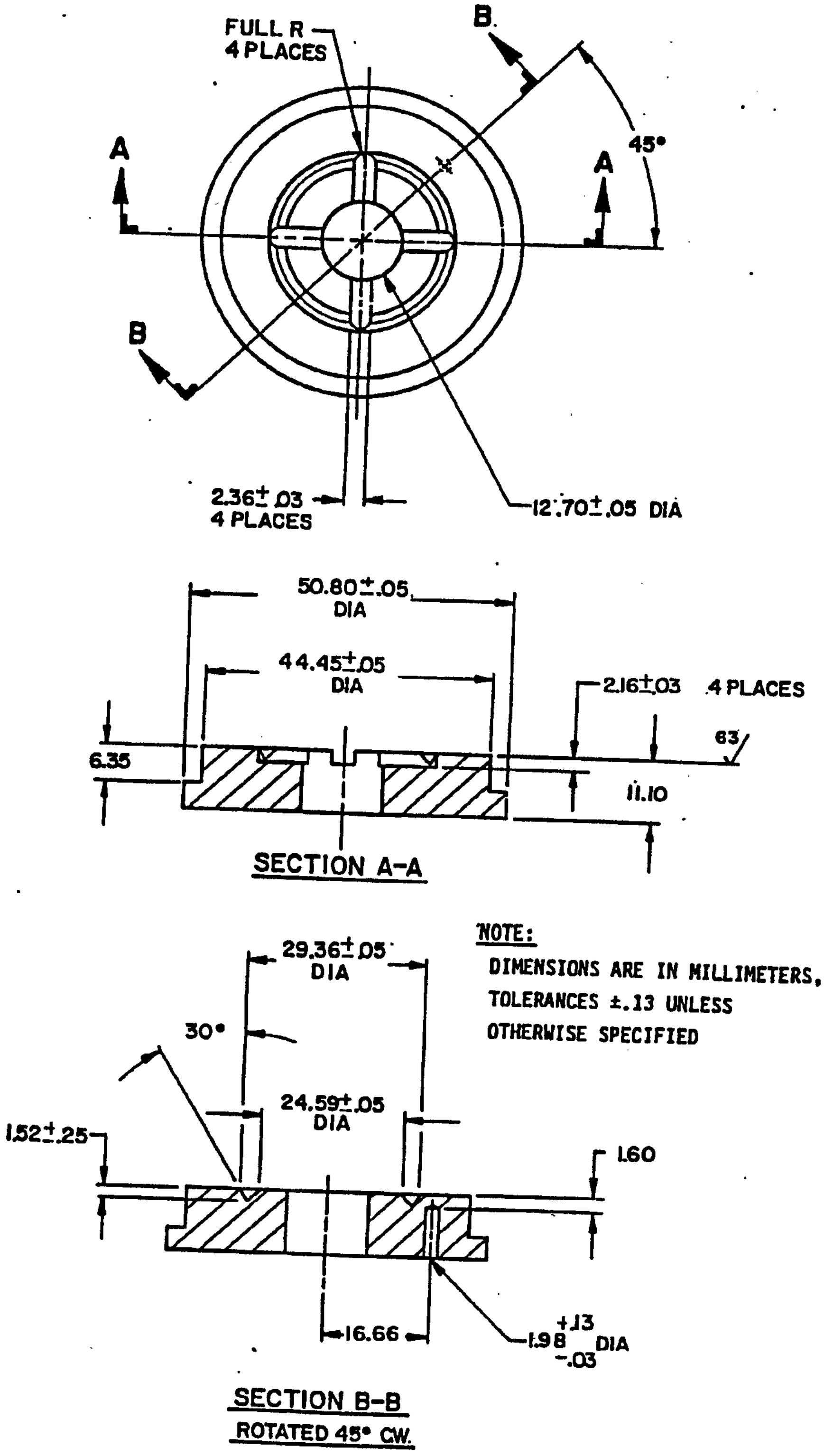
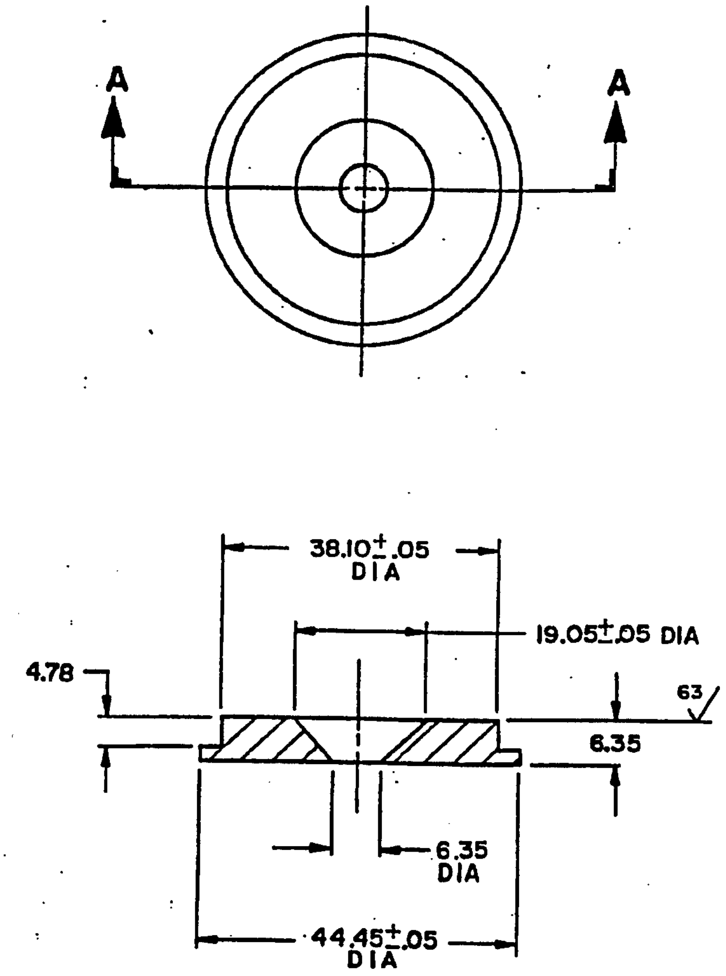


FIGURE 1. Test apparatus.



NOTE:
DIMENSIONS ARE IN MILLIMETERS,
TOLERANCES ±.13 UNLESS
OTHERWISE SPECIFIED

FIGURE 2. Aluminum specimen.



SECTION A-A

NOTE:
DIMENSIONS ARE IN MILLIMETERS,
TOLERANCES ±.13 UNLESS
OTHERWISE SPECIFIED

FIGURE 3. Phenolic sample.

METRIC

MIL-H-83282C
INTERIM AMENDMENT 1
31 JANUARY,1997

MILITARY SPECIFICATION

HYDRAULIC FLUID, FIRE RESISTANT, SYNTHETIC HYDROCARBON BASE, METRIC, NATO CODE NUMBER H-537

This interim amendment is approved for use within the Naval Air Systems Command, Department of the Navy, with MIL-H-83282C, dated 25 March 1986, and is available for use by all Departments and Agencies of the Department of Defense.

PAGE 1

Bottom of page: DELETE the 'Beneficial comments' block and SUBSTITUTE the following:

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Air Warfare Center Aircraft Division, Code 414100 B120-3, Highway 547, Lakehurst, NJ 08733-5100, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

PAGE 2

2.1.1: DELETE "FED-STD-313 - Material Safety Data Sheets, Preparation and Submission of" and SUBSTITUTE "FED-STD-313 - Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities."

2.1.1: DELETE "MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes."

2.1.1, just above 2.1.2, ADD "(Unless otherwise indicated, copies of specifications, standards and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)"

AMSC N/A 1 of 6 FSC 9150

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

MIL-H-83282C
INTERIM AMENDMENT 1

PAGE 3

2.2, ADD:

"ASTM-D4898 -	Insoluble Contamination of Hydraulic Fluids by Gravimetric Analysis, Standard Test Method for
ASTM-D5185 -	Determination of Additive Elements, Wear Metals, and Contaminants in Used Lubricating Oils by Inductively Coupled Plasma Atomic Emission Spectrometry, Standard Test Method for."

2.2, DELETE the street address for the American Society for Testing and Materials and SUBSTITUTE "100 Barr Harbor Drive, West Conshohocken, PA. 19428-2959."

2.2, ADD:

"AMERICAN SOCIETY FOR QUALITY CONTROL
ASQC Z1.4- Sampling Procedures and Tables for Inspection by Attributes (DoD Adopted)

(Applications for copies should be addressed to American Society for Quality Control, 611 East Wisconsin Avenue, Milwaukee, WI 53202.)"

PAGE 7

4.3.1, line 16 and 17: DELETE "Aircraft and Crew Systems Technology Directorate, Code 60612, Naval Air Development Center, Warminster, PA 18974," and SUBSTITUTE "Commander, Attn: Code 4.3.4.1 Building 2188, Naval Air Warfare Center Aircraft Division, 22347 Cedar Point Road, Unit 6, Patuxent River MD 20670-1161"

4.3.1: DELETE and SUBSTITUTE:

"4.3.1 Qualification sample. The qualification test sample shall consist of two 1-gallon containers of the finished fluid, two quarts of the base stock without additives, two quarts of the blending fluids used, eight ounces of the anti-wear additive, one ounce of the oxidation inhibitor and one ounce each of any additional additives used in the finished fluid. In the event that the additives are supplied as concentrated solutions, an equivalent quantity of the solution shall be furnished. Upon receipt of authorization (see 6.3) from theCommander, Attn: Code 4.3.4.1 Building 2188, Naval Air Warfare Center - Aircraft Division, 22347 Cedar Point Road, Unit 6, Patuxent River MD 20670-1161 to submit samples for qualification testing, samples shall be forwarded as directed. The samples shall be accompanied by a test report from the manufacturer or a commercial laboratory containing complete information as to the source and type of base stock and additive materials used, the formulation and composition of the finished fluid, and laboratory data showing quantitative results of all the tests required by this specification, except storage stability. Separate qualification inspections shall be required for each base stock used. A material safety data sheet shall accompany the samples being submitted for test. Samples shall be identified as follows:

- Sample for qualification inspection
- HYDRAULIC FLUID, FIRE RESISTANT, SYNTHETIC HYDROCARBON BASE, METRIC, NATO CODE NUMBER H-537
- Name of ingredient (for ingredient material)
- Name of manufacturer
- Product code number
- Date of manufacture
- Submitted by (name) and (date) for qualification inspection in accordance with the requirements of MIL-H-83282C under authorization of (reference authorizing letter) (see 6.3)."

PAGE 8

4.4, line 8, 4.4.4, line 3, and 4.4.5, line 4: DELETE "MIL-STD-105" and SUBSTITUTE "ASQC Z1.4."

PAGE 14

6.3, line 10: DELETE "AIR-5304C2, Department of Navy, Washington, DC 20361," and SUBSTITUTE "AIR-4.3.4, Arlington, VA 22243."

6.3, lines 13 and 14: DELETE "Aircraft and Crew Systems Technology Directorate, Code 60612, Naval Air Development Center, Warminster, PA 18974," and SUBSTITUTE "Commander, Attn: Code 4.3.4.1 Building 2188, Naval Air Warfare Center - Aircraft Division, 22347 Cedar Point Road, Unit 6, Patuxent River MD 20670-1161."

6.4: DELETE and SUBSTITUTE "6.4 Standard rubber samples. Samples of the standard synthetic rubber NBR-L (see 3.3.4) for the test specified in table VIII may be obtained from Wynn's Precision Company, 708 West 22nd Street, Tempe, AZ 85282."

MIL-H-83282C
INTERIM AMENDMENT 1

PAGE 16

TABLE II, ADD the following entry:

Characteristic	Requirement
Barium content, parts per million (ppm) (mass percent), maximum	10

PAGE 18

TABLE VI, ADD the following entry:

Inspection	Paragraph	
	Requirement	Test method
Barium content	3.3	4.5.2

PAGE 19

TABLE VIII, DELETE entry for "Solid particle contamination" and SUBSTITUTE the following:

Characteristic	Test method	
	FED-STD-791	ASTM
Solid particle contamination	—	D4898 2/
Barium Content	—	D5185

PAGE 20

TABLE VIII, footnote 2/: DELETE and SUBSTITUTE: "2/ For ASTM-D4898, a single 0.45 micron, cellulose membrane filter shall be used. Particle contamination may also be measured, following FED-STD-791, Method 3012, using an automatic particle counter capable of measuring the limits defined in table III; the HIAC/ROYCO brand, model 8011, has been found capable of measuring these limits."

PAGE 26

DELETE DD Form 1426, "Standardization Document Improvement Proposal," and SUBSTITUTE the form on the last page of this amendment.

MIL-H-83282C
INTERIM AMENDMENT 1

The margins of this amendment are marked with an asterisk to indicate where changes (additions, modifications, corrections, deletions) from the previous amendment were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous amendment.

Preparing activity:
Navy - AS
(Project No. 9150-N830)

H-08-36

MIL-H-83282C
25 March 1986
SUPERSEDING
MIL-H-83282B
10 February 1982

MILITARY SPECIFICATION

HYDRAULIC FLUID, FIRE RESISTANT, SYNTHETIC HYDROCARBON BASE, AIRCRAFT, METRIC, NATO CODE NUMBER H-537

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements for a synthetic hydrocarbon base hydraulic fluid for use in the -40° to +205°C temperature range in aircraft and missile hydraulic systems. The fluid is also used in airborne engine compressors and related equipment. This hydraulic fluid is identified by NATO Code Number H-537 (see 6.5).

2. APPLICABLE DOCUMENTS

2.1 Government documents.

* 2.1.1 Specifications and standards. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solication.

SPECIFICATIONS

FEDERAL

TT-T-656 - Tricresyl Phosphate.
PPP-C-96 - Can, Metal, 28 Gage and Lighter.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Systems Engineering and Standardization Department (Code 93), Naval Air Engineering Center, Lakehurst, NJ 08733-5100, by using the self-addressed standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC-N/A FSC 9150

DISTRIBUTION STATEMENT A, Approved for public release; distribution is unlimited.

THIS DOCUMENT CONTAINS 25 PAGES.

SPECIFICATIONS (continued)

MILITARY

MIL-H-5606 - Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordnance.

STANDARDS

FEDERAL

FED-STD-313 - Material Safety Data Sheets, Preparation and Submission of.

FED-STD-791 - Lubricant, Liquid Fuel and Related Products, Methods of Testing.

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.

MIL-STD-290 - Packaging of Petroleum and Related Products.

* 2.1.2 Other Government publications. The following other Government publications form a part of this specification to the extent specified herein. Unless otherwise specified, the issues shall be those in effect on the date of the solicitation.

PUBLICATIONS

CODE OF FEDERAL REGULATIONS

49 CFR - Transportation.

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, DC 20402.)

(Copies of specifications, standards, handbooks, drawings, and publications required by manufacturers in connection with specific acquisition functions should be obtained from the acquisition activity or as directed by the contracting officer.)

* 2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted shall be those listed in the issue of the DODISS specified in the solication. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issue of the nongovernment documents which is current on the date of the solication.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z129.1 - American National Standard for the Precautionary Labeling of Hazardous Chemicals.

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 92 - Flash and Fire Points by Cleveland Open Cup.
ASTM D 97 - Pour Point of Petroleum Oils.
ASTM D 445 - Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity).
ASTM D 664 - Neutralization Number by Potentiometric Titration.
ASTM D 892 - Foaming Characteristics of Lubricating Oils.
ASTM D 1298 - Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
ASTM D 1500 - ASTM Color of Petroleum Products (ASTM Color Scale).
ASTM D 1744 - Water in Liquid Petroleum Products by Karl Fischer Reagent.
ASTM D 4172 - Wear Preventive Characteristics of Lubricating Oil (Four-Ball Method).
ASTM D 4057 - Manual Sampling of Petroleum and Petroleum Products.
ASTM D 4177 - Automatic Sampling of Petroleum and Petroleum Products.
ASTM E 659 - Autoignition Temperature of Liquid Chemicals.
ASTM F 313 - Insoluble Contamination of Hydraulic Fluids by Gravimetric Analysis.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

Aerospace Material Specifications (AMS)

AMS 3217/2 - Test Slabs, Acrylonitrile Butadiene (NBR-L), Low Acrylonitrile, 65-75.

(Applications for copies should be addressed to Society of Automotive Engineers, 400 Commonwealth Dr., Warrendale, PA. 15096.)

* (Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

* 2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Qualification. The hydraulic fluid furnished under this specificaton shall be products which are qualified for listing on the applicable qualified products list at the time set for opening of bids (see 4.3 and 6.3). Any change in the formulation of an approved product shall require requalification.

3.2 Materials. The materials used in formulating the hydraulic fluid shall consist of a synthetic hydrocarbon base stock (see 3.2.1), and shall contain additives as specified in 3.2.2. The hydraulic fluid shall contain no admixture of resins, soaps, gums, fatty oils or oxidized hydrocarbons.

* 3.2.1 Base stock requirements. The properties of the synthetic hydrocarbon base stock used in formulating the finished fluid, before the addition of any other ingredients required herein, shall be as designated in Table I when tested as specified in 4.5.

3.2.2 Additives. There shall be no restriction on the types of materials used as additives in the fluid except those listed and those imposed by the technical requirements of this specification. No pour point depressant materials or viscosity index improvers may be used.

3.2.2.1 Oxidation inhibitors. Oxidation inhibitors of the phenolic type shall be added to the base oil in quantities not to exceed 2.0 percent by weight.

* 3.2.2.2 Anti-wear agent. Anti-wear agents, such as tricresyl phosphate (TCP) conforming to TT-T-656, shall be blended in sufficient quantity to permit the finished oil to meet the lubricity requirements specified in 3.3.9. When tricresyl phosphate is used, it shall contain not more than three percent total weight TCP and not more than one percent of the ortho-isomer.

3.2.2.3 Blending fluid. Blending fluids, such as diesters, shall be blended in a quantity not to exceed 33 percent by weight to permit the finished fluid to meet the rubber swell requirements, as specified in 3.3.4, and the viscosity requirements in centistokes at -40°C as specified in Table II.

3.2.2.4 Red dye. The fluid shall contain red dye in a concentration not greater than one part of dye per 10,000 parts of oil by weight.

3.3 Finished fluid. The properties of the finished fluid shall be as specified in Table II and 3.3.1 through 3.3.13.

3.3.1 Specific gravity. The specific gravity of the hydraulic fluid shall be determined as specified in 4.5.2, but shall not be limited. Samples of hydraulic fluid submitted for quality conformance tests shall not vary more than ± 0.008 at 15.6°C/15.6°C from the specific gravity of the sample originally approved for qualification.

3.3.2 Corrosiveness and oxidation stability.

3.3.2.1 Corrosiveness. When tested as specified in 4.5.2, the change in weight of steel, aluminum alloy, magnesium alloy and cadmium-plated steel subjected to the action of the hydraulic fluid shall be not greater than ± 0.2 milligrams per square centimeter of surface. The change in weight of copper under the same conditions shall be not greater than ± 0.6 milligrams per square centimeter of surface. There shall be no pitting, etching, nor visible corrosion on the surface of the metals when viewed under magnification of 20 diameters. Any corrosion produced on the surface of the copper shall be not greater than No. 3 of the ASTM copper corrosion standards. A slight discoloration of the cadmium shall be permitted.

3.3.2.2 Resistance to oxidation. When tested as specified in 4.5.2, the fluid shall not have changed more than 10 percent from the original viscosity in centistokes at 40°C after the oxidation corrosion test. The neutralization number shall not have increased by more than 0.20 over the acid or base number of the original sample. There shall be no evidence of separation of insoluble materials nor gumming of the fluid.

3.3.3 Low temperature stability. When tested as specified in 4.5.2 for 72 hours at a temperature of -40 ± 1°C, the fluid shall show no evidence of gelling, clouding, crystallization, solidification or separation of ingredients.

3.3.4 Swelling of synthetic rubber. When tested as specified in 4.5.2, the volume increase of the standard synthetic rubber NBR-L (as referenced in AMS 3217/2) by the fluid shall be within the range of 18.0 to 30.0 percent.

3.3.5 Solid particle contamination. When tested in accordance with 4.5.2, the number of solid contaminant particles per 100 ml of the fluid shall not exceed the number specified in Table III, nor shall the weight of the residue exceed 0.3 mg. The filtering time for each determination shall be 15 minutes maximum.

3.3.6 Foaming characteristics. The foaming characteristics of the hydraulic fluid shall not exceed the limits indicated in Table IV when tested as specified in 4.5.2.

3.3.7 Water. The fluid shall contain less than 100 ppm total water when tested as specified in 4.5.2.

3.3.8 Flammability.

3.3.8.1 High temperature - high pressure spray ignition. If ignited, when the test flame is applied as specified in 4.5.2, the test fluid shall not continue to burn when the source of ignition is removed.

3.3.8.2 Flame propagation. When tested as specified in 4.5.5, the flame propagation rate shall be not more than 0.30 cm/sec.

3.3.8.3 Effect of evaporation on flammability - wick ignition. When tested as specified in 4.5.2, a minimum of 10 cycles shall be required to produce a self-sustaining flame on the wick.

3.3.9 Lubricity. When tested in accordance with 4.5.2, wear values for hydraulic fluid shall be as specified in Table V.

3.3.10 Storage stability. The fully blended product shall show no separation of ingredients nor evidence of crystallization, shall be clear and transparent when examined visually, and shall conform to the requirements of section 3 after 12 months storage as specified in 4.5.2.

3.3.11 Compatibility. The hydraulic fluid shall be compatible in all concentrations with each of the fluids approved under this specification when tested as specified in 4.5.3. The hydraulic fluid shall be miscible with MIL-H-5606 fluids in all proportions from -40°C to 135°C, in that no formation of resinous gums, sludges or insoluble materials will occur.

3.3.12 High temperature stability. When tested in accordance with 4.5.6, the change in fluid viscosity at 40°C shall not exceed 5 percent; neutralization number of the fluid shall not increase more than 0.1 and there shall be no formation of precipitate or insoluble material.

3.3.13 Color of finished fluid. There shall be no readily discernible difference in the color of the finished fluid and the standard color when tested as specified in 4.5.7.

* 3.4 Material safety data sheets. Material safety data sheets shall be prepared and submitted in accordance with FED-STD-313. Material safety data sheets shall also be forwarded as specified in 4.3.1. Questions pertinent to the effect of MIL-H-83282 hydraulic fluid on the health of personnel, when used for its intended purpose, shall be referred by the acquiring activity to the appropriate medical service who will act as adviser to the acquiring activity (see 4.4.6 and 6.2.1e).

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

* 4.1.1 Responsibility for Compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products of supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.2 Classification of inspection. The inspection requirements specified herein are classified as follows:

a. Qualifcation inspection (see 4.3).

b. Quality conformance inspection (see 4.4).

4.3 Qualification inspection. Qualification inspection shall consist of a review for approval of the submitted manufacturer's test report and subjecting the qualification samples (see 4.3.1) to examination and testing for all the requirements of this specification.

* 4.3.1 Qualification samples. The qualification sample shall consist of two 1-gallon containers of the finished fluid, two quarts of the base stock without additives, two quarts of the blending fluids used, eight ounces of the anti-wear additive, one ounce of the oxidation inhibitor and one ounce each of any additional additives used in the finished fluid. In the event that additives are supplied as concentrated solutions, an equivalent quantity of the solution shall be furnished. The samples shall be accompanied by a test report from the manufacturer or a commercial laboratory containing complete information as to the source and type of base stock and additive materials used, the formulation and composition of the finished fluid, and laboratory data showing quantitative results of all the tests required by this specification except storage stability. Separate qualification inspections shall be required for each base stock used. When the material safety data sheet is a requirement, one copy shall accompany the samples being submitted for test. The samples, material safety data sheets and reports shall be forwarded to the Aircraft and Crew Systems Technology Directorate, Code 60612, Naval Air Development Center, Warminster, PA 18974. The samples shall be plainly identified by securely attached durable tags or labels marked with the following information:

Sample for qualification inspection
HYDRAULIC FLUID, FIRE RESISTANT, SYNTHETIC HYDROCARBON BASE, AIRCRAFT, METRIC, NATO CODE NUMBER H-537
Name of ingredient (for ingredient material)
Name of manufacturer
Product code number
Date of manufacture
Submitted by (name) and (date) for qualification inspection in accordance with the requirements of MIL-H-83282C under authorization of (reference authorizing letter) (see 6.3).

4.3.1.1 Formulation sheets. An example of a satisfactory form for the formulation sheet, indicating the percent by weight and purpose of each ingredient, is as follows:

Base stock (composition)	percent
Blending fluid (composition)	percent
Anti-wear additive (manufacturer's name and no.)	percent
Oxidation inhibitor (manufacturer's name and no.)	percent
Other additives	percent

4.3.2 Retention of qualification. In order to retain qualification of a product approved for listing on the Qualified Products List (QPL), the manufacturer shall verify by certification to the qualifying activity, that the manufacturer's product complies with the requirements of this specification. The time of periodic verification by certification shall be in two-year intervals from the date of original qualification. The Government reserves the right to re-examine the qualified product whenever deemed necessary to determine that the product continues to meet any or all of the specification requirements.

4.4 Quality conformance inspection. The quality conformance inspection shall consist of a sample for tests (see 4.4.3), samples for examination of filled containers (see 4.4.4), samples for determination of solid particle count (see 4.4.5), and the tests specified in Table VI. Samples shall be labeled completely with information identifying the purpose of the sample, name of product, specification number, lot and batch number, date of sampling and contract number. Unless otherwise specified, sampling of the hydraulic fluid shall be in accordance with MIL-STD-105.

4.4.1 Bulk lot. A bulk lot (batch) is an indefinite quantity of a homogeneous mixture of material offered for acceptance in a single isolated container; or manufactured in a single plant run (not exceeding 24 hours) through the same processing equipment, with no change in ingredient material.

4.4.2 Packaged lot. A packaged lot is an indefinite number of 55-gallon drums or smaller unit containers of identical size and type, offered for acceptance, and filled with a homogeneous mixture of material from one isolated container; or filled with a homogeneous mixture of material manufactured in a single plant run (not exceeding 24 hours) through the same processing equipment, with no change in ingredient material.

* 4.4.3 Sample for tests. Take samples for tests in accordance with ASTM D 4057 or ASTM D 4177. This sample shall be subjected to all the applicable quality conformance tests. If the sample for tests fails any of the quality conformance tests, the inspection lot shall be rejected. In addition, a random sample of base oil shall be selected for each lot of the finished fluid and shall be subjected to all the applicable quality conformance tests for base oil.

4.4.4 Sample for examination of filled containers. A random sample of filled unit containers and a sample of shipping containers fully prepared for delivery shall be selected from each lot of fluid in accordance with MIL-STD-105, Inspection Level II and an Acceptable Quality Level (AQL) of 2.5 percent defective.

4.4.5 Sample for determination of solid particle count. Samples of filled and sealed containers shall be taken at such periodic intervals as to be representative of each day's operation. The number of samples taken each day shall be in accordance with MIL-STD-105, Inspection Level S-3. The sample size and number of determinations shall be as specified in Table VII.

* 4.4.6 Submission of material safety data sheets. The contractor shall furnish to the contracting activity the toxicological data and formulations required to evaluate the safety of the material for the proposed use through the submission of the material safety data sheet detailed in FED-STD-313.

4.5 Method of inspection and test.

4.5.1 Inspection. Inspection shall be in accordance with Method 9601 of FED-STD-791 and 4.5.8 of this specification.

4.5.2 Tests. The hydraulic fluid properties shall be determined in accordance with the applicable methods specified in Table VIII and 4.5.3 through 4.5.7. Physical and chemical values specified in section 3 apply to the average of the determinations made on the samples for those values which fall within any stated repeatability or reproducibility limits of the applicable test method.

4.5.3 Compatibility. Samples of candidate hydraulic fluid in amounts of 20 ml, 100 ml and 180 ml shall be mixed with samples from each of the fluids previously approved under this specification. Total volume of each mixture shall be 200 ml. Mixtures shall be prepared in 250 ml stoppered flasks. The flasks shall be thoroughly agitated and then stored in an oven at 205°C for 2 hours. At the end of this time, none of the mixtures shall show any signs of sediment, turbidity or crystallization. The samples shall then be stored at -40°C for a period of 2 hours. Slight turbidity, at this time, that later disappears will be permitted in the samples. Compatibility tests described herein shall also be conducted with a representative fluid qualified to MIL-H-5606. Temperature extremes for these latter tests shall be 135°C and -40°C .

4.5.4 Bulk modulus.

4.5.4.1 Apparatus. The bulk modulus of the hydraulic fluid shall be determined using a calibrated, precision capillary pycnometer of the type shown in Figure 1 (modified 21 T 50 Jerguson pressure gauge). A suitable pressure vessel and auxillary equipment for this determination are shown in Figures 2 and 3.

4.5.4.2 Procedure. The pycnometer volume to capillary diameter ratio shall be chosen to provide a precision of measurement for liquid density of ± 2 parts in 10,000. The pycnometer shall be charged with candidate fluid to the top of the capillary at 40°C and atmospheric pressure, and determination made as follows: Insert the pycnometer in the high-pressure pycnometer housing so that the capillary tube is visible through the window of the pressure vessel and parallel to the outside vertical surfaces of the pressure vessel. Assemble the pressure vessel containing the pycnometer, place it in a 40°C constant-temperature bath, allow equilibrium to be reached, and take volume reading at atmospheric pressure. (Since the precision of the unit depends on visual readings, care must be taken to avoid errors due to parallax and distortion in the pressure vessel window and the walls of the constant-temperature bath.) Increase nitrogen pressure to a new level, and after a 1-hour soak, take a third reading. For any pressure range, the secant bulk modulus is defined by the following equation:

$$\text{Bulk modulus} = \frac{V\,\Delta P}{\Delta V + \Delta V_g}$$

Where:

V is the original volume of the fluid,
ΔV is the observed volume change due to [P increase in pressure,
ΔP is the pressure change between the two measurements in kPa, and
ΔV_g is the correction factor.

The correction factor (ΔV_g) considers the bulk modulus of glass in determining the true volume of the pycnometers at pressures above atmospheric. The bulk modulus of pyrex glass is 3.28×10^7 kPa.

Therefore:

$$\Delta V_g = \frac{V\Delta P}{3.28 \times 10^7}$$

4.5.5 Flame propagation test.

4.5.5.1 Apparatus. Flame propagation rate shall be determined using the apparatus shown schematically in Figure 4. The following additional equipment will be required:

4.5.5.1.1 Recorder. A zero centered fast response strip chart recorder with a ± 5 mv range and a 0.5 second full scale deflection capability has been found to be satisfactory. Chart speed of 7.5 mm per minute is desirable.

4.5.5.1.2 Pair of differential thermocouples. A pair of differential thermocouples, 24 gauge, with bare junctions and fiberglass wrap insulation, ISA Type J (see Figure 4) are required.

4.5.5.1.3 Fume hood. A draft free fume hood shall be used so that when the ventilation system is not operative, no draft will occur.

4.5.5.1.4 Weights. Two 50 gram weights with attached hooks are required.

4.5.5.1.5 Stainless steel tube or rod. A stainless steel tube or rod, approximately 1.3 cm in diameter and 38 cm in length, shall be used.

4.5.5.1.6 Evaporating dish. An evaporating dish, 100 mm diameter, (approximately 125 ml capacity) shall be used.

4.5.5.1.7 Ceramic fiber cord. Ceramic fiber cord, 0.13 cm in diameter, Nextel 312-390, 415, 2.7 TPI, as manufactured by Minnesota Mining Manufacturing Company, St. Paul, MN 55101, or equivalent, shall be used.

4.5.5.1.8 Absorbent paper wipers. Absorbent papers wipers, 38 by 21.6 cm shall be used.

4.5.5.1.9 Matches. A commercially available kind of matches shall be used.

4.5.5.2 Procedure. Assemble the apparatus as shown in Figure 4, and place it in a suitable fume hood. Support the stainless steel rod on a ring stand in a horizontal position, about 60 cm above the table surface. Carefully wrap an absorbent paper wiper around the steel rod and secure it to the rod with a small piece of 2.5 cm masking tape. Leave about 10 cm of the rod uncovered by the wiper.

4.5.5.2.1 Tie small loops in each end of a 50 cm section of the ceramic string. Place 50 ml of the hydraulic fluid sample into the evaporating dish. Place string in fluid taking care not to immerse the loops at the ends of the string.

4.5.5.2.2 Allow the string to remain in the fluid for at least 3 minutes.

4.5.5.2.3 Remove the string from the fluid and attach a 50 gram weight to the loop at each end. Hang the soaked string with attached weights over the unwrapped section of the steel rod. Pull down gently on the uppermost weight to cause the soaked string to pass over the bare rod, flexing it gently as it moves. When the lower weight has been drawn up to the rod, reverse the process until the first weight has again been drawn up to the rod. Repeat the cycle four times to work the sample thoroughly into the string.

4.5.5.2.4. Transfer the string to the covered portion of the rod. Pass the string over the absorbent paper in the same manner described in 4.5.5.2.3. After each double cycle, lift the string and rotate it through 180 degrees while it is held taut in a vertical position, and replace it on a fresh area of the absorbent paper. Repeat until four double cycles have been completed.

4.5.5.2.5 Place the prepared string on the test apparatus, with the weights in place to provide tension in the strings. Adjust the differential thermocouple junctions so that they are exactly 2 mm above the string.

4.5.5.2.6 Start the recorder chart. With a match, ignite the sample on the string near its support at one end of the apparatus. Permit the flame to advance along the string past each thermocouple until it extinguishes itself upon reaching the opposite string support. Stop the recorder and start the hood to exhaust combustion products. Recorder display should be similar to that shown in Figure 5.

4.5.5.2.7 Measure the interval between peak maxima on the recorder chart. From the measured interval, the chart speed of the recorder and the known distance between thermocouples in the test apparatus, calculate the linear flame propagation rate in cm/sec. Triplicate runs should be made for each sample. Report the average of the three runs as the flame propagation rate for the sample.

$$\text{Linear propagation rate} = \frac{D\ v}{T}$$

Where:

D is the distance between thermocouples in centimeters (see Figure 4).
v is the chart speed in cm/sec.
T is the distance measured from peak to peak (see Figure 5).

4.5.6 High temperature stability.

4.5.6.1 Apparatus. Thermal stability characteristics of the hydraulic fluid shall be determined using the following test apparatus: A 50 ml round bottom flask (Ace Glass Inc., Vineland, NJ 08360, or equivalent); a 75 degree angle adapter (24/40) (Ace Glass Inc., or equivalent); gas inlet tube (6 mm OD pyrex tubing); a high temperature bath, capable of maintaining temperature of 205 ± 2°C.

4.5.6.2 Procedure. Place 25 ml of candidate fluid in flask fitted with 75 degrees angle adapter and gas inlet tube. The height of the gas inlet tube should be adjusted to within 1.0 cm above the level of the fluid. Place a 2.5 cm length of .635cm OD stainless steel tubing, Type 304, in the fluid. Heat the fluid for 100 hours at a temperature of 205 ± 2°C while maintaining a 1 liter per hour flow of dry nitrogen (lamp grade) on the surface of the fluid via the gas inlet tube. Upon completion of the test, the fluid shall meet the requirements of 3.3.12.

4.5.7 Color of finished fluid. The color of the hydraulic fluid shall be compared with a standard sample prepared by adding 1 part of dye "Oil Red 235" to 10,000 parts of an oil not darker than ASTM D 1500 Color Number 1.0.

4.5.7.1 Oil red dye source. "Oil Red 235" is manufactued by Passaic Color and Chemical Company.

4.5.8 Examination of filled containers. Each sample of filled container and shipping container shall be examined for defects of construction of the container and closure, evidence of leakage and net content. Any container in the sample having one or more defects or under required fill shall be rejected, and if the number of defective containers in any sample exceeds the acceptance number for the appropriate sampling plan of MIL-STD-105, the lot represented by the sample shall be rejected. Rejected lots may be resubmitted for quality conformance inspection, provided that the contractor has removed or repaired all non-conforming containers.

5. PACKAGING

* 5.1 Preservation and packing. The preservation and packing of the hydraulic fluid shall be in accordance with MIL-STD-290. The levels of preservation and packing shall be as specified (see 6.2.1). Unless otherwise specified, the fluid shall be furnished in 1-quart and 1-gallon metal cans conforming to Type I of PPP-C-96. All materials used in the construction of the containers shall be such as will not affect or be affected by the contained hydraulic fluid. Just prior to filling, all containers shall be

thoroughly cleaned, rinsed with clean filtered fluid and examined to insure absolute absence of loose solder, dirt, fibers, lint, metal particles, seaming compound, corrosion products, water or other foreign contaminants. The bottom seam shall show no extruded seaming compound and there shall be no seaming compound on the body immediately adjacent to the side seam. Visible seaming compound, evenly distributed and forming a very fine edge at the point of contact of the seam with the body, shall not be cause for rejection. If a soldered seam is used in the fabrication of the can, residual soldering flux shall not be present on the inside seam of the container.

* 5.2 Marking. The marking of the hydraulic fluid containers shall be in accordance with MIL-STD-290 and Title 49 of the Code of Federal Regulations and any other special markings specified by the acquiring activity (see 6.2.1). All unit and intermediate packs of toxic and hazardous chemicals and materials shall also be labeled in accordance with the applicable laws, statutes, regulations or ordinances, including Federal, State and Municipal requirements. In addition unit and intermediate containers, including unit containers that serve as shipping containers, such as pails and drums, shall be marked with the applicable precautionary information detailed in ANSI Z129.1.

6. NOTES

6.1 Intended use. The hydraulic fluid covered by this specification is intended for use from -40°to +205°C in automatic pilots, shock absorbers, air compressor gear boxes, brakes, flap-control mechanisms, missile hydraulic servo-controlled systems and other hydraulic systems using synthetic sealing material.

6.1.1 Storage conditions. Prior to use in the intended equipment, the product may be stored under conditions of covered or uncovered storage in geographic areas ranging in temperature from -40°to +50°C.

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number and date of this specification.

b. Type and size of containers (see 5.1).

c. Quantity.

d. Selection of applicable levels of preservation and packing with requirements in detail (see 5.1).

e. Specify FAR Clauses 52.223-3.

f. Any special markings required (see 5.2).

6.2.2 Purchase unit. The fluid covered by this specification should be purchased by volume, the unit being a U.S. gallon of 231 cubic inches at 15.6°C.

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time set for opening of bids, qualified for inclusion in Qualified Products List (QPL-83282) whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. The actvity responsible for the Qualified Products List is the Commander, Naval Air Systems Command, Attn: AIR-5304C2, Department of the Navy, Washington, DC 20361; however, information pertaining to qualification of products and letter of authorization may be obtained from the Aircraft and Crew Systems Technology Directorate, Code 60612, Naval Air Development Center, Warminster, PA 18974.

6.3.1 Qualification information. It is understood that the material furnished under this specification subsequent to final approval should be of the same composition and shall be equal to products upon which approval was originally granted. In the event that the fluid furnished under contract is found to deviate from the composition of the approved product, or that the product fails to perform satisfactorily, approval of such products will be subject to immediate withdrawal from the Qualified Products List.

6.4 Standard rubber samples. Samples of the standard synthetic rubber NBR-L (see 3.3.4) for the test specified in Table VIII may be obtained from the Precision Rubber Products Corp. Aerospace Division, 1217 South 26 Place, Phoenix, AZ 85035.

6.5 International standardization agreements. Certain provisions of this specification (see 1.1) are the subject of international standardization agreement, ASCC Air Standard 15/1, NATO STANAG NAT-STD-1135. When amendment, revision, or cancellation of this specification is proposed, which will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accomodations.

* 6.6 Contractual notes. In addition to Qualification and Quality Conformance Testing, the Air Force will perform final acceptance testing on each contract awarded. Specific requirements and instructions addressing this matter will be called out in each contract. Questions in regard to this action should be forwarded to: Commander, San Antonio ALC, Attn: SFTT, Kelly AFB, TX 78241.

* 6.7 Changes from previous issues. The margins of this specification are marked with asterisks to indicate where changes (additions, modifications, corrections, deletions) from the previous issue were made. This was done as a convience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

* 6.8 Subject term (Keyword) listing.

Airborne engine compressors, hydraulic fluid for
Aircraft hydraulic fluid
Aircraft and missile hydraulic systems
Fire resistant hydraulic fluid
Hydraulic fluid
Hydraulic fluid for aicraft and missiles
Hydraulic system
Missiles hydraulic fluid
Synthetic hydrocarbon base
Synthetic hydraulic fluid

Custodians:
Army - ME
Navy - AS
Air Force - 20

Preparing activity:
Navy - AS

(Project 9150-0741)

Review activities:
Army - AV, MI, AR
Navy - SH
Air Force - 68

User:
Navy - OS

International Interest:
NATO (see 6.5)

TABLE I. Properties of synthetic hydrocarbon base stock.

Characteristic	Requirement
Viscosity in centistokes at 100°C minimum	3.5
Viscosity in centistokes at 40°C	Report
Viscosity in centistokes at -40°C maximum	2,600
Flash point,°C minimum	205
Fire point,°C minimum	245
Evaporation, weight percent, maximum	14.0
Neutralization number, maximum	0.10
Specific gravity at 15.6°C/15.6°C	Report
Color number, ASTM, maximum	1.0
Pour point,°C maximum	-55

TABLE II. Properties of the finished fluid.

Characteristic	Requirement
Viscosity in centistokes at 205°C, minimum	1.0
Viscosity in centistokes at 100°C, minimum	3.45
Viscosity in centistokes at 40°C, minimum	14.0
Viscosity in centistokes at -40°C, maximum	2,200
Flash point,°C minimum	205
Fire point,°C minimum	245
Auto-ignition temperature, °C, minimum	345
Neutralization number, maximum	0.10
Evaporation, weight percent, maximum	20.0
Bulk modulus (isothermal secant 0 to 6.9 x 10^4 kP$_a$) at 40°C: kP$_a$ minimum	1.379 x 10^6
Pour point,°C maximum	-55

TABLE III. Solid contaminant particles.

Particle size range (largest dimension), microns	Allowable number (max) microscopic count	Each determination automatic count
5-15	2,500	10,000
16-25	1,000	1,000
26-50	250	150
51-100	25	20
Over 100	10	5

TABLE IV. Foaming characteristics of hydraulic fluid.

Test	Foaming tendency	Foam stability
	Foam volume, ml, at end of 5 minute blowing period	Foam volume, ml, at 10 minute settling period
at 25°C	65 ml, maximum	Complete collapse 1/

1/ A ring of small bubbles around the edge of the graduate shall be considered complete collapse.

TABLE V. Wear values.

Load (kg)	Scar diameter mm (max)
1	0.21
10	0.30
40	0.65

TABLE VI Quality conformance tests.

Inspection	Paragraph	
	Requirement	Test method
Pour point	3.3	4.5.2
Flash point	3.3	4.5.2
Fire point	3.3	4.5.2
Neutralization number	3.3	4.5.2
Evaporation (finished fluid)	3.3	4.5.2
Viscosity (finished fluid)	3.3	4.5.2
Specific gravity	3.3.1	4.5.2
Low temperature stability	3.3.3	4.5.2
Solid particle contamination	3.3.5	4.5.2
Foaming characteristics	3.3.6	4.5.2
Water	3.3.7	4.5.2
Effect of evaporation on flammability	3.3.8.3	4.5.2
Lubricity	3.3.9	4.5.2
Color of finished fluid	3.3.13	4.5.7
Inspection of filled containers	5.1	4.5.8

TABLE VII. Sample for particle contamination.

Container	Sample size (ml) 1/	Number of determinations per sample
1 quart	100	1
1 gallon	200	2
5 gallon	300	3
55 gallon	600	6

1/ Each determination shall be made on 100 ml portions of the sample. Should the particle count on any individual determination be considered excessive, two additional determinations on another sample from the same container may be used. The container shall be thoroughly shaken immediately prior to withdrawing each 100 ml portion for such additional determinations. The arithmetic average of the two closer particle counts shall be considered the particle count for the sample.

TABLE VIII. Test methods for hydraulic fluid properties.

Characteristic	Test method	
	FED-STD-791	ASTM
Pour point		D 97
Flash point		D 92
Fire point		D 92
Color (base stock)		D 1500
Evaporation 1/	350	
Specific gravity		D 1298
Viscosity		D 445
Solid particle contamination 2/	3009	
Foaming		D 892
Water		D 1744
Neutralization number		D 664
High temperature-high pressure spray ignition	6052	
Auto-ignition temperature		E 659
Corrosiveness and oxidation stability 3/	5308	
Swelling of synthetic rubber 4/	3603	
Low temperature stability	3458	
Storage stability	3465	
Lubricity 5/		D 4172
Effect of evaporation on flammability 6/	352	

1/ Test temperature 205°C. Test time, 6.5 hours.

TABLE VIII. Hydraulic fluid properties. (continued)

2/ Particulate contamination may also be measured by the use of automatic particle counters in lieu of the optical procedure detailed in Method 3009 of FED-STD-791. HiAc counter, Models PC-202, PC-203, PC-305, or equivalent, counting to the limits specified in Table III. Directions in the manual for the respective instruments shall be followed. A gravimetric determination shall also be made, by ASTM F 313, using a single 0.45 micron filter membrane.

3/ Bath, constant temperature, 135°C. Test time, 168 hours.

4/ Use standard rubber NBR-L (see 3.3.4 and 6.4) within 6 months of date of manufacture.

5/ A 10 ± 0.5 ml sample shall be used, and the test shall be conducted for 1 hour at each load specified in Table V.

6/ Eliminate oven storage and recheck.

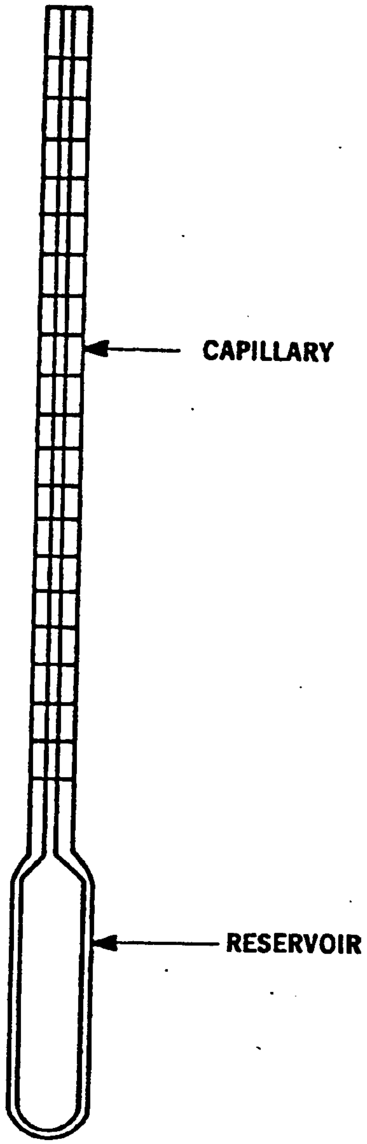


FIGURE 1. Precision capillary pycnometer.

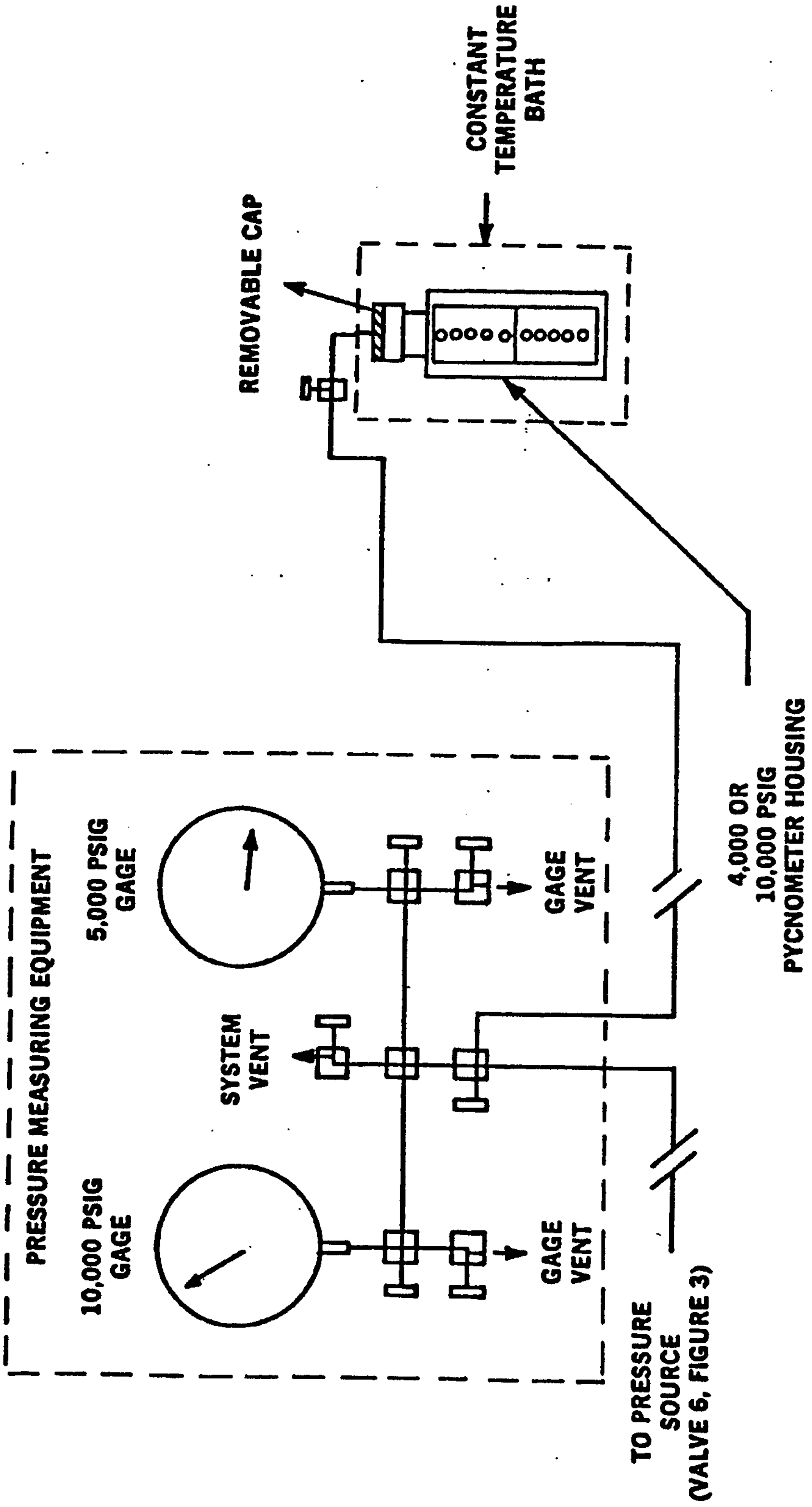


FIGURE 2. Diagram of bulk modulus equipment.

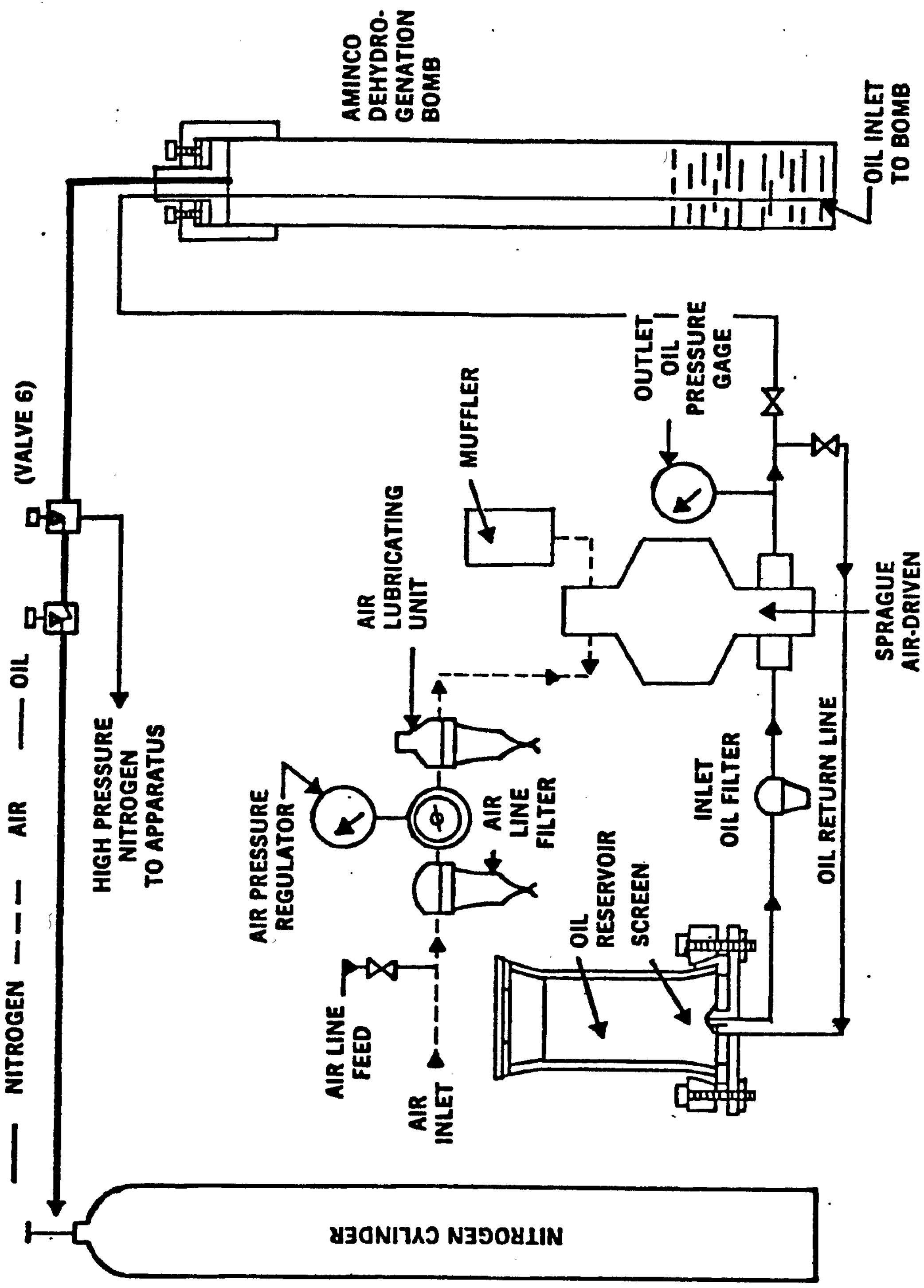
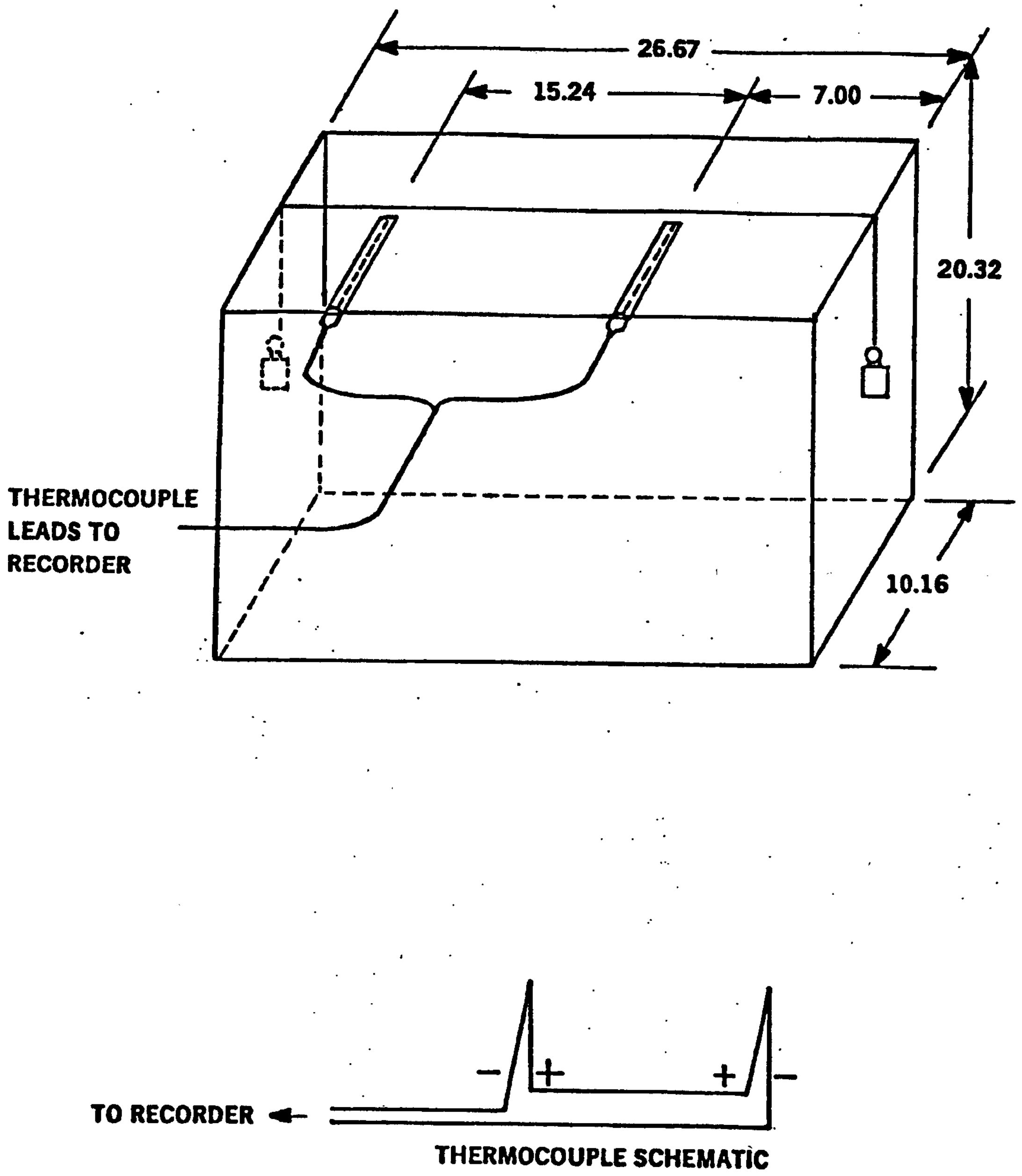


FIGURE 3. Auxiliary equipment



THERMOCOUPLE SCHEMATIC

DIMENSION IN CENTIMETERS

FIGURE 4. Apparatus for the determination of linear flame propagation rates.

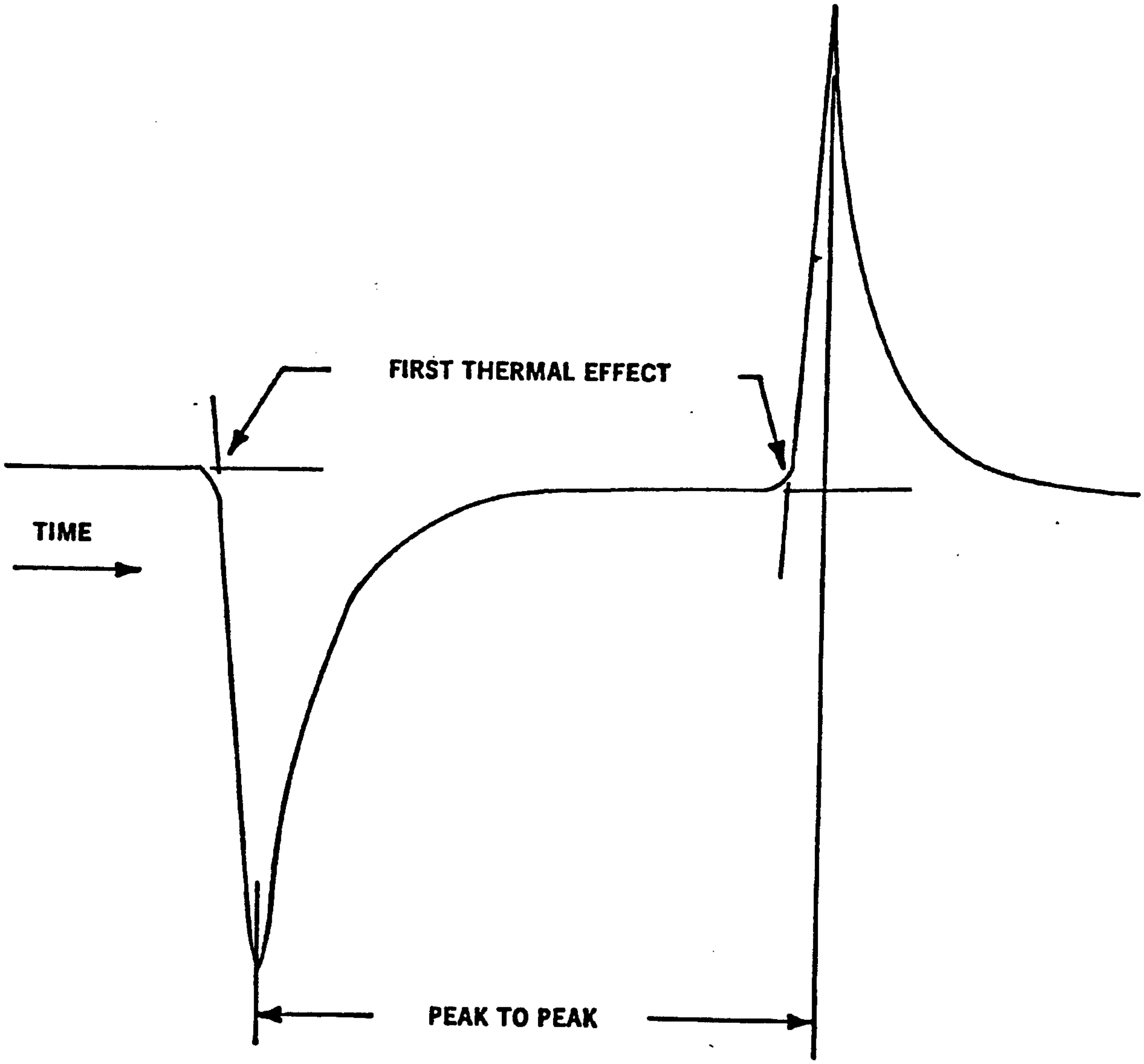


FIGURE 5. Determination of linear flame propagation rates: typical strip-chart record.

NOTICE OF INACTIVATION FOR NEW DESIGN

INCH-POUND

MIL-S-7952A
NOTICE 2
12 December 1994
SUPERSEDING
NOTICE 1
20 January 1989

MILITARY SPECIFICATION

STEEL, SHEET AND STRIP, UNCOATED, CARBON (1020 AND 1025) (AIRCRAFT QUALITY)

This notice should be filed in front of MIL-S-7952A, dated 12 July 1963 and Amendment 1 dated 22 August 1963. Future acquisition for this material should refer to AMS 5046, Sheet, Strip and Plate, Carbon Steel (SAE 1020 and 1025) Annealed.

(Application for copies of AMS publication should be addressed to the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096).

MIL-S-7952A and Amendment 1, is inactive for new design and is no longer used by the Air Force except for replacement purposes.

Custodians:
Army - MR
Navy - AS
Air Force - 11

Preparing activity:
Air Force - 11

(Proj No. 9515-1066)

AMSC N/A

FSC 9515

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

G-27-03

MIL-S-7952A(ASG)
AMENDMENT-1
22 AUGUST 1963

MILITARY SPECIFICATION

STEEL, SHEET AND STRIP, UNCOATED, CARBON (1020 AND 1025) (AIRCRAFT QUALITY)

This amendment forms a part of Military Specification MIL-S-7952A(ASG), 12 July 1963, and has been approved by the Department of the Air Force and by the Bureau of Naval Weapons.

Page 1, preamble: Delete, and substitute:

"This specification has been approved by the Department of the Air Force and by the Bureau of Naval Weapons."

Custodians:
Navy - Weps
Air Force - ASD

Preparing activity:
Air Force - ASD

FSC 9515

M

THIS DOCUMENT CONTAINS 1 PAGES.

G-27-03

MIL-S-7952A(ASG)
12 JULY 1963
Superseding
MIL-S-7952
29 August 1952

MILITARY SPECIFICATION

STEEL, SHEET AND STRIP, UNCOATED, CARBON (1020 AND 1025) (AIRCRAFT QUALITY)

This specification has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy, and the Air Force.

1. SCOPE

1.1 This specification covers low-carbon steel, sheet or strip, of aircraft quality.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

SPECIFICATIONS

Military

MIL-L-7870	Lubricating Oil, General Purpose, Low Temperature

STANDARDS

Federal

Fed. Test Method Std. No. 151	Metals; Test Methods
Fed. Std. No. 183	Continuous Identification Marking of Iron and Steel Products

Military

MIL-STD-163	Steel Mill Products Preparation for Shipment and Storage

Air Force-Navy Aeronautical

AND10355	Tolerances - Carbon Steel Sheet and Strip

FSC 9515

THIS DOCUMENT CONTAINS 5 PAGES.

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Manufacturing process.- The steel shall be manufactured by the open-hearth, basic-oxygen, or electric-furnace process. Sheet and strip shall be annealed, and finished by cold rolling. Sufficient discard shall be taken from each ingot to insure freedom from injurious piping and undue segregation.

3.2 Chemical composition.- The chemical composition shall conform to the acceptable limits specified in table I.

3.2.1 If the composition, 1020 or 1025, is not specified, either composition may be furnished at the option of the manufacturer.

TABLE I. Chemical composition

Elements	Analysis percent by weight		Check analysis tolerance (percent) 1/
	1020	1025	
Carbon	0.18 - 0.25	0.22 - 0.30	+0.03, -0.04
Manganese	0.30 - 0.60	0.30 - 0.60	±0.03
Phosphorus	0.040 max.	0.040 max.	+0.01
Sulfur	0.050 max.	0.050 max.	+0.01

1/ The average of the determinations shall be within the limits specified under the "analysis" column. Individual determinations may vary to the extent indicated in the "check analysis tolerance" column, except that several determinations of a single element in any one heat shall not vary both above and below the specified range.

3.3 Physical properties.- The physical properties shall be as specified in table II.

TABLE II. Physical properties

Tensile strength (min)	Yield strength at 0.2 percent offset		Elongation in 2 inches (min)
	(min)	Extension under load	
psi	psi	inch in 2 inches	percent
55,000	36,000	0.0065	22 1/

1/ For each 2,000 pounds per square inch in excess of 55,000 pounds per square inch tensile strength, a reduction in elongation of 1 percent to a minimum of 10 percent will be allowed.

3.4 Bending.- Test specimens shall withstand bending at room temperature through an angle of 180 degrees around a diameter equal to the thickness of the specimen, without cracking on the outside of the bent portion.

3.5 Tolerances.- The permissible variation in dimensions shall be as specified in Standard AND10355.

3.6 Product identification.- The marking of sheet and strip steel shall be in accordance with Federal Standard No. 183 and shall include nominal thickness. A suitable marking fluid which is not soluble in water or lubricating oil conforming to Specification MIL-L-7870 shall be used. The markings produced shall not rub off or be smeared by contact incident to normal handling during shipment and storage.

3.7 Workmanship.- All sheet or strip shall be clean, smooth, free from seams, laminations, blisters, appreciable scale, or other defects, and shall have a good finish.

3.7.1 The grain size shall be fine and uniform in all parts of the sheet or strip. The sheet or strip shall not be decarburized to such an extent that the specified physical properties are affected.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection.- Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of tests.- All the tests required herein are classified as quality conformance tests, for which necessary sampling techniques and methods of testing are specified.

4.3 Sampling plans.-

4.3.1 Sampling for chemical analysis.- Sampling for chemical analysis shall be in accordance with Method 111 or 112 of Federal Test Method Standard No. 151.

4.3.1.1 Waiver.- Samples for check chemical analysis may be waived at the discretion of the inspector, provided that all of the material under inspection can be identified as being made from a heat previously analyzed and found to conform to the chemical composition specified in 3.2.

4.3.2 Sampling for tensile test.- Sampling for tensile strength shall be in accordance with Method 211 of Federal Test Method Standard No. 151, using type F1 or F2 specimens. Test specimens shall be prepared with the longitudinal axis transverse to the direction of rolling, when the width of the material permits.

4.3.2.1 Number of samples.- One or more tensile test samples shall be selected from each coil submitted for acceptance. When material is produced in sheet form, one or more tensile test samples shall be selected from each 500 or less sheets of the same heat and condition, of the same thickness, and submitted for acceptance at one time.

4.3.3 Sampling for bend test.- Two or more bend test samples (one from each end of the coil) shall be selected in accordance with Method 231 of Federal Test Method Standard No. 151 from each coil submitted for acceptance. When material is produced in sheet form, one or more bend test samples shall be selected in accordance with Method 231 of Federal Test Method Standard No. 151 from each 500 or less sheets of the same heat and condition, of the same thickness, and submitted for acceptance at one time.

4.3.3.1 Preparation of specimens.- Strip specimens shall be cut from each sample with the longitudinal axes transverse to the direction of rolling.

4.4 Test methods.-

4.4.1 Examination of product.- Sufficient spot checks shall be made to insure conformance to the requirements of this specification for surface condition, identification, dimensions, and workmanship.

4.4.2 Chemical analysis.- Specimens shall be analyzed in accordance with Method 111 or 112 of Federal Test Method Standard No. 151. In the event of dispute, analysis shall be by Method 111. Results of this test shall be within the limits specified in 3.2.

4.4.3 Tensile test.- Yield strength at 0.2 percent permanent set and ultimate tensile strength shall be determined by Method 211 of Federal Test Method Standard No. 151. Yield strength may be determined by either the offset or extension-under-load method. Results of this test shall be within the limits specified in 3.3.

4.4.4 Bend test.- Specimens shall be bent cold, either by pressure or blows, in accordance with Method 231 of Federal Test Method Standard No. 151. In case of dispute, tests shall be made by pressure. The results of this test shall conform to the requirements of 3.4.

4.5 Rejection criteria.- If a test specimen fails to conform to any of the tests required by this specification, the lot represented by the sample shall be rejected.

4.6 Packaging, packing, and marking.- Preparation for delivery shall be inspected for conformance to section 5.

5. PREPARATION FOR DELIVERY

5.1 Preservation, packaging, and packing.-

5.1.1 Level A.- Materials shall be properly separated by composition, condition, and size when prepared for delivery. Materials shall be preserved and packaged in accordance with Standard MIL-STD-163.

5.1.2 Level C.- Materials shall be prepared for delivery in accordance with the manufacturer's commercial practice.

5.2 Marking of shipments.- Marking and labeling shall be in accordance with Standard MIL-STD-163.

6. NOTES

6.1 Intended use.- The steel is intended for use in the manufacture of aircraft fittings and miscellaneous parts. It is not suitable for deep forming or cupping operations.

6.2 Ordering data.- Procurement documents should specify:

(a) Title, number, and date of this specification.
(b) Composition, size, thickness, and condition of the steel.
(c) Level of preservation, packaging, and packing required (see section 5).

6.3 Marginal indicia.- The margins of this specification have been marked to indicate where changes, deletions, or additions from the previous issue have been made. This has been done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content as written, irrespective of the marginal notations and relationship to the last previous issue.

Custodians:
Navy - Weps
Air Force - ASD

Preparing activity:
Air Force - ASD

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29 November 1985
SUPERSEDING
MIL-I-6866B
26 February 1964

MILITARY STANDARD

INSPECTION, LIQUID PENETRANT

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

NO DELIVERABLE DATA
REQUIRED BY THIS DOCUMENT

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MIL-STD-6866

DEPARTMENT OF DEFENSE
Washington, DC 20402

Inspection, Liquid Penetrant

1. This military standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: AFWAL/MLSE, Standardization Manager, Wright-Patterson AFB, Ohio 45433-6533, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

MIL-STD-6866

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1. SCOPE

1.1 Purpose. This standard establishes the minimum requirements for conducting liquid penetrant inspection of nonporous, metal and nonmetal components.

1.2 Application. The penetrant inspection processes described in this standard are applicable to in-process, final, and maintenance (in-service) inspections. These processes are applicable for the detection of discontinuities that are open or connected to the surface of the component under inspection.

1.3 Classification. Penetrant inspection processes are classified in accordance with the material classification contained in MIL-I-25135.

1.3.1 Penetrant systems. Penetrant systems covered by this standard shall be of the following types, methods and sensitivity levels.

Type

Type I - Fluorescent dye.
Type II - Visible dye.
Type III - Visible and fluorescent dye (dual mode).

Method

Method A - Water-washable.
Method B - Post emulsifiable, lipophilic.
Method C - Solvent removable.
Method D - Post emulsifiable, hydrophilic.

Sensitivity

Sensitivity Level 1 - Low.
Sensitivity Level 2 - Medium.
Sensitivity Level 3 - High.
Sensitivity Level 4 - Ultrahigh.

1.3.2 Developers. Developers shall be of the following forms:

Form a - Dry powder.
Form b - Water soluble.
Form c - Water suspendable.
Form d - Nonaqueous.
Form e - Specific application.

1.3.3 Solvent removers. Solvent removers shall be of the following classes:

Class (1) - Halogenated.
Class (2) - Non-halogenated.
Class (3) - Specific application.

2. REFERENCED DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. Unless otherwise specified, the following specifications and standards, of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitation form a part of this standard to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-I-25135	Inspection Materials, Penetrant
MIL-P-47158	Penetrant Inspection, Soundness Requirements for Materials, Parts, and Weldments

STANDARDS

MILITARY

MIL-STD-410	Nondestructive Testing Personnel Qualification and Certification
MIL-STD-792	Identification Marking Requirements for Special Purpose Components
MIL-STD-45662	Calibration Systems Requirements

(Copies of specifications, standards, drawings, and publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this standard to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the solicitation. The issues of documents which have not been adopted shall be those in effect on the date of the cited DODISS.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D95	Water in Petroleum Products and Bituminous Materials by Distillation, Test for
ASTM D2512	Compatibility of Materials with Liquid Oxygen (Impact Sensitivity Threshold Technique), Test for

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia PA 19103.)

(Industry association standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the requirements of this standard and the references cited herein, the requirements of this standard shall take precedence.

3. DEFINITIONS

3.1 Background. The surface of the component against which an indication is viewed.

3.2 Black light. Electromagnetic radiation in the near-ultraviolet range. Wavelength is from 320 to 400 nm.

3.3 Black light filter. A filter that transmits near-ultraviolet radiation while absorbing other wavelengths.

3.4 Bleedout. The action of entrapped liquid penetrant in surfacing from discontinuities to form indications.

3.5 Component. The part(s) or element(s) of a system described, assembled, or processed to the extent specified by the drawing.

3.6 Contaminant. Any foreign substance present on the test surface or in the inspection materials which will adversely affect the performance of liquid penetrant materials.

3.7 Contracting agency. A prime contractor, subcontractor or Government agency procuring liquid penetrant inspection services.

3.8 Dark adaptation. The adjustment of the eye that enhances visual perception in a darkened area.

3.9 Defect. A discontinuity or group of discontinuities that exceed the specified acceptance criteria for a component.

3.10 Developer. A material applied to the test surface to accelerate bleedout and enhance the contrast of indications.

3.11 Developer, dry. A fine, free-flowing powder used as supplied.

3.12 Developer, nonaqueous. A developer that is either dissolved or suspended in a volatile solvent (other than water) as supplied, and rapidly dries to an adsorptive (or absorptive) coating.

3.13 Developer, wet (aqueous) soluble. A developer, normally supplied as a dry concentrate, that is completely soluble in water, and dries to an absorptive (or adsorptive) coating.

3.14 Developer, wet (aqueous) suspendible. A developer, normally supplied as a dry powder concentrate, that is suspended in water and dries to an adsorptive (or absorptive) coating.

3.15 Drain time. The portion of dwell time during which excess penetrant or emulsifier drains from the component.

3.16 Drying oven. The oven used to increase the evaporation rate of rinse water or an aqueous developer from component.

3.17 Dwell time. The total time that a penetrant, emulsifier or remover, or a developer spends in contact with the component. For aqueous and nonaqueous developers, the dwell time starts after the developer is dry on the component.

3.18 Emulsifier. A liquid that renders the excess penetrant on the component surface water-washable.

3.19 Emulsifier, hydrophilic. An emulsifier that is water-soluble.

3.20 Emulsifier, lipophilic. An emulsifier that is oil-soluble and not water-soluble.

3.21 Etching. The uniform removal of surface material by chemical or electrochemical methods (also known as chemical milling).

3.22 Evaluation. The review following interpretation of indications that determines the acceptability of the component.

3.23 Fluorescence. The emission of visible radiation by a material as a result of, and only during, the absorption of black light.

3.24 Government procurement agency. The Government agency for which the system is built or service provided.

3.25 Hydro-air nozzle. Water nozzle that mixes compressed air with water.

3.26 Indication. The visible result of penetrant bleedout.

3.27 In-process. That which occurs during manufacturing before a component is in final form.

3.28 In-service. Refers to components that are in use or storage for their intended function.

3.29 Inspection. Visual examination under appropriate illumination of a component after completion of the liquid penetrant processing steps.

3.30 Interpretation. The determination of the cause(s) of indications and the classification of such cause(s).

3.31 Linear indication. Penetrant indications with at least a three to one length to width ratio.

3.32 NDT facility. The organization responsible for providing nondestructive inspection service.

3.33 Penetrant. A solution of dye capable of entering discontinuities open to the surface.

3.34 Penetrant, post emulsifiable. A penetrant that requires the use of a separate emulsifier to render the penetrant water-washable.

3.35 Penetrant, solvent removable. A penetrant used in the process whereby the excess surface penetrant is removed with solvent. Postemulsifiable or water-washable penetrants can also be used in the solvent removable mode.

3.36 Penetrant, water-washable. A penetrant that contains an integral emulsifier or otherwise can be removed with water.

3.37 Postcleaning. The removal of residual penetrant inspection materials after evaluation.

3.38 Precleaning. The component cleaning done immediately before penetrant inspection processing.

3.39 Prime contractor. The organization that has responsibility to the Government for the total system. The prime contractor may be the Government in the procurement of such items as spare parts, special items, or basic materials.

3.40 Relevant indication. An indication of a true discontinuity.

3.41 Reprocess. Repeat, after cleaning, the application and appropriate processing of penetrant, emulsifier (as required) and developer (as required).

3.42 Solvent remover. A volatile solvent that is used to remove excess surface penetrant.

4. GENERAL REQUIREMENTS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the prime contractor is responsible for the performance of all inspection requirements as specified herein. The prime contractor shall specify more stringent requirements than the minimum specified in this standard when necessary to assure that a component meets its functional and reliability requirements. Except as otherwise specified, the supplier may utilize his own facilities or any other facilities suitable for the performance of the inspection requirements specified herein. The Government reserves the right to perform any of the inspections set forth in the standard where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Specifying. When inspection is required in accordance with this standard, orders, contracts or other appropriate documents shall indicate the criteria by which components are judged acceptable. An example of such criteria is contained in MIL-P-47158; however, other criteria may be utilized. Engineering drawings or other applicable documents shall indicate the acceptance criteria for the entire component; zoning may be used. Inspection on a sampling basis shall not be allowed unless specifically permitted by the contract.

4.3 Personnel qualification. Personnel making accept/reject decisions described in this standard shall be qualified to at least Level II in liquid penetrant inspection in accordance with MIL-STD-410. Personnel performing the processing as described in this standard shall be qualified to at least Level I in liquid penetrant inspection in accordance with MIL-STD-410. If a Level I performs the processing, it shall be under the direct supervision or observation of a Level II or higher individual.

4.4 Materials.

4.4.1 Qualified materials. Only materials listed or approved for listing on QPL-25135 (reference MIL-I-25135) shall be utilized for penetrant inspection. Materials not conforming to the requirements of MIL-I-25135 may be used only when a waiver is obtained from the contracting agency.

4.4.2 LOX compatible materials. Penetrant materials tested in accordance with ASTM D2512 and passing at 70 foot-pounds (95J) or higher, shall be used on LOX (Liquid Oxygen) wetted surfaces which cannot be thoroughly post-cleaned. Use of these materials shall be in accordance with the material supplier instructions and shall require approval of the contracting agency when such materials do not meet the requirements of MIL-I-25135.

4.5 Equipment and facilities.

4.5.1 Processing. The penetrant inspection processing equipment shall be constructed and arranged to permit a uniform and controlled operation.

The equipment shall meet all applicable national and local safety requirements as well as the requirements specified herein.

4.5.2 Viewing. Viewing areas shall be kept clean at all times. For visible dye inspection, Type II, the lighting system shall provide at least 100 foot-candles (1000 lx/m^2)of white light at the surface of the component being inspected. For stationary fluorescent dye inspection, Type I, the ambient white light background shall not exceed 2 foot-candles (20 lx/m^2) and the black lights shall provide a minimum of 800 micro watts/cm^2 when measured 15 inches (38 cm) from the front face of the black light filter or bulb. Viewing areas for portable fluorescent dye inspection shall utilize dark canvas, photographer's black cloth, or other methods to reduce the white light background to the lowest possible level during inspection and black light intensity shall be adequate.

4.6 Written procedure. All liquid penetrant inspections shall be performed to a specific written procedure that implements the requirements of this standard for the components under test. Since the inspection procedures are similar for many components, a master written procedure may be utilized that covers the details common to a variety of components. As a minimum, the following information is required either in individual procedures, a master procedure, or a combination thereof:

a. Details of the precleaning and etching process, including the materials used, the drying parameters and the processing times. If these operations are performed by other than inspection personnel, details concerning the operations may be specified in other documents but must be referenced in the procedure(s).

b. Classification of the penetrant inspection materials required in accordance with MIL-I-25135.

c. Complete processing parameters for the penetrant inspection materials including dwell times, application methods, drying times, concentrations, temperatures, and controls to prevent excessive drying of penetrant or overheating of component, as appropriate.

d. Complete inspection/evaluation requirements including light intensities (both inspection and ambient), the accept/reject criteria and the method and location of marking (see 5.9).

e. Identification of the components or areas within a component to be inspected in accordance with the procedure.

f. Complete postcleaning procedures. If postcleaning is performed by other than inspection personnel, details concerning this operation may be specified in other documents, but must be referenced in the procedure.

4.7 Inspection sequence. Final penetrant inspection shall be performed after completion of all operations that could cause surface connected discontinuities. Such operations include, but are not limited to, grinding, welding, straightening, machining, and heat treating.

4.7.1 Surface treatment. Final penetrant inspection may be performed prior to treatments that can smear the surface but not by themselves cause surface discontinuities. Such treatments include, but are not limited to, vapor blasting, deburring, sanding, buffing, sandblasting, lapping, or peening. Performance of final penetrant inspection after such surface treatments requires that etching be included in the precleaning operation.

4.7.2 Surface coatings. Final penetrant inspection shall be performed before surface coatings such as paint, primer, anodize, plating, and thermal barrier, are applied. Final penetrant inspection may be performed after conversion coatings are applied provided that preparation for the coating included an etch. Chrome plated surfaces shall be inspected after final grinding only when specifically required. In-service components, unless otherwise specified, shall be inspected after removal of surface coatings and etching.

4.8 Materials and process limitations. Not all penetrant sensitivity levels, materials, and process methods are applicable to all inspection requirements. The sensitivity level shall be adequate for the intended purpose of the inspection. Unless there is an approval for deviation given by the contracting agency, the following selections are mandatory or forbidden, as indicated:

a. Forms a and b (dry powder and water soluble) developers shall not be used with Type II (visible dye) penetrant systems. This is not intended to prohibit the use of a Form e developer that has been qualified with a particular Type II system in accordance with MIL-I-25135.

b. Type II penetrant inspection shall not be used for final acceptance inspection of aerospace products. In addition, Type II penetrant inspection shall not be used prior to a Type I penetrant inspection of the same surface. This is not intended to eliminate the use of in-process Type II inspections where subsequent fabrication/forming operations remove the surfaces inspected.

c. The maintenance or overhaul inspection of turbine engine critical components shall be done only with Type I, Method D (post emulsified, hydrophilic) processes and either sensitivity Levels 3 or 4 penetrant materials.

d. Penetrant inspection without a developer shall be allowed only for those penetrant systems listed in QPL-25135 as having met the appropriate sensitivity level requirement without a developer. However, the use of a developer is mandatory for any in-service inspection.

4.9 Records. The results of all penetrant inspections shall be recorded. All recorded results shall be identified, filed, and made available to the contracting agency upon request. Records shall provide for traceability to the specific part or lot inspected. As a minimum, the records shall include: a reference to the specific procedures used; location, classification, and disposition of relevant indications; the inspector's signature and certification level; and the date of inspection.

5. SPECIFIC REQUIREMENTS

5.1 Surface Preparation. All surfaces to be inspected shall be clean, dry, and free of soils, oil, grease, paint and other coatings, corrosion products, scale, smeared metal, welding flux, chemical residues or any other material that could prevent the penetrant from entering discontinuities, suppress dye performance, or produce unacceptable background. Cleaning methods, including etching, selected for a particular component shall be consistent with the contaminants to be removed and shall not be detrimental to the component or its intended function.

5.1.1 Solvent cleaning. Solvent cleaning, which includes vapor degreasing and ultrasonic cleaning, shall be used for the removal of oils, greases, waxes and as the final cleaning step prior to penetrant inspection.

5.1.2 Chemical cleaning. Chemical cleaning shall be used for the removal of paints, varnishes, scale, carbon, or other contaminants that are not removable by solvent cleaning methods.

5.1.3 Mechanical cleaning. Mechanical cleaning shall be used for the removal of soils and other contaminants that cannot be removed by solvent or chemical cleaning methods.

5.1.4 Etching. Etching, unless otherwise specified, shall be performed when evidence exists that previous cleaning, surface treatments, or service usage has produced a surface condition that degrades the effectiveness of penetrant inspection. Etching processes shall be developed and controlled to prevent damage to the component under test. Etching is not required for those features such as close tolerance holes, close tolerance surfaces, faying surfaces, etc., where the function of the component or assembly would be degraded. Etching is not required for intermediate inspections when the surfaces(s) are not retained in the final part/component configuration or when the final penetrant inspection is preceded by etching.

5.2 Penetrant application and dwell. Unless otherwise specified, the entire surface of the component shall be covered with penetrant. Those areas not to be covered with penetrant shall be masked or otherwise protected. Penetrant shall be applied by spraying, dipping or brushing to provide coverage as required. The component, penetrant, and ambient temperatures shall all be in the range of 4° - 49°C (40° - 120°F) unless otherwise specified. The dwell time, unless otherwise specified, shall be a minimum of 10 minutes. Rotate or otherwise move components, if required, during dwell to prevent pooling of the penetrant. For dwell times greater than 2 hours, the penetrant shall be reapplied as required to prevent drying. The component shall be immersed in penetrant, if that is the application method, no more than 1/2 the total dwell time.

5.3 Penetrant removal.

5.3.1 Method A process. Water-washable penetrants shall be removed with a manual or automated water spray or a manual wipe. Immersion in agitated water shall be permitted only for Level 1 and Level 2 sensitivity processes.

5.3.1.1 Manual spray. Maximum water pressure shall be 275 kPa (40 psi). Water temperature shall be between 10° - 38°C (50° - 100°F). A coarse spray shall be used with a minimum of 30 cm (12 inches), when possible between the spray nozzle and the part. Hydro-air nozzles shall be permitted only for Level 1 or Level 2 sensitivity processes with a maximum of 172 kPa (25 psi) added air pressure. Washing shall be conducted under appropriate illumination to assure that over-washing does not occur. Washing times shall be held to a minimum to prevent over-washing. If over-washing occurs, the component(s) shall be thoroughly dried and reprocessed. After rinsing, drain water from the component and utilize repositioning, suction, blotting with clean absorbent materials, or filtered shop air at less than 170 kPa (25 psi) to prevent pooling.

5.3.1.2 Automated spray. For automated spray systems, the wash parameters shall be such that the requirements of this standard are met. Water temperature shall be maintained between 10° - 38°C (50° - 100°F).

5.3.1.3 Manual wipe. Excess penetrant shall be removed with a clean, dry, lint free cloth or absorbent toweling. The remainder of the surface penetrant shall then be removed with a water dampened cloth or towel. The surface shall not be flushed with water and the cloth or towel shall not be saturated with water. The component shall be examined under appropriate illumination to assure adequate removal of the surface penetrant. Over-removal of the surface penetrant shall require that the component be cleaned and reprocessed. The surface shall be dried by blotting with a clean, dry towel or cloth, or by evaporation.

5.3.2 Method B process. Lipophilic post emulsified penetrant systems shall be removed by water immersion or with a water spray rinse after application of an emulsifier and an appropriate emulsifier dwell time.

5.3.2.1 Lipophilic emulsifier application and dwell. Lipophilic emulsifiers shall be applied by immersion or flowing. Lipophilic emulsifiers shall not be applied by spray or brush and shall not be agitated while on the surface of the component. Maximum dwell times, unless otherwise specified, shall be 3 minutes for Type I systems and 30 seconds for Type II systems. Actual dwell times shall be the minimum necessary to produce an acceptable background on the component.

5.3.2.2 Rinsing. After the appropriate emulsifier dwell time, emulsification shall be stopped by immersion or water spray. For spray removal of the penetrant/emulsifier mixture, the parameters of 5.3.1 apply. Dwell time in an agitated immersion rinse, if used, shall be the minimum required to remove the emulsified penetrant. Examine the components under appropriate illumination after rinsing. Clean and reprocess those components with excessive background. The water used in rinsing shall be free of any contaminant that will leave a residue on the component when dried. After rinsing, drain water from the component and utilize repositioning, suction, blotting with clean absorbent materials or filtered shop air at less than 170 kPa (25 psi) to prevent pooling. If over-emulsification is observed, the component must be cleaned and reprocessed.

5.3.3 Method C process. Solvent removable penetrants are removed by first wiping the excess penetrant with a clean, lint free, dry cloth or absorbent toweling. The remainder of the surface penetrant is then removed with a solvent dampened lint free cloth or towel. The surface of the component shall not be flushed with solvent and the cloth or towel shall not be saturated with solvent. The component and cloth or toweling shall be observed under appropriate illumination to assure adequate removal of the surface penetrant. Over-removal of the surface penetrant shall require the component to be cleaned and reprocessed. The surface shall be dried by blotting with a lint free dry cloth or towel, or by evaporation.

5.3.4 Method D process. Hydrophilic post emulsified penetrant systems shall be removed with a water prerinse, application of the hydrophilic emulsifier and then a postrinse.

5.3.4.1 Prerinse. The water prerinse shall be applied for the minimum amount of time required to achieve removal of the bulk surface penetrant. The rinse parameters of 5.3.1 shall apply.

5.3.4.2 Hydrophilic emulsifier application and dwell. The hydrophilic emulsifier shall be applied by immersion, flowing, foaming, or spray. For immersion applications, the concentration shall be no higher than specified by the penetrant system supplier and shall not exceed 35 percent by volume. For immersion applications, the emulsifier or part shall be mildly agitated. Dwell time shall be the minimum required for adequate penetrant removal, but unless otherwise specified, shall not exceed 2 minutes. For spray applications, the concentration shall not exceed 5 percent.

5.3.4.3 Postrinse. After the application and dwell of the hydrophilic emulsifier, the component under test shall be rinsed with water. The water shall be free of contaminants that could leave a residue on the component after drying. The spray rinse parameters of 5.3.1 shall apply. Evidence of over-removal shall require the part to be cleaned and reprocessed. Excessive background may be removed by additional (touch-up) application of the hydrophilic emulsifier provided the maximum allowable dwell time is not exceeded for the hydrophilic emulsifier. Additional rinsing of the touch-up area will be required after application and dwell of the hydrophilic emulsifier. If careful touch-up application of the hydrophilic emulsifier does not produce an acceptable background, the part shall be cleaned and reprocessed. Manual systems shall require the use of appropriate illumination to assure adequate penetrant removal.

5.4 Drying.

5.4.1 Sequence. The components shall be dried prior to the application of dry developer, nonaqueous developer, or inspection without developer. The components may be dried before the application of aqueous soluble or suspendible developers. The components shall be dried after the application of aqueous developers.

5.4.2 Drying parameters. Components shall be air dried at room temperature or in a drying oven. Oven temperature shall not exceed 70°C (160°F) and drying time shall not exceed that necessary to adequately dry the component. Components shall not be placed in the oven with pooled water or pooled aqueous solutions/suspensions.

5.5 Developing.

Unless otherwise specified, developers shall be utilized for penetrant inspection in accordance with the requirements of this standard. Type I penetrants that are qualified to MIL-I-25135 without the standard dry developer are so noted in QPL-25135 and may be used without developer. Minimum and maximum dwell times without developer shall be 10 minutes and 2 hours respectively. For all developing conditions, components that are not inspected before the maximum dwell time shall be cleaned and reprocessed.

5.5.1 Dry developers. Components shall be dry before the developer is applied. Dry developer shall be applied in such a manner as to contact all surfaces to be inspected. Minimum dry developer dwell shall be 10 minutes; the maximum dwell shall be 4 hours. Excess dry developer may be removed after the dwell time by light tapping. Dry developers shall not be used with Type II penetrants.

5.5.2 Nonaqueous developers. Components shall be dry before application of the developer. Nonaqueous developer shall be applied by spraying only. For Type I penetrants the developer shall be applied as a uniform thin coating over the entire surface to be inspected. For Type II penetrants, the developer shall be applied over the entire surface to form a uniform, white coating to provide suitable color contrast for the penetrant indications. The uniformity and thickness of the developer coating is important for both types of penetrant systems. If the developer coating thickness is too heavy for Type I systems such that the metallic surface is completely masked, the component shall be cleaned and reprocessed. The minimum and maximum dwell times for nonaqueous developers are 10 minutes and 1 hour respectively. For nonaqueous suspendible developer, the developer container shall be frequently agitated during application.

5.5.3 Aqueous developers, soluble and suspendible. Aqueous developers may be applied to the component after rinsing, or they may be applied after the component is dry. Aqueous soluble developers shall not be used with Type II penetrants or Type I, Method A penetrants unless otherwise specified. Aqueous suspendible developers, unless otherwise specified, shall not be used with Type I penetrants. Developers shall be applied by spray, flowing or immersion. The applied developer shall not be allowed to puddle and shall completely cover all surfaces to be inspected. Components shall be air dried or oven dried to the requirements of 5.4.2. Minimum and maximum dwell times, after the component is dry, are 10 minutes and 2 hours.

5.6 Inspection. The viewing area shall meet the appropriate requirements of 4.5.2. Components shall be inspected before the maximum developing dwell time, and if required by specific procedures, monitored periodically during the developing dwell time. Components not inspected before the maximum developing dwell time shall be cleaned and reprocessed.

5.6.1 Type I processes. Personnel shall be dark adapted for a minimum of 1 minute prior to inspecting components and shall not wear photochromic or permanently darkened lenses. Black lights shall provide a minimum of 1200 micro watts/cm^2 at the component surface and be positioned so that the inspection of the component is not impeded. All areas of fluorescence shall be interpreted. Components with no indications or only non-relevant indications shall be accepted. Components with relevant indications shall be evaluated against the appropriate acceptance criteria. Components with excessive background fluorescence shall be cleaned and reprocessed.

5.6.2 Type II processes. All indications shall be interpreted. Components with no indications or only non-relevant indications shall be accepted. Components with relevant indications shall be evaluated against the appropriate acceptance criteria. Components with excessive background shall be cleaned and reprocessed.

5.6.3 Evaluation. If allowed by the specific procedure, indications may be evaluated by wiping the indication with a solvent dampened swab, allowing the area to dry, and redeveloping. Redevelopment time shall be as long as the original development time. If no indication re-appears, the original indication is considered false. This procedure may be performed twice for any given original indication. Unless allowed by a specific procedure, indications of cracks, laps, and folds shall be cause for rejection. Indications that exceed the specific acceptance criteria for the component shall be cause for rejection.

5.6.3.1 Mechanical evaluation. When allowed by the specific inspection procedure, indications may be removed by an approved procedure such as sanding, either powered or manual, or grinding to determine the depth and extent of the discontinuity. After the mechanical operation, the area shall be cleaned, etched, and re-inspected. The process used for re-inspection shall be at least as sensitive as the original process.

5.7 Postcleaning. Components shall be cleaned after inspection to remove developers and other inspection material residues if they are detrimental to subsequent operations or the components' intended function.

5.8 Quality assurance provisions. This section provides the controls necessary to assure that the penetrant system materials and equipment provide an acceptable level of performance. The frequency of the required checks is based upon a facility operating for a full, one-shift-operation daily. For facilities operating less frequently, the frequency of daily and weekly checks may be reduced, but must be performed prior to inspections. Other checks should be performed at the same frequency as for full time operations. The NDT facility may perform these process control operations or contract for their performance with an independent laboratory.

5.8.1 Black lights. All black lights shall be checked daily, and after bulb replacement, for output. A longer period may be used if a plan justifying this extension is prepared by the NDT facility and approved by the contracting agency. Minimum acceptable intensity is 800 micro watts/cm^2 measured at a distance of at least 38 cm (15 inches) from the front of the bulb or filter. Black light reflectors and filters shall be checked daily for cleanliness and integrity. Damaged or dirty reflectors or filters shall be replaced or corrected as appropriate.

5.8.2 White light. Viewing areas for Type II penetrant systems shall be checked weekly to assure a minimum of 100 foot-candles (1000 lx/m^2) white light intensity at the working level (for example, bench or table top).

5.8.3 System performance. The penetrant system shall be checked daily for performance. The check shall be made with known defect standards. The check shall be performed by processing the known defect standard through the system using appropriate processing parameters and comparing the indications thus obtained to those obtained with unused samples of the same materials. This comparison may be made with photographs or other such records of previously obtained indications or with a similar known defect standard processed with the unused materials. When the performance of the in-use materials falls below the performance of the unused materials, the in-use material quality shall be checked with the appropriate tests and corrected prior to conducting any penetrant inspection in accordance with this standard.

5.8.3.1 Known defect standards. The selection and procedures for the maintenance of known defect standards shall be approved by the contracting agency. The defects in the standard shall be capable of demonstrating unsatisfactory system performance. The maintenance procedures shall assure that cleaning of the standards between usages is adequate and that physical changes in the standard that make it unsuitable for use can be detected.

5.8.4 Materials. Prior to being placed in use, the conformance of materials to the requirements of MIL-I-25135 shall be verified. Use of materials not conforming to MIL-I-25135 shall be approved by the contracting agency and shall be allowed only when materials conforming to MIL-I-25135 are inadequate for the particular application. Operators shall be alert to any changes in performance, color, odor, consistency or appearance of all penetrant materials in use and shall conduct the appropriate checks and tests if they have reason to believe the quality may have deteriorated. Penetrant inspection shall be conducted in accordance with this standard only after acceptable quality of materials has been established.

5.8.4.1 Penetrants. The following checks on in-use penetrants shall be conducted at least monthly with the exception of brightness which shall be conducted at least quarterly. Unsatisfactory performance shall be cause for replacement of the in-use material or corrective action as appropriate.

5.8.4.1.1 Brightness. Brightness tests of in-use penetrants shall be conducted in accordance with MIL-I-25135 with a sample of the unused penetrant serving as the reference. Brightness values less than 90 percent of the unused penetrant brightness are unsatisfactory.

5.8.4.1.2 Water content (Method A penetrants only). Water content of in-use Method A penetrants shall be measured in accordance with ASTM D 95. Water content in excess of 5 percent by volume is unsatisfactory.

5.8.4.1.3 Removability (Method A penetrants only). The removability of Method A penetrants shall be tested in accordance with MIL-I-25135 with a sample of the unused penetrant serving as a reference. If the removability is noticeably less than the reference, the in-use penetrant shall be replaced.

5.8.4.1.4 Sensitivity. The sensitivity of penetrants shall be checked in accordance with the procedures of 5.8.3 where the in-use penetrant is used with the unused emulsifier, if applicable, and unused developer if applicable and compared to the results obtained using the unused penetrant, unused emulsifier, if applicable, and unused developer. Sensitivity of the in-use penetrant noticeably less than the reference is unsatisfactory.

5.8.4.2 Emulsifiers. The following checks on in-use emulsifiers shall be performed as specified. Unsatisfactory performance shall be cause for replacement of the in-use emulsifier or corrective action as appropriate.

5.8.4.2.1 Removability. Removability of the in-use emulsifier shall be checked weekly in accordance with MIL-I-25135. The in-use emulsifier will be used with the unused penetrant and compared to the reference system of unused emulsifier used with the unused penetrant. Removability less than that of the reference system is unsatisfactory.

5.8.4.2.2 Water content (lipophilic emulsifier). Water content shall be checked monthly in accordance with ASTM D 95. Water content in excess of 5 percent is unsatisfactory.

5.8.4.2.3 Concentration (hydrophilic emulsifier). Concentration of immersion solutions shall be checked weekly with a refractometer. Variation of concentration greater than three percentage points from the initial, unused concentration is unsatisfactory. Spray concentrations shall be checked weekly with the refractometer and shall not exceed the specified concentration for the system.

5.8.4.3 Developers. The following checks on in-use developers shall be performed as specified. Unsatisfactory performance shall be cause for replacement or corrective action as appropriate.

5.8.4.3.1 Dry developer. Dry developer shall be checked daily to ensure it is fluffy and not caked. Caked dry developer is unsatisfactory. For dry developer that is recycled, 10 or more fluorescent specks observed in a 10 cm (4 inch) circle, when a sample is spread into a thin layer on a flat surface, is unsatisfactory.

5.8.4.3.2 Aqueous developer (soluble and suspended). Aqueous developers shall be checked daily for fluorescence, as appropriate, and coverage. Immerse a clean aluminum panel, about 8 cm x 25 cm (3 inches x 10 inches) and remove for drying and observation under a black light, as appropriate. Failure to uniformly wet the panel or observed fluorescence is unsatisfactory. Concentration shall be checked weekly with a hydrometer and shall be in accordance with the developer supplier recommended concentration.

5.8.5 Inspection area. The inspection area for stationary Type I systems shall be checked weekly for cleanliness, freedom from fluorescent contamination, and residual white light background. Background white light shall not exceed 2 foot-candles (20 lx/m^2), and the area shall be free of clutter and fluorescent contamination.

5.8.6 Operating pressures/temperatures. Indicators and controls shall be checked at the start of each shift to assure proper settings. Those indicators displaying out of control settings shall be adjusted to the proper settings. Indicators and controls shall be calibrated at intervals in accordance with MIL-STD-45662.

5.9 Marking. Unless otherwise specified, each component which has been penetrant inspected and found to conform to the requirements of this standard and the acceptance requirements of the contract or purchase order shall be marked as specified herein. Marking shall be applied in a manner and location that is harmless to the component, or its intended function, and to preclude removal, smearing or obliteration by subsequent handling. When subsequent processing would remove such identification, the records accompanying the component shall be marked. The methods of marking are listed below in descending order of preference. Marking shall conform to MIL-STD-792.

5.9.1 Impression stamping. Impression stamping shall be used where explicitly permitted by applicable specifications or drawings. Marking shall be located in areas adjacent to the part number or the inspector's stamp.

5.9.2 Etching. If impression stamping is not permitted, parts may be marked by etching, and suitable etchants and application methods shall be used. Etching methods other than chemical or electrochemical may be used.

5.9.3 Dyeing. Where etching or impression stamping is not permitted, identification may be accomplished by dyeing or ink stamping.

5.9.4 Other identification. Other means of identification, such as tagging, may be applied when the construction, finish, or functional requirements of the component preclude etching, dyeing, or stamping. Items such as bolts or nuts may be identified by conspicuously marking each package.

5.9.5 Symbols. Each component that has successfully passed inspection shall be marked as follows:

a. When etching or stamping is applicable, symbols shall be used. The stamping may contain an identification symbol of the facility and the last two digits of the year of inspection.

(1) Except for specialized applications, use the symbol P to denote 100 percent inspection.

(2) All components, in the lot sampled, accepted on sampling basis shall be marked with the symbol P enclosed by an ellipse.

b. When dyeing is used, maroon dye shall be used to denote components accepted on a 100 percent inspection basis. Yellow dye shall be used to denote a sampling basis.

6. NOTES

6.1 Intended use. The penetrant inspection process is intended for the detection of discontinuities open to the surface, such as lack of fusion, corrosion, cracks, laps, cold shuts and porosity.

6.2 Nonmetallic components. Some cleaners, penetrants, and developers can have a deleterious effect on nonmetallic materials such as plastics. Prior to inspection, tests should be conducted to ensure that any cleaning or inspection materials are not harmful to the components to be examined. Caution must also be exercised in the usage of elevated temperature with components manufactured from thermoplastic materials.

Custodians:
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Navy - AS
Army - MR

Preparing Activity:
Air Force - 20

(Project: NDTI-0055)

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Section E:

Environmental Checklist

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								alifornia EPA Chemical Lists													
Cod	Manufacturer	Product name	Hazardous Ingredients	CAS#		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Aerocote Corp.	Aeroclean DN30	Organic Surfactants		none																
			Sodium Metasilicate	6834-92-0	none																
39	Aerocote Corp.	Aerosolve 2000	Propylene Glycol t-Butyl Ether	67018-62-7	none																
			Ethoxylated Alcohol	68439-46-3	none																
56	Eldorado Chemical	ALK 660	none	n/a	none																
3	Heatbath Corp.	Alu-Kleen 1157	Sodium Tetraborate-penta	1330-43-4	none																
			Nonionic Surfactant	9016-45-9	none																
			Tetrasodium Pyrophosphate	7722-88-5														M	N		
47	Petroferm Inc.	Axarel 56	none	n/a	none																
4	Petroferm Inc.	BioAct 40	none	n/a	none																
38	Petroferm Inc.	BioAct 50	none	n/a	none																
40	Petroferm Inc.	BioAct 113	Propylene Glycol Ether																		
			Terpene Hydrocarbon		none																
5	Ecolink	Blend 300	Dipropylene Glycol Methyl Ether	12002-25-4	none																
			Isopropyl Alcohol	67-63-0					D			G						M	N		P
6	Brulin	Brulin 815 GD	none	n/a	none																
43	Zip-Chem Prod.	Callasolve 120	d-Limonene	5989-27-5	none																
			Dipropylene Glycol Monomethyl Ether	34590-94-8								G						M	N		
42	McGean-Rohco	Cee-Bee Cleaner A	Diethylene glycol butyl ether	112-34-5								G									
7	Inland Technology	Citrex	1-Butoxy,2-Propanol	5131-66-8	none																
			2-Butoxy,2-Propanol	15821-83-7	none																
			n-Methyl Pyrrolidone	872-50-4	none																
			d-Limonene	5989-27-5	none																
8	Solvent Kleene	D-Greeze 500	none	n/a	none																
10	Courtaulds Aerospa	Desoclean 20	1-Methoxy-2-Propanol	107-98-2								G						M	N		P
			Methyl propyl Ketone	107-87-9														M	N		
			Methyl Isobutyl Ketone	108-10-1				C	D			G		I	J			M	N	O	
			Isopropyl Alcohol	67-63-0					D			G						M	N		P
			N-Propanol	71-23-8														M	N		
			Butyl Acetate	123-86-4														M	N		
			Xylene	1330-86-4				C	D						J			M	N	O	P
			Ethyl Benzene	100-41-4			B	C	D		F	G		I	J			M	N	O	

						alifornia EPA Chemical Lists															
Cod	Manufacturer	Product name	Hazardous Ingredients	CAS#		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
10.1	Caurtaulds Aerospa	Desoclean 45	Methyl Ethyl Ketone	78-93-3				C	D			G		I	J			M	N	O	
			Toluene	108-88-3			B	C	D			G	H	I	J	K		M	N	O	
			Isopropyl Alcohol	67-63-0					D			G						M	N		P
			Methyl Isobutyl Ketone	108-10-1				C	D			G	H	I	J			M	N	O	
52	Delta-Omega Tech	DOT 111/113	none	n/a	none																
46	Dynamold	DS-108 Wipe Solve	Isoparaffininc Hydrocarbons (Isopar H Solvent)	64742-48-9	none																
			Ethyl S (-) Hydroxy Propionate	97-64-3	none																
			n Prpoxypropanol Mixed Isomers	1569-01-3	none																
22.1	LPS Laboratories	Electro 140	Isoparaffinic Solvent	64742-48-9																	
			3-Methoxy-3-Methyl-1-Butanol	56539-66-3																	
			Carbon Dioxide (propellant)	124-38-9													L	M	N		P
11	Ecolink	Electron	Hydrotreated Light Distillate	64742-47-8	none																
12	Inland Technology	EP 921	Propylene Carbonate	108-32-7	none																
			d-Limonene	5989-27-5	none																
14	DuBois	Jettacin	Nonyl Phenoxy Polyethoxy Glycol	9016-45-9	none																
15	Betz MetChem	Kleen 182	Tetrasodium Pyrophosphate	7722-88-5														M	N		
			Silicic Acid, Disodium Salt	6834-92-0	none																
			Alkoxylated Fatty Alcohol	69227-21-0	none																
			Sodium Carbonate	497-19-8																	P
			Nonylphenoxypoly (Ethyleneoxy) Ethanol	9016-45-9	none																
			Alcohols, C12-C15 Ethoxylated	68131-39-5	none																
41	Loctite Corp.	Loctite 7070	Hydrotreated heavy naphtha	64742-48-9	none																
			d-Limonene	5989-27-5	none																
22	LPS Laboratories	LPS PreSolve	Solvent Naphtha	64741-65-7	none																
			d-Limonene	5989-27-5	none																
44	Magnaflux	Magnaflux 1-2-3	Poly (oxy-1,2-ethanediyl),a(nonylphenyl)-w-hydrox	9016-45-9	none																
			2-methyl-2,4-pentanediol	107-41-5														M	N		
			Ethanol, 2-(2-Butoxyethanol)	112-34-5								G									
55	PCT Technology	Metal-Aid DR	none	n/a	none																
18	Loctite Corp.	Natural Blue	Propylene Glycol Monomethyl Ether	107-98-2								G						M	N		P
			Amine soap	2272-11-9	none																
20	Ecolink	PartsPrep	1-n-Methyl-2-Pyrrolidone	872-50-4	none																

						alifornia EPA Chemical Lists															
Cod	Manufacturer	Product name	Hazardous Ingredients	CAS#		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
53.1	West Penetone	Penair HD1	d-Limonene	5989-27-5	none																
21	P-T Technologies	PF 32	Monocyclic Terpene	68647-72-3	none																
21.1	P-T Technologies	PF-145HP	Aliphatic Hydrocarbon	64742-48-9	none																
23	Quaker Chemical	Quaker 624-GD	Sodium Hydroxide	1310-73-2								G						M	N		P
			Poly (oxy-1,2-ethanediyl),a(nonylphenyl)-w-hydrox	68412-54-4	none																
			Silicic Acid, Sodium Salt	1344-09-8	none																
			Borates, Tetra, Sodium Salts - Pentahydrate	1330-43-4	none																
23.1	Quaker Chemical	Quaker 697-UT	Potassium Hydroxide	1310-58-3														M	N		P
			Silicic Acid, Sodium Salt	1344-09-8	none																
			Alcohols, C8-10, Ethoxylated Propoxylated	68603-25-8	none																
			Sodium Xylene Sulfonate	1300-72-7	none																
24.1	XxCel Technology	Rebound 4	none	n/a	none																
24	XxCel Technology	Rebound 7	none	n/a	none																
25	Buckeye Intl. Inc.	Shopmaster	Propylene Glycol Phenyl Ether	770-35-4	none																
			Tripropylene Glycol Methyl Ether	25498-49-1	none																
			Sodium Metasilicate Anhydrous	6834-92-0	none																
			Isodecyloxypropyliminodipropionic Acid	64972-19-6	none																
26	Working Solutions	Solvall 5234	4-Methylaminobutyrate Lactam	872504	none																
50	Magnaflux	Spotcheck SKC-S	Light Aliphatic Solvent Naphtha	64742-89-8	none																
			Carbon Dioxide (propellant)	124-38-9													L	M	N		P
51	Magnaflux	Spotcheck SKC-HF	Naphtha, Hydrotreated Heavy	64742-48-9	none																
			Carbon Dioxide (propellant)	124-38-9													L	M	N		P
22.2	LPS Laboratories	Super 140	Aliphatic Hydrocarbon	64742-47-8	none																
			Alkyl Acetate	90438-79-2	none																
			Dipropylene Glycol, n-Butyl Ether	29911-28-2	none																
			Carbon Dioxide (propellant)	124-38-9													L	M	N		P
27	Madison Bionics	Super Chemtrust 90	Aliphatic Petroleum Distillate	64742-47-8	none																
			d-Limonene	5989-27-5	none																
29	Madison Bionics	Take It Off	Sodium Silicate	6834-92-0	none																
			Ethylene Glycol Monobutyl Ether	111-76-2								G						M	N		
			Nonylphenoxypolethoxyethanol	9016-45-9	none																
			Monoethanolamine	141-43-5														M	N		P
31	Inland Technology	Teksol EP	C10-C11 Paraffinic Hydrocarbons	64742-48-9	none																

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Cod	Manufacturer	Product name	Hazardous Ingredients	CAS#		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
			d-Limonene	5989-27-5	none																
32	Turco Products	Turco 4215 NC-LT	Nonylphenoxypoly (Ethyleneoxy) Ethanol	9016-45-9	none																
			Alkyl Polyoxyalkylene Glycol Ether	68154-97-2	none																
			Diethylene Glycol Monobutyl Ether	112-34-5								G									
			Sodium Tetraborate, Pentahydrate	1303-96-4																	P
			Sodium Nitrate	7631-99-4																	P
			Sodium Silico Flouride	16893-85-9																	P
			Sodium Tripolyphosphate	7758-29-4	none																
32.1	Turco Products	Turco Sprayeze LT	Potassium Silicate	1312-76-1	none																
			Potassium Hydroxide	1310-58-3														M	N		P
			Tetrapotassium Pyrophosphate	7320-34-5																	P
34	Heatbath Corp.	Uni Kleen 14B	Sodium Hydroxide	1310-73-2								G						M	N		P
			Sodium Carbonate	497-19-8																	P
			Sodium Metasilicate	6834-92-0	none																
33	Heatbath Corp.	Uni Kleen 1293	Sodium Hydroxide	1310-73-2								G						M	N		P
			Tetrasodium Pyrophosphate	7722-88-5														M	N		
			Sodium Carbonate	497-19-8																	P
			Nonionic Surfactant	9016-45-9	none																
			Nonionic Surfactant	9036-19-5	none																
35	Ecolink	Vortex	Citrus Terpene	5989-27-5	none																
36	Inland Technology	X-Caliber	n-Methyl Pyrrolidone	872-50-4	none																
			d-Limonene	5989-27-5	none																

KEY TO LISTS:

A: Cal OSHA Carcinogen User Register Chemicals
B: EPA List of Priority Pollutants
C: AB1803 - Well Monitoring Chemicals
D: SARA 313 Toxic Release Inventory Chemicals
E: SARA 302 Extremely Hazardous Chemicals
F: MCL (Maximum Contaminants Levels) List
G: AB2588 Air Toxics Hot Spots Chemicals
H: D.H.S. Drinking Water Action Levels
I: AB 1807 - Toxic Air Contaminants
J: NESHAP (National Emission Standard for Hazardous Air Pollutants) Specific Chemicals
K: Proposition 65 Chemicals
L: DOT Inhalation Hazard Chemicals
M: Permissible Exposure Limits for Chemical Contaminants
N: Hazardous Substances List
O: Hazardous Air Pollutants (1990 Amendments to the Federal Clean Air Act)
P: Actively Registered Pesticides in California

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D GARCIA
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1 CDR US ARMY ARDEC
SMCAR CCS C
A SEBASTO
BLDG 1
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AMSRL WM MD
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Alternatives to 1,1,1 Trichloroethane Prior to Adhesive Bonding and Non-Destructive Inspection (NDI)

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12a. DISTRIBUTION/AVAILABILITY STATEMENT

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12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 words)***

The utilization of chlorinated solvents, specifically Class I Ozone Depleting Compounds (ODCs), has been continually scrutinized by the U.S. Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA). This is a direct result of the United States entering into an agreement with several other nations throughout the world to limit the production of these materials (Montreal Protocol 1987). In fact, the EPA has placed very heavy restrictions on the production of 1,1,1 trichloroethane, one of the most commonly known and utilized chlorinated solvents, as of January 1996. This announcement prompted the Aviation and Troop Command (ATCOM) to fund a program designed to identify, test and evaluate commercially available cleaners to replace 1,1,1 trichloroethane during the processing of aviation components. ATCOM requested the Army Research Laboratory - Materials Directorate to develop and execute this test program. Two critical cleaning applications were identified based upon a thorough review of all cleaning processes utilized during part manufacture, and repair at Army depots: cleaning prior to non-destructive inspection (NDI) and cleaning prior to adhesive bonding. This report discusses the rational behind identifying alternative cleaners for these applications, the test and evaluation plan, and the results of the test program.

14. SUBJECT TERMS

adhesive bonding; NDT; solvent cleaning 1,1,1; trichloroethane; solvent replacement; solvent alternatives

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Name
Street or P.O. Box No.
City, State, Zip Code

(Remove this sheet, fold as indicated, tape closed, and mail.)

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