

THE COST EFFECTIVENESS OF FLAME SPRAYED COATINGS
FOR SHIPBOARD CORROSION CONTROL

June 1990

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ABSTRACT

With corrosion control taking up almost 30 percent of the cost of maintaining ships, the maritime industry must respond by utilizing the most effective and economical methods of corrosion control available. Wire sprayed aluminum (WSA) has proven to be an effective corrosion control method for many shipboard applications. Data will be compiled which will assist ship owners in comparing the cost of WSA coatings with selected representative paint systems regarding application, repair, and life cycle costs. We will also describe methods used to repair WSA and compare the life cycle cost of these coatings to conventional paint coating systems. We will also help the user determine ship areas best suited for WSA.

OBJECTIVES

The objective of this project is to develop guidelines for selecting shipboard areas where wire sprayed aluminum coatings would be the most effective method of corrosion control. Within the scope of the project we will determine application costs of WSA and selected representative paint systems. Application parameters and constraints as well as repair methods will be compared. We will also analyze life cycle costs of currently available corrosion control methods and recommend the most cost effective shipboard applications for WSA.

BACKGROUND

Corrosion control takes up almost 30 percent of the cost of maintaining ships. The maritime industry must respond by utilizing the most effective and economical methods of corrosion control to extend the life cycle of components.

Wire sprayed aluminum is a proven, effective corrosion control method for many shipboard applications.

PROJECT OVERVIEW

Various data was compiled to assist the maritime industry in comparing the cost of wire sprayed aluminum coatings with representative paint coatings.

Application, repair, and life cycle costs were identified. Repair methods for wire sprayed aluminum and paint coating systems were described as well as quality assurance and parameters and limitations.

Wire sprayed aluminum and paint facility setup costs were investigated. Current cost information and equipment descriptions are provided.

Corrosion tests were performed in an accelerated salt spray booth for a total of 2,360 hours. For the first 2,000 hour test, the scribing of the faulted samples did not completely penetrate to the base metal. The Panels were scribed a second time to expose the base metal and returned to the salt spray booth for the 360 hour test.

Six corrosion resistant systems were tested. There was a total of eight panels for each system, four faulted and four non-faulted.

System 1: Wire sprayed aluminum and Navy specification seal coating system (per #2138). The surface preparation was SP-5, white metal blast. Test panels 1 through 8.

System 2: Wire sprayed aluminum and commercial seal coat system (International brand paint). The surface preparation was SP-5, white metal blast. Test panels 9 through 16.

System 3: Navy specification: Mare Island series (epoxy polyamide) seal coating system (per #631). The surface preparation was SP-10, near-white metal blast. Test panels 17 through 24.

System 4: Commercial equivalent to Navy specification Mare Island system (International brand paint coating system, "FP" series). The surface preparation was Sp-10, near-white metal blast. Test panels 25 through 32.

System 5: Navy specification "inorganic zinc", Mare Island system. The surface preparation was SP-10, near-white metal blast. Test panels 33 through 40.

System 6: Commercial seal coat system: inorganic zinc with "FP" series topcoats (International brand paints). The surface preparation was SP-10, near-white metal blast. Test panels 41 through 48.

The test panel surface preparation for the selected Navy paint systems was performed in accordance with Naval Ships Technical Manual, Chapter 631. Surface preparation for wire sprayed aluminum test panels was in accordance with Military Standard 2138. All commercial paint systems surface preparation was performed in accordance with manufacturers instructions and specifications.

The results and conclusions of this test are as follows.

The wire sprayed aluminum/commercial seal coat system used in System 2 provided better protection from the salt fog environment than any of the other five systems.

The results from the 360 hour test should be representative of the indications found in the six systems. If the test panels had been scribed to the base metal for the first 2,000 hours, the corrosion and blistering would have been more severe. A more detailed account is provided in the report.

APPLICATION AND LIFE CYCLE COSTS

Application costs are identified within the report. As expected, thermal spray application costs are more than twice that of most paint systems, but certain components, because of their nature, are more cost effective to thermal spray. When looking at life cycles, a list of components are identified in the report. The Navy has, historically over the past ten years, consistently thermal sprayed these components during overhaul periods.

CONCLUSIONS AND RECOMMENDATIONS

Because of sheer numbers, component configuration, and accessibility, we found it impossible to identify cost comparisons for individual components. Though application costs are identified for thermal spray and paint systems, the three aforementioned factors must be known and considered before an accurate cost estimate can be established. Before bidding any thermal spray job, Puget Sound Naval Shipyard either looks at the component or a drawing of the component. Although the report does not give cost comparisons for individual components, the information provided will assist the industry in identifying components aboard naval vessels they may be required to thermal spray during overhauls.

Our recommendation is that this report be used as a guide for application selection, repair, quality assurance, parameter designation, and facility setup pertinent to equipment. We further recommend that thermal spray be used as a facility maintenance tool to combat corrosion. Puget Sound Naval Shipyard currently thermal sprays hundreds of components in dry docks and pier side, extending the life cycle of components in severe environments.

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LIST OF PHOTOGRAPHS

Water Jet Removal System
Containerized Flame Spray Unit
 Portable Skid/Water Wash Booth
 Rail Extending Through Blast Container
 Drop Table/Round Table
 Through Shot From Container Side To Blaster
 Rail Between Blast Container And Spray Container
 Spray Container/Bottle Rack/Bag House/Blast Container/Air Dryer
WSA Panels
Paint Panels
Systems #1 - #6 (Sealed)
System #1, Side A
System #1, Side B
System #2, Side A
System #2, Side B
System #3, Side A
System #3, Side B
System #4, Side A
System #4, Side B
System #5, Side A
System #5, Side B
System #6, Side A
System #6, Side B
Log Bronc Bilge After Arc Spray Aluminum
CV-63 Head Floor (Thermal Spray Complete)
Thermal Sprayed Deck Light
Gauge Brackets (Thermal Sprayed)
Piping Assembly (After Thermal Spray)
Thermal Spraying Of Vent Duct Interior
Valves (Thermal Spray Complete)
Corroded Valve
Thermal Sprayed Foundation
Condenser Being Thermal Sprayed
Condenser (Thermal Spray Complete)
Tie Down (Thermal Sprayed Aluminum)
Thermal Sprayed Deck
Thermal Spraying Inside Of Pipe
Thermal Sprayed Valve

WIRE SPRAYED ALUMINUM

PROCESSES

Wire Flame Spray - A metal spraying process where an oxy fuel flame is the source of heat which melts the metal to resprayed in wire form and propels the molten metal onto the substrate. The flame spray process is the oldest metallizing process.

The flame spray process is portable and primarily used for small components such as valve bodies.

The coating thickness is easily controlled because of the low deposition rate and is an advantageous process for spraying intricate parts.

The wire flame spray process has a lower bond strength than electric arc spray (average bond - 2,000 PSI) .

Electric Arc Spray - An electric arc is the source of heat between two consumable wires. Compressed air or inert gas is used to propel molten metal onto the substrate.

This system is very portable and utilizes a variety of wire filler materials.

The electric arc spray system is the least expensive thermal spray process to operate and maintain, has a high bond strength (average 2,500+ PSI), and has the highest production rate.

Disadvantages of the arc process include generation of more dust and fumes than other processes and the high deposition rate makes control of coating thickness difficult on intricate parts.

SUBSTRATE PREPARATION

Surface Cleaning - Areas to be thermal sprayed and adjacent areas shall be free from oil, grease, paint, corrosion products, moisture, or any other foreign material that may contaminate the surface and coating.

Solvent Cleaning - Prior to masking, blasting, or spraying, all surfaces which have come in contact with oil or grease shall be solvent cleaned. Vapor degreasing is the preferred method but solvent washing may be used. Solvents shall not cause any detrimental attack of the substrate material and must not leave any residue film on the substrate. Acceptable cleaners are Trichloroethane (Type I or II) in accordance with 0-T-620 or xylene in accordance with ASTM D 846. Cleaning may be done by wiping, brushing, or spraying. Precautions must be taken to protect any parts which may be attached by the solvents.

Abrasive Cleaning - Preliminary abrasive blast cleaning may be used to remove heavy or insoluble deposits. An inexpensive, disposable abrasive is recommended. Dust and debris shall be removed by dry compressed air before solvent cleaning or washing.

Heat Cleaning - Porous materials that have been contaminated with grease or oil shall be solvent cleaned. If required, parts shall be heated in electric or gas ovens for sufficient time to remove grease or contamination remaining after decreasing cleaning processes. Steel alloys shall be heated to 600 degrees F maximum. Aluminum alloys, except large hardened alloys, shall be heated to 300 degrees F maximum. Caution shall be given to parts which may distort from original dimensional tolerances (ie., valve seats).

Contaminated Surfaces - Surfaces shall be cleaned with a trisodium phosphate solution, rinsed with clear, potable water, and dried after solvent cleaning.

Masking - Masking shall be performed on all adjacent areas which may be affected by abrasive blasting or thermal spraying. The mask (tape) must be applied tight enough to prevent grit from seeping under the mask. When using tape, apply two layers with the second layer at right angles to the first. The masking shall be inspected for damage between abrasive blasting and thermal spray processes and shall be replaced if damaged.

Abrasive Anchor Tooth Blasting - Prior to thermal spraying for corrosion control, the surface to be prepared by abrasive blasting to provide an anchor tooth for the thermal spray.

The final surface preparation of the substrate shall be achieved by using aluminum oxide or angular chilled iron grit. Chilled iron grit shall not be reused. Only aluminum oxide may be reused.

for anchor tooth blasting. Prior to reuse, the aluminum oxide shall be screened using a 30 mesh screen, visually inspected for debris and oil contamination, and shall pass an oil contamination test.

The blasted surface shall have a white metal blast appearance defined as a gray-white, uniform metallic color, with an anchor tooth (not peened) surface profile of .002" to .003", measured with profile tape and a dial micrometer. The surface shall then be visually inspected and shall be free of oil, grease, dirt, mill scale, rust, corrosion products, oxides, paint, or other foreign matter. The color of the clean surface may be affected by the particular abrasive medium used. Abrasive blasted surfaces shall not be allowed to come in contact with contaminated surfaces prior to completion of thermal spray and sealing processes. Prepared surfaces shall be handled only with clean gloves, rags, or slings. Contact with any oil may cause failure of the coating. Blasting shall not be so severe as to distort the component being prepared for thermal spray.

Blast-Spray Restrictions - The thermal spraying operation shall not proceed if there is visible moisture present on the surface of the substrate. Visible evidence of rust bloom or oxidation on the surface shall be removed by a brush off blast. No thermal spraying shall be conducted if the substrate temperature is not greater than 10 degrees F above the dew point. The substrate surface shall have a white metal blast appearance. The thermal spray operation shall be started within four hours after anchor tooth surface preparation for steel and shall be finished within six hours. The thermal spray operation on aluminum shall be started within two hours after anchor tooth surface preparation and shall be finished within four hours. If more than 15 minutes is expected to elapse, or if the part must be moved to another location, the prepared surface shall be protected from moisture, contamination, and fingerprints. Adequate protection will normally be provided by wrapping with clean paper (free of newsprint). For periods longer than four hours, a thermal sprayed flash coat (at least 0.001") shall be used to protect the surface until the final thermal sprayed coating can be applied. If the surface becomes deteriorated or contaminated, it shall be reblasted. The flash coated surface shall not be allowed to stand for more than four hours without application of the final coating thickness. The substrate or flash coat shall be reblasted if they become contaminated.

SEALER APPLICATION (TYPE I AND II)

Application - The seal coat used depends on the normal operating temperature of the component to be thermal sprayed. Application of seal coats shall be completed within 24 hours of thermal spraying. Seal coats shall only be applied to clean, dry thermal sprayed surfaces. The presence of moisture in the thermal sprayed coating pores may lead to premature coating failure. If the presence of moisture is suspected, the thermal sprayed coating shall be heated to 250 degrees F to remove the moisture before applying the seal coats.

Requirements - Thermal sprayed aluminum coatings are sealed to prevent moisture, oil, dirt, etc. from attacking the coating of the bond. The seal coat must be applied before the coating is exposed to traffic or dampness. The coating shall be sealed as soon as possible after spraying and in all cases within 16 hours of spraying.

Type I Sealer Application - A Type I sealer is a high temperature coating system for use on structures and components whose operating surface temperature is 175 degrees F and above. These components are generally found in machinery spaces and include steam valves, piping, and traps. For high temperature applications, the thermal spray coating is applied to a white metal blasted surface with a 2 - 3 mil anchor tooth profile and a thermal spray coating thickness of 10 - 15 mils. (See Figure 1)

The thermal spray coating is sealed and coated with two coats of heat resistant aluminum paint, 1.5 mil DFT per coat. The first sealing coat shall be applied as soon as practical but no later than four hours after spraying.

Type II Sealer Application - A Type II sealer is a low temperature coating system used for the corrosion protection of steel components whose operating temperature is below 175 degrees F. For example, stanchions and foundations.

A pure aluminum coating is deposited on the surface to be protected. The aluminum coating is then covered with a thin coat of diluted Formula 150, Formula 150, and Formula 151 in accordance with MIL-P-24441. (See Figure 2)

Topcoats - Topcoats for thermal sprayed components, if required, shall be as specified in the applicable contract, work order, specification, ship requirement, or NAVSEA publication.

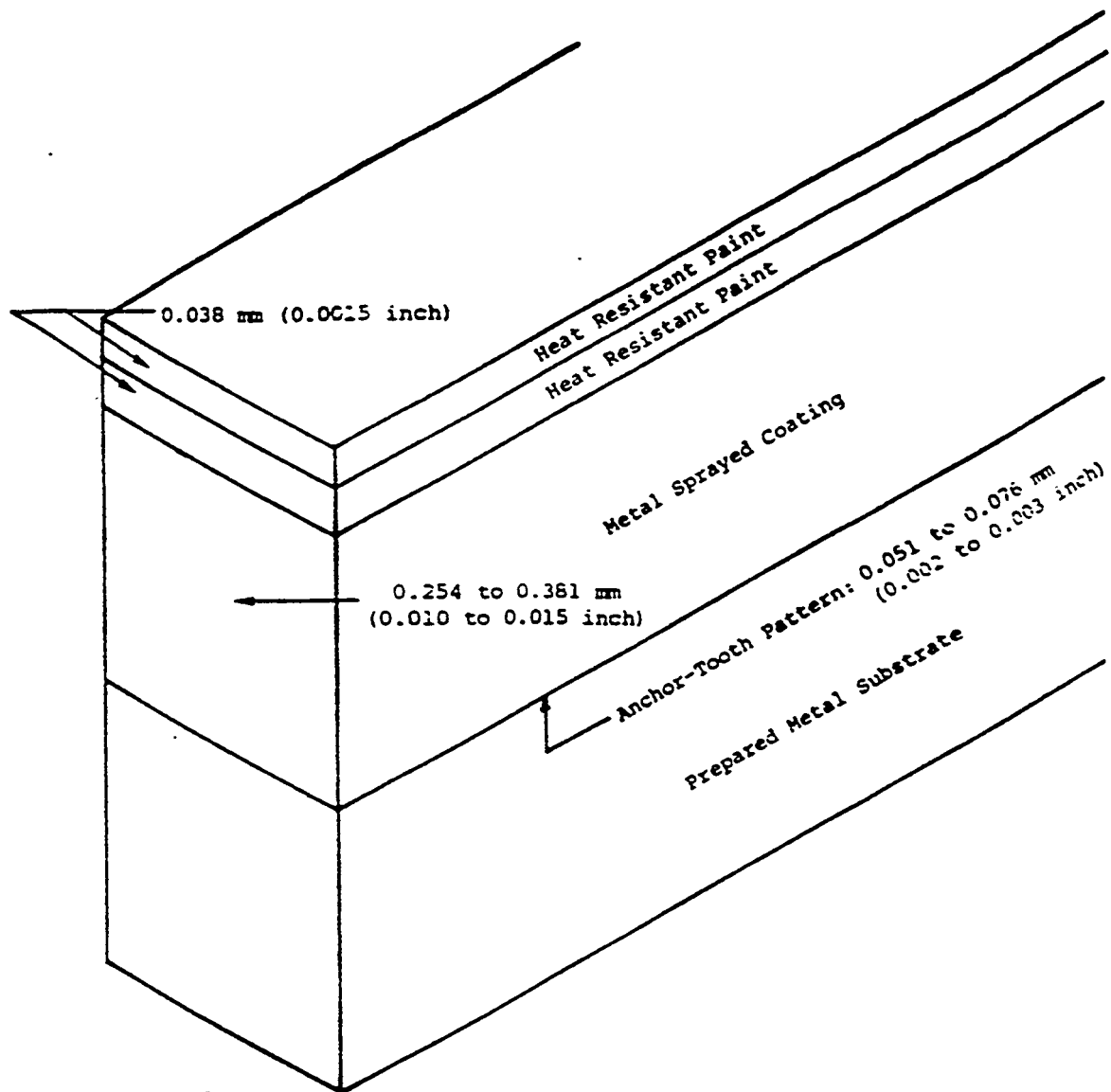


Figure 1 - Type I System for High-Temperature Applications

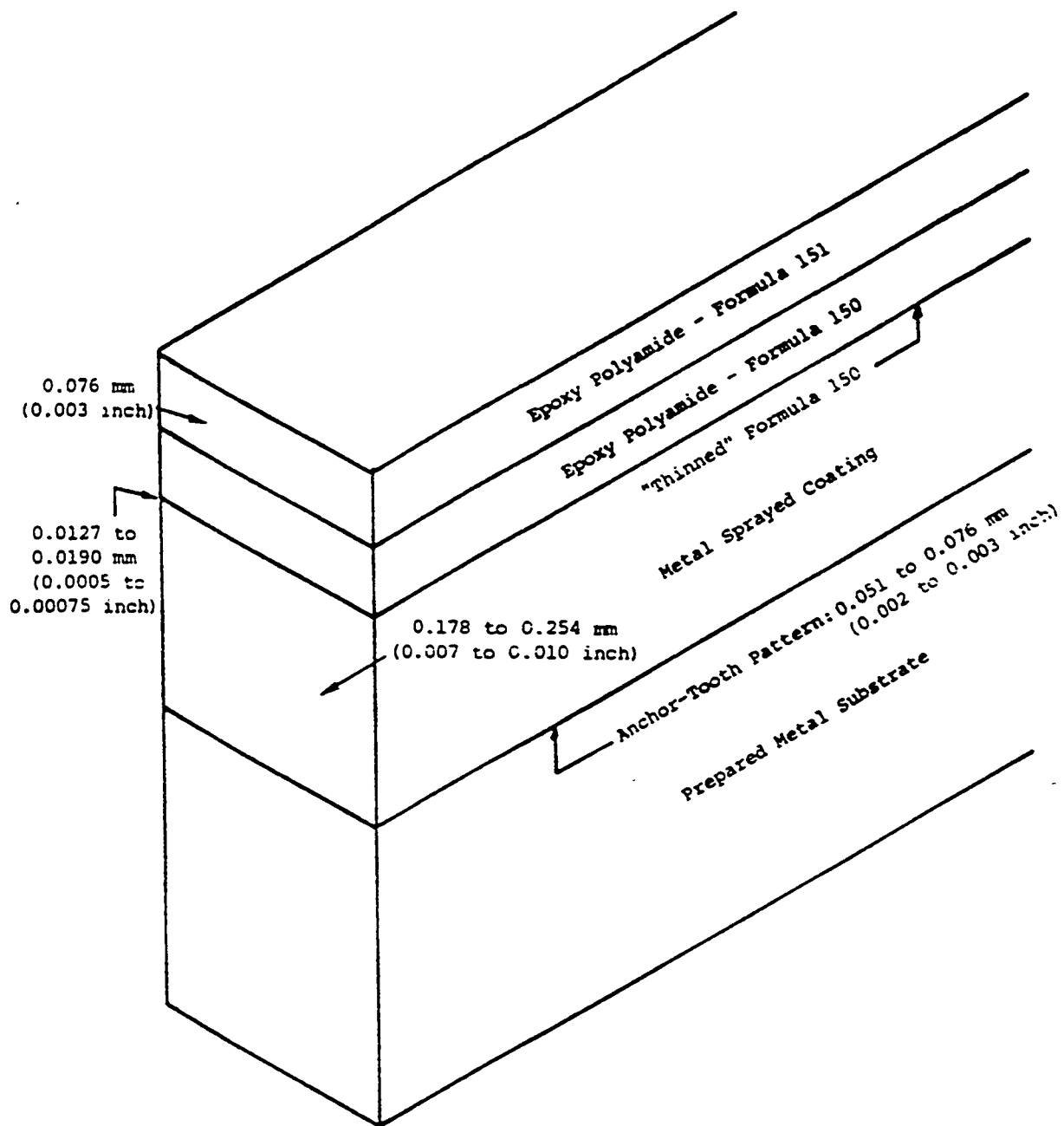


Figure 2 - Type II System for Low-Temperature Applications

COATING CHARACTERISTICS

The wire sprayed aluminum (WSA) process provides for the protection of iron and steel in corrosive environments where paint coatings are not effective. The WSA process provides barrier protection as well as galvanic coating protection.

The steel surface being sprayed with the WSA process remains cool and there is no distortion. There is also no effect on the metallurgical properties of the steel. The WSA coating must be sealed and topcoated with the appropriate paint system to fill the pores of the coating providing protection from moisture and improving the appearance and life of the coating. This also simplifies maintenance and requires only the renewal of the sealer. Topcoats provide additional barrier protection and a cosmetic finish.

The general advantages of thermal sprayed coatings that should be initially considered when choosing a protective coating system are as follows:

1. Predictable life.
2. Single application system.
3. No drying time is needed.
4. Protection of damaged areas by cathodic protection.
5. Good abrasion resistance.
6. Wire sprayed aluminum can be applied on site.
7. Structures of any size can be coated.
8. Thickness of coating can be built up as desired.

PARAMETERS AND LIMITATIONS

Approved Applications of Thermal Spray Coatings - The following is a list of approved application of thermal sprayed coatings for corrosion control on Navy surface ships. This list is for illustrative purposes and does not limit all applications of thermal sprayed coating systems.

Category I - Machinery Space Components
Aluminum coating 0.010" - 0.015" thick may be applied to the following:

1. Low pressure air piping.
2. Steam valves, piping, and traps (except steam turbine control valves).
3. Auxiliary exhaust (stacks, mufflers, manifold, and so forth).
4. Air ejection valves.
5. Diesel header and exhaust piping.

Category II - Topside Weather Equipment
Aluminum coating 0.007" - 0.010" thick may be applied to the following:

1. Helo tie downs.
2. Coamings and bulwark.
3. Steel stanchions.
4. Scupper brackets.
5. Deck machinery foundations.
6. Chocks, bitts, rollers, and cleats.
7. Steel pipe hangers and brackets.
8. Capstans/gypsy heads (except wear area).
9. Rigging fittings (block).
10. Fire station hardware.
11. Lighting fixtures and brackets.
12. Vent plenum.
13. Hatches, doors, and scuttles.
14. Fueling stations.

Category III - Interior Wet Spaces
Aluminum coating 0.007" - 0.010" thick may be applied to the following:

1. Decks in wash rooms and water closets.
2. Pump room deck and equipment support foundations.
3. Fan room decks and equipment support foundations.
4. Water heater room decks and equipment support foundations.
5. Air conditioning room decks and equipment support foundations.
6. Deck plate supports.
7. Machinery foundation.
8. Boiler air casting (skirts).
9. Turnstile.
10. Bilges and applicable wet spaces.
11. Well deck overheads.

Prohibited Application of Thermal Spray Coatings Thermal sprayed coatings for use in corrosion control applications are intended for selected application to steel and aluminum surfaces. Thermal spray coatings for corrosion control applications shall not be used for the following:

1. plastic, rubber, and painted surfaces.
2. Internal surfaces of moving machinery (pump casings, valves, and so forth).
3. Copper, brass, bronze, copper-nickel, or monel surfaces.
4. Stainless steels, 17-4 PH, 15-4 PH.
5. Surfaces subject to strong acids or bases (aircraft catapult slides).
6. Threads of fasteners.
7. Valve stems.
8. Within 3/4 inch of surfaces to be welded.
9. Steel alloys with yield strength greater than 120,000 psi.
10. Nonskid slip resistant deck coatings.
11. Helo deck corrosion control coating.
12. Exterior underwater hull surfaces.
13. Sanitary tanks interior.
14. Nuclear related applications without prior approval of the Nuclear Propulsion Directory of NAVSEA (SEA 08), Washington, DC 20362.

QUALITY ASSURANCE

Job Control Record - A Corrosion Control Thermal Spray Job Control Record (Figure 3) shall be completed for each lot of components sprayed. The record shall be prepared before production thermal spraying begins. Corrosion control thermal spray job control records assign responsibility and provide accountability for performing work and assuring quality control.

Lot Production Quality Assurance - Two sample coupons shall be prepared and sprayed for bend testing, visual inspection, and thickness measurement and must accompany each lot of production items. One sample coupon shall be sprayed and evaluated before the beginning of the shift and one during the shifts production run.

If the sample coupon sprayed at the beginning of the shift is judged acceptable, production spraying of the lot may proceed. If the sample coupon is rejected, the cause of the coating problem shall be identified and corrected before production spraying may begin.

If the sample coupon sprayed during the shift passes inspection, the components in the lot are acceptable provided they meet the criteria. If the sample coupon is rejected, the cause of the coating problem shall be identified and corrected before production spraying continues. Components already sprayed shall be visually inspected by thermal spray personnel at 10X magnification.

Knife Peel Test - In the event thermal spray personnel suspect failure of a coating job, the knife peel test or adhesion test shall be performed to determine coating acceptability. The knife peel test shall consist of a single knife cut one and one-half inches long through the thermal sprayed coating to the substrate. If any part of the coating system along the cut can be lifted from the substrate using the knife, the bond shall be considered unsatisfactory and the coating shall be removed. If the coating cannot be lifted with the knife, the coating is acceptable.

Adhesion Test - An aluminum or steel dolly (0.5 square inch surface contact area) shall be cemented to the thermal sprayed surface. After curing, the dolly shall be pulled off the surface with a calibrated elcometer adhesion tester. A coating with an adhesive failure less than 1,000 psi shall be removed. The coating is acceptable--if there is no adhesive failure below 1,000 psi. This test shall be performed on a noncritical area of the job so the area can be recoated with the top coat if no failure occurs.

SECTION I JOB DATA	JOB ORDER		SHIP		SYSTEM	
	COMPONENT		QTY.	MATERIAL		SPECIFICATION & CLASS/TYPE
SECTION II PREPARATION	ROUGH BLAST: GRIT TYPE/SIZE					
	ANCHOR-TOOTH BLAST: GRIT TYPE/SIZE					
	MASKING INFORMATION					
SECTION III SPRAYING	APPENDIX		COATING MATERIAL		COATING THICKNESS	
SECTION IV SEALING	☐ TYPE I (ABOVE 175°F SERVICE TEMPERATURE) TWO COATS OF .0015" DFT HEAT-RESISTANT ALUMINUM PAINT (DOD-P-24555 OR EQUIV.)					
	☐ TYPE II (BELOW 175°F SERVICE TEMPERATURE): STRONTIUM CHROMATE (.00050"-.00075"), FORMULA 150 (.002"-.003), FORMULA 151 (.002"-.003")					
SECTION V TOPPING	TOP COAT: TYPE/COLOR					
SECTION VI INSPECTION	SAMPLE COUPONS HAVE BEEN TESTED AND MEET THE REQUIREMENTS OF SECTION 2.5.6.2.					
	SIGNATURE (SHOP 26 INSPECTOR)				DATE	

PROCEDURES FOR FILLING OUT THE CORROSION CONTROL THERMAL SPRAY JOB CONTROL RECORD

SHOP 26 FOREMAN, PLANNER OR LEAD MECHANIC ORIGINATE FIVE COPIES OF THIS FORM FOR EACH LOT OF COMPONENTS, FILLING IN ALL AREAS OF SECTIONS I THROUGH IV. PULL ONE COPY AND SEND THE REMAINING FORMS TO SHOP 71 PLANNING.

SHOP 71 COMPLETE SECTION V. PULL ONE COPY FOR SHOP PLANNING RECORDS AND SEND ONE COPY TO PAINTERS. SEND REMAINING TWO FORMS TO SHOP 26 PLANNING.

SHOP 71 AND SHOP 26, AS APPLICABLE, PREPARE COMPONENTS FOR SPRAYING, FOLLOWING DIRECTIONS OF SECTION . . . SHOP 26 PERFORM SPRAYING AND INSPECTION IN ACCORDANCE WITH SECTIONS III AND VI. SEND COMPONENTS TO SHOP 71 FOR SEAL AND TOP COATING IN ACCORDANCE WITH SECTIONS IV AND V.

SHOP 26 SEND ORIGINAL COPY OF THIS FORM TO CODE 136.1, RECORDS SECTION, AND REMAINING COPY TO SHOP 26 PLANNING.

Inspection Sample Coupon - Each coupon, approximately 3" x 2" x 0.050" shall be sprayed on one of the large faces with a 0.007" to 0.010" coating using the production spraying procedure and tested and evaluated to the requirements.

Bend Test - The sprayed coupons shall be bent approximately 180 degrees around a 1/2" diameter rod with the coating on the tensile side of the bend. No disbanding or delamination of the coating shall occur due to bending. Small, irregular cracks in the coating near the bend are permissible.

Visual Inspection - The sample coupons shall be visually examined by thermal spray personnel at 10X magnification. The coating shall have a smooth, uniform appearance. The coating shall not contain cracks, blisters, chips or loosely adhering particles, pits exposing the substrate or oil or internal contaminants.

Thickness Measurements - Thickness measurements shall be made on the sample coupons with a thickness gauge or by direct caliper measurement of the increased dimension.

Inspection of Surface Preparation - Before thermal spraying, the surfaces to be coated shall be abrasive blasted to create an anchor tooth profile. The surface profile shall be measured with profile tape and a dial micrometer. The blasted surface shall be visually inspected. Inspection at 10X magnification is recommended when practical.

Acceptance Criteria for Surface Preparation - The anchor tooth profile shall measure 0.002" to 0.003". Visual inspection shall assure that surface appearance is uniform. Steel substrates shall have a white metal blast finish, defined as a gray-white, uniform metallic color. The surface shall be free of oil, grease, dirt, mill scale, rust, corrosion products, oxides, paint, or any other foreign matter.

In-Process Spraying Inspection - No moisture, oil, grit, contaminants, blisters, cracks, chips, pits, or coating separation may be present during spraying.

Final Inspection - After spraying, the coating shall be visually examined by thermal spray personnel. There shall be no cracks, blisters, chips or loosely adhering particles, oil or other contaminants which bleed out through the coating, pits exposing the substrate, or coating separation. Coating thickness shall be measured. Any defects shall be cause for rejecting the coating.

Certification - Shipyards shall obtain certification of facilities from the NAVSEA authorized agent.

OPERATOR QUALIFICATION AND TRAINING

Application Procedures - The shipyard shall prepare written application procedures and perform the required tests to obtain certification of these procedures. Included in the written procedures shall be a description of the proposed application procedure and a listing of the various processes (ie., blasting, thermal spraying, inspection, and sealing). Record forms shall be provided as evidence of the performance of quality assurance examinations.

Application Procedure Approval - Prior to using a thermal spray procedure, the supporting certification test data must be authorized by the NAVSEA Materials and Assurance Engineering Office or its authorized agent.

Certification Test Requirements - Application procedure certification shall consist of a visual examination, bend test, bond test, and shape test or thermal sprayed samples prepared by an operator using the proposed procedure. Four visual examination and bend test specimens shall be prepared and tested and must meet the requirements. Five bond test specimens shall be prepared and tested and also must meet the requirements.

Visual Examination Specimens - The thermal sprayed coating must have a uniform appearance prior to sealing. Surface defects of the thermal sprayed coating shall be limited to small nodules not to exceed 1.1 mm (0.045 inch) in diameter and shall not exceed 0.6 mm (0.025 inch) in height above the surrounding sprayed surfaces. The coating shall not contain any of the following:

1. Blisters
2. Cracks
3. Chips or loosely-adhering particles
4. Oil or other internal contaminants
5. Pits exposing the undercoat or substrate

Bend Test - No disbonding, delamination, or gross cracking of the coating occur due to bending. Small hairline cracks or alligatoring of the coating in the vicinity of the bend are permissible.

Bond Test - The bond strength of the thermal sprayed coating on the individual test specimens shall be 10.3 MPa (1500 lb/in²) or greater. The average bond strength of five samples of the metallized coating on the tested specimens shall be 13.8 MPa (2000 lb/in²) or greater.

Shape Test - The thickness of the thermal sprayed coating shall meet the requirement for the thermal spray process and shall be 0.25 to 0.40 mm (0.010 to 0.015 inch).

Certification of Thermal Spray Operators - Each operator shall be certified by demonstrating the ability to apply the specified coating system using the applicable spray process, and correct and safe usage of the equipment.

Certification Test Requirements - Operator qualification shall consist of a visual examination, bend test, bond test, and shape test of thermal sprayed samples prepared by an operator. Four visual examination and bend test specimens shall be prepared and tested. Two shape test specimens shall also be prepared and evaluated.

Limits of Certification - Operators must certify separately for each procedure they will use in production. An operator who certifies a procedure by meeting the requirements becomes certified to spray to that procedure.

Retest of Operators - operator failing the initial certification tests may perform one retest for each type of test failed. If the operator fails the retest, the operator shall not be certified until completion of retraining and subsequent complete certification retesting.

Term of Certification - Operator certification shall be retained as long as Period of six months does not elapse between production use of the applicable thermal spray process. Production use is defined as performing thermal spraying operations at least eight hours in a consecutive day period.

Recertification Time Lapse Less Than Six Months - Operators whose certification has lapsed may be recertified by satisfactorily completing the certification tests.

Certification Time Lapse Less Than Six Months - Visual examination and bend tests are required if the operator has not performed thermal spraying processes for a period of 30 days.

Certification Time Lapse Greater Than Six Months - Visual examination, bend tests, and bond tests are required if the operator has not performed thermal spraying processes for a period of six months.

Special - Recertification testing may also be required at any time an operator's performance is questionable as evidenced by production quality assurance.

Training - Puget Sound Naval Shipyard utilizes 40 hours preparatory training prior to qualification. Total cost of training is \$1,850 based on Shop 26 labor rate of \$46.26 Per hour plus material (as of 3/90).

APPLICATION COSTS

The cost per square foot of applying WSA coatings with a flame spray system is \$6.75. The cost per square foot of applying WSA coatings with an arc spray system is \$4.51. These figures include \$1.50 per square foot for materials, \$1.00 per square foot for blasting, and \$.89 per square foot for paint coatings.

The cost per square foot for non-uniform shop work will vary with shape, size, accessibility, etc. of each job. The per square foot rate for non-shop work will vary depending on a number of factors affecting each job. These factors include location, accessibility, set-up time, breakdown time, required transportation of equipment between work sites on the project, and the degree of dependence on support trades, such as riggers and ventilation. Because of these considerations, thermal spray production supervisors should inspect each project before advising the planning and estimating department on thermal spray costs. This is the only way an accurate estimate can be determined.

Application Time - The following is an estimate of application time used for determining the time involved to thermal spray certain items.

Flame Spray - 27 sq. ft./man hour - Flat plate, shop environment

Arc Spray - 84 sq. ft./man hour - Flat plate, shop environment

MAINTENANCE, REPAIR METHODS AND COST

Thermal sprayed coatings that have been sealed can last years without maintenance, even in a relatively aggressive environment. Coating maintenance is essential when the coating shows visible signs of sealant disintegration and before any corroding of the metal coating has begun.

Maintenance usually involves cleaning down and brushing to remove corrosion products and accumulated debris, and then overcoating with the same type of sealant or paint that was originally used. Maintenance may be performed at an earlier stage than this for decorative reasons. Paint coatings designated for distinct color effects should be compatible with the original sealant applied.

When a thermal sprayed coating is damaged, exposing the coating or the substrate, the following repair methods shall apply.

Surface Preparation, Small Areas - Surface preparation of small areas (less than 100 square inches) shall be as follows:

Solvent clean as required.

Use a 1-inch, flexible blade, paint scraper and remove loose paint around worn or damaged area to the boundary of well bonded paint. Be careful to not gouge or further damage the thermal sprayed coating.

Vigorously brush away loose debris using a stiff, hand-held, nonferrous, bristle brush. Power tools should not be used as they will polish smooth the thermal sprayed coating and may wear through the coating to the substrate.

Feather a 2 to 3 inch collar into the undamaged area.

Lightly abrade the feathered paint area around the exposed thermal sprayed coating with sand paper to provide a mechanical bonding surface for the paint primer and sealer.

Surface Preparation Large Areas - Surface Preparation for large areas (greater than 100 square inches) shall be as follows:

Solvent clean as required.

Abrasive brush blast away loose paint using aluminum oxide grit over the exposed thermal spray coated area. Low blasting pressures shall be used to minimize abrasion and removal of thermal sprayed coating, but great enough for reasonable paint removal and development of sufficient anchor tooth pattern for sealers and topcoat paints.

Feather a 2 to 3 inch collar into the well bonded paint area.

- Cosmetic differences between new and old paint can be minimized by brush blasting or using sand paper and repainting the area bordered by a weld bead or a structural item.

Damage Exposing the Substrate - Surface preparation requiring paint touch up shall be as follows:

- Solvent clean as required.
- Using a paint scraper, push the blade underneath the thermal sprayed coating to lift off all loosely bonded sprayed coating until reaching a well bonded area.

Surface Preparation for Thermal Sprayed Coating Touch Up - Thermal sprayed coating touch up shall be accomplished as follows:

- Solvent clean as required.
- Abrasive blast area to be repaired with 16-30 mesh aluminum oxide to white metal to give a 0.002" - 0.003" anchor tooth.
- Feather 2 to 3 inches into the good coating area.
- Apply thermal sprayed coating.

Sealing and Topcoating Damaged Areas - When damage has exposed the thermal sprayed coating or the thermal sprayed coating has been replaced, sealing and topcoating shall be accomplished with products identical to or compatible with existing sealer/topcoat.

WSA Coating Removal - Grit blasting and grinding are currently recognized as the methods for removal of wire sprayed aluminum coatings. These methods are also recognized as having limitations. Grit blasting can not be accomplished in any space where rotating machinery is located. Grinding is expensive because of the labor costs involved.

Removal of WSA coatings has been an area of concern when discussing the increasing usage of WSA as a corrosion control method aboard US Naval ships. As a result, NAVSEA 07 tasked Puget Sound Naval Shipyard with investigating the feasibility of cost effectively removing WSA coatings using high pressure water jet technology. This project was accomplished over a two year period. Reports (Thermal Spray Removal, Phase I and Phase II) were submitted to NAVSEA 07011 in FY-87 and FY-88.

The reports presented the results of a number of evaluations in addition to establishing the feasibility of removing WSA coatings cost effectively using high pressure water jet technology.

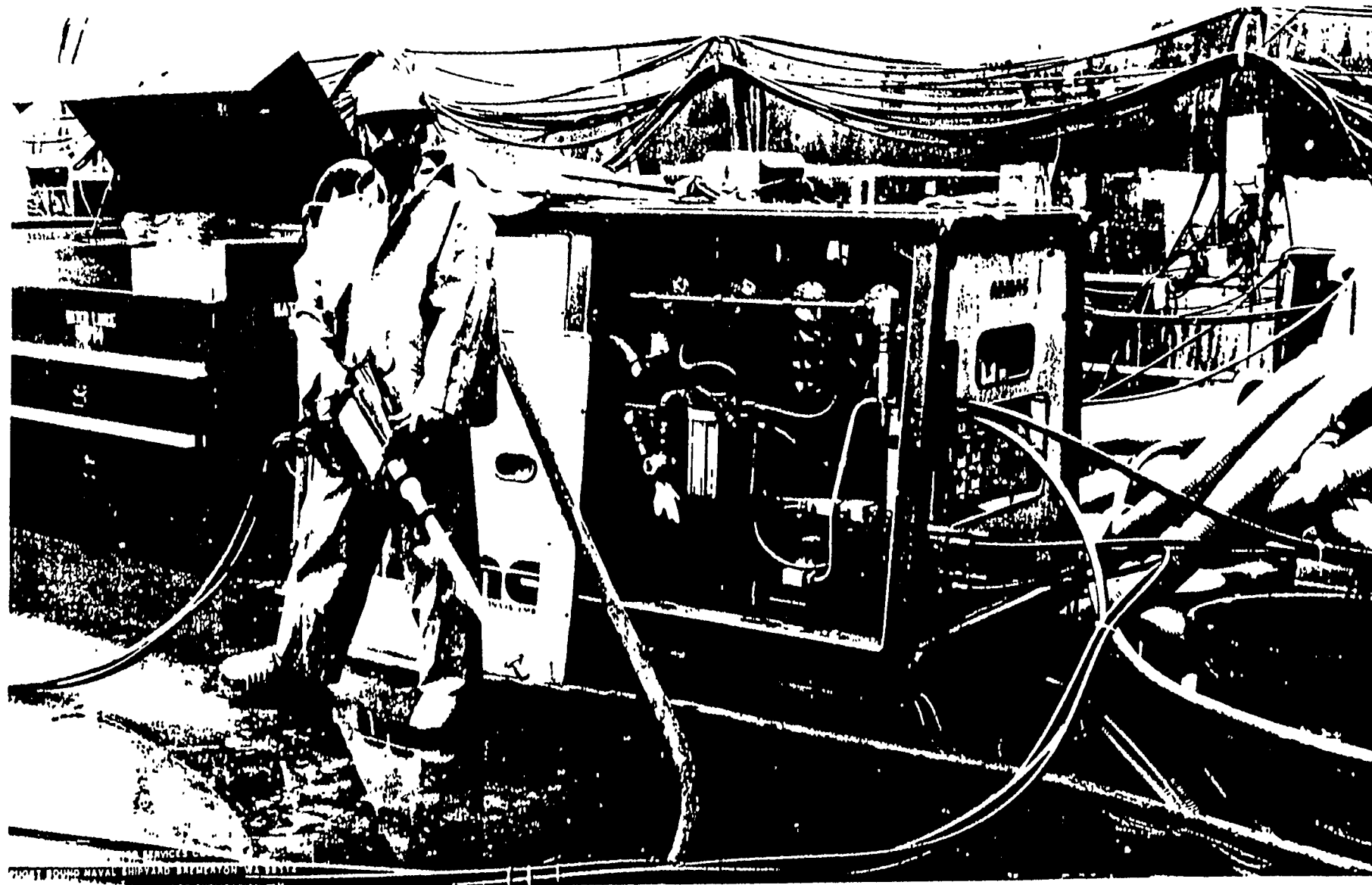
Removal rates, operating pressures, limited access removal, effect of water jet removal on anchor tooth profile, containment systems for water and debris, and high pressure water jet and grinding removal rate comparisons were a few of the areas evaluated.

GRINDING VS HIGH PRESSURE WATER JET

Removal Rate Cost Comparison

Square Feet	Grinding	(Man) (Hrs)	High Pressure Water Jet Sys.	(Man) (Hrs)	cost Savings
1000	\$ 28,993	(683)	\$1,401	(33)	\$ 27,592
2000	57,987	(1366)	2,802	(66)	55,185
3000	86,980	(2049)	4,203	(99)	82,777
4000	115,973	(2732)	5,603	(132)	110,370
5000	144,967	(3415)	7,004	(165)	137,963
6000	173,960	(4098)	8,405	(198)	165,555
7000	202,953	(4781)	9,806	(231)	193,147

NOTE: Dollar amounts are based on \$42.45 per hour, labor, multiplied by the number of man hours per 1000 square feet.



CATERPILLAR REMOVAL SET-UP

WIRE SPRAYED ALUMINUM
GENERAL INFORMATION

ALUMINUM COATING APPLICATION

The aluminum coating shall be applied in multiple layers and in no case shall less than two crossing passes, at right angles, be made over every part of the surface. The sprayed aluminum shall overlap on each pass to assure uniform coverage.

The steps in thermal spray application are as follows:

1. Grit blast.
2. Thermal spray.
3. Seal or paint.
4. Drying time.

Thermal Spraying Technique - Follow gun manufacturers recommendations for optimum spray distance. The angle of the spray stream to the surface shall be as close to 90 degrees as possible and never less than 45 degrees. Accessories for the gun are available to maintain proper spray angles. When spraying complex shapes, the operator shall mask and thermal spray to minimize over spray onto areas of the component where no coating is desired. Cooling during the coating operation may be accomplished by blasting clean dry air, carbon dioxide, or other suitable gas near but not directly on the area being sprayed. The thermal spray operation shall be interrupted only to measure coating thickness or temperature or to permit cooling to prevent overheating.

Cooling After Thermal Spraying - Under normal conditions, the completed work should be allowed to cool at room temperature at a normal rate before sealing. If required, accelerated cooling maybe accomplished with a blast of clean dry air, carbon dioxide, or other suitable gas. The air or gas shall be maneuvered to obtain a uniform cooling rate over the entire thermal sprayed area. The component shall not be quenched with liquid to accelerate cooling.

WORKING AREA REQUIREMENTS

Abrasive Blasting Areas - If abrasive blasting is carried out in an enclosed area other than a designated blasting booth, the air in the enclosed area shall change at least once per minute. Additional safe breathing apparatus (operator's hood) shall be used.

Spray Booths - The wet spray booth shall be constructed with surfaces angled to deflect the thermal spray blast inward and not blow out of the booth. The booth shall be equipped with a wet collector and an exhauster that will maintain air flow of at least 200 cubic feet per minute per square foot of booth opening into the booth entrance.

Enclosed Areas - Enclosed areas shall be equipped with a water wash dust collector with a capacity in cubic feet per minute at least three times the volume of the enclosed space. Air inlets to the areas shall be located near the ceiling on the side opposite the working area. The air exhaust shall be located at or near the floor along the entire side of the room adjacent to the working area. The duct work shall be large enough to permit air velocities greater than 2,000 feet per minute. An air respirator mask shall be provided for the operator, as well as eye and ear protection.

Open Areas - Thermal spraying in open areas shall be carried out only when suitable eye and ear protection and an air respirator are being used.

SAFETY EQUIPMENT

Protective Equipment - The following protective equipment shall be worn by the thermal spray operator.

1. Air line respirator.
2. Noise protection (ear muffs and ear plugs).
3. Eye protection for ultraviolet light.

Special Clothing - The following clothing is recommended when blasting operations are performed in an enclosed space.

1. Helmet with forced air supply.
2. Protective jacket.
3. Protective trousers.
4. Safety shoes.
5. Rubber gloves.
6. Protective shoe covers.

PAINT

PROCESSES

Paint shall be applied by spraying (conventional, airless, or electrostatic), brushing, roller coating, dip coating, or fill and drain coating.

SUBSTRATE PREPARATION

Proper surface preparation is a major factor in the performance of paint coatings. It is estimated that 75 percent of all paint failures are the result of inadequate surface preparation. Poor cleaning prevents the coating from bonding properly to the steel surface. Peeling can result.

Selection of surface preparation shall be based on:

1. The nature of the substrate.
2. Existing condition of the surface to be painted.
3. Type of exposure.
4. Past history of the surface to be prepared.
5. Practical limitations such as time, location, space, and equipment availability.
6. Economic considerations.
7. Type of paint to be applied.
8. Safety factors.

The initial cost of adequate surface preparation is justified due to the increase in durability and maximum coating life with only minimal repairs and repainting to be performed.

The goal of surface cleaning is to provide a roughened surface which is free of contamination and gouges or sharp projections. Surface contaminants must be removed to ensure coating adhesion and minimize the possibility of defects such as blistering, peeling, flaking, and underfilm rusting. Surfaces to be painted for preservation must be completely free of mill scale, rust, loose paint, dirt, oil, grease, salt deposits, and moisture. To prevent imbedding contaminants during surface preparation, oil or grease must be removed before using power tools or abrasive blast surface preparation. Rusted surfaces shall be fresh water rinsed, where practicable, to remove water soluble contaminants before abrasive blasting or additional surface preparation by other means. Weld splatters and flux compounds should be removed by grinding or chipping.

Surface cleaning methods vary with the type of surface preparation needed, location, and size of area being cleaned.

After the surface has been properly cleaned, it must be abrasive blasted to achieve a rough but uniform surface which is called the "anchor tooth". The pattern of roughening on the surface affects paint adhesion and improves the ability of the paint to bond to the steel. The anchor tooth pattern is controlled primarily by the shape and the hardness of the abrasive used.

The surface profile peaks should be approximately 1/3 as high as the required coating thickness.

Most marine coating work procedures refer to SSPC Standards or Swedish Pictorials as a standard to provide written and visual descriptions for judging the acceptability of a blast cleaned surface. These are widely used throughout the world. The four standard grades for blast cleaned steel are: brush-off, commercial, near-white, and white metal. The appearance of the blasted steel surface is shown on colored photographs. There are four different sets of photographs for each blast grade. The original appearance of the steel surface is taken into account. For example, if old pitted and rusted steel is blasted to a near-white surface, it will not have the same appearance as a near-white grade achieved on new steel.

Brush-Off Blast Cleaning (SSPC-SP7)

All dirt, oil, rust scale, mill scale, and loose rust and paint are removed completely. Tightly adhering mill scale, rust, and paint are permitted if the blasting has exposed numerous flecks of the underlying metal. These flecks must be uniformly distributed over the entire surface.

Commercial Grade Blast Cleaning (SSPC SP-6)

All oil, dirt, rust and mill scale, and old paint are completely removed. Slight shadows, streaks, or stains from rust or mill scale oxide may remain in the bottom of pits. At least 66 percent of each square inch of surface is free of all visible residues.

Near-White Blast Cleaning (SSPC-SP10)

Complete removal of all dirt, oil, mill scale, rust, paint, or other foreign matter. Very light shadows or slight streaks or discolorations may remain. At least 95 percent of each square inch of surface is free of all visible residues.

White Metal Blast Cleaning (SSPC-SP5)

Complete removal of all foreign matter. The steel has a gray-white uniform metallic color and is slightly roughened to form an anchor pattern. (Note: The color of the cleaned surface may be affected by the abrasive used.)

PREFERRED APPLICATIONS

Information was gathered from the following 5P-3 members and/or facilities regarding preferred paint systems, areas of application, and how the paint coatings performed: Inorganic Coatings, Puget Sound Naval Shipyard Painters (Shop 71), NAVSEA, National Steel and Shipbuilding Company, Integrated Systems Analysis, Ingalls Shipbuilding, Electric Boat Works, Newport News Shipbuilding, Bay Shipbuilding Company, and Norfolk Shipbuilding and Dry Dock Company.

The results of this survey indicated that the epoxy polyamide paint system is widely used by Naval and private shipyards. Areas of application are tanks, bilges, wet spaces, and exterior surfaces. This coating was stated to perform well but regular maintenance is required for maximum coating performance.

Another widely used paint system in Naval shipyards on surface ships and aircraft carriers is solvent-based inorganic zinc with epoxy polyamide topcoats. This system is being applied to exterior horizontal surfaces and waterways and exterior vertical and near vertical surfaces from six inches above the upper boottopping limit (in accordance with Naval Ships Technical Manual, NAVSEA S9086-VD-STM-000/Chapter 631).

Private shipyards also use inorganic zinc with epoxy polyamide topcoats for application on surface ships and tankers as a corrosion control method for topside areas.

According to the surveyed shipyards who are applying solvent-based inorganic zinc, this corrosion control system performs well and has an average life span of seven to ten years with little maintenance required. Various reports on inorganic zinc coatings show evidence of this coating system lasting for 15 to 20 years of service.

INORGANIC ZINC

Inorganic zinc primers provide years of corrosion free protection to steel. Zinc coatings are protective in two different ways. They serve as a barrier and also as a galvanic protector of steel surfaces.

When the zinc coating is first applied, it is a porous film of zinc encapsulated in a silicate binder. In this state, moisture and oxygen penetrate the film, causing the zinc to corrode to protect the substrate. This is part of the sacrificial action which occurs. As time goes on, the zinc corrosion products fill in all of the pores in the coating and the combination of the remaining zinc and the zinc corrosion products (which are insoluble) form a permanent barrier coating. This barrier coating seals off the moisture and oxygen and the zinc stops corroding. In this state, the coating represents the ultimate barrier coating. The coating also retains its sacrificial properties if and when the zinc and the substrate are exposed to moisture and oxygen (ie., when the coating is damaged).

When damage occurs, all of the elements required for corrosion are present in the area of the damage and the zinc will sacrifice itself to protect the substrate. For a small damaged area (up to 1/4 inch wide), the sacrificial action of the zinc will actually heal the damage with the zinc corrosion products. For larger damaged areas, the sacrificial action of the zinc will prevent corrosion of the substrate until the damage can be repaired. Zinc coatings are also resistant to undercutting due to the chemical bond of the coating to the substrate.

Depending on the binder used, zinc primers can be classified as either organic or inorganic. The use of zinc rich primers serves several purposes.

1. zinc rich primers can be applied in the shop as a pre-construction primer, eliminating most of all field surface preparation.
2. Simplified coating systems. Zinc rich primers can be topcoated with a wide variety of industrial topcoats.
3. Minimized touch-up. Zinc rich primers are extremely tough and abrasion resistant.
4. zinc rich primers offer excellent resistance to corrosion, both as pre-construction primers and as topcoated primers in coating systems.

All inorganic zinc primers have excellent abrasion resistance, hardness, and toughness, but not flexibility.

Inorganic zinc primers are often used when a delay between priming and topcoating is expected. They offer excellent protection from corrosion and from handling damage. There is also an advantage to aging an inorganic zinc primer before topcoating, because blistering will be minimized and so will topcoat bubbling problems. When freshly applied inorganic zinc is topcoated, it often blisters. Care should be taken to topcoat before major primer degradation and corrosion begins. The greater the thickness of the zinc primer (up to an optimum point), the longer the time before the underlying steel will begin to corrode.

The appearance of a zinc coating is improved by the application of a suitable sealer coat. Guidance on type of topcoat to be used should be obtained from the supplier of the zinc rich coating, especially if the surface is exposed between applications. Members and assemblies coated with zinc rich paints may be handled or stacked as soon as the coating is dry, but exposure to freshly applied zinc silicate paints to moisture within a stack can result in deleterious changes.

Inorganic zinc paint is usually furnished as a two-part system, paint base and zinc pigment. The two parts should be mixed just prior to use. Thorough mixing is important for a uniform, consistent application. Paint must also be mixed periodically during application.

EPOXY POLYAMIDE

Epoxy polyamide coatings are similar to other epoxy coatings in that they consist of a two-component system that includes a pigmented polyamide resin (A component) and an epoxy resin (B component). Once they are mixed together and applied as a paint film, the coating cures to a hard film by chemical conversion. During this curing period, the solvents used to maintain the composition in liquid form are released by evaporation.

The epoxy polyamide paint system is used as the standard topcoat system (MIL-P-24441). This paint is designed to provide a durable, hard, chemical-resistant, non-porous coating which is very resistant to the marine environment. It can be applied under conditions of dampness and coldness (down to 35 degrees F) where few other coatings will adhere.

In order to be used under these conditions, it is necessary that that a good job of surface preparation be done. Surfaces to be coated should be completely free from rust, loose paint, dirt, scale, oil, grease, salt deposits, moisture, and other contaminants. is also necessary to carefully follow mixing and application instructions in order for the coating to be successful under severe conditions.

The Navy epoxy polyamide Coating (MIL-P-24441) consists of seven individual formulations, Formulas 150 through 156. These coatings are suitable for use in tanks, bilges, wet spaces, and on exterior surfaces.

PARAMETERS AND LIMITATIONS

Specific paint parameters are indicated by the manufacturer's application instructions. The following parameters and limitations are derived from Process Instruction No. 0631-216A CH-3.

General

Paint shall not be applied over mill scale, rust, loose paint, dirt, scale, oil, grease, salt deposits, and moisture (except application over minor quantities of mill scale and residual rust in the crater of pits when hand preparation prior to "touch up" painting is authorized).

Paint shall not be applied when the air temperature is expected to drop to 32°F or below before the paint has dried. Paint should not be applied when the surrounding air temperature is below 40°F.

Paints should not be applied when metal surface temperatures are **below 35°F or within 1°F of the dewpoint**. Paint shall not be applied to wet or damp surfaces or in rain, snow, fog, or mist.

Any applied paint exposed to freezing, excess humidity, rain, snow, or condensation shall be permitted to dry. Damaged areas of paint should then be removed and the surface again prepared, inspected, and then repainted with the same number of coats and type of paint as the undamaged areas.

If paint is applied in damp or cold weather, the metal should be painted under cover (ie., protected, sheltered) with the surrounding air and the metal heated to at least the temperature specified above. In all such cases, the required temperature and humidity conditions should be met. Such metal should remain under cover or be protected until dry or until weather conditions permit its exposure.

All corners, crevices, rivets, bolts, uncontoured welds, and sharp edges shall receive a brush coat of paint preferably before the metal receives the first full prime coat or before the last finish coat of paint. If possible, allow this brush coat to dry to the touch prior to application of the full prime coat or the next full coat of paint. Apply the full prime coat to ferrous materials as soon as possible to prevent "flash" rusting.

Painters should use wet film thickness (WFT) gauges periodically during coating application to monitor the thickness of the applied wet film. The equipment and painter technique shall be adjusted to apply a **WFT** which will dry or cure to the desired minimum dry film thickness (DFT). However, excessive WFT shall be avoided to reduce solvent entrapment in the dried coating. Painter use of WFT gauges and the comparison of WFT measurements

to resulting DFT measurements will aid in a more accurate wet film application and less rework required to obtain a minimum DFT.

Each coat of paint, to the maximum extent practical, shall be applied as a continuous film of uniform thickness free of pores. Any thin spots or areas missed in the application shall be repainted and permitted to dry before the next coat of paint is applied.

APPLICATION OF PAINT COATINGS

The following list of shipboard equipment and accessories as a general rule shall not be painted. It is provided as general guidance information.

General

1. CRES decks, CRES galley equipment, and CRES bulkheads in wet spaces.
2. Decorative plastic surfaces such as on bulkheads or table tops l
3. Dogs or operating gear of watertight doors, hatches, scuttles and similar items.
4. Hatch and door rubber gaskets; rubber window moldings.
5. Identification plates.
6. Knife edges of watertight doors and hatches.
7. Porcelainized bulkheads.
8. Threaded parts.
9. Anodes and cathodic protectors.
10. The following interior surfaces constructed of aluminum:
 - a. Bins, shelves, dressers, cabinets, battens and fittings.
 - b. Interior gratings, handrails, and floor plates.
 - c. Internal surfaces of ventilation ducts.
11. Activating mechanisms of electrical safety devices and control switchboards on machinery elevators.
12. Bell pulls, sheaves, annunciator chains, and other mechanical communication devices.
13. corrosion resisting steel piping and components in ship's interior compartments (except non-nuclear piping/components in bilge and tank areas).
- 14 l Composition metal water ends of pumps.
15. Condenser heads and outside surfaces of condensers when of composition metal.
16. Dry sprinkling piping within magazines of the type having holes drilled in the pipe top.

17. Exposed composition metal part of any machinery.
18. Glands, stems, yokes, toggle gear, and all machined external parts of the valve.
19. Heat exchange surfaces of heating or cooling equipment.
20. Joint faces of gaskets and packing surfaces.
21. Lubricating gear, such as oil holes, oil or grease cups, lubricators, and surfaces in contact with lubrication oil.
22. Lubricating oil reservoirs.
23. Machined metal surfaces of reciprocating engines or pumps and all "oil wetted" surfaces of internal combustion engines.
24. Metal lagging.
25. Rods, gears, universal joints and coupling of valve operating gear.
26. Expansion joints, pipe hangers, flexible hose connections, items partially fabricated of rubber and resilient elements of isolation mounts.
27. Sliding feet of turbines and boilers.
28. Springs.
29. strainers.
30. Turbine *casing* joints, nuts, and bolts.
31. Working surfaces.
32. Deck fittings and joiner hardware on plastic boat.
33. Light reflecting and transmitting surfaces of items such as light fixtures, ports, and windows.
34. Sea chest waster rings.

The above items should be covered, masked, or otherwise protected from paint application.

QUALITY ASSURANCE

General - The coating system shall be inspected for the defects listed herein. Where a single type of paint system (ie., vinyl or silicone alkyd) is applied (topcoated) over another type (ie., epoxy), an inspection shall be conducted before and after the application of the topcoats. Each system shall be judged individually. Defects are categorized as major and minor. Major defects shall be corrected prior to coating system acceptance.

Inspection Criteria - Inspect after drying or curing of each coat of the system being used for the following attributes.

Major Defects

1. Incorrect coating system.
2. Incorrect number of coats (less than the minimum specified).
3. Inadequate dry film thickness (DFT).
 - a. Determine if the coating system is applied at the correct dry film thickness as specified on the Job Order or documents referenced thereon. Using a magnetic dry film thickness (DFT) gauge, take a minimum of five thickness measurements taken approximately ten feet apart for each approximate 1,000 feet of area. If any one of the five measurements is below the minimum required DFT, take two additional measurements at arms reach about the site of the discrepant measurement. The average of these three measurements shall be used as one of the five measurements. The five measurements shall be averaged to determine acceptance or rejection for the total area (1,000 square feet) in question.
 - b. After application of additional coating to any deficient area, additional measurements are not required unless the original DFT measurements indicated the DFT deficient by more than 1.5 mils.
4. Not cured or dried.
5. Intercoat adhesion failure.
6. Incomplete coverage (holidays, touch-up, etc.).
7. Touch areas not free of sharp or protruding edges.
8. Cratering (deep depressions or holes on paint) greater than 1%.
9. Wrinkling (prune-like appearance) greater than 1%.
10. Puddling (thick pockets of paint in corners or low points) greater than 1%.

11. Contaminants in film (sand, dirt, water, oil, debris) greater than 1%.
12. Wrong color (exterior weather boundaries or habitability spaces).
13. Other conditions which will result in premature failure of coating system.

Minor Defects

1. Cratering less than 1%.
2. Wrinkling less than 1%.
3. Puddling less than 1%.
4. Contaminants less than 1%.
5. Other conditions not considered normal but not considered to be defects which will result in premature failure of the coating system.

Inspection Equipment

Mikrotest thickness gauges or other NAVSEA approved gauge shall be utilized by inspecting personnel to determine the DFT applied. Correction tables shall be established and accompany each gauge for the different steel alloys typically encountered during testing. Tables indicating gauge error at typical millage thicknesses encountered shall accompany each-gauge.

Dry film thicknesses of coatings applied to aluminum substrates can be obtained by use of "Demitron" electromagnetic thickness gauge or by coating steel coupons during the process of work and taking DFT readings from the coupons.

OPERATOR QUALIFICATION AND TRAINING

Painters at Naval shipyards are not given specific paint qualifications. Painters that are inexperienced or newly hired are assigned to work with a mechanic for an average of two to three years in order to gain valuable experience needed in the trade. During this time, they are assigned jobs such as masking, sanding, and descaling to prepare areas for paint application.

Painters must be experienced at performing the following trade related tasks before they are assigned actual paint application jobs.

1. Ability to set up and properly adjust and maintain equipment.
2. Prepare surfaces to be painted.
3. Protection of components in paint application areas.
4. Proper application of paint coatings per process instructions, technical manuals, and manufacturers specifications.
5. Correct use of paint thinners.
6. Protection of area to be painted from fire hazards.
7. Coordinate work with other trades.
8. Show ability to work with minimum or no supervision.

APPLICATION COSTS

The following information is based on average rates obtained from National Steel and Shipbuilding Company in San Diego, California and the Planning and Estimating Department at Puget Sound Naval Shipyard in Bremerton, Washington. The figures reflect the cost estimates for non-uniform (ie., non-flat) surfaces with a variety of accessibilities for the painter and sandblaster.

Epoxy Polyamide = \$1.24 per square foot
(Mare Island series)

Inorganic Zinc/Epoxy Polyamide = \$1.60 per square foot
(Mare Island)

MAINTENANCE AND REPAIR METHODS

Maintenance of Inorganic Zinc Coatings - Maintenance costs of the inorganic zinc with epoxy topcoats would be minimal. topcoat should be applied as required to avoid the initiation of incipient corrosion. The life of the original coating would vary depending on the severity of the exposure, but in a mild environment, the first recoat would probably not be required for 15 to 20 years.

It is recommended that these coatings be evaluated on a regular basis so that a fresh topcoat can be applied before an substantial degree of failure is experienced in the coating system. Attention should also be paid to any small areas of point fracture so that they may be quickly repaired. These areas will be small because they metallize. Zinc coating will tend to inhibit or prevent undercutting and delamination.

Preparation of painted surfaces includes the removal of surface contaminants, corrosion, old paint, moisture, blending (touch-up paint), and roughening of the surface (old paint in good condition).

Recleaning is necessary before touch-up or re-coating work is performed. Damage to a coating on board ship can occur in a number of ways: burns from welding, chipping from metal tools, and equipment or scaffolding being dragged across painted steel surfaces. Any kind of damage to the paint film must be repaired to prevent corrosion attack at the exposed areas.

Repair of Localized Areas - It is imperative that removal of the old paint is carried back around the edges of the area or spot to be repaired until an area of completely intact and adhering paint, free of blisters and underlying rust, is attained. The edges of the tightly adhering paint surrounding the area to be re-coated must be feathered, with no sharp edges, to allow proper blending and prevent laying new paint over loose or cracked paint. Areas of intact paint to be overcoated must first be roughened (ie., brush blasting or light sanding) and a tack coat should then be applied.

When evidence of corrosion, peeling, blistering, scaling, or general disintegration is apparent, the paint should be removed down to the bare surfaces. Removal of the paint coating may be performed by a variety of methods of which the most common are abrasive blasting, water blasting, grinding, descaling, wire brushing, and needle guns. The removal method depends upon the area of the ship to be painted and the type of paint being applied.

Old paint which is still in good condition provides an excellent base for repainting. The surface shall be roughened, cleaned, and dried before new paint is applied. When painting over previously painted steel and an application of an intermediate

topcoat is performed, any contaminants remaining on the first coat will interfere with the bonding of the newly applied paint coating. Inter-coat cleanliness can be achieved by removing dust, oil spots, chalking, markings, and spills.

Paint that is visibly cracked, loose, or flaking must be totally removed before repainting. Old layers of unsound or dead paint will lift from the surface and will cause the new paint to crack. As a result, delamination or peeling of large layers of paint will occur.

Coating Over Inorganic Zinc Coatings

If epoxy coatings are applied over aged inorganic zinc coatings, or if the topcoat over an inorganic zinc coating has been removed by mechanical damage, the inorganic zinc coating should be scrubbed and washed with a detergent solution. Flush the cleaned surface with fresh water to remove loosened dirt, grime, and cleaning solution. Allow surface to dry. Lightly roughen the dry surface by mechanical means, feathering the edges of the intact topcoat. Reapply the topcoat system. Apply the first coat of the topcoat system as a thin film, coating the inorganic zinc, and allow to dry. This fills the pores and seals the surface of the inorganic zinc coating. Follow this procedure with the complete topcoat system.

PAINT
GENERAL INFORMATION

GENERAL ADVANTAGES

The general advantages of paint coatings that should be considered when choosing a protection system are:

1. Ease of application in shop or on site.
2. Wide availability of painting facilities.
3. No effect on the mechanical properties of the steel substrate (this is true of sprayed metal coatings also).
4. Easy repair of coatings.
5. Wide range of colors available for cosmetic purposes.

SURFACE PREPARATION LIMITATIONS

Certain surface conditions that are frequently encountered on board ships must be corrected prior to coating application. These surface conditions consist of the following.

Sharp Edges - Will cause paint to draw thin. The edges should be ground to smooth edges.

Inside Corners - Provide a collection point for excess paint. Inside corners should be welded and ground to form a smooth, rounded inside contour. The coating shall be properly sprayed in order to prevent thick, cracked, and spongy deposits of paint.

Other - Metal splinters, weld splatter, etc. should be ground flush. Crevices and pits should be filled with weld metal and ground flush to the surface.

CURING OR DRYING AND RECOAT TIMES

Each coat of paint shall be in a proper state of cure or dryness before the application of a succeeding coat (recoat time).

The normal recoat times between succeeding coats of epoxy polyamide (MIL-P-24441) formulas are 24 hours at 50-60 degrees F; 16 hours at 60-80 degrees F; and 6-8 hours at 80-90 degrees F. Although a longer time can be allowed between succeeding coats, it is desirable to recoat within 24 hours to reduce the possibility of surface contamination.

If epoxy primed or intermediate coated surfaces become contaminated, surface shall be cleaned with water and detergent, and solvent if required, rinsed with fresh water and then apply a tack coat (1-2 wet mils), of the same material as the last coat applied, before application of the succeeding full coat of epoxy. A tack coat shall also be applied when intact epoxy has been brush blasted or roughened to serve as a base coat for the application of additional epoxy coats.

VOLATILE ORGANIC COMPOUNDS (VOC)

The volatile organic compound (VOC) levels of the paint systems that were tested in the 2,360 hour accelerated salt spray booth are as follows:

International Brand "FP" Series (Epoxy Polyamide)
VOC grams per liter = 190

Commercial Inorganic Zinc (International Brand)
VOC grams per liter = 430

Inorganic Zinc (Navy Specification)
VOC grams per liter = 540

TYPE I Mare Island System (Military Exterior Topcoat):

MIL-P=24441/1 Epoxy Polyamide (Formula 150) Green
VOC grams per liter = 347

MIL-P=24441/2 Epoxy Polyamide (Formula 151) Haze Gray
VOC grams per liter = 365

TT-E-490 Enamel Exterior Topcoat (Gray)
VOC grams per liter = 380

Currently, these are the systems being used with the guidelines set forth in the State of Washington. The International brand "FP" series (epoxy polyamide) falls within California VOC compliance regulations. The Navy has until September 1, 1991 to make these paint formulas fall within 340 VOC grams per liter for VOC compliance.

WIRE SPRAYED ALUMINUM AND PAINT

EQUIPMENT AND MATERIAL COSTS

AND CONSUMABLES

The following information is provided with the understanding that Puget Sound Naval Shipyard is not endorsing any single manufacturer or product and that said information is to be used only as a guide to possible sources and the approximate pricing of these products.

EQUIPMENT AND MATERIAL COSTS

Much of the equipment and many of the consumable items are used in both thermal spray and paint facilities. The following list is a combination of these items and utilizes the following legend. (P) = paint Facility, (TS) = Thermal Spray Facility, and (B) = Both Paint and Thermal Spray Facilities.

- A. Vapor Degreaser (P)
- B. Containerized Abrasive Blast Unit (B)
- C. WSA Spray Equipment (TS)
- D. Arc Spray Equipment with Running Gear and Angle Nozzle (TS)
- E. Water Wash Booth (B)
- F. Paint Spray Equipment (p)
- G. Paint Mixers (P)
- H. Control Console/Power Supply - Electrostatic Spray (P)
- I. Powder Spray Gun - Electrostatic Spray Powder (P)
- J. Powder Hopper/Feeder - Electrostatic Spray Powder (P)
- K. Powder Spray Booth - ESP (Cartridge Type) (p)
- L. Oven: Curing Type, Walk-In (B)
- M. Storage Cabinet (B)
- N. Flammable Liquid Storage Cabinet (B)
- O. Pre-Expend Bin Storage (B)
- P. Small Parts Storage (B)
- Q. Oxygen and Acetylene Bottle Storage Racks (TS)
- R. Work Table (B)
- S. One-Ton Electric Hoist and Swing Boom (3)
- T. Half-Ton Hand-Operated Chain Hoist (B)
- U. Mobile Hydraulic Floor Crane (Engine Hoist) (B)
- v. Hydraulic Pallet Truck (B)
- w. Platform Truck (3)
- x. Surface Profile Measurement Apparatus (B)
- Y. Portable Electric Psychrometer (B)
- Z. Holiday Detector (Portable) (P)
- AA. Wet Film Thickness Gauge (p)
- BB. Dry Film Thickness Gauge (P)
- CC. Air Compressor and Dryer (P)
- DD. Battery Operated Hand Truck (B)
- EE. Direct Current power Source (450 and 650 Amp) (TS)
- FF. Water Jet Removal System (B)
- GG. Site Containerized Thermal Spray Facility (TS)

A. VAPOR DEGREASER (P)

1. Intended Use

The intended use of this equipment is to remove all oil and grease from a variety of shipboard steel and aluminum components using 1,1,1-Trichloroethane.

2. Design

Parts basket, 92" x. 32" x 38"

Tank vapor space dimensions shall be not less than 96" long x 36" wide x 42" deep.

3. Operational Requirements

- Heating Element: 480 VAC, 3 phase, 60 Hz, 135 amps, 112.5 kW
- Pump: 480 VAC, 3 phase, 60 Hz, 4.6 kW

4. Estimated Cost

\$16,000

B. CONTAINERIZED ABRASIVE BLAST UNIT (B)

1. Intended Use

The intended use of this system is to provide a containerized walk-in SSPC-10 white metal blast capability.

2. Design

- Container dimensions: 8' X 8' X 20'
- Blast room: 7'-1/2' X 7'-1/2' X 10'

3. Operational Requirements

- 480 VAC, 3 phase, 60 Hzr 40 amps, 33.3 KW
- Air: 200 CFM, 100 PSI

4. Estimated Cost

\$80,000

C. WSA SPRAY EQUIPMENT (TS)

1. Intended Use

Equipment is to be used to apply corrosion resistant coatings, such as aluminum and zinc, in the form of a molten metal spray developed from a metal wire using oxygen-acetylene.

2. Design

MIL-M-3800D lists items to be provided in metallizing system. The major items are listed. Additional requirements and remarks are noted where applicable.

EQUIPMENT

Metallizing Gun

Wire fed, air turbine or air motor wire device. The metallizing gun must produce high quality coatings while operating within the 15 psi maximum allowable acetylene pressures specified by the safety codes. The gas head and cylinder valve for controlling the mixture of oxygen, air, and acetylene must have "O-ring" fits for ease of PM\CM and prevention of galling and freezing from prolonged storage and use in low temperatures. Add flow rate and pressure envelope number. Lubrication sight plug required for checking gear case Lubricant.

Carrying Case

Manuals, parts lists, diagrams

operator manuals, illustrated parts breakdown, indexed to a parts/stock number list, system assembly/operating diagrams and preventive/corrective maintenance instructions.

Air Caps

Circular and elliptical spray patterns.

Wire Nozzles

Hose Set

Federal Specification ZZ-H-461

C. **WSA SPRAY EQUIPMENT (TS)**
(Continued)

Oxygen Regulator	UL-252, Table III of MIL-M-3800D
Fuel Gas Regulator	U1-252, Table III of MIL-M-3800D
Oxygen Flow Meter	Design per MIL-M-3800
Fuel Gas Flow Meter	Design per MIL-M-3800
Air Flow Meter	Design per MIL-Z4-3800
Air Control Unit	
Wire Reel and Stand	Preserved with wire sprayed aluminum per DOD STD 2138(SH)
Wire Straightener	
Gun Mounting Fixture	Not required
Flame Arrester	
Angular Air Caps	To produce a 45 degree deflection of the spray.
Gun Extension	1-foot extension capable of operating with and without a 45 degree deflection angular air cap.

Utility Requirements

- 30 CFM at 65 PSI
- **2.8 M³ per HR O₂**
1.4 M³ per HR Acetylene

4. Estimated cost

\$4,500

D. ARC SPRAY EQUIPMENT WITH RUNNING GEAR AND ANGLE NOZZLE (TS)

1. Intended Use

Equipment is to be used to apply corrosion resistant coatings, such as aluminum, using an electric arc as the source of heat between two consumable wires. Compressed air or inert gas is used to propel molten metal onto the substrate.

EQUIPMENT

Wire Feed Assembly

Spray Gun Assembly

Electrical Assembly

1/8" Wire Drive Kit (includes feed rolls, contact tips, electronic parts)

2. Estimated Cost

\$13,110

E. WATER WASH BOOTH (B)

1. Intended Use

The water wash spray booth is a partially enclosed structure designed to remove airborne metallic particles, dust, and fumes generated by the metal spray process.

2. Design

- Water wash booth working dimensions shall be nominally 10' wide x 8' high x 10' deep.

3. Utility Requirements

- Fan: 480 VAC, 60 Hz, 3 phase, 15 amps, 22.5 kW

- Pump: 480 VAC, 60 Hz, 3 phase, 12 amps, 10 kW

- Water: 10 GPM

4. Estimated Cost

\$11,000

F. PAINT SPRAY EQUIPMENT (P)

1. Intended Use

Apply Silicon Alkyd (TT-E-490), Epoxy Polyamide (MIL-P-244411 Formula 150 and 151, Inorganic Zinc Silicate Primer (MIL-P-15929), Heat Resistant Aluminum Paint (DOD-P-24555), Zinc Chromate (TT-P-645), Wash Primer (MIL-P-15328), Conversion Coat (MIL-C-5541), and Primer (MIL-P-23377) by commercially available, lightweight, medium production, hand-held, pressure feed, compressed air paint spray gun. Intended for use within a ventilated and water wash filter paint spray booth.

2. Design

- Spray Gun: Commercially available, lightweight, medium production, hand-held, pressure feed, compressed air paint spray gun.
- Two Quart Pressure Cup: Commercially available, two quart fluid capacity pressure cup with pressure regulating valve and pressure gauge 0-160 psig range.
- Air Hoses: Commercially available, oil resistant compressed air hose. Two six foot lengths of air hose for connection from air supply to the pressure cup.
- Fluid Hoses: Commercially available, two six foot lengths of fluid hose to connect pressure cup to the spray gun.

3. Utility Requirements

- 15 cfm, Air at 50 PSI

4. Estimated Cost

\$327

G. PAINT MIXERS (P)

1. Intended Use

To mix paints and primers in one and five gallon cans.

2. Design

A one gallon paint can mixer shall be designed with a 1/4" diameter by 10" long shaft with blading to mix the paint on one end. The end opposite the blading shall be used in a drill motor chuck. The drill motor will provide rotation to the mixer. Minimum rotational speed of mixer shall be 500 RPM.

A five gallon can mixer shall be similarly designed with a 1/2" diameter by 20" long shaft.

3. Utility Requirements

None

4. Estimated Cost

- One gallon mixer: \$10
- Five gallon mixer: \$37

H. CONTROL CONSOLE/POWER SUPPLY - ELECTROSTATIC SPRAY (P)

1. Intended Use

Houses all electrical and air inputs, powder feed and high voltage controls, gauges and switches for a complete single gun electrostatic spray system.

2. Design

- Chassis size, 18" x 18" x 10", typical
- Console shall be wall or cart mounted

3. Operational Requirements

- Electrical, typical

Input	120/240 VAC, 60 Hz
output	30-90 KV
Current (short circuit)	150 MicroAmperes

- Pneumatic, typical

Input Air	60-100 psi
Total Air Consumption	15 SCFM

- UC can only be used with same manufacturer's spray guns and powder hoppers

I. POWDER SPRAY GUN - ELECTROSTATIC SPRAY POWDER (P)

1. Intended Use

For the manual application of electrostatically sprayed powder coatings.

2. Design

- The spray gun shall be less than 2 lbs. *in* weight
- The gun barrel shall be designed for ease of cleaning
- The gun shall have lance extensions of 6' and 12' for coating interior areas

3. Operational Requirements

The gun manufacturer shall be the same for the control console and powder hopper. Interchangeability is not acceptable.

J. POWDER HOPPER/FEEDER - ELECTROSTATIC SPRAY POWDER (P)

1. Intended Use

As a portable container to hold and feed powders for the powder spray gun.

2. Design

Powder capacity of 50 lbs.

The hopper/feeder shall be equipped with a venturi system to transfer powder to spray gun

Two additional hopper/feeders of 6-8 lb capacity shall be provided

The 6-8 lb hopper/feeders shall have a size of 35" x 15" x 15", typical.

3. Operational Requirements

- The pneumatic requirements of the hopper/feeder shall be in the ranges of:

Hopper Fluidizing Air	3-4 SCFM	5-15 psi
Ejection Air	4-6 SCFM	40-100 psi
Dilution Air	4-6 SCFM	40-100 psi

4. Estimated Cost

Powder Spray System
(control console/power supply/spray gun/hopper/feeder)

\$4,186

K. POWDER SPRAY BOOTH - ESP (CARTRIDGE TYPE) (P)

1. Intended Use

To provide a safe and nuisance-free area for the application of electrostatically sprayed powder.

2. Design

- Overall work area shall be 10' x 10' x 10'
- Plenum shall have a cartridge bank face of 10' x 10'

3. Operational Requirements

- Face velocity: refer to NFPA No. 33
- Utilities

Blower: 3 phase, 440V, 60 Hz, 7.5 Amps
Lights (total): 110V, 60 Hz, 3.5 Amps

4. Estimated Cost

\$25,000

L OVEN; CURING TYPE, WALK-IN (B)

1. Intended Use

To provide uniform heating to parts that have to be electrostatically powder coated so that the coating will flow and *cure* to a smooth hard finish. The oven **shall also** be used for preheating parts.

2. Design

- Work space: 84" wide x 120" deep x 84" high

3. Operational Requirements

- Oven shall have the operational range of 100-450°F.
- With the 450°F limit, the oven shall be set on a concrete floor. The oven heating area will not have its own floor.
- Utilities

Heat source:

Electric Oven	3 phase, 440V, 140 KW, Maximum
Recirculation System	3 phase, 440v, 12 Amps, Maximum

4. Estimated Cost

\$38,000

M STORAGE CABINET (B)

1. Intended Use

The intended use of this cabinet is to store nonflammable supplies for use *in* an industrial environment.

2. Design

Exterior cabinet dimensions shall be 36" wide x 78" high x 18" deep as a minimum.

3. Utility Requirements

None

4. Estimated Cost

\$288

N. FLAMMABLE LIQUID STORAGE CABINET (B)

1. Intended Use

The intended use of this cabinet is to store volatile liquids.

2. Design

Cabinet shall be of double-wall construction.

Cabinet shall contain vapor vent openings equipped with removable screw caps protected by flash arrester.

Minimum 2" deep leak proof pan bottom.

Internal cabinet dimensions shall be 30" x 18" x 60" minimum.

3. Utility Requirements

None

4. Estimated Cost

\$591

0. PRE-EXPENDED BIN STORAGE (B)

1. Intended Use

The intended use of this unit is to provide storage of fastener assemblies, classified by material and size.

2. Design

- Shelving shall be 36" wide x 12" deep x 75" high.

Bins shall be 6" wide x 12" deep x 4" high.

Bins shall have a handle and label holder.

3. Utility Requirements

None

4. Estimated Cost

\$184

P. SMALL PARTS STORAGE (B)

1. Intended Use

The intended use of this cabinet is to store small rubber plugs and miscellaneous masking supplies.

2. Design

- Dimensions shall be at a minimum 16-1/2" deep x 35" high x 25 1/2" wide.

3. Utility Requirements

None

4. Estimated Cost

\$251

Q. OXYGEN AND ACETYLENE BOTTLE STORAGE RACKS (TS)

1. Intended Use

To provide upright protection for high pressure gas cylinders (particularly the neck and valve assemblies) while transporting and during use.

2. Design

- Rack capable of holding 8 oxygen or 6 acetylene bottles. The racks will be constructed such that the storage rack containing bottles may be used to lift and load the bottles onto a vehicle for transportation.
- The rack shall have a door/panel or bar to hold the bottles in place.
- A padlock hasp or locking device shall secure the bottles.

3. Utility Requirements

None

4. Estimated Cost

\$500

R. WORK TABLE (B)

1. Intended Use

General purpose, commercially available, work table for use in Corrosion Control Shop for masking, assembly, disassembly, and various repair functions.

2. Design

- 6' length x 29" width x 33-1/2" (+/- 1/2") height steel top work table supported by steel leg assembly, stringer and shelf.

3. Utility Requirements

None

4. Estimated Cost

\$199

S. ONE-TON ELECTRIC HOIST AND SWING BOOM (B)

1. Intended Use

To lift heavy objects from an equipment cart, immerse and remove product from the degreaser and return to cart.

2. Design

- Capable of lifting and lowering 2,000 pounds a height of 15 feet and moving the load along an I-beam trolley.
- Load hook shall be a swivel type and must be fitted with a safety device to bridge the throat opening. Hook throat opening shall be 29/32 inch minimum.
- Motor speed governor shall limit lowering speed to 10 feet per minute.

3. Utility Requirements

- 480 VAC, 3 phase, 60 Hz, 4 amps, 3.33 KW

4. Estimated Cost

Swing Boom	\$ 858
Hoist, Trolley & Chain Container	\$1,462

TOTAL	\$2,319

T. HALF-TON HAND OPERATED CHAIN HOIST (B)

1. Intended Use

General equipment/heavy product/objects handling within and at the entrance to the grit and anchor tooth blast booths.

2. Design

- 1/2 ton capacity, hand operated by chain, suspended from an I-beam by a plain trolley capable of lifting 8 feet.

Load hook shall be a swivel type with a hook throat opening safety device. Hook throat opening with safety device shall not be less than 3/4 inch.

3. Utility Requirements

None

4. Estimated Cost

\$482

U. MOBILE HYDRAULIC FLOOR CRANE (ENGINE HOIST) (B)

1. Intended Use

General equipment handling.

2. Design

- 2,000 pound capacity.

Telescopic boom with a locking device to prevent boom length from changing during use.

3. Utility Requirements

None

4. Estimated Cost

\$836

V. HYDRAULIC PALLET TRUCK (B)

1. Intended Use
General equipment handling.
2. Design
- 4,000 pound capacity.
3. Utility Requirements
None
4. Estimated Cost
\$799

W. PLATFORM TRUCK (B)

1. Intended Use
To aid in the movement of equipment, supplies, product, etc., between production work stations.
2. Design
- 1,400 pound capacity, 60 inch x 30 inch hand-pushed steel platform truck/cart. Arc welded steel platform and top. Two rigid and two swivel, roller bearing, rubber wheels attached to the platform by nuts, bolts, and washers. Handle is tubular steel with an offset away from projection of the platform top. Handle is removable from cart for versatility.
3. Utility Requirements
None
4. Estimated Cost
\$246

X. SURFACE PROFILE MEASUREMENT APPARATUS (B)

1. Intended Use

To provide a fast, reliable, and permanent record of surface profile.

2. Design

Profile replica tape shall form an exact reverse image of substrate profile, 0-2 mil (0-0.002") range.

Dial micrometer is used to measure profile on tape, and have a scale of 0.0001"-0.05" +/- 0.0001", typical.

3. Utility Requirements

None

4. Estimated Cost

\$140

Y. PORTABLE ELECTRIC PSYCHROMETER (B)

1. Intended Use

To measure relative humidity of operating environment, to ensure that WSA and ESP applications will not be in jeopardy.

2. Design

- Psychrometer (excluding batteries) shall weigh approximately 4 lbs. and be of the dimensions 10" x 5" x 2", typical.
- One thermometer shall be "dry bulb" type to measure temperature of ambient air and the second thermometer shall be "wet bulb" type by having its *reservoir* end covered in a water wetted wick, to measure the temperature of an evaporating surface.
- Thermometers shall be spirit filled (red liquid) and calibrated with a range of 10 degrees to 150 degrees.

3. Operational Requirements

- Power shall be supplied by three standard flashlight batteries, Type D, typical.

4. Estimated Cost

\$160

Z. HOLIDAY DETECTOR (PORTABLE) (P)

1. Intended Use

To detect voids or discontinuities in non-conductive coatings on metallic surfaces.

2. Design and Operational Requirements

Size of unit shall be 10" x 8" x 5", typical.

Weight of unit shall be 20 lb., maximum.

Voltage range shall be 0-10,000 volts.

Voltage shall be variably controlled and indicated on a volt meter (0-10,000 volts).

Detection of holidays and pin holes shall be indicated by an audible signal, manufacturer's standard.

Probe shall be manufacturer's standard band brush.

3. Utility Requirements

None

4. Estimated Cost *

\$2,200

* Estimated cost reflects 1985 price.
More current price information was not available.

AA. WET FILM THICKNESS GAUGE (P)

1. Intended Use

To measure thickness of wet paint to insure that the proper amount and technique is being used.

2. Design

- Pocket size, 4" x 1.5", typical.
- Square type.

3. Operational Requirements

Capable of measurements from 0-20 mils +/- mil (0-0.02" +/- 0.001").

4. Estimated Cost

\$24

BB. DRY FILM THICKNESS GAUGE (P)

1. Intended Use

To measure the thickness of paint and/or WSA on steel; and the thickness of electrostatic spray powder coatings on steel or aluminum.

2. Design

- Pen size (6" long, 0.5" diameter) gauge shall be designed for measurement of non-magnetic coatings on mild steel substrates.

Pen size gauge shall have an accuracy of at least +/- 15% full scale.

3. Utility Requirements

None

4. Estimated Cost

\$190

CC. AIR COMPRESSOR AND DRYER (P)

1. Intended Use

To supply compressed air of breathing quality for use in strip and anchor tooth blasters, powder and paint spray booths, and shop support air.

2. Design

800 CFM 125 psig rotary screw air compressor.

Skid mounted, sound attenuation enclosure.

Water cooled, built-in aftercooler.

3. Utility Requirements

- 450 VAC, 3 phase, 60 Hz, 350 amps, 292 kW

4. Estimated Cost

\$41,000

DD. BATTERY OPERATED HAND TRUCK (B)

1. Intended Use

To move pallets of materials and equipment.

2. Design

- 8,000 lb load

-48" fork length

Hydraulic lift

3. Operational Requirements

-24 volt battery powered

4. Estimated Cost

\$7,216

2 E.E. DIRECT CURRENT POWER SOURCE (450 & 650 AMPS)

1. Intended Use

Power source for arc spray equipment.

2. Design

Solid state contactor

Line voltage compensation (+/- 10%)

Low voltage on/off push button

Power failure reset

Thermal overload protection

115 volt duplex receptacle with 15 amp breaker

Voltmeter/ammeter

Single range load voltage control

-Contactor and 115 volt receptacles

-Standard/remote contactor switch

3. Estimated Cost

\$2,080

FF. WATER JET REMOVAL SYSTEM (B)

Intended Use

Designed for the removal of paint coatings and thermal sprayed coatings.

2. Design

Basic 3 component system:

- High pressure pumping unit

- Delivery hoses

Lance unit for delivering the water to the work piece

Estimated Cost

\$175,000

GG . SITE CONTAINERIZED THERMAL SPRAY FACILITY (TS)

1. Intended Use

Designed for spraying aluminum and zinc coatings for corrosion control applications.

2. Estimated cost

\$283,791

Labor and materials to build and install (turnkey) one MDL 5003M containerized flame spray (wire sprayed aluminum) system	\$230,516.00
Palletized thermal spray skid	\$ 53,275.00
Site labor, engineering development, and after-sale technical support	NSP
TOTAL	\$283,791.00

3. Specifications:

See Following 18 Page Specification Document and Photographs Provided By Flame Spray, Inc. (Flame Spray Leasing)

1. **SPECIFICATIONS**

1.1 **SCOPE** This specification covers a containerized Thermal Spray System and 20a Portable Skids designed for spraying aluminium and zinc coatings for corrosion control applications. All of the following equipment where applicable, are in compliance with the American National Standards ANSI Z49.1- Issue 1973.

1.2 The containerized system shall including the following:

- a. A waterwash spray booth - including tank, pump and exhsust apparatus.
- b, 2 each, combustion wire guns with all related hoses, gauges, flow meter and wire racks in accordance with MIL-M-S800D Feb 86.
- c. All quality assurance equipment required per DOD-STD-2138(SH), NOV. 1981.
- d. A Portable Container which will house the equipment listed in items a through c above.
- e. A regenerative air-dryer mounted in a separate enclosure.
- f. A Self-contained ABRASIVE BLAST ROOM for use in strip blasting and anchor tooth blasting.
- g. A twin 690 lb abrasive pot system suited to rapidly change grits from strip blasting to anchor tooth blasting.
- h. *All* blasting safety equipment and hoses and lighting.
- i. Portable container which will house all the equipment llsted in items f through h.
- J. A self-contained Dust collector system mounted outside the Blast Container
- k. Ramp 8' x 12' mounted in between Spray and Blast Units.
1. Overhead Crane System running through both the Blast and Spray containers with 12' span in between and a 6' over run at each end of containers.
- m. Corrugated Metal roof 40' long and 14' wide centered on overhead crane system.
- n. CO Monitor Alarm System for Air Breathing System

1.9 The Portable Skids are wire sprayed aluminum stations, providing a centralized work staging area for wire spraying out of shop.

Each Skid includes:

- a. Air-dryer System
- b. Storage cabinet
- c. Air/Gas
Distribution Manifold
- d. Electric Power Panels
- e. Bottle Storage Area
- f. Air and Gas Hose Storage Racks
- g. 2/es Metco 12E wire guns and assoolated accessories
- h. Q.A. Equipment
- i. Safety Equipment
- j. Skid and all appendages, are wire sprayed aluminum coated and painted.
- k. All components are clearly identified with label plates.

Each unit will be furnished as a complete thermal spray system with al: I.nter-connecting hoses, piping and electrical connect-ions.

2. **REQUIREMENTS**

2.1 DESIGN- The equipment shall be new and unused, capable of performing its intended function in accordance with the operation and performance requirements specified herein. The equipment shall be complete so that when connected to the utilities identified herein, it can be used for any function for which it is designed and constructed.

2.1.1 SAFETY AND HEALTH REQUIREMENTS - Covers, guards, or other safety devices shall be provided for all parts of the equipment that present safety hazards. The safety devices shall not interfere with operation of the equipment. The safety devices shall prevent unintentional contact with the guarded part, and shall be removable to facilitate inspection, maintenance and repair of the parts. All machine parts, components, mechanisms, and assemblies furnished on the units shall comply with all specific requirements of "OSHA Safety and Health Standards (29 VFR 1919), "General Industry" that are applicable to the equipment itself. Additional safety and health requirements shall be as specified in other paragraphs Of *this* specification.

2.1.1.2 CONTROLS -All operating controls shall be located convenient to the operator at his normal work station.

2.1.2 ENVIRONMENTAL PROTECTION - The equipment shall be designed and constructed so that, under the operating, service, transportation and storage conditions described herein, the equipment shall not omit materials hazardous to the ecological system as prescribed by federal, state or local statutes in effect at point of installation.

2.1.3 LUBRICATION - All bearings (except sealed-for-life and self-lubricating type), mating gears and sliding parts shall be provided with means for Lubrication. The reservoirs of splash-type systems shall be fitted with oil level sight gauges. Automatic torque feed and manually operated force feed systems shall be supplied with a filter. Manually operated systems shall have control handles mounted in an accessible location convenient to the operator. All oil holes, grease fittings and filler caps shall be easily accessible.

2.1.4 ELECTRICAL DESIGN

2.1.4.1 ELECTRICAL EQUIPMENT - all electrical components including motors, starters, relays, switches, and wiring shall conform to and be located in accordance with applicable NEMA, ANSI and NFPA standards for the intended application as defined in NFPA *78.

2.1.4.2 ELECTRICAL POWER DISCONNECT - A supply circuit disconnect device, fusible motor circuit breaker, shall be provided and Installed on the equipment.

2.1.4.3 MOTORS - Motors shall be rated for Industrial duty and shall be equipped with ball bearings of the sealed and permanently lubricated type.

2.1.4.4 CONTROL CIRCUITS - Main and auxiliary control circuit shall operate on a circuit of 116 volts or less derived from isolation transformer(s) integral with the equipment.

2.1.4.5 ELECTRICAL CONNECTIONS - All electrical connections within the equipment shall be complete and shall be made via terminals on the components, terminal/circuit boards and bussing. In no instance shall splicing of wiring between terminations be permitted in the construction nor the repair of the equipment. Connections/terminals shall be adequately supported and spaced without dependence upon the wiring in the components and braced as necessary to assure withstanding the distortion forces associated with available shortcircuit currents. All wiring to interconnect the two containers shall be provided. Proper identification of wiring, bussing, terminals and circuits for function, polarity, phasing, etc., shall be adhered to throughout the equipment. Identification shall be in the form of wire markers, color coding, permanently engraved plates, and permanent markings on the devices. Adequate spacing shall be maintained throughout to avoid excessive bending of cabling and wiring, to maintain adequate separation and creepage distances between electrical potential and between these potentials and ground, and to permit ease in connecting and disconnecting wiring and cabling during trouble shooting and repair. In no instance shall clearance and creepage distances be less than those prescribed under NEMA ICS Part ICS 1-111.

2.1.4.6 GROUNDING - For cord connected equipment, a NEMA type grounding plug which effectively grounds the equipment for safety of personnel shall be acceptable in lieu of a ground stud or lug on the equipment.

2.2 CONSTRUCTION - The equipment shall be constructed of parts which are new, without defects and free of repair. The equipment shall be complete so that when connected to the specified utilities it can be used for any operation for which it is being purchased.

2.2.1 FERROUS PARTS - All exposed ferrous parts such as screws, bolts, nuts, washers, etc., shall be cadmium or chrome plated, galvanized or otherwise surface protected by an electrical/chemical process or of stainless steel, to resist corrosion in a salt-laden, moist, variable temperature atmosphere.

2.2.2 CONTROL PANELS, INSTRUMENT, AND PLATES - Wording and numbers on control panels, instruments, and plates shall be in the English language, permanently and legibly displayed in bold faced characters on a contrasting background.

2.2.3 CONTROLS AND INSTRUMENTATION - All operator controls, instrumentation, and indicators shall be mounted with convenience to operating personnel. All such devices shall be clearly and legibly marked for function and identification. Each control shall be fitted with suitable handle(s), pushbutton(s) or control knob(s), as applicable. Gauges and indicators shall be designed for recalibration.

2.2.4 HANDLING DEVICES

2.2.4.1 LUGS/LIFTING EYES - The equipment shall be provided with forklift slots and crane eyes arranged with the vertical center of gravity for safe handling and transport by overhead crane. The equipment when suspended shall hang perpendicular within 6 degrees of true vertical. The arrangement shall provide a stable and balanced lift with a load safety factor of at least five times the total weight of the equipment.

2.2.5 WORKMANSHIP - Workmanship of the equipment to be furnished shall be commensurate with the requirements of this specification and of each quality which denotes the performance of skilled and experienced personnel trained in the field of work performed.

2.3 ADDITIONAL REQUIREMENTS

2.3.1 METER, TIME TOTALIZING

2.3.1.1 METER(S) - The containers and skids shall be fitted with a meter(s) to measure operating time of the Air-drying systems and exhaust blower for the abrasive blastroom. The meter shall be located as to be readily visible, but not subject to abuse relative to the operating environment of the equipment .

2.3.2 CAUTION - WARNING PLATES - Corrosion resistant "Caution" or "Warning" plates shall be securely attached to the equipment in visible locations, with any *safety* precautions to be observed by the operator or maintenance personnel, permanently on the plates.

2.3.3 TECHNICAL DATA - Technical data (3 copies), written in the English language shall be furnished. The Technical manual shall be the manufacture's standard commercial manual covering operation/maintenance and spare parts.

2.4 UTILITIES - The equipment shall be designed and constructed to be complete for operation on the following available utilities:

- a. Container System
Electrical - **Single Service 440 Volts (+10%), 3 phase,**
60 hertz, 60 AMP/MIN.
Compressed Air - 250 CFM at 108 PSI
- b. Portable skids
Electrical - Single Service 440 Volts, 3 phase,
60 Hertz, 20 AMP
Compressed Air - 175 CFM at 100 PSI

2.5 COMPONENTS- The equipment shall consist of, but is not limited to the following described principal components, attachments and accessories necessary to meet the operational and performance requirements specified herein:

2.5.1 - SKID - All locations and dimensions *of* the following equipment are designated on DWG# FSI-5997.

2.5.1.1 - AIR-DRYING -

- a. 159 CFM (Input Rated) Regenerative Air-drying System
- b. 259 CFM Aftercooler
- c. 259 CFM Particle Filter
- d. Coalescent 011 Filter
- e. 259 CFM Moisture Separators (2/ea)
- f. System is equipped with automatic drains

2.6.1.2 - STORAGE CABINET - Lockable for storage of the Wire sprayed aluminum guns, consoles, gages, Q.A. equipment, spare parts, safety equipment.

2.5.1.3 - AIR DISTRIBUTION MANIFOLD -

- a. 1-1/4" Galvanized piping from air in to outlets
- b. Air in to Moisture Separator
- c. Moisture Separator to After cooler
- d. After cooler to 2nd moisture separator
- e. Moisture separator to Oil Filter
- f. 011 Filter to Regenerative Dryer
- g. Regenerative Dryer to Particle Filter
- h. Particle Filter to distribution
- i. 1/ea 1-1/4" Ball Valve (Blasting Supply)
- j. 2/ea 3/4" Ball Valves (Supply to guns)
- k. 2/ea 1/2" Ball Valves (air Breather)
- l. 1. 2/ea 1/4" Ball Valves (Blow down Hoses)

2.5.1.4 -ELECTRICAL POWER PANELS -
(Weather Proof and Lockable Boxes)

- a. 1/ea 448 Volt 38 Amp Main Disconnect
- b. 1/ea Switch Box for After-cooler
- c. 1/ea Switch box for Regenerative Dryer
- d. 2/ea 110 Volt Utility Outlets
- e. 1/ea Transformer

2.5.1.5 -BOTTLE STORAGE AREA -

- a. 8/ea high pressure oxygen bottles and
4/ea acetylene bottles
- b. Lockable skid mounted area for securing bottles
for transport and usage with fire wall
separating oxygen and acetylene.

2.5.1.6 - AIR AND GAS HOSE -

- a. 8/ea - 60' of 3/8" oxygen/acetylene hose
- b. 8/ea - 60' of 1/2" air line
- c. 8/ea - 60' of 1/4" air line

2.6.1.7 - WIRE SPRAY GUN -

- a. 2/ea - Metco 12E Wire Guns with 35' of gun hose (plastic wrapped for hose wear)
 - b. 1/ea - 6" Extension
 - c. 1/ea - 3' Extension
 - d. 3/ea - 45 Degree Angle Air Cap
 - e. 2/ea - Air Control
 - f. 2/ea - Air Flow Meter
 - g. 2/ea - Gas Flow Meter
 - Items (e) thru (g) are mounted in a cabinet with Tripod stand
 - h. 2/ea Wire racks and straighteners
 - i. 2/ea Gauge sets - Oxygen and acetylene
 - j. Manifold for acetylene and oxygen.
- All acetylene gas lines equipped with flash arrestors.

2.5.1.8 - Q.A. EQUIPMENT -

- a. Magnetic Thickness Gauge
- b. Testex Field Kit (anchor Tooth profile kit)
- c. Pyrometer and sensor
- d. Bend Test Fixture
- e. All coupons (Bend test & Bond Test)

2.5.1.9 - SAFETY EQUIPMENT -

- a. 1/ea - Air Fed Mask
- b. 1/ea - Air breathing Filter
- c. 1/pr - Safety Glasses
- d. 1/pr - Ear Muffs and Plugs
- e. 1/pr - Gloves

2.5.1.10 - SKID 8' x10' (WELDED CONSTRUCTION)

- a. Forklift Slots
- b. Eye Hooks for Crane Rigging
- c. All Steel components of the skid are coated with wire sprayed aluminum and epoxy painted. Caged in expanded metal with solid roof and floor, fire wall surrounding and separating oxygen and acetylene compressed gas cylinders.
- d. 3' extended platform to carry blast pot and accessories

2.6.1.11 - LABEL PLATES - All components are clearly identified with label plates.

2.5.2 - THERMAL SPRAY CONTAINER - The container shall be fabricated from not less than 12 gauge steel plate suitable for outdoor use. The walls, ceilings and doors shall be supported and stiffened by structural steel shapes of sufficient strength and size to prevent warping and permanent deformation. The inside dimensions of the container shall be as DWG# FSI S093M. The outside surface of the container shall be wire sprayed aluminum coated per DOD STD 2138. Topcoat system on container shall consist of 1 sealer coat and 1 barrier coat of epoxy polyamide and 1 topcoat of polyurethane. The inside surface of the container shall be grit blasted per SSPC No 5 and painted in accordance with manufacturers standards. Two sets of double doors shall be provided for access to the thermal spray room as shown in DWG #FSI 5003M. Also a set of double doors shall be provided for access to the air drying system, electrical panels, waterwash pump and blower as shown in DWG #FSI 5003M. The sizes of the doors shall be as per DWG #FSI 5003M. Makeup air vent doors which will provide the free air required for the water wash booth shall be installed. The vents shall be lockable and capable of opening and closing from either inside or out.

2.5.3 - ABRASIVE BLAST CONTAINER - The container shall be fabricated from not less than 12 gauge steel plate suitable for outdoor use. The walls, ceilings and doors shall be supported and stiffened by structural steel shapes of sufficient strength and **size to prevent warping and permanent deformation.** The inside dimensions of the container shall be as per DWG #FSI 5003M. The outside surface of the container shall be wire sprayed aluminum coated as per DOD-STD-2138. Topcoat system on container shall consist of 1 sealer coat and 1 barrier coat of epoxy polyamide and 1 topcoat of polyurethane. The inside surface of the container shall be grit blasted per SSPC No 5 and painted in accordance with manufacturers standard. Three sets of double doors shall be provided for access to the abrasive blast room as shown in DWG #FSI 5093M. A door shall be provided for access to the abrasive pot system as shown in DWG #FSI 5003M. The size of the door is as per DWG #FSI 5003M. The inside walls of the containers shall be rubber lined. The container wall shall have access openings for air and electricity. The 'Air In fitting shall be furnished with removable pipe plug and a retaining cable. The electrical receptacle for input power cord shall be corrosion resistant and weatherproof. The floor shall have access panels for clean-out in all necessary areas.

2.5.4 - AIR DRYING SYSTEM - A twin tower regenerative air dryer 350 cfm @ 190 psi with a moisture trap, oil separator and automatic drains shall be provided. This unit is mounted in a separate enclosure, which shall be Wire Sprayed Aluminum coated per DOD STD-2138 and finished painted with the same paint system as the outside of the containers. The system shall use outside compressed air supply (source of outside air may vary depending upon the location of the containerized unit) and deliver air having quality conforming to the requirements of DOD-STD-2138 for metal spray processes. The size of the regenerative air dryer enclosure shall be per DWG #FSI 5003M.

The Air Drying System consists of the following components:

- 350 CFM Aftercooler
- 350 CFM Regenerative Air Dryer
- 350 CFM Coalescer Filter
- 350 CFM Particulate Filter
- 350 CFM Water trap - Automatic Drains (moisture separator)

2.5.6 - WATERWASH SPRAY BOOTH

2.5.5.1 FABRICATION AND CONSTRUCTION - The waterwash spray booth exhaust chamber shall comply with OSHA -1910.107 and shall provide complete vapor, **fume** and mist removal from the spray room. Air velocity at the face of the water curtain chamber shall be not less than 200 feet per minute. The **water** curtain shall be recirculating water type. The length of water curtain shall be at least 7 feet with a collection pan or sump holding sufficient water to provide suction for the circulating pump. The water curtain shall discharge 40 gallons per minute per foot of its length.

2.5.5.2 - ENCLOSURE - The spray booth enclosure, water wash curtain, exhaust chamber, and collecting pan shall be constructed of 18 gauge (minimum) steel with **baked** enamel finish. The spray booth shall have inside dimensions as per DWG #FSI 5003M.

2.5.5.3 - COVERED AREAS - The areas adjacent to the water wash curtain **and exhaust chamber shall be coved and covered to isolate the top and both sides preventing the accumulation of debris and metal dust residue.** The coving and covering material shall be of the same gauge and type as the water wash curtain and the exhaust chamber.

2.5.5.4 - ACCESS - The covering panels shall be installed in such a way so as to allow easy removal for access to the water wash curtain, exhaust chamber.

2.8.5.5 - WATER CIRCULATION SYSTEM - Water circulation system shall include frame mounted circulation pump with motor complying with NFPA #70. Circulating pump discharge shall be 289 gallons per minute as required to maintain the specified flow on the water curtain.

2.5.5.6 - EXHAUST FAN - Exhaust fan shall remove a minimum of 11,900 SCFM air, at 3.4 inch water column in a 30 inch round duct or equivalent, complying with NFPA-91.

2.5.6.7 - CONTROLS

2.5.5.7.1 - ENCLOSURES - Enclosures for control panels and controls for the circulating pump and the exhaust vent motor shall be enclosures approved as per OSHA 1910.70, and NEMA IC.

2.5.6.7.2 - START/STOP CONTROLS - Motor controls shall be provided with a "Power-On" indicating light, and the panels shall be located 4 feet above the floor. Label to indicate function, use, and sequence of operation.

2.6.6.8 - STACK - Booth shall have one straight stack terminating above the roof. It shall be fabricated from not less than 12 gauge galvanized stack material. A cap shall be included with the stack.

2.6 - BLAST ROOM ENCLOSURE - The blast room shall be fabricated from not less than 12 gauge steel plate suitable for Installation inside the container. All erection joints shall be sealed to form a dust and air tight joint. The walls, ceilings and doors shall be supported and stiffened by structural steel shapes of sufficient strength and size to prevent warping or permanent deformation. The enclosure shall be designed to allow entrance of adequate ventilating air, while preventing the escape of dust or other pollutants. The Inside working dimensions of the blast room shall be as per DWG #FSI 6003M. Two sides of the blast room shall be comprised of a set of double work doors, as shown on DWGS FSI 5003M.

2.6.1 WORK DOORS - The work doors shall be fabricated from no less than 12 gauge steel plate, framed and stiffened sufficiently with structural steel shapes to prevent distortion. The door shall be mounted on heavy duty ball bearing hinges and secure with lock devices capable of opening from inside or outside. The periphery of the doors shall be designed to provide an air-tight seal when closed. One work door shall be provided with an exterior vision window complete with abrasive resistant glass seal mounted, at standard eye-level height.

2.8.1.1 - FLOOR GRATING - The floor grating and support structures shall be constructed so as to eliminate the retention of spent abrasive and debris. Grating shall be in sections so as to permit easy removal. The entire floor shall have capabilities to withstand and support weights of 1000 lb. per square foot without any deformation.

2.6.1.2 - LIGHTING - Lighting shall be dust protected with wire-molded glass. The lights shall provide no less than 80 foot-candles of illumination.

2.6.1.3 - VENTILATION - Ventilation within the blast room shall be of the down-draft type, with a minimum velocity of 50 feet per minute over the entire floor area.

2.6.1.4 - VENTILATOR - A motor driven blower shall be provided to furnish adequate ventilation in the system to maintain clear vision for the operator and hygienic surroundings. It shall be equipped with a drive motor of sufficient horsepower to handle efficiently the volume of air required for the system. The blower and fan shall be dynamically balanced in order to deliver quiet operation.

2.6.2 - DUCTING - Ducting shall be provided as required to connect the blast, reclamation, re-circulation and dust collection systems. All components necessary for ducting shall be located adjacent to each other.

2.6.3 - FLOOR RECOVERY SYSTEM - The floor recovery system shall remove spent abrasive from the floor by means of air velocity ducts, to the abrasive separator. The recovery system shall be capable of recovering 20 mesh to 80 mesh abrasive media from being conveyed into the abrasive separator.

2.6.4 - ABRASIVE RECOVERY, CONVEYING AND RECLAIMING SYSTEM -

The unit shall incorporate an adequate system for recovery and conveying of spent abrasives from the blast room floor into the reclaimer or cleaner. Upon entering the inlet of the reclaimer, abrasive and debris shall be separated from the conveying air stream in a cyclone chamber from which the air stream will continue on to the main dust collector. The clean abrasive shall then pass on to the blast generator for reuse.

2.6.4.1 - DUST COLLECTOR - A dry type collector shall be provided. The dust collector shall be completely compatible for use with the abrasive blast room furnished under this specification. The collector shall house a series of cloth composition bags providing a 3.5 to 1 air to cloth ratio. The dust collector furnished shall be designed for exterior installation and operation.

The bags shall be independently suspended from a sturdy frame located at the top of the unit. The bags shall also be independently replaceable. An automatically operated mechanism shall be provided to periodically shake the bags, releasing the accumulated dust into the hopper and into the 55 gallon disposal drums located in the extreme bottom of the hopper.

Provisions shall be provided to assure easy access to the bag area for inspection and replacement of the filter bags as necessary, as well as the performance of other types of unit maintenance.

2.7.5 - BLAST GENERATOR - The blast machine shall consist of 2 pressure blast pots each having a 690 lb. capacity. Intermittent action pressure type generator, with an adjustable pressure range shall be furnished. It shall be rigidly constructed in accordance with ASME specifications for unfired vessels with working pressure up to 100 psig. The generator shall be of the proper design (size and capacity) to utilize coarse abrasives and obtain desired performance results per DOD-STD-2138. The generator shall have an efficient transfer or refilling mechanism, actuated by the operator at the blasting nozzle. The blast generator furnished shall be designed to supply an adequate amount of abrasive to sustain one operator using a 5/16" nozzle as required to obtain satisfactory blasting results. A pressure gage shall be installed on the generator. Abrasive delivery from the generator chamber to the blast hose shall be controlled by adjustable operated abrasive feed valves. The valves shall be

open to a pre-set stop, which may be set by the operator to provide any degree of abrasive feed density. Control of the starting and stopping of the flow of air to the blast nozzle shall be by a remote air valve mounted on the blast hose near the nozzle end.

2.7.6 - HOSE AND NOZZLE - The hose shall be 1-1/4" I.D., 4 -ply non-static type, at least 16 foot length, having suitable streamline fittings including tungsten carbide nozzles with 5/16" orifice. Two complete hose assemblies shall be furnished.

2.7.8 - PIPING - All piping shall conform to American National Standards Institute, Code of Power Piping ANSI B31.1.

2.7.9 - OPERATORS EQUIPMENT - The following equipment shall be furnished with the Abrasive Blasting Facility.

- (a) One set of operator's gear, complete, including protective apron, leather gloves, ventilated helmet with an air-in-line filter, to protect the operator from carbon dioxide and carbon monoxide. CO Monitor with 3 electrochemical sensors, gas concentrations display on digital meter with range of 0-1999 parts per million (ppm) Equipped with audible alarm and calibration kit.
- (b) Two sets of "deadman" type remote controls pneumatically controlled feed valve and remote blowdown complete with control lead.
- (c) Two 16 foot length of 1-1/4" I.D. blast hose, 4 braid, abrasive resistant, complete with couplings.
- (d) Two 5/16 inch tungsten carbide lines blast nozzle.
- (e) 25 Ea. spare lens for helmet.
- (f) 25 Ea spare gaskets for hose couplings.

2.8 SIZES AND CAPACITIES - The sizes and capacities of the blast room shall conform to the requirements in DWG #FSI 5903M. Unless otherwise specified, sizes and capacities shall be considered a minimum.

2.9 ADDITIONAL EQUIPMENT

2.9.1 -RAMP- A fabricated 1/4" steel platform shall be fastened in between the blast and spray container. The platform will be 8 foot wide by 12 foot long and level with the spray room floor. The entire platform shall be WSA coated and furnished painted with the same paint system as the outside of the containers.

2.9.2 ROOF - A corrugated metal roof mounted on a steel angle iron frame which is attached to both the spray and blast containers shall be provided. The frame work shall be WSA coated and finished painted. The metal corrugated roof panels are overlapped and attached to the frame and sealed with silicon caulking. The roof frame is centered on the blast and spray booth doors. The overall dimensions are 14' wide x 40' long. Where the roof extends beyond the containers an angled bracket is mounted for support.

2.9.3 - OVERHEAD TROLLEY SYSTEM - A 6" I Beam 40' long is attached to the inside roof of the blast and spray containers and extends out each side 6' and spans the 12' in between the units. Two 1-1/2 ton capacity pneumatic hoists with manual trolleys are mounted on the I beam. The overhead trolley system will be certified for a 2000 lb. capacity.

2.9.4 -TURNTABLES - 2 Ea manual rotating round tables shall be furnished. The tables are 40" dia. and 12" high. They have handles for rotation and lifting.

2.9.6 TABLES - A spray table 36" X 36" is fabricated and attached to the front of the spray booth. It is hinged and can be collapsed laying in front of the spray booth.

A work table 16" x 38" is fabricated and attached underneath the spray console. It is hinged and collapsable.

2.9.6 BOTTLE RACK - 1 Ea 8 cylinder acetylene bottle storage rack is fabricated and furnished. The bottle rack has fork lift opening and lifting eyes for use with a crane. The cylinders are chained in place in accordance with Standard Safety Practices for cylinder handling.

2.9.7 MANIFOLD - A complete piped manifold shall be furnished for 8 Each acetylene culminating in a single outlet to a 2 stage acetylene regulator. Each line shall contain a flash arrestor for connection to cylinder.

A single high pressure line for oxygen will be supplied to connect a customer furnished 12 pack of high pressure oxygen cylinders to the 2 stage regulator mounted inside the container.

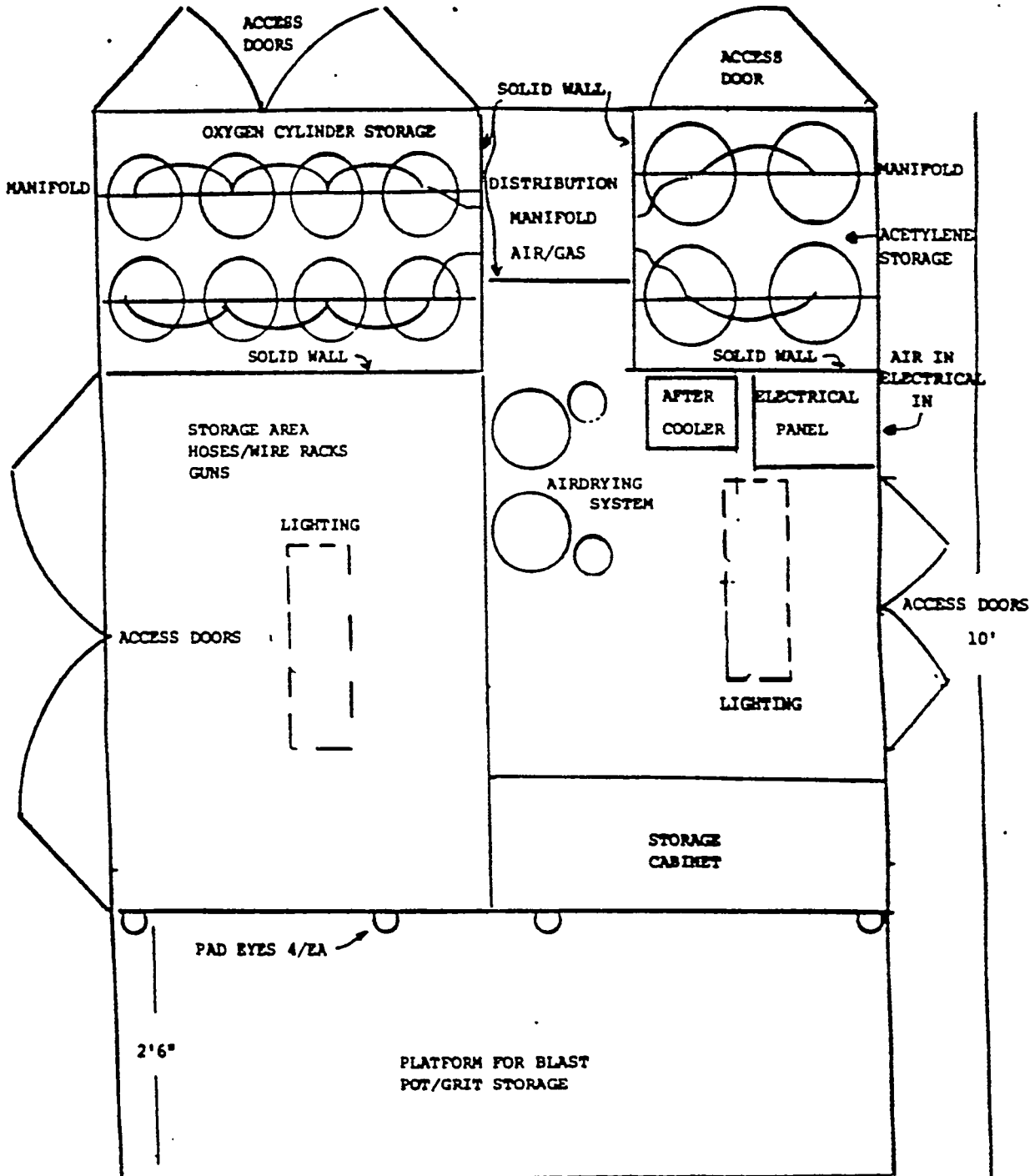
2.9.8- QUALITY ASSURANCE EQUIPMENT - The following equipment will be supplied for compliance with the quality requirements of DOD-STD-2138

- (a) Magnetic Thickness Gauge
- (b) Testex Field Kit (anchor tooth profile kit)
- (c) Pyrometer and sensor
- (d) Bend test fixture
- (e) All coupons (Bend test and Bond Test)

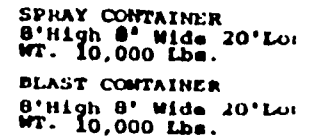
2.10 - IN SERVICE TEST - Upon completion of installation, the equipment shall be placed in service in actual production for a period of two weeks to demonstrate reliable operation and performance.

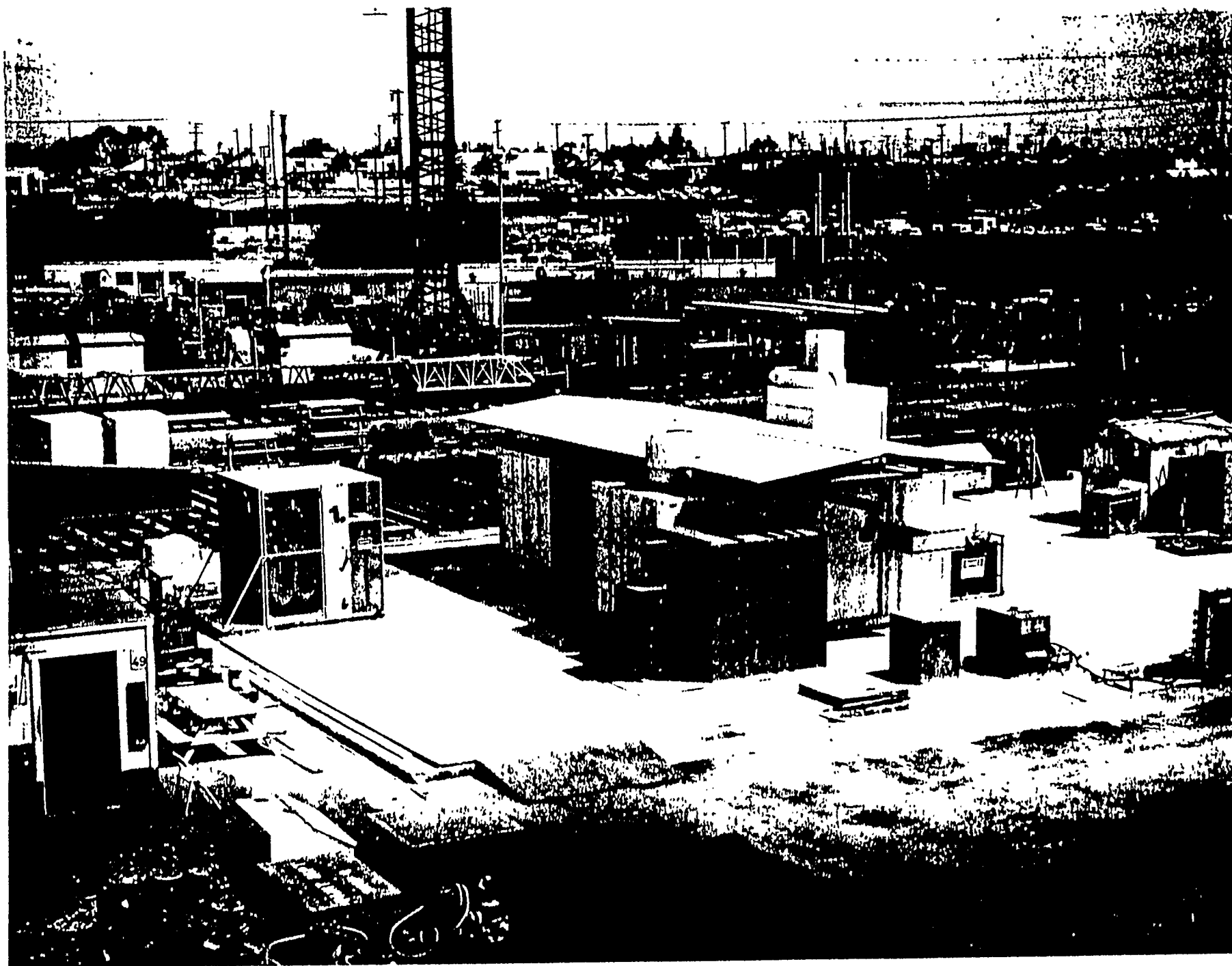
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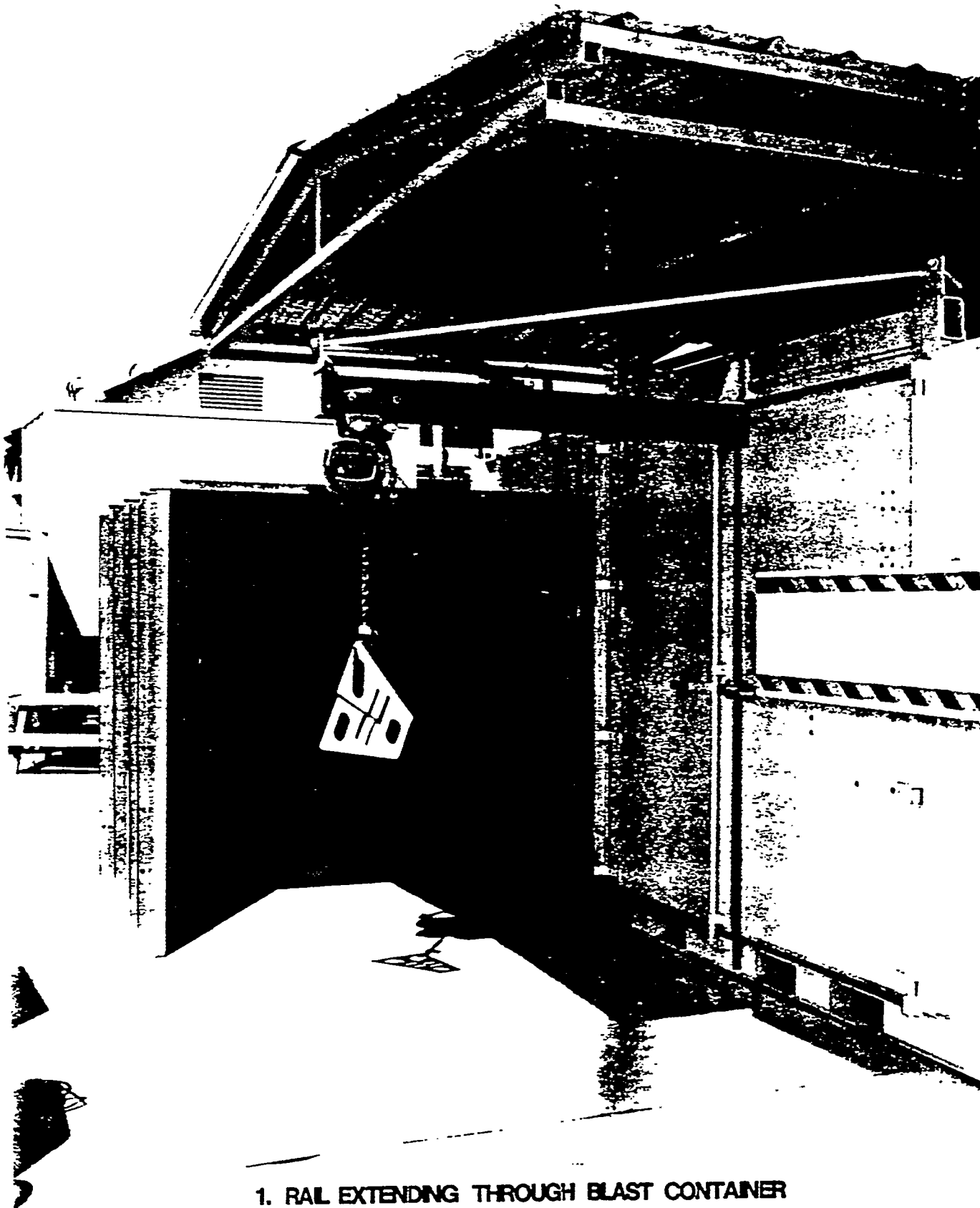
8' WIDE X 10' LONG X 8' HIGH
WEIGHT UNLOADED
SOLID FLOOR & ROOF
SOLID WALLS AROUND GASES
EXPANDED METAL CONSTRUCTION



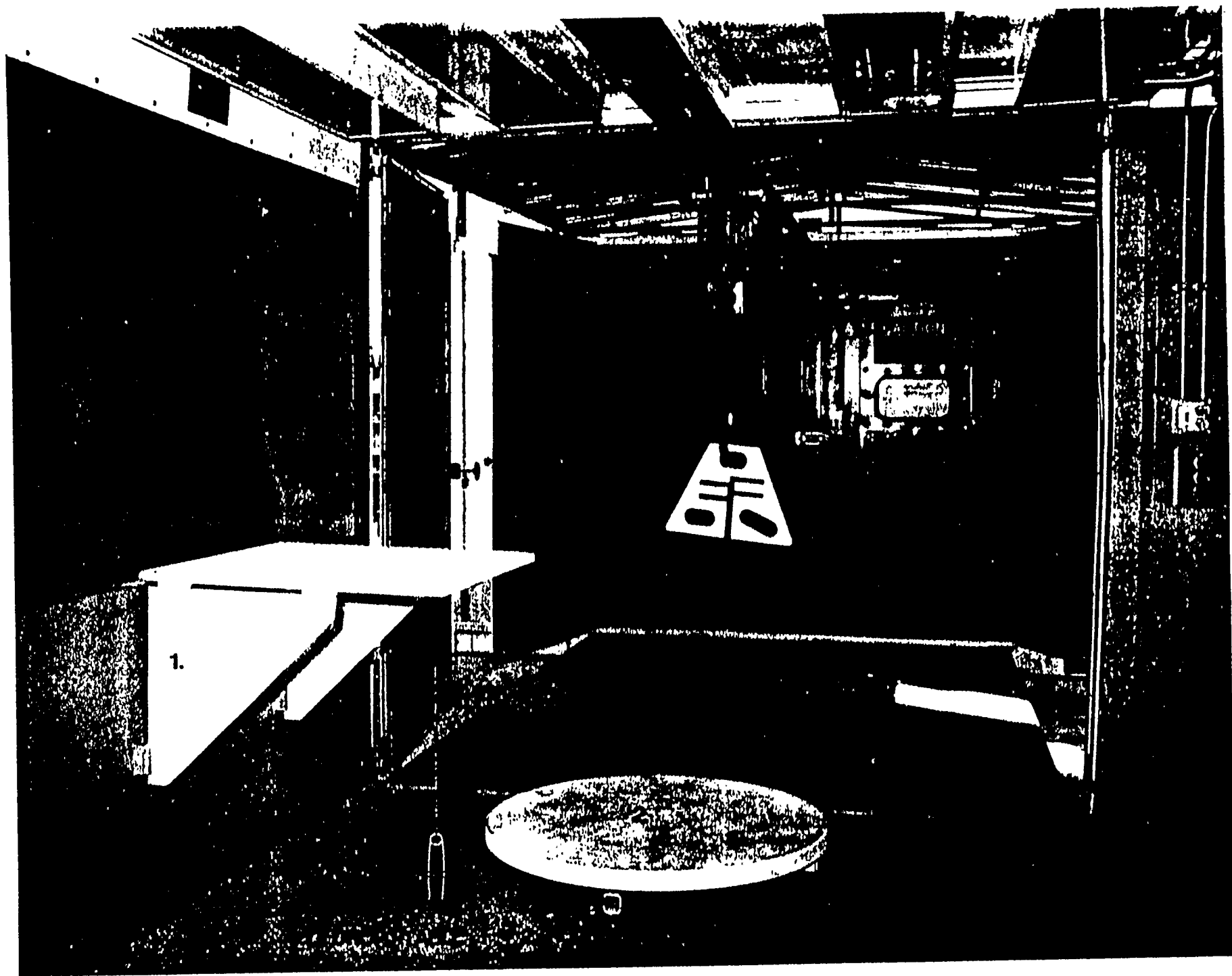
FLOOR PLAN



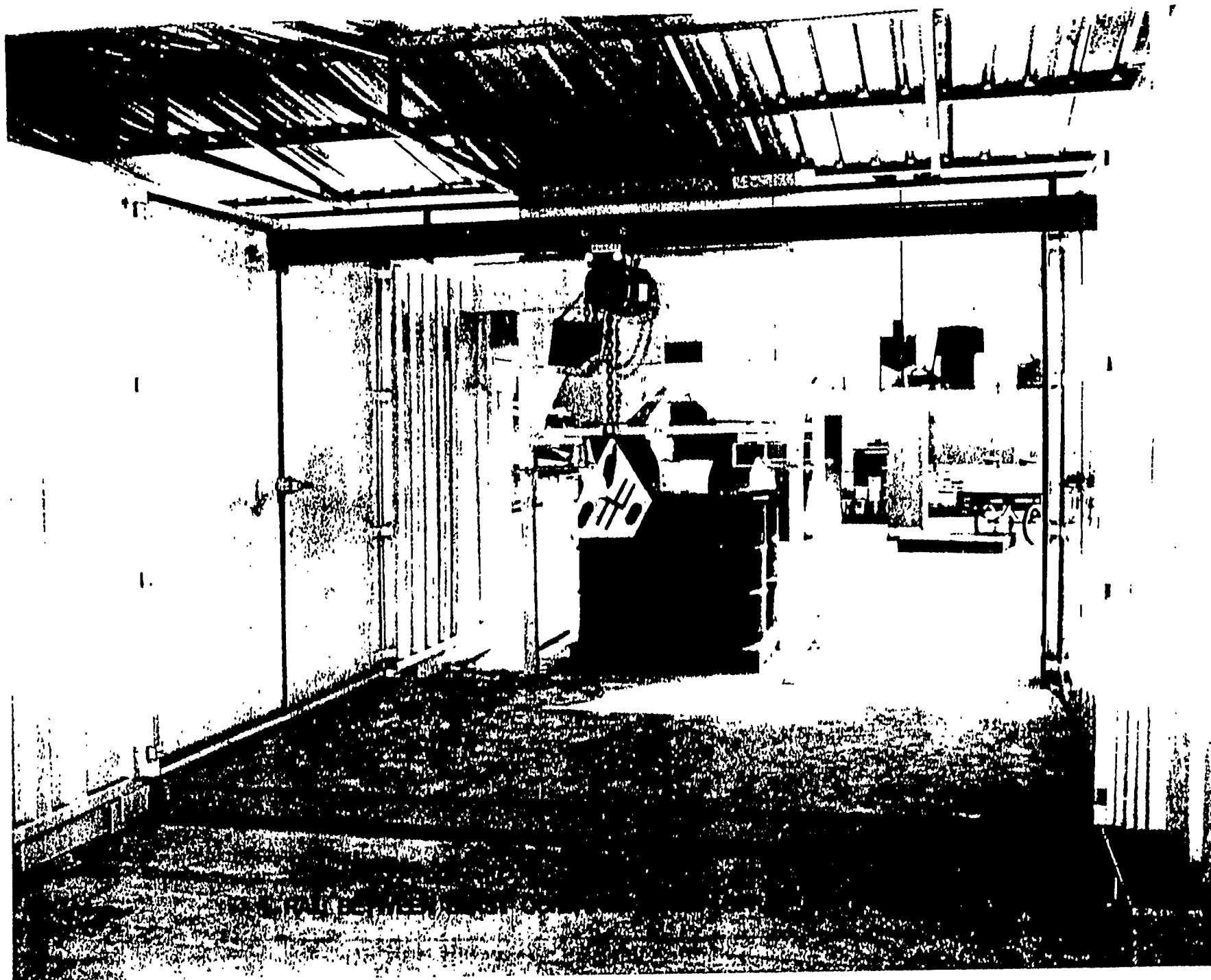


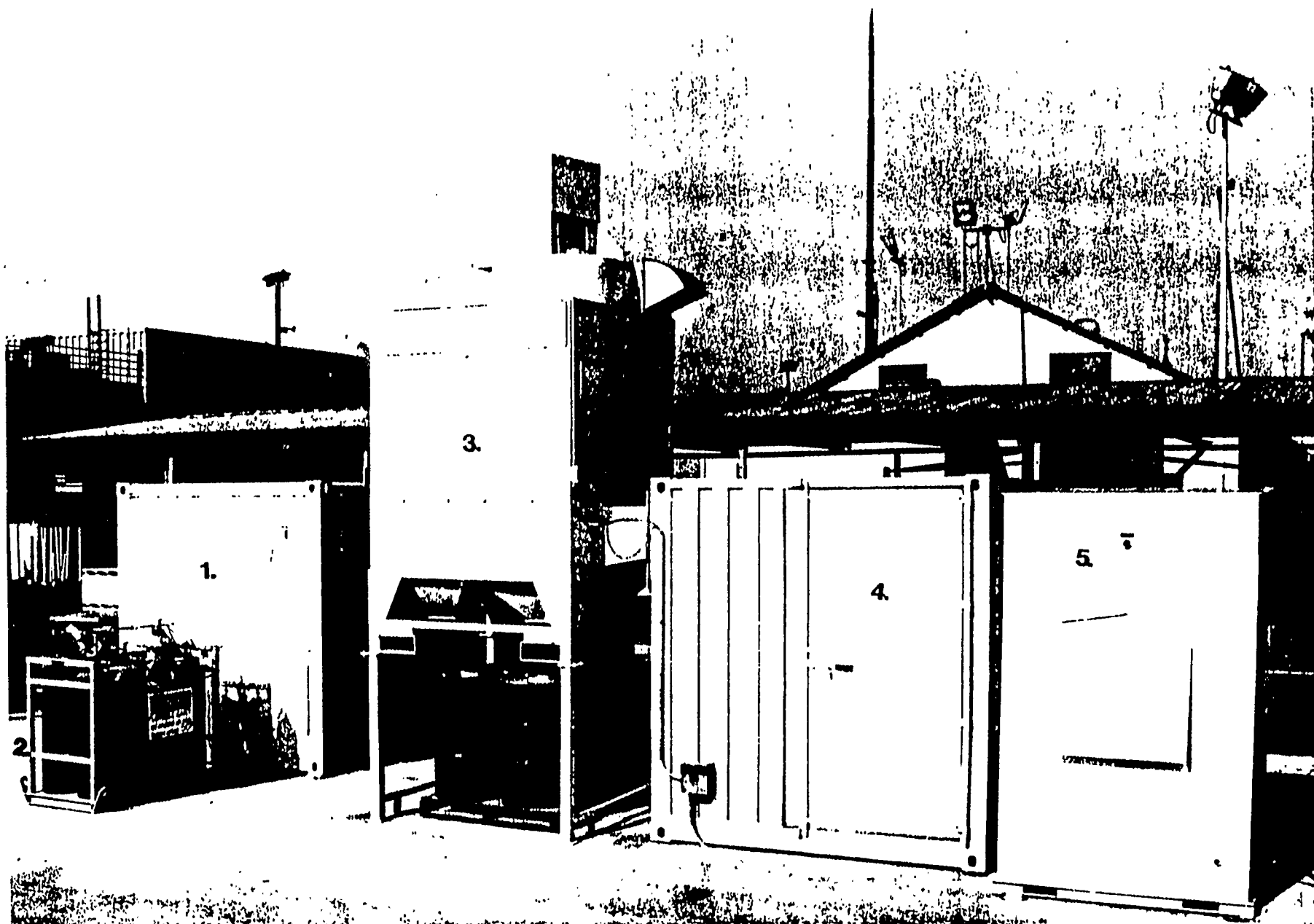


1. RAIL EXTENDING THROUGH BLAST CONTAINER









1. CONTAINER 2. BOTTLE RACK 3. BAG HOUSE 4. REAST CONTAINER 5. AIR DRYER

CORROSION CONTROL SHOP CONSUMABLES

Many of the consumable items are used in both thermal spray and paint facilities. The following list is a combination of these items and utilizes the following legend. (P) = Paint Facility, (TS) = Thermal Spray Facility, and (B) = Both Paint and Thermal Spray Facilities.

ITEM	QUANTITY	APPROX. COST
1. Ear Plugs (B)	1 Bx (200 pair)	10.16
2. Air-Fed Hood (B) (disposable)	1 Ea	10.75
3. Bracket Face Shield (B) (disposable)	1 Ea	6.07
4. Cotton Gloves (B)	1 Pair	1.89
5. Silver Duct Tape (B)	1 Roll	3.50
6. Rigid Plastic Disk (B) (capping off valves)	1 Ea	.30
7. press-O-Film (B)	1 Roll	29.00
8. Rubber Gloves (B) (lightweight)	1 Pair	.81
9. Cotton Rags (B) (wiping)	1 Bundle	26.09
10. oxygen (TS)	Cubic Ft.	.04
11. Acetylene (TS)	Cubic Ft.	.09
12. Formula 150 (B) (EPOXY Primer, green)	5 Gal. (2 parts/kit)	127.81
13. Formula 151 (p) (EPOXY coating kit, haze gray semi-gloss, topcoat)	5 Gal. (2 parts/kit)	211.68
14. TT-E-490 Enamel (P) (haze gray)	5 Gal.	62.87

ITEM	QUANTITY	APPROX. COST
15. Type H Filter (B)	1	5.70
16. Copper Slag (B) (medium grade)	100 Lb. Bag	3.15
17. Steel Shot (B)	50 Lb. Container	.32/lb
18. Aluminum Oxide (B) (#24 grit)	100 Lb. Bag	35.71
19. Flame Spray Wire (TS) (1/8" aluminum)	50-100 Lbs.	3.38/lb
20. Arc Spray Wire (TS) (1/8"- aluminun)	130 Lbs.	4. 04/lb
Non-Consumable		
21. Respirator (B) (full face)	1 Ea	99.85
22. Respirator (TS) (back pack)	1 Ea	62.45

WIRE SPRAYED ALUMINUM AND PAINT

LIFE EXPECTANCY &
LIFE CYCLE COST COMPARISONS

LIFE EXPECTANCY

Thermal Sprayed Coatings

The results of a 19 year study by the American Welding Society of the corrosion protection afforded by wire-flame sprayed aluminum applied to low carbon steel showed that aluminum sprayed coatings 0.003 to 0.006 inches thick, both sealed and unsealed, gave complete base metal protection from corrosion in sea water and also in severe marine and industrial atmospheres.

The sealing system for aluminum primarily enhanced appearance and showed no base metal rust after 19 years.

Where aluminum coatings showed damage such as chips and scrapes, corrosion did not progress, suggesting the occurrence of galvanic protection.

Inorganic Zinc Coatings

The six "Universe" class tankers, 320,000 tons each, are a good example of ships protected both on the interior and exterior with inorganic zinc. These ships were first coated with an inorganic zinc preconstruction primer and in the most critical areas with an additional full coat of inorganic zinc. The total footage coated was over 18 million square feet or 1,700,000 square miles. After five to seven years of service, no corrosion was evident and no maintenance was required on the exteriors except at severely abraded areas. Even after 12 to 14 years service, the exterior surfaces are thought to be well protected on the remaining ships.

THERMAL SPRAY AND PAINT COMPARISON

Low Temperature Service (Below 175 Degrees F)

- Thermal spray (Type II) system
 1. 20 year life cycle.
 2. Ten percent renewal of paint every five years.
 3. One percent renewal of thermal spray every five years.
- Epoxy paint system
 1. Five year life cycle.
 2. 100 percent renewal every five years.
 3. 15 percent renewal every year.

High Temperature Service (Above 175 Degrees F)

- Thermal spray (Type I) system
 1. 20 year life cycle.
 2. One percent renewal of thermal spray every five years.
 3. 20 percent renewal of paint sealer every five years.
- Heat resistant aluminum paint
 1. Five year life cycle.
 2. 100 percent renewal every five years.
 3. 20 percent renewal annually.

LIFE CYCLE COST ANALYSIS

USS STANDLEY (CG-32) (USS STANDLEY Report #TM-28-83-178)

571 steam valves were thermal sprayed.

Cost savings after 5-year evaluation:

cost of Painting -

571 valves x \$45 x 8 cycles = \$ 205,560.00

cost of Thermal Spraying -

571 valves x \$90 (2 mhrs ea.) = \$ 51,390.00

COST SAVINGS TO NAVY \$ 154,170.00
USING WSA COATINGS

USS CONSTELLATION

Puget Sound Naval Shipyard was tasked by David Taylor Research Center (DTRC) to examine the life cycle cost of thermal sprayed coatings on the catwalks of the USS CONSTELLATION. A 20-year life cycle of catwalks was investigated. The following information is provided as an example of cost savings.

Life cycle of thermal spray coating is 20 years with 10% repair every five years.

Catwalks receive painting every 2-1/2 years.

Catwalks are replaced every 5 years.

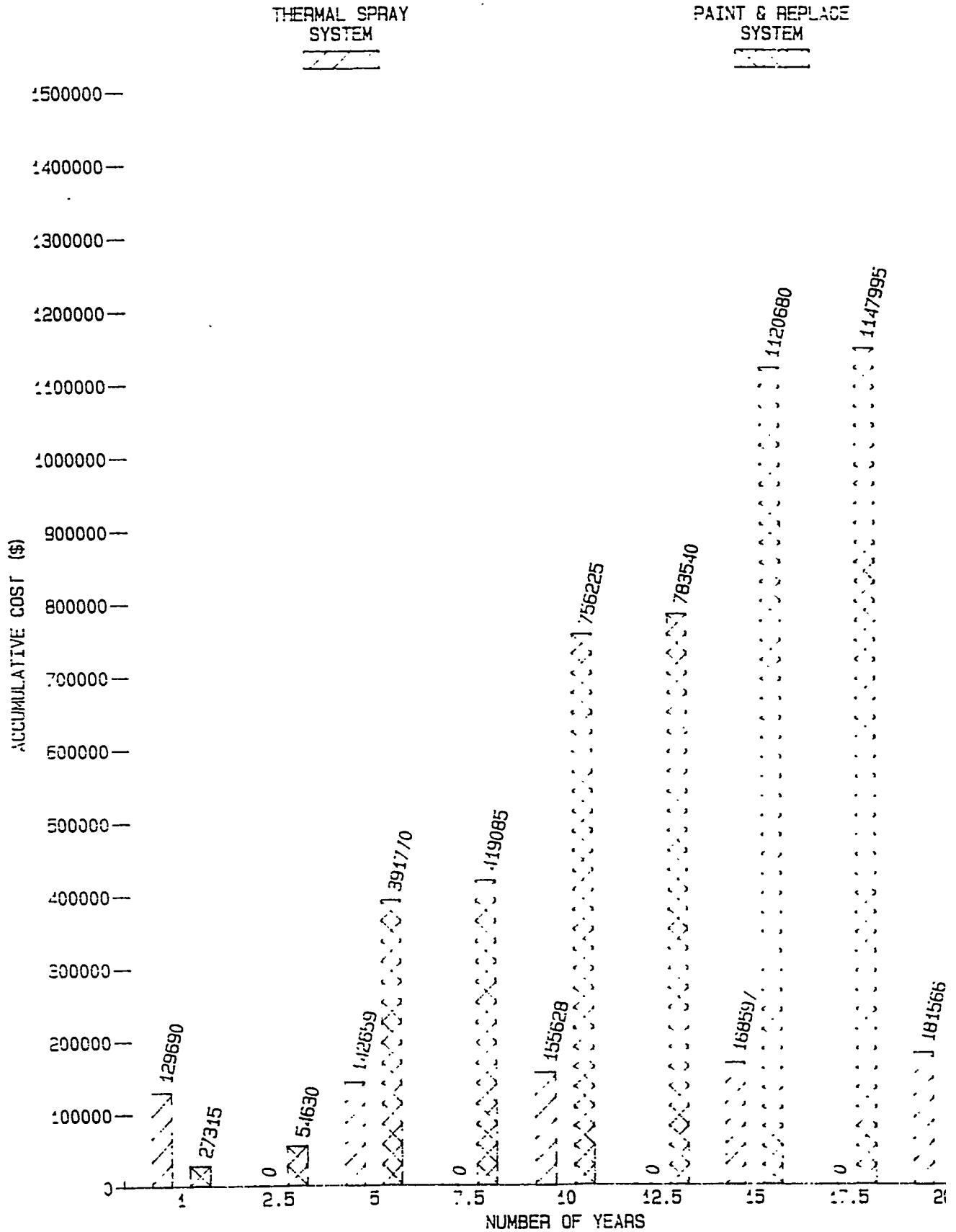
Production man hour rate is \$45 per hour.

2,096 square feet.

JOB	COST/FREQUENCY	20 YR. COST
Cost of Painting	607 mhrs x 9 cycles x \$45	\$ 245,835
Cost of Replacement (Painting not incl.)	6,885 mhrs x 4 cycles x \$45	\$ 1,239,300
TOTAL		\$ 1,485,135
Cost of Thermal Spray	2,882 mhrs x 1 cycle x \$45	\$ 129,690
Repair Costs	288.2 mhrs x 4 cycles x \$45	\$ 51,876
TOTAL		\$ 181,566
		\$ 1,485,135
		- \$ 181,566
NET SAVINGS		\$ 1,303,569

- Cost of thermal spray includes preparation, sealing, and painting.

20 YEAR COST COMPARISON PAINT THERMAL SPRAY CAT WALKS



CORROSION TESTS

A 2,360 hour accelerated corrosion test was conducted to help determine life expectancy. Six corrosion control systems were tested. Eight panels were prepared for each system. Four panels were faulted and four non-faulted.

As a result of surveying several shipbuilding and repair facilities, the following corrosion control systems were tested.

1. Wire sprayed aluminum (WSA) / Standard Navy topcoat system for low temperature components (175 degrees F and below).
2. Wire sprayed aluminum (WSA) / "International" brand commercial equivalent to Navy topcoat system.
3. Epoxy polyamide paint system (Mare Island system).
4. Epoxy polyamide paint system (International Paint Co.).
5. Inorganic zinc primer (solvent based) / Epoxy polyamide topcoats (Mare Island system).
6. Inorganic zinc primer (solvent based) / Epoxy polyamide topcoats (International Paint Co.).

Test panel surface preparation of the selected Navy paint systems was performed in accordance with Naval Ships Technical Manual, Chapter 631. Surface preparation for wire sprayed aluminum test panels was performed in accordance with Military Standard 2138. All commercial paint systems test panel surface preparation was performed in accordance with manufacturers instructions and specifications.

Coating System #1: WIRE SPRAYED ALUMINUM AND STANDARD MARE
ISLAND COATING SYSTEM FOR LOW TEMPERATURE
COMPONENTS

Test panel Material: Carbon Steel Size: 3"1 X 4" X 3/16"
Procedure (WSA): Process Instruction 705
procedure (paint) : NAVSEA S9086-VD-STM-000, Chapter 631

< Test Panel parameters >

Panel Numbers: 1 - 8

Date: 11-28-69

Faulted 1 - 4 Non-faulted 5 - 8

I. ANCHOR TOOTH BLASTING (SP-5 WHITE METAL BLAST)

- A. Grit Type: Aluminum oxide
- B. Grit Size: # 2 4
- C. Profile: 4.5

II. COATINGS

A. Wire Spray Parameters

- 1. Time between blasting and spraying: 2 hours
(less than 4 hours)
- 2. Wire type: 99.5% pure aluminum
- 3. Wire size: 1/8"
- 4. Gun type: METCO 10-E
- 5. Atomizing air pressure: 47 PSI
- 6. Nozzle size: 1/8"
- 7. Fuel gas: Acetylene
- 8. Fuel gas regulator:
 - a Air regulator (PSI):
- 10. Fuel gas flow meter (CFH) : 40
- 11. Oxygen flow meter (CFH): 43
- 12 l Air flow meter (CFH): 53

Panel Numbers (cont): 1 - 8

13. Wire tip length (Inches): 1/2

14. Spray distance: 6 inches

15. Air pressure: 52 PSI

16. Operator: Larson

B. Thermal Spray Aluminum Coating Data

1. Actual readings of coating thickness:

7.0 7.0 8.0 7.5 8.0

2. Average reading: 7.5

c. Time Between WSA and Seal Coating System:

16 hours maximum

D. Paint Coating Parameters

1. Method of Application: Conventional Devilbiss #MBC

2. Tip Range: 30 air cap/"E" fluid needle

3. Total Output Fluid Pressure: N/A

4. Temperature (F): 71 75 72 74 74

5. Humidity (%): 44 43 40 41 41

6. Induction Time: 30 min 1 hr 1 hr 1 h r 1 h r

7. Percentage of Thinner: 50% 0% 5% 3% 0%

8. Agitator Pot: No

9. Dry Film Thickness: 1.5 3.0 6.5 9.2 2.7
(mils per coat)

10. Wet Film Thickness: 2.0 3.5 4.0 4.0 4.0
(mils per coat)

11. Operator: Dobbelare/Newland

Coating System #2: WIRE SPRAYED ALUMINUM AND INTERNATIONAL BRAND
SEAL COATING SYSTEM (COMMERCIAL EQUIVALENT TO
MARE ISLAND SYSTEM)

Test Panel Material: Carbon Steel Size: 3" X 4" X 3/16"
Procedure (WSA) : Process Instruction 705
Procedure (Paint) : Manufacturer's Instructions

< Test Panel Parameters >

Panel Numbers: 9 - 16

Date: 11-28-89

Faulted 9 - 12 Non-faulted 13 - 16

I. ANCHOR TOOTH BLASTING (SP-5 WHITE METAL BLAST)

- A. Grit Type: Aluminum oxide
- B. Grit Size: # 24
- c. Profile: 3.5

II. COATINGS

A. Wire Spray Parameters

- 1. Time between blasting and spraying: 2 hours
(less than 4 hours)
- 2. Wire type: 99.5% pure aluminum
- 3. Wire size: 1/8"
- 4. Gun type: METCO 10-E
- 5. Atomizing air pressure: 47 PSI
- 6. Nozzle size: 1/8"
- 7. Fuel gas: Acetylene
- 8. Fuel gas regulator: 15
- 9. Air regulator (PSI): 100
- 10. Fuel gas flow meter (CFH) : 40
- 11. Oxygen flow meter (CFH): 43
- 12. Air flow meter (CFH): 53

Panel Numbers (cent): 9 - 16

- 13. Wire tip length (Inches): 1/2
- 14. Spray distance: 6 inches
- 15. Air pressure: 52 PSI
- 16. operator: Larson

B. Thermal Spray Aluminum Coating Data

- 1. Actual readings of coating thickness:

9.0 10.0 11.0 10.0 10.0

- 2. Average reading: 10.0

c. Time Between WSA and Seal Coating System:

16 hours maximum

D. Paint Coating Parameters

- 1. Method of Application: Brush
- 2. Tip Range: N/A
- 3. Total Output Fluid Pressure: N/A
- 4. Temperature (F): 75 71
- 5. Humidity (%) : 44 50
- 6. Induction Time: 30 min 1 hr
- 7. Percentage of Thinner: 0% 0%
- 8. Agitator Pot: No
- 9. Dry Film Thickness: 3.5 8.2 25.0
(mils per coat)
- 10. Wet Film Thickness: 4.0
(roils per coat)
- 11. Operator: Dobbelare/Newland

Coating System #3: NAVY SPECIFICATION MARE ISLAND SYSTEM

Test Panel Material: Carbon Steel Size: 3" X 4" X 3/16"
Procedure (Paint) : NAVSEA S9086-VD-STM-000, Chapter 631

< Test Panel Parameters >

Panel Numbers: 17 - 24

Date: 12-07-89

Faulted 17 - 20 Non-faulted 21 - 24

I. ANCHOR TOOTH BLASTING (SSPC SP-10 NEAR WHITE METAL)

A. Grit Type: Aluminum oxide

B. Grit Size: 120

co Profile: 2 - 4

11. COATING

A. Paint Coating Parameters

1. Method of Application: Conventional Devilbiss +MBC

2. Tip Range: 30 cap/ "E" needle

3. Total Output Fluid Pressure: N/A

4. Temperature (F): 72 73 76

5. Humidity (%): 46 46 44

6. Induction Time: 1 hr 1 hr 1 hr

7. Percentage of Thinner: 10% 5% 5%

8. Agitator Pot: No

9. Dry Film Thickness: 1.0 4.0 7.0 7.5 9.5
(mils per coat) 11-m 12.1

10. Wet Film Thickness: 1.5 4.0 4.0 3.5 3.5
(mils per coat) 3.5 3.0

11. Operator: Dobbelare/Newland

Coating System #4: "INTERNATIONAL" BRAND EQUIVALENT TO MARE
ISLAND SYSTEM

Test Panel Material: Carbon Steel Size: 3" x 4" x 3/16"
procedure (paint) : Manufacturer's Instructions

< Test Panel Parameters >

Panel Numbers: 25 - 32

Date: 12-07-89

Faulted 25 - 28 Non-faulted 29 - 32

I. ANCHOR TOOTH BLASTING (SSPC SP-10 NEAR WHITE METAL)

- A. Grit Type: Aluminum oxide
- B. Grit Size: 120
- c. Profile: 2-4

II. COATING

A. Paint Coating Parameters

- 1. Method of Application: Brush/Spray
- 2. Tip Range: Brush/30 cap/"E" needle
- 3. Total Output Fluid Pressure: N/A
- 4. Temperature (F): 75
- 5. Humidity (%): 42
- 6. induction Time: 1 hr
- 7. Percentage of Thinner: 0%
- 8. Agitator Pot: No
- 9. Dry Film Thickness: 2.0 4.0 6.2 8.4 9.9 11.3
(mils per coat)
- 10. Wet Film Thickness: 3.0 3.5 2.5 4.0 3.5 3.3
(mils per coat)
- 11. Operator: Dobbelare/Newland

Coating System #5: NAVY SPECIFICATION INORGANIC ZINC WITH MARE ISLAND SYSTEM

Test Panel Material: Carbon Steel Size: 3" X 4" X 3/16"
procedure (paint) : NAVSEA S9086-VD-STM-000, Chapter 631

< Test Panel Parameters >

Panel Numbers: 33 - 40

Date: 12-07-89

Faulted 33 - 36 Non-faulted 37 - 40

ANCHOR TOOTH BLASTING (SSPC SP-10 NEAR WHITE METAL)

A. Grit Type: Aluminum oxide

B. Grit Size: 120

c. Profile: 2-4

II. COATING

A. Paint Coating Parameters

1. Method of Application: Conventional Devilbiss #MBC

2. Tip Range: 30 cap/"E" needle

3. Total Output Fluid Pressure: N/A

4. Temperature (F): 72 avg.

5. Humidity (%): 42 avg.

6. Induction Time: 1 hr

7. Percentage of Thinner: 0%

8. Agitator Pot: No

9. Dry Film Thickness: 1.5 3.5 5.4 8.6 12.4 15.0
 (mils per coat)

10. Wet Film Thickness: 4.0 2.0 3.5 4.0 4.0 4.5
 (mils per coat)

11. Operator: Dobbelare/Newland

Coating System #6: "INTERNATIONAL" BRAND INORGANIC ZINC WITH
"INTERNATIONAL" EQUIVALENT TO MARE ISLAND
SYSTEM

Test Panel Material: Carbon Steel Size: 3" X 4" X 3/16"
Procedure (Paint): Manufacturer's Instructions

< Test Panel Parameters >

Panel Numbers: 41 - 48

Date: 12-07-89

Faulted 41 - 44 Non-faulted 45 - 48

I. ANCHOR TOOTH BLASTING (SSPC SP-10 NEAR WHITE METAL)

A. Grit Type: Aluminum oxide

B. Grit Size: 120

C. Profile: 2-4

II. COATING

A. Paint Coating Parameters

1. Method of Application: Conventional Devilbiss #MBC

2. Tip Range: 30 cap/"E" needle

3. Total Output Fluid Pressure: N/A

4. Temperature (F) 73 avg.

5. Humidity (%): 42 avg.

6. Induction Time: 1 hr

7. Percentage of Thinner: 0%

8. Agitator Pot: No

9. Dry Film Thickness: 2.5 3.5 5.2 8.8 12.1 15.7
(mils per coat)

10. Wet Film Thickness: 4.0 2.0 3.5 4.0 4.0 4.0
(mils per coat)

11. Operator: Dobbelare/Newland

PUGET SOUND NAVAL SHIPYARD
QUALITY ASSURANCE OFFICE
Laboratory Division

Code 134.6

MFA:lms

Metallurgy Branch

Report No. 90PS06804A

Subj: EVALUATION OF SIX CORROSION RESISTANT SYSTEMS AFTER 2360 HOUR
SALT FOG TEST

Ref: (a) ASTM B117-74
(b) ASTM D714-87

1. Experimental Procedure

Six corrosion resistant systems were tested in accordance with reference (a). There was a total of eight panels for each system, four faulted and four nonfaulted. The test ran for 2000 hours; the samples were removed for evaluation; and the test continued for another 360 hours. The six [Rev. systems are described below.

Wire sprayed aluminum and Navy specification seal coating system(per #2138). The surface preparation was SP-5, white metal blast. Test panels 1 through 8.

System 2: Wire sprayed aluminum and commercial seal coat system (International brand paint). The surface preparation was SP-5, white metal blast. Test panels 9 through 16.

System 3: Navy specification: Hare Island series (epoxy polyamide) seal coating system (per 1631). The surface preparation was SP-10, near-white metal blast. Test panels 17 through 24.

System 4: Commercial equivalent to Navy specification Mare Island system (International brand paint coating system, 'FP series"). The surface preparation was SP-10, near-white metal blast. Test panels 25 through 32.

System 5: Navy specification "Inorganic zinc," Mare Island system. The surface preparation was SP-10, near-white metal blast. Test panels 33 through 40.

System 6: Commercial seal coat system; Inorganic zinc with series topcoats (International brand paints). The surface preparation was SP-10, near-white metal blast. Test panels 41 through 48.

2. Results.

For the first 2000 hour test, the scribing of the faulted samples did not completely penetrate to the base metal. The panels were scribed a second time to expose the base metal before the 360 hour test. The results of the two salt [Rev. fog tests are tabulated below.

		CONDITION AFTER 2000 HR	CONDITION AFTER 2360 HR
SYSTEM 1	FAULTED	NO INDICATIONS	MED. DENSE BLISTERS #2
	NON FAULTED	NO INDICATIONS	NO INDICATIONS
SYSTEM 2	FAULTED	NO INDICATIONS	NO INDICATIONS
	NON FAULTED	NO INDICATIONS	NO INDICATIONS
SYSTEM 3	FAULTED	CORR., FEW BLISTERS #6	SIGNIFICANT CORR.
	NON FAULTED	NO INDICATIONS	NO INDICATIONS
SYSTEM 4	FAULTED	MINOR CORROSION	CORROSION
	NON FAULTED	NO INDICATIONS	NO INDICATIONS
SYSTEM 5	FAULTED	NUMEROUS SMALL PITS	NUMEROUS SMALL PITS
	NON FAULTED	NUMEROUS SMALL PITS	NUMEROUS SMALL PITS
SYSTEM 6	FAULTED	NO INDICATIONS	MINOR CORROSION
	NON FAULTED	NO INDICATIONS	NO INDICATIONS

3. Comments.

All of the blistering and corrosion in the faulted samples was adjacent to the scribed lines, or where the paint had been chipped off. The corrosion was significantly worse in the samples from System 3 than either Systems 4 or 6. The evaluation of frequency and size of blisters is from the reference standards in reference (b). The pitting in System 5 covered both sides of all eight test panels. The majority of the pits extended into the primer although there was some penetration into the base metal. The panels were cross-sectioned and evaluated to determine the source. The pits originated in the 150 coat and were subsequently covered by the following LTE-490, and No. 27 gray.

The wire sprayed aluminum/commercial seal coat system used in System 2 provided better protection from the salt fog environment than any of the other five systems. The results from the 360 hour test should be representative of the indications found in the six systems. If the test panels had been scribed to the base metal for the first 2000 hours, the corrosion and blistering would have been more severe.

5. Revision-A is issued to correct an incorrect reference to the number of hours of testing performed.

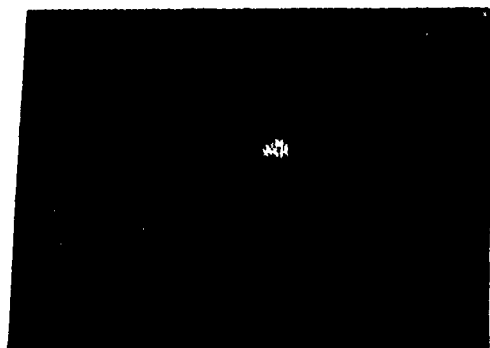
Michael Fallon
Metallurgist

5-15-90
Date

A. K. Rudelbach
Head, Metallurgy Branch

5/16/90
Date

Distribution:
Shop 26



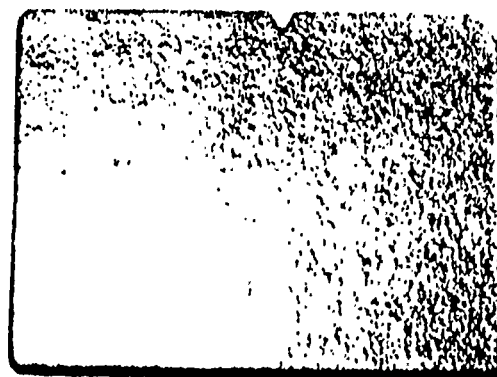
PLAIN PANEL



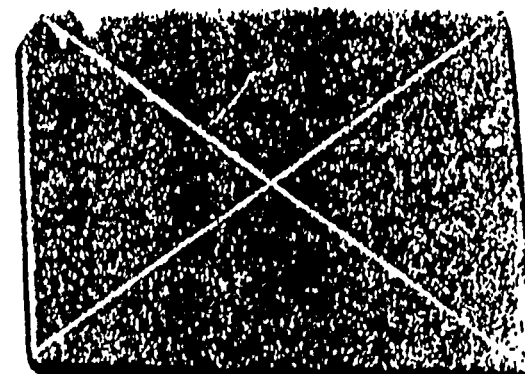
WHITE METAL BLAST



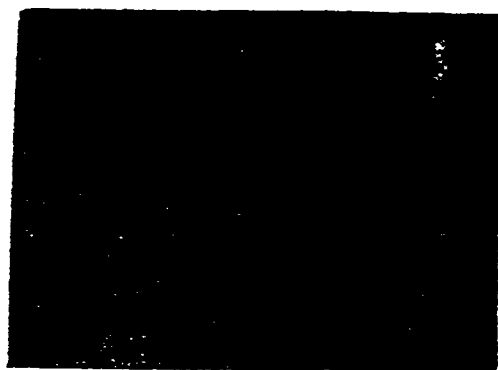
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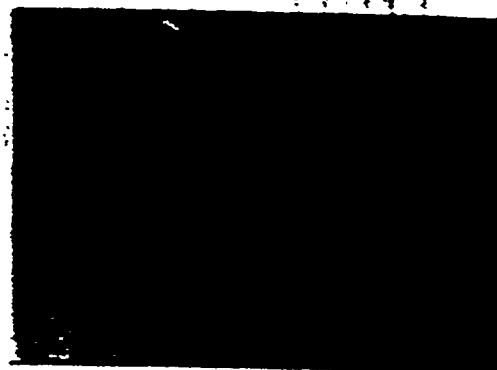
**SEALED PANEL
(NON-FAULTED)**



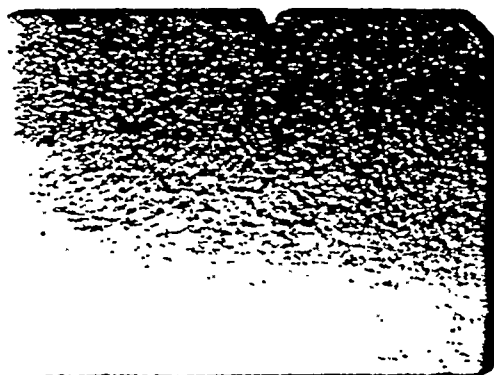
**SEALED PANEL
(FAULTED)**



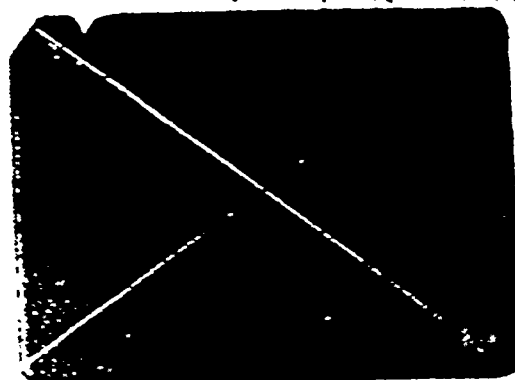
PLAIN PANEL



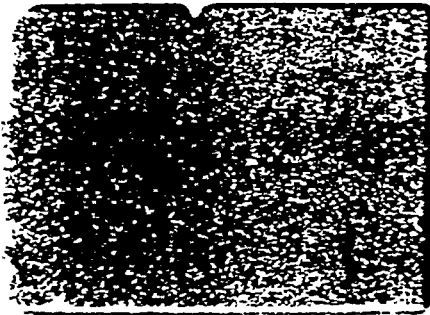
NEAR WHITE BLAST



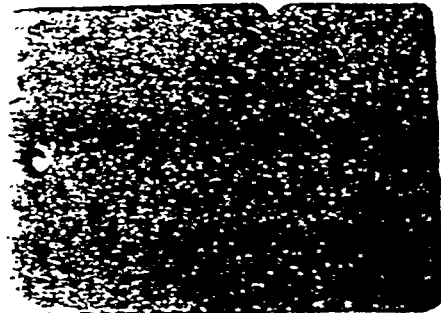
SEALED PANEL
(NON-FAULTED)



SEALED PANEL
(FAULTED)



SYSTEM # 1



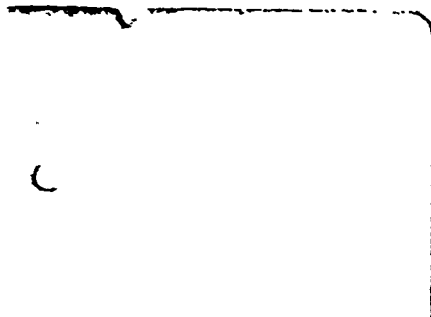
SYSTEM # 4



SYSTEM # 2



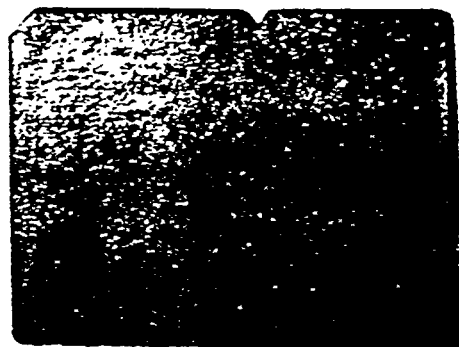
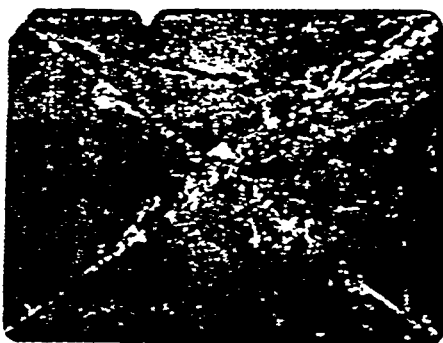
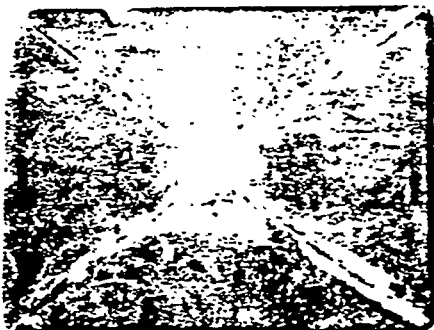
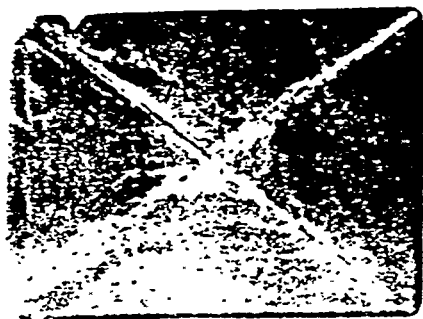
SYSTEM # 5

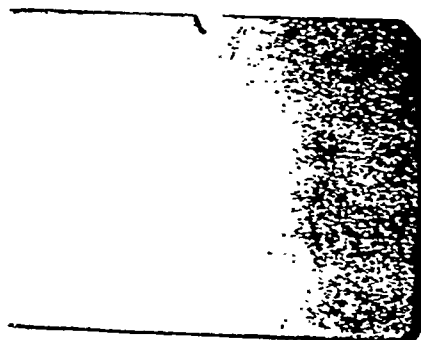
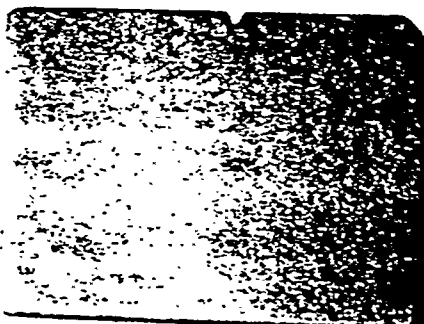
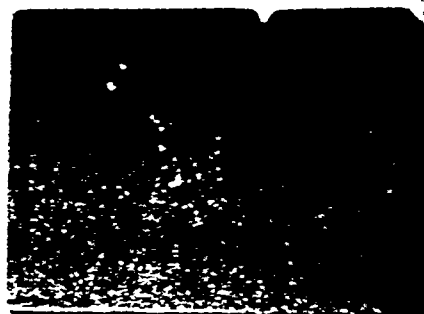
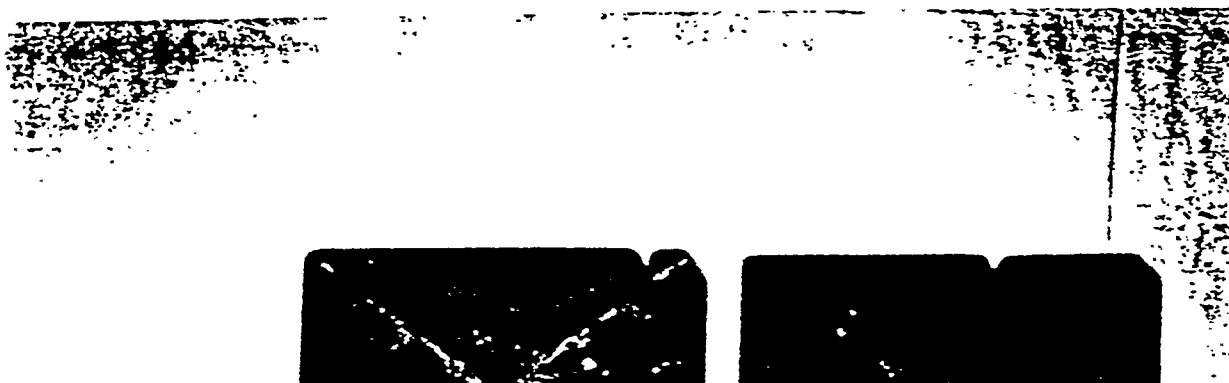


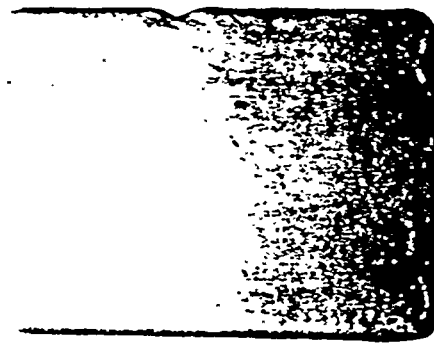
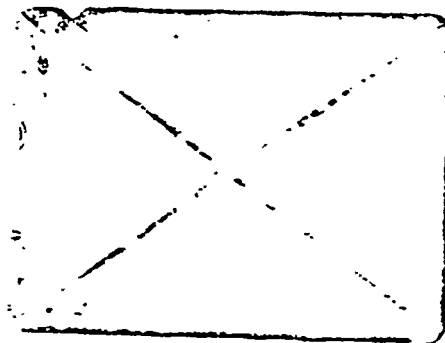
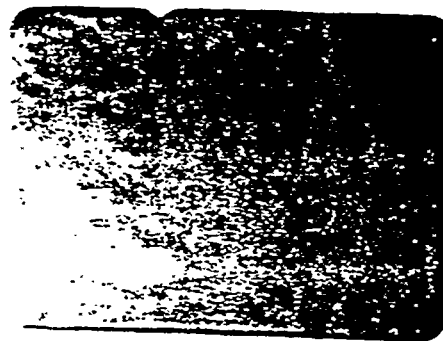
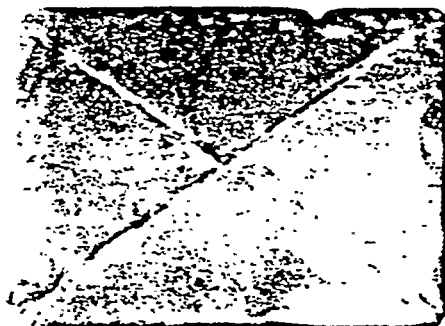
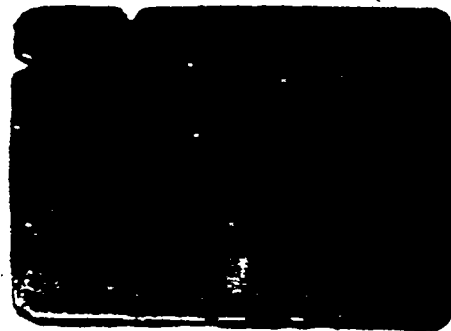
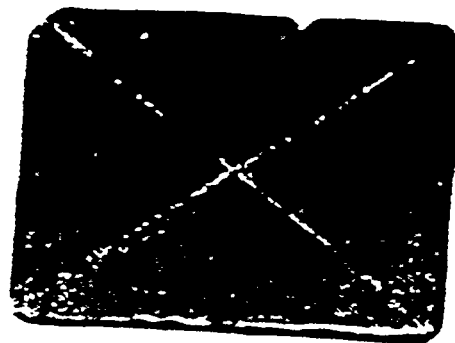
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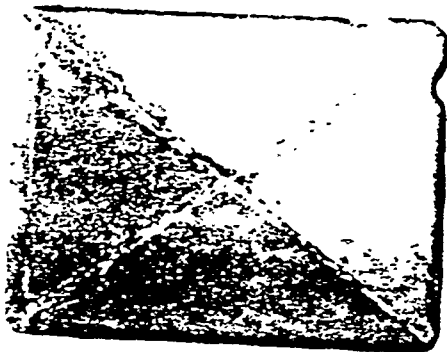
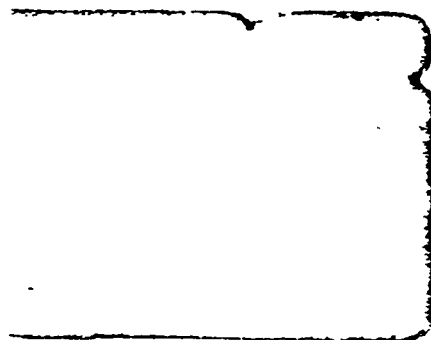
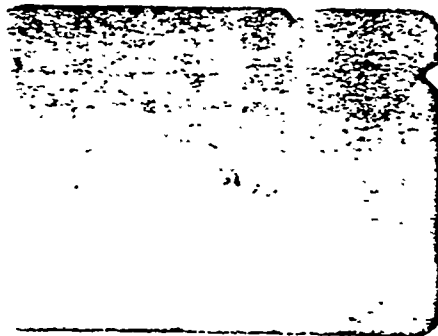
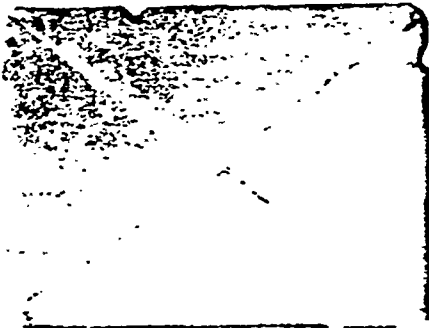


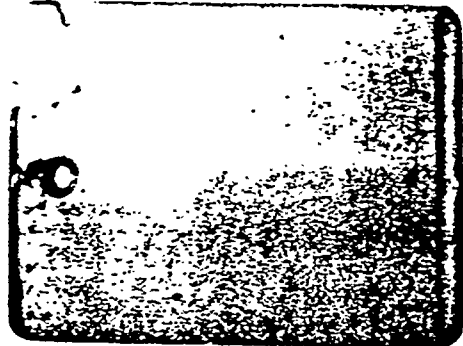
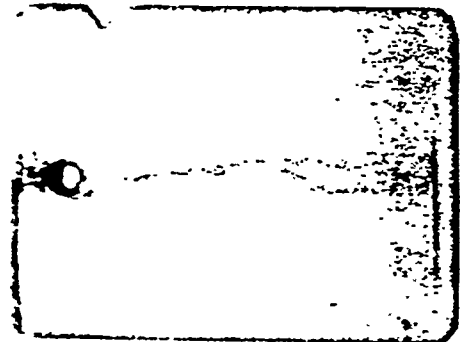
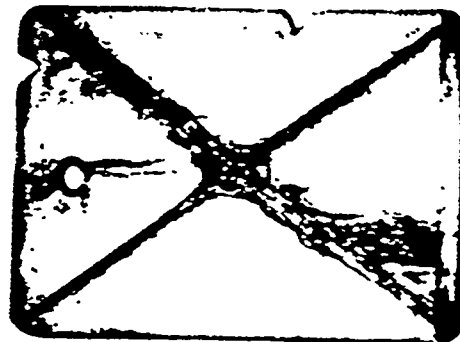
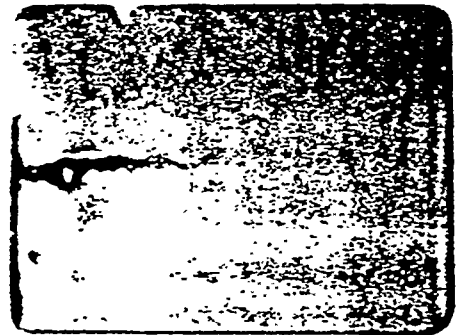
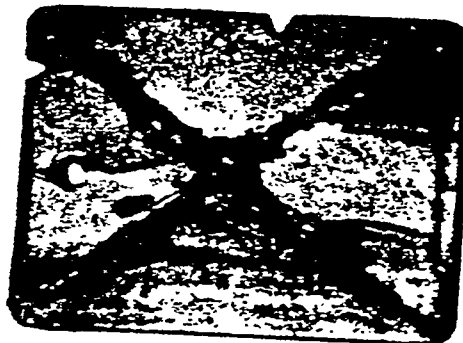
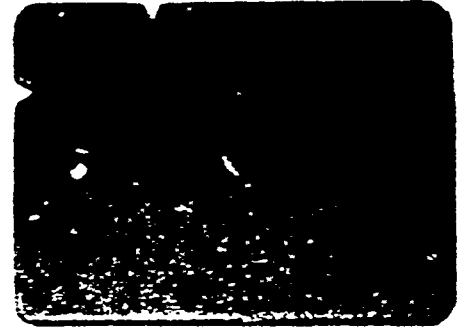
SYSTEM # 6

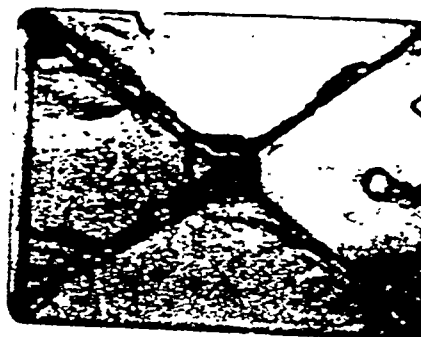
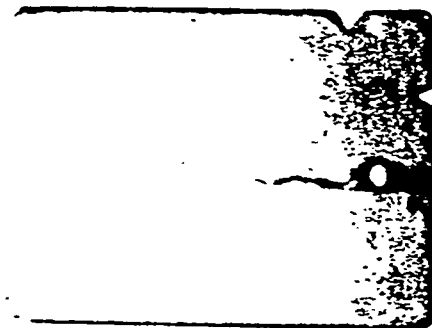
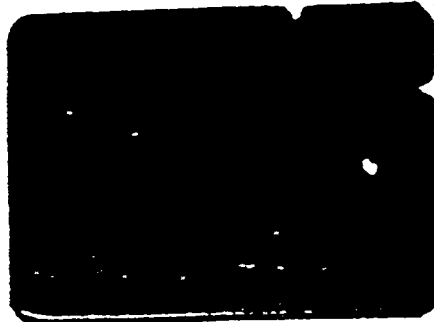
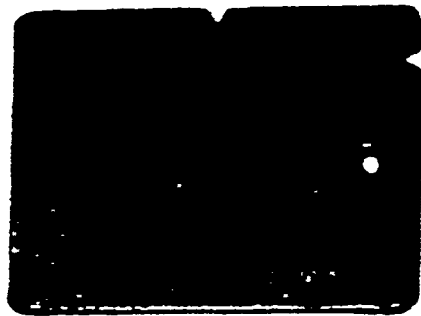


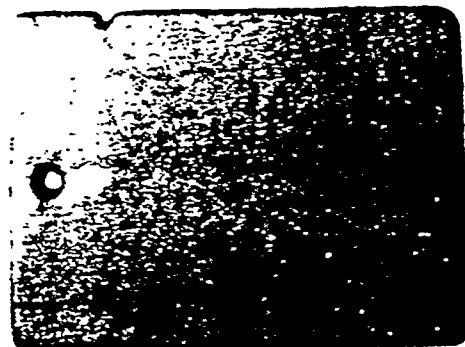
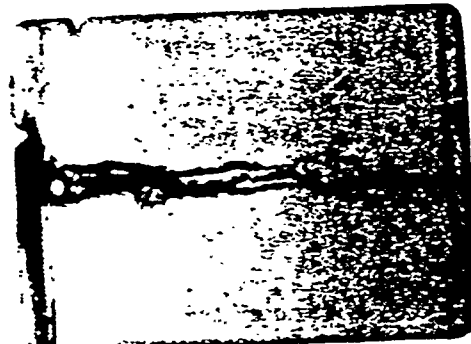
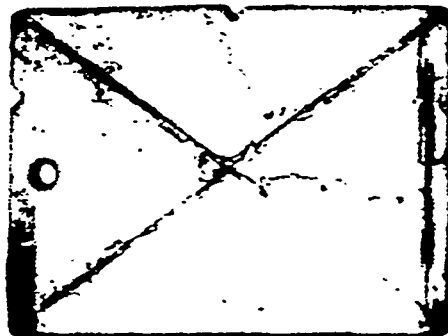
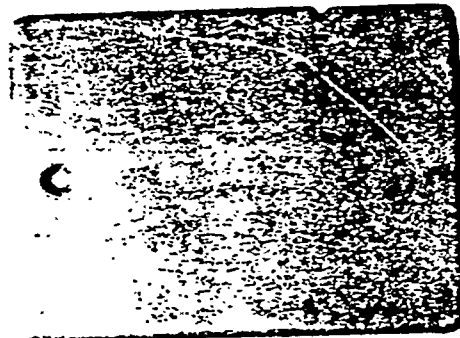
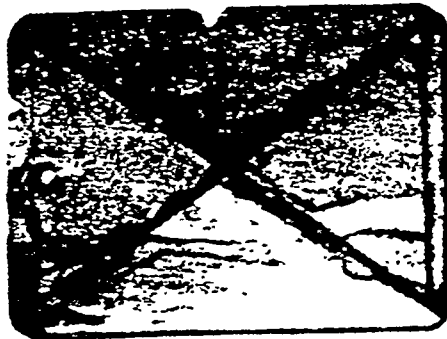


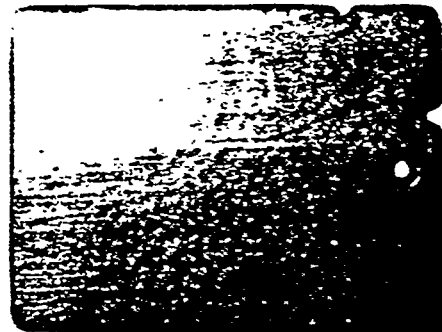
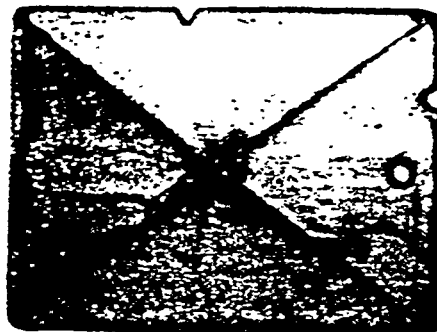
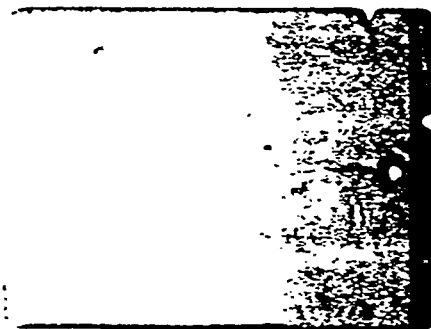
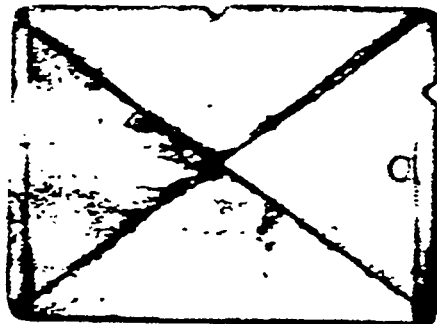
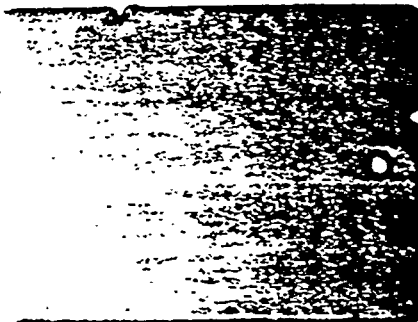
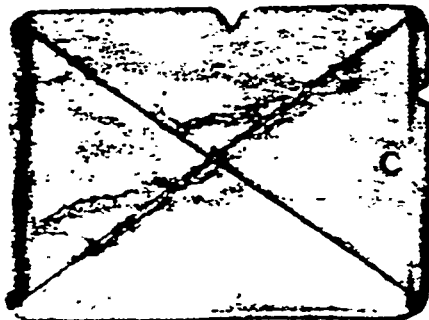
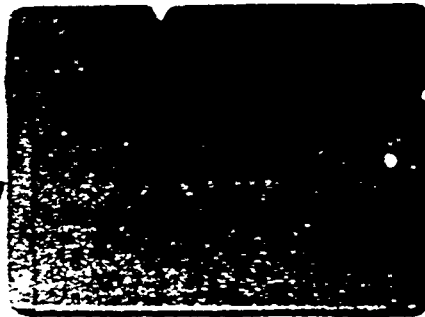


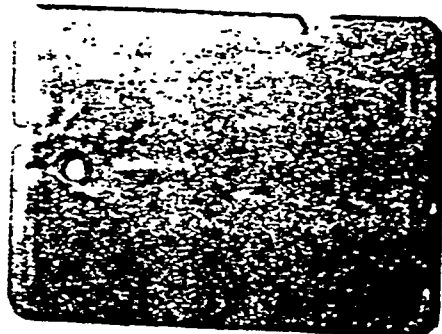
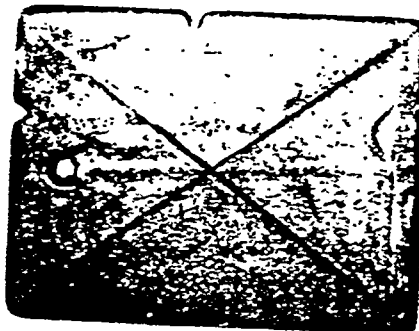
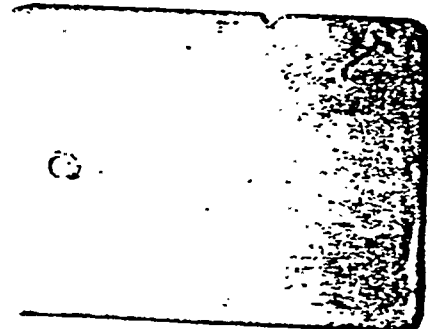
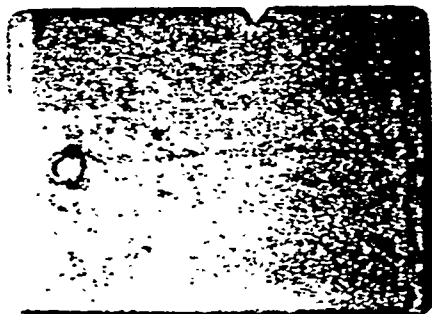
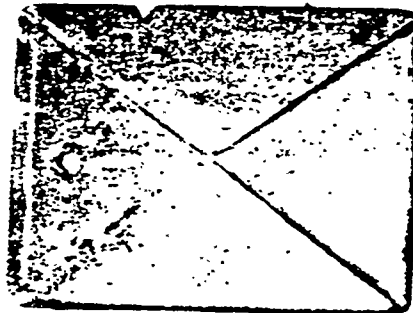
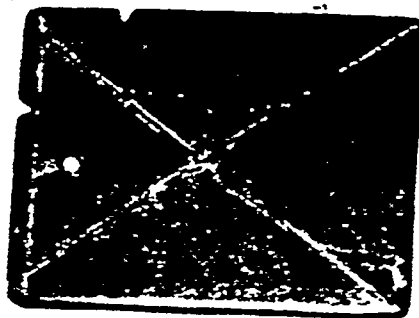


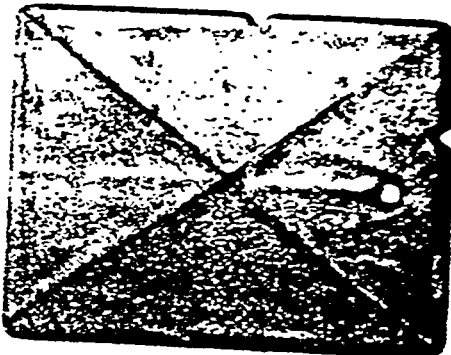
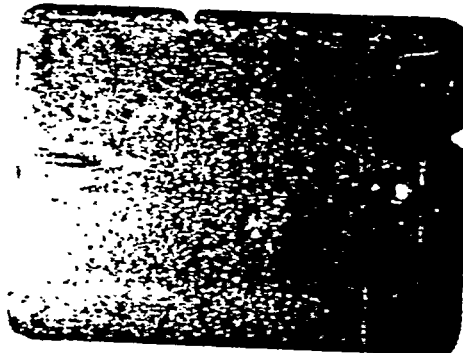
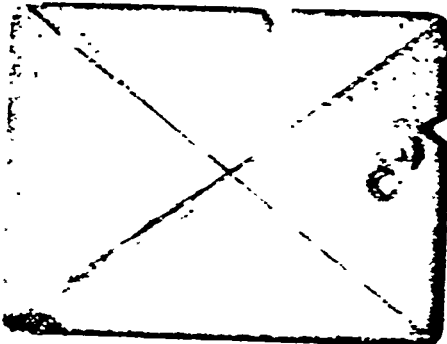
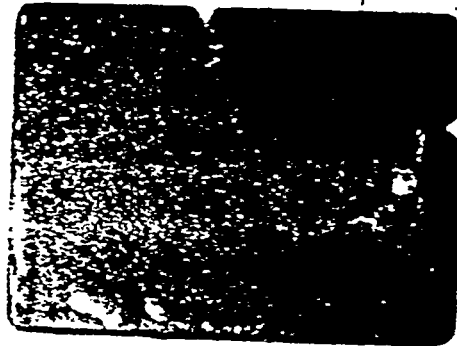
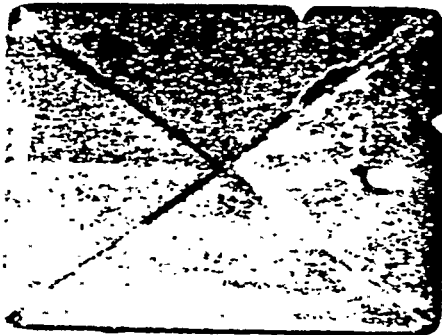


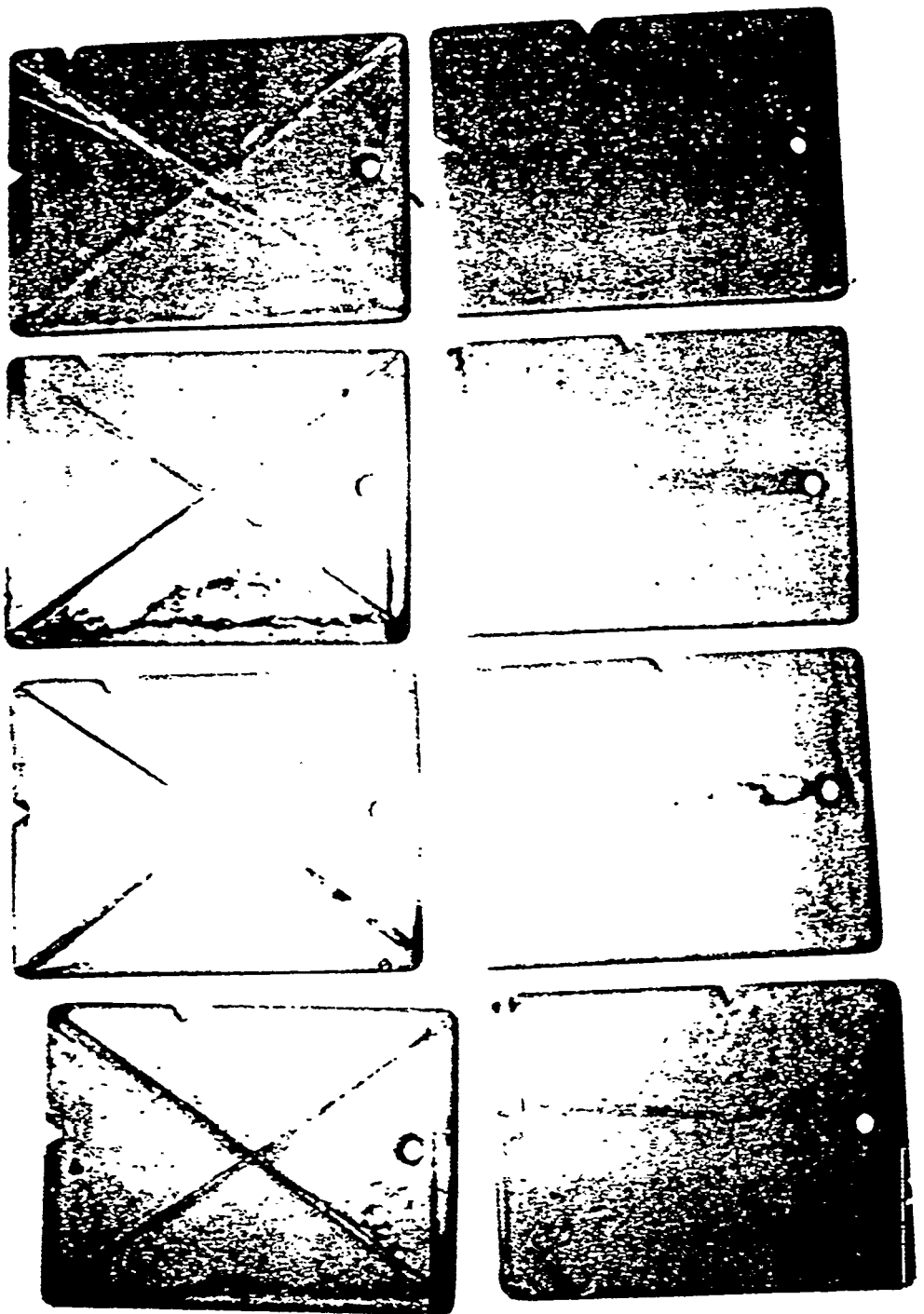




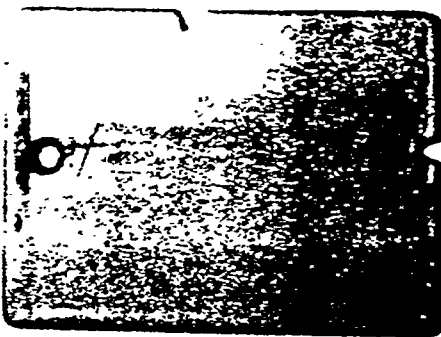
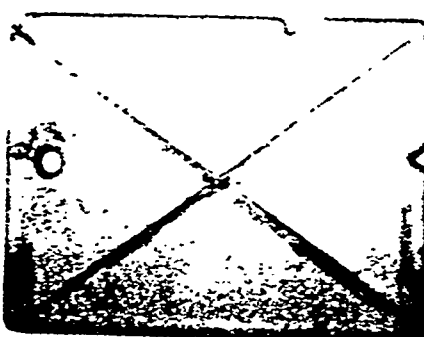
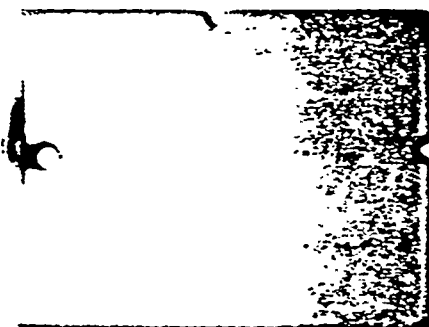
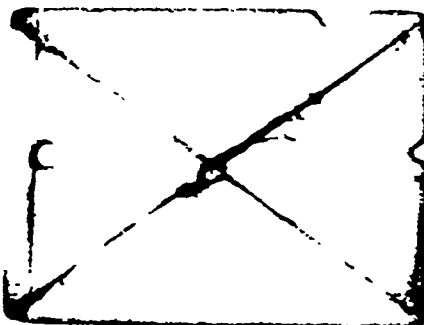
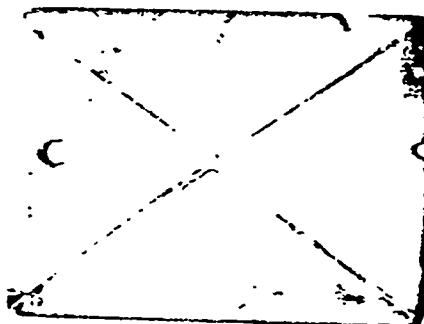
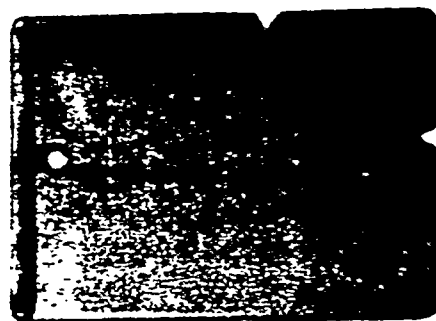
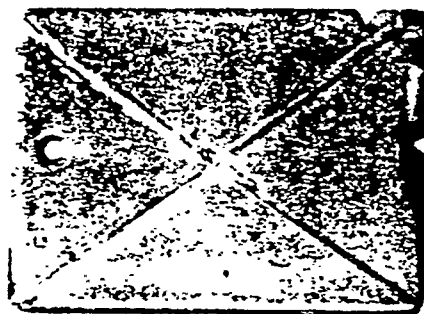








WIRE SPRAYED ALUMINUM
RECOMMENDED AREAS &
HISTORICAL PHOTOGRAPHS



NEW CONSTRUCTION

- Preinstallation (shop)

1. Vent inlets
2. Shore steam valves
3. Inflatable lifeboat stow racks
4. Life net frames
5. Ensign staff and deck socket
6. Jackstaff and deck socket
7. Support clips for exterior inclined ladders
8. Support clips for exterior vertical ladders
9. Portable stanchions and deck sockets
10. Light brackets and foundations for:
 - a. Waterline floodlights
 - b. General purpose floodlights
 - c. Red floodlights
 - d. White floodlights
 - e. LPS floodlights
 - f. High intensity floodlights
 - g. Navigation lights including drop line lights
 - h. Masthead lights
 - i. Blinker lights
11. Light fixture spool mounts
12. Waterline security floodlight brackets
13. Firemain stations on gal. walkway consisting of:
 - a. Strainer supports
 - b. Pipe Hangers
 - c. Hose baskets and covers
14. Retractable sheave assembly consisting of sheave well, pan, housing and cable trunk
15. Climber safety rail supports
16. Support structure and foundation of whistles
17. foundations and bed plates for:
 - a. Nixie winches
 - b. Radar antennas
 - c. Communications antennas
 - d. Main feed pumps
 - e. Main circulating water pumps
 - f. Aux. machinery cooling water pumps
 - g. Anchor windlass
 - h. Fire pumps
 - i. Sewage pumps
 - j. Bilge stripping pumps
 - k. Ras winches
 - l. Motor whaleboat winches
 - m. Announcing systems loudspeakers (weather deck only)
 - n. Distilling plant pumps

Shipboard

1. Island peripheral bulkheads, interior and exterior
2. Barricade stanchion recessed deck well surfaces and exposed steel surfaces of the stanchion foot stools

REPAIR AREAS FOR THERMAL SPRAY

Shipboard

Sanitary spaces
Bulkheads
Weather decks
Pump room floors
Tie downs
Deck lights
Catwalk stanchions
Fire stations
Deck wells

Rule of Thumb: If you can't sandblast in a space on board ship, then you can't thermal spray in that space.

Shop

Hundreds of components have been thermal sprayed at Puget Sound Naval Shipyard. Eighty-five to 90 percent of these items are interchangeable items with private industry. Following are examples of some of the components thermal sprayed in-shop.

Bench supports	Deck gratings
Fire pump foundations	Muffler chamber
Ladder treads	Trench covers
Fire pump bed plates	Sluice gate cover
strainers	Duct covers
Gas cylinder containers	Reduction gear
Staging platforms	Brackets
Right-hand track section	Pipe flange
Left-hand track section	Manifolds
Access cover assembly	Hand rails
Safety net frames	Shore hatches
Track cover	Racks
Hinge protectors	Light brackets
smoke stack	Drain trough covers
Hydraulic cylinder	Fire main pump
Sewer pump	Discharge spool
Transition spools	Guard shanks
Base plates	Antenna stands
Foundation legs	Water trough
HP drain pipe	Clamps

Ladders
 Piping lengths
 Scupper rings
 Blast pads
 Booster pump foundations
 Safety nets
 Flanges
 Outlet box
 Fire pump housing
 stop log
 Impeller
 Pump well covers
 Dry dock sewer connection
 Pistons
 Doors
 Muffler extension
 Pipe hangers
 Stanchions
 Stairs
 Capstan foundation
 Seal ring
 Sliding foot assembly

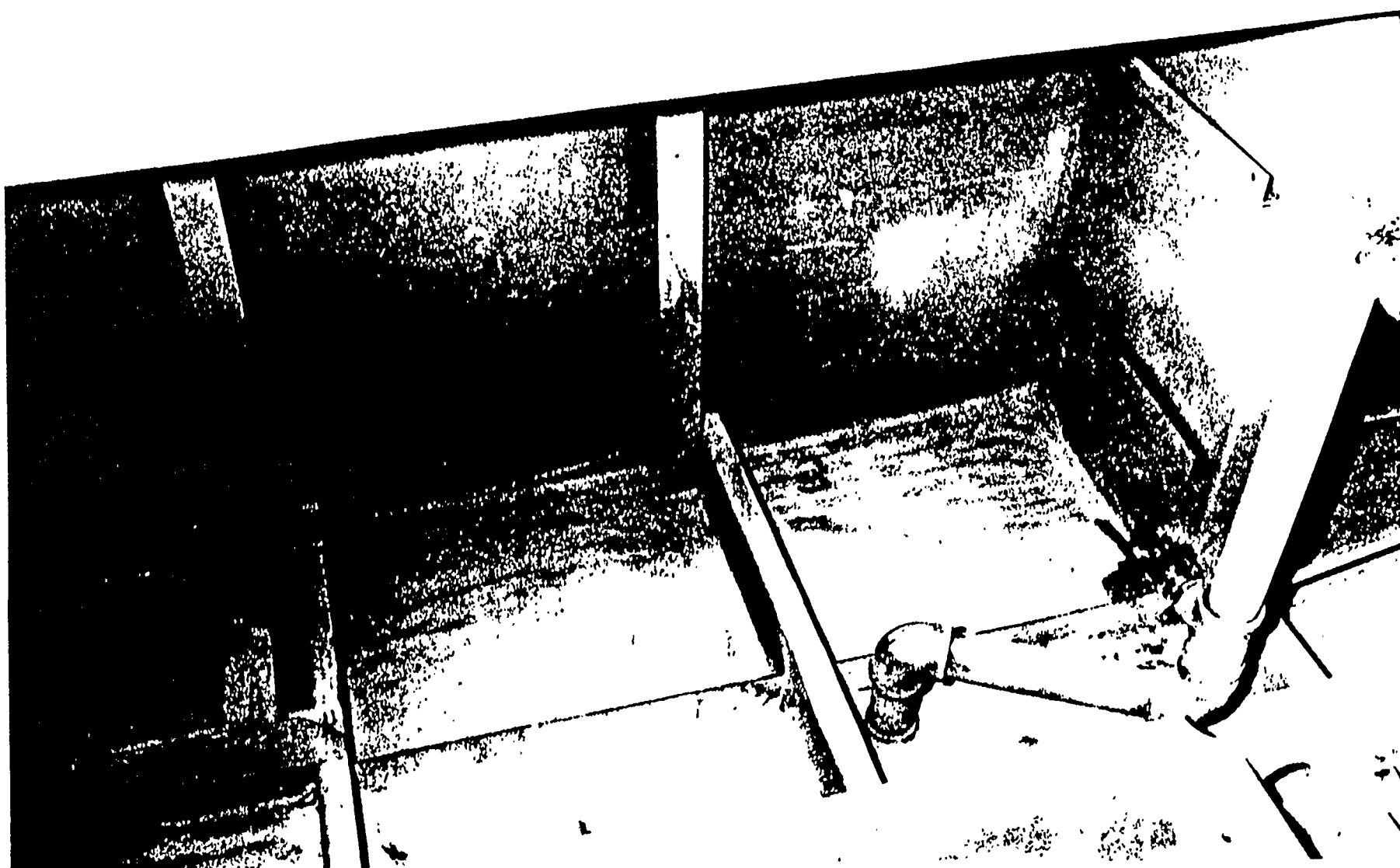
Winch foundations
 Barricade stanchions
 Fitting panel lift
 Manway cover
 Condenser
 Tow plate
 Whistle, steam pump foundation
 Air elbow
 Holdback trough
 Arresting gear component
 2" "Y" pattern
 Strut arms
 Eye assembly
 Exhaust "Y"
 Hinge leaf
 Hot water heater enclosure
 Trip throttle
 Trunk
 Pump sub-base
 Crank arm
 Hinge bearings
 Platforms

Valves and valve bodies - Numerous types:

- Globe
- Gate
- Relief
- Needle
- Combination
- Steam
- Lift Check
- Blowoff
- Exhaust, etc.

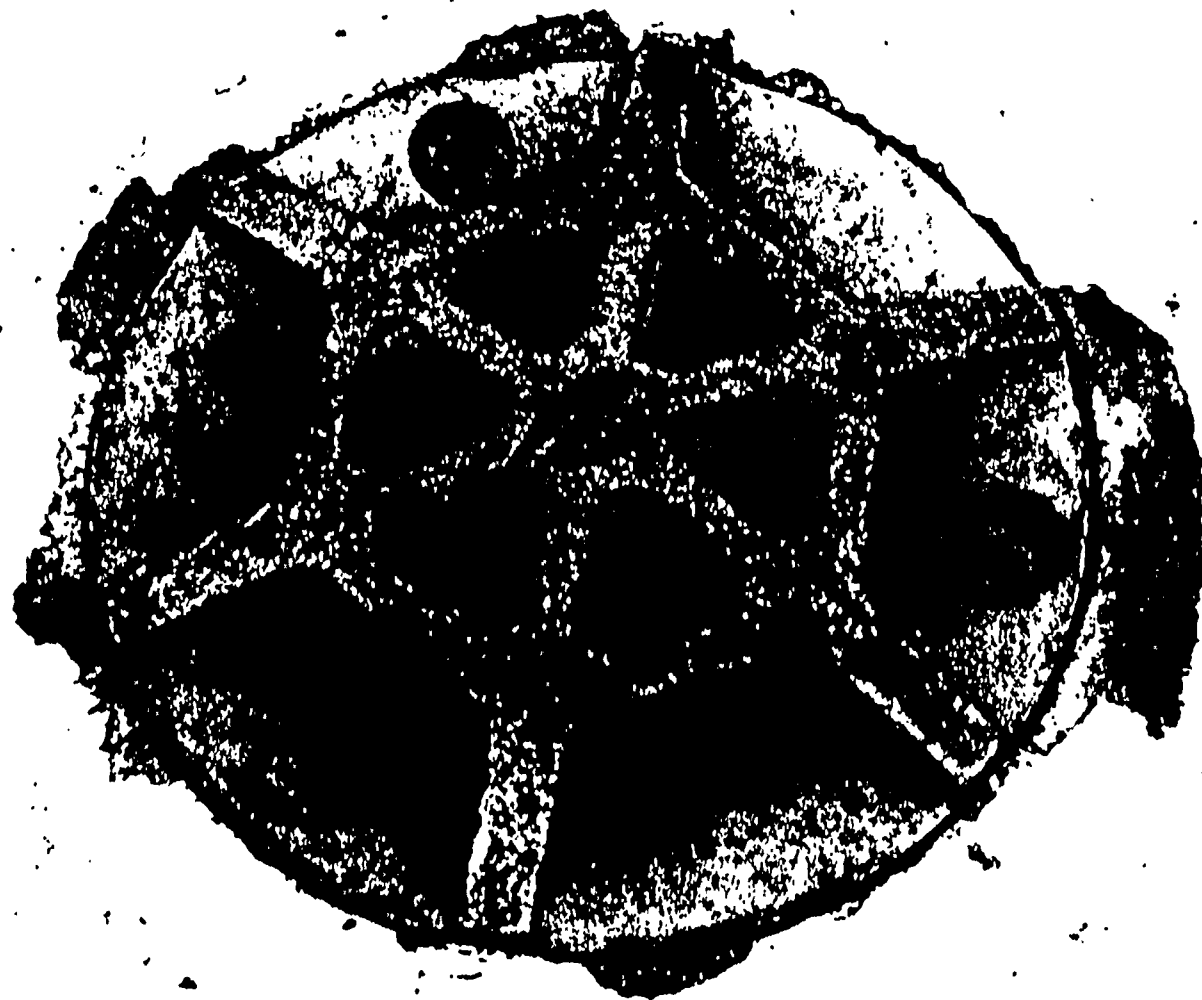
Sizes range from 1/4" globe valves to 48" flapper check valves.

HISTORICAL PHOTOGRAPHS

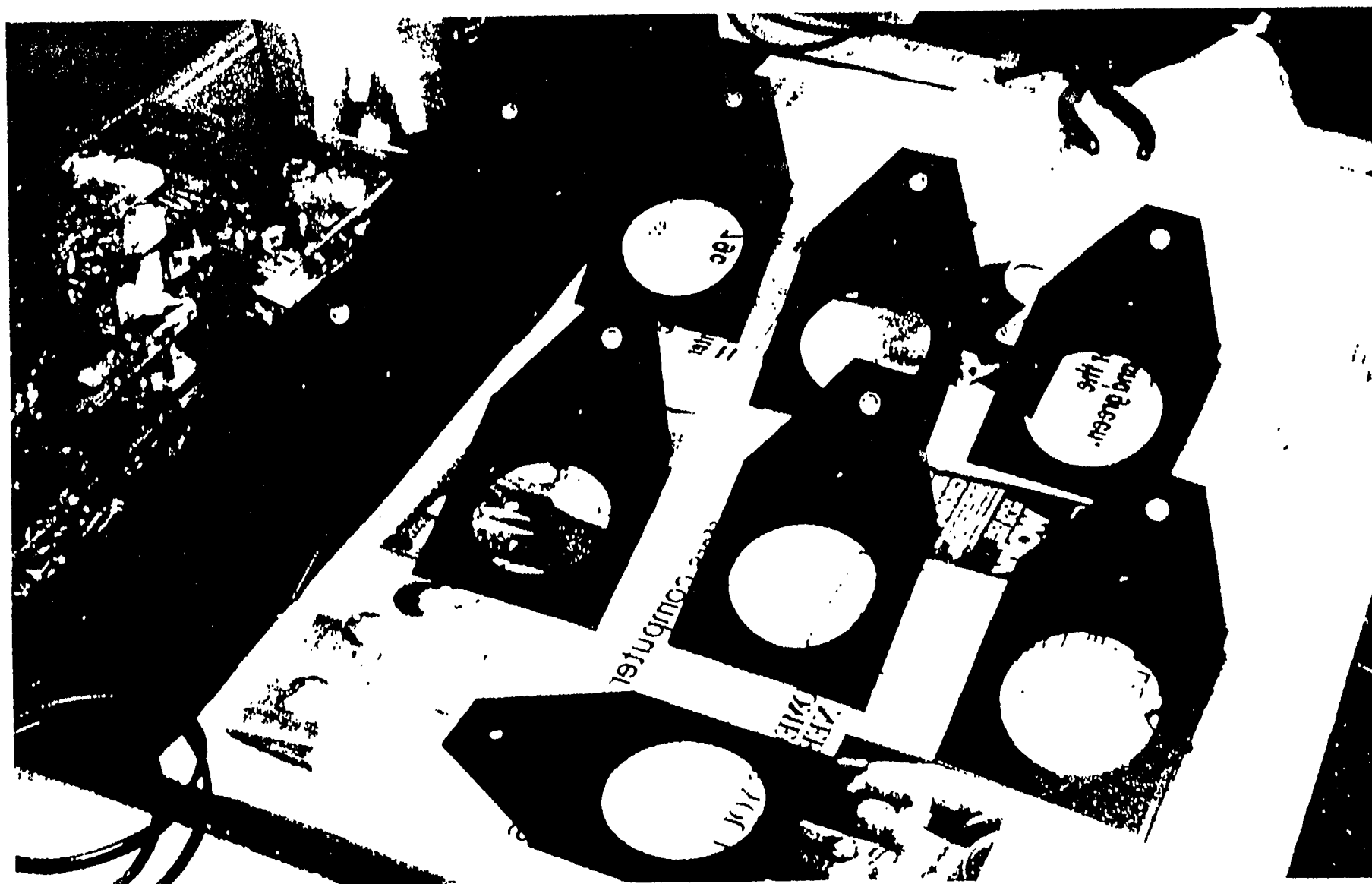


LOC FROM BIRD VIEW
LOC ON TRAIL





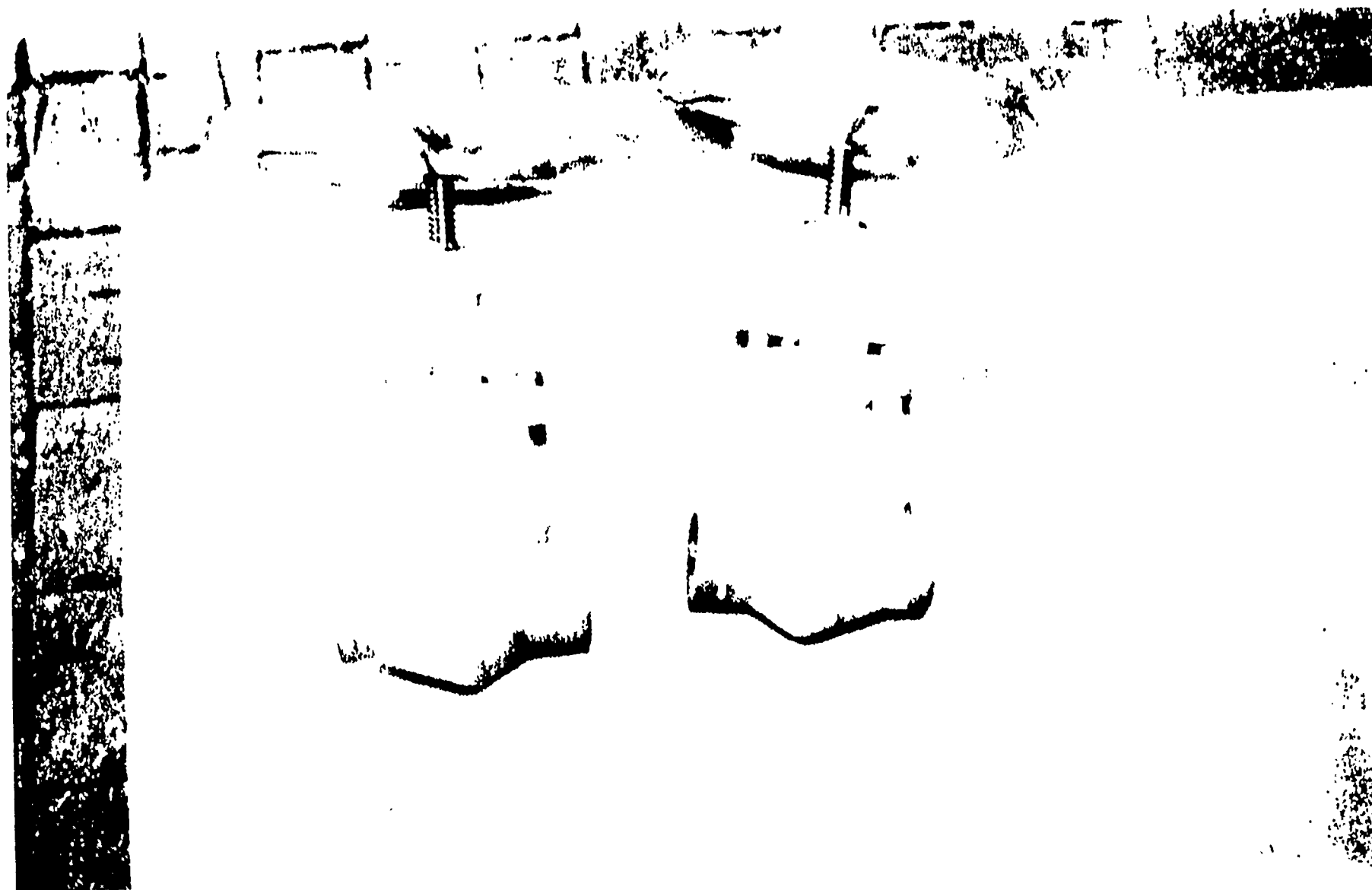
INTERNAL OPERATED BY THE



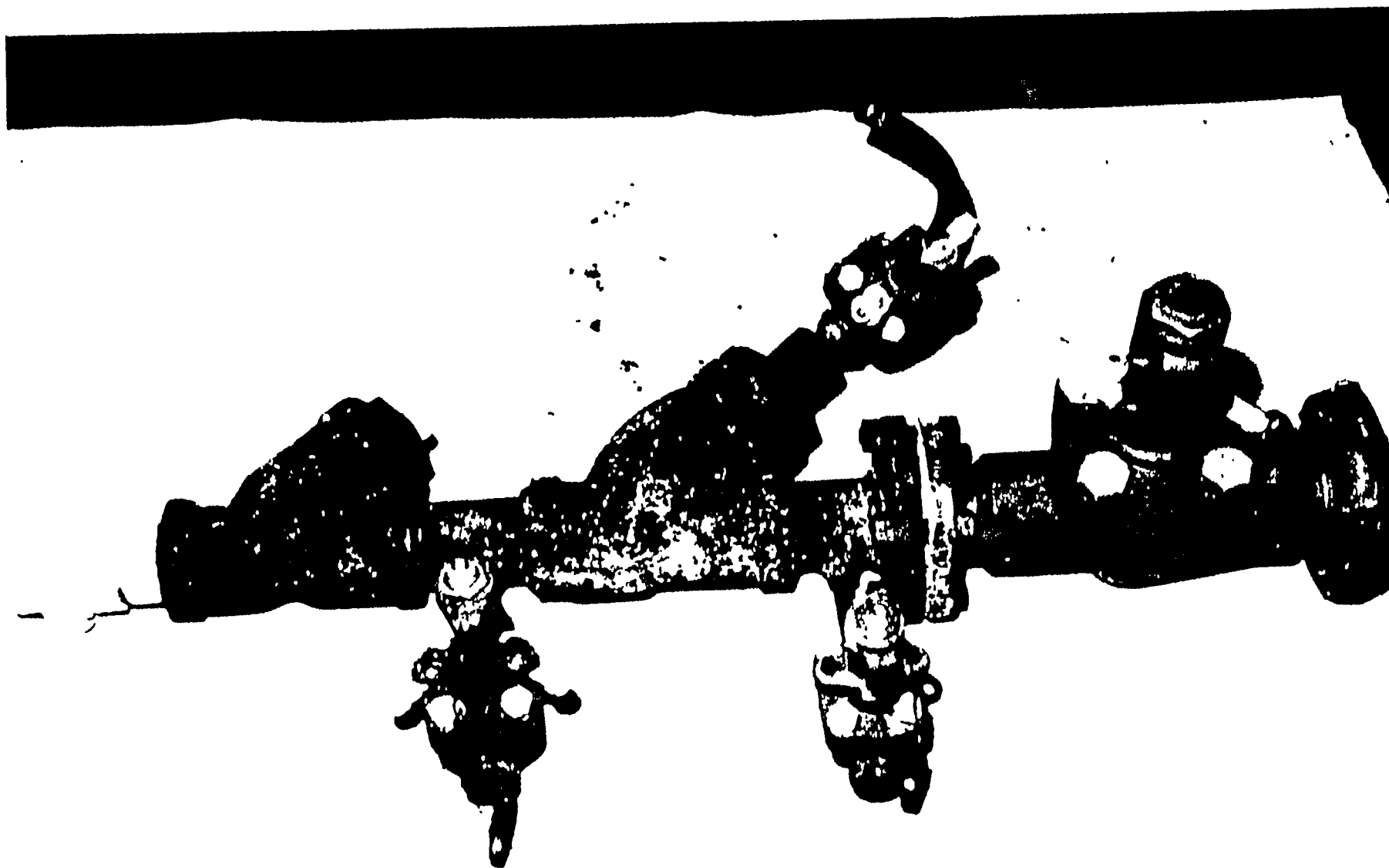


PIPE ASSEMBLY
(AFTER THERMAL SPRING)

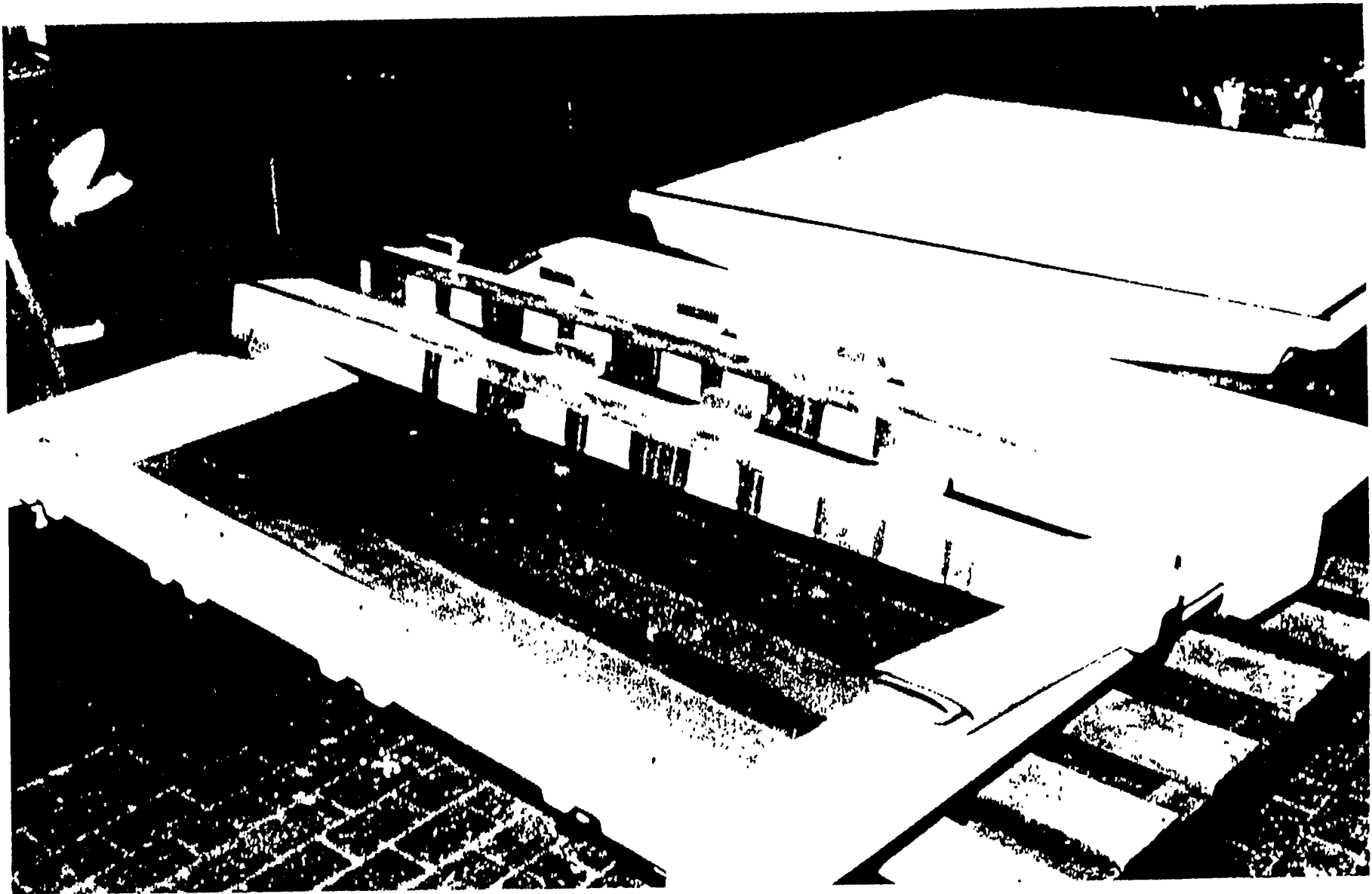


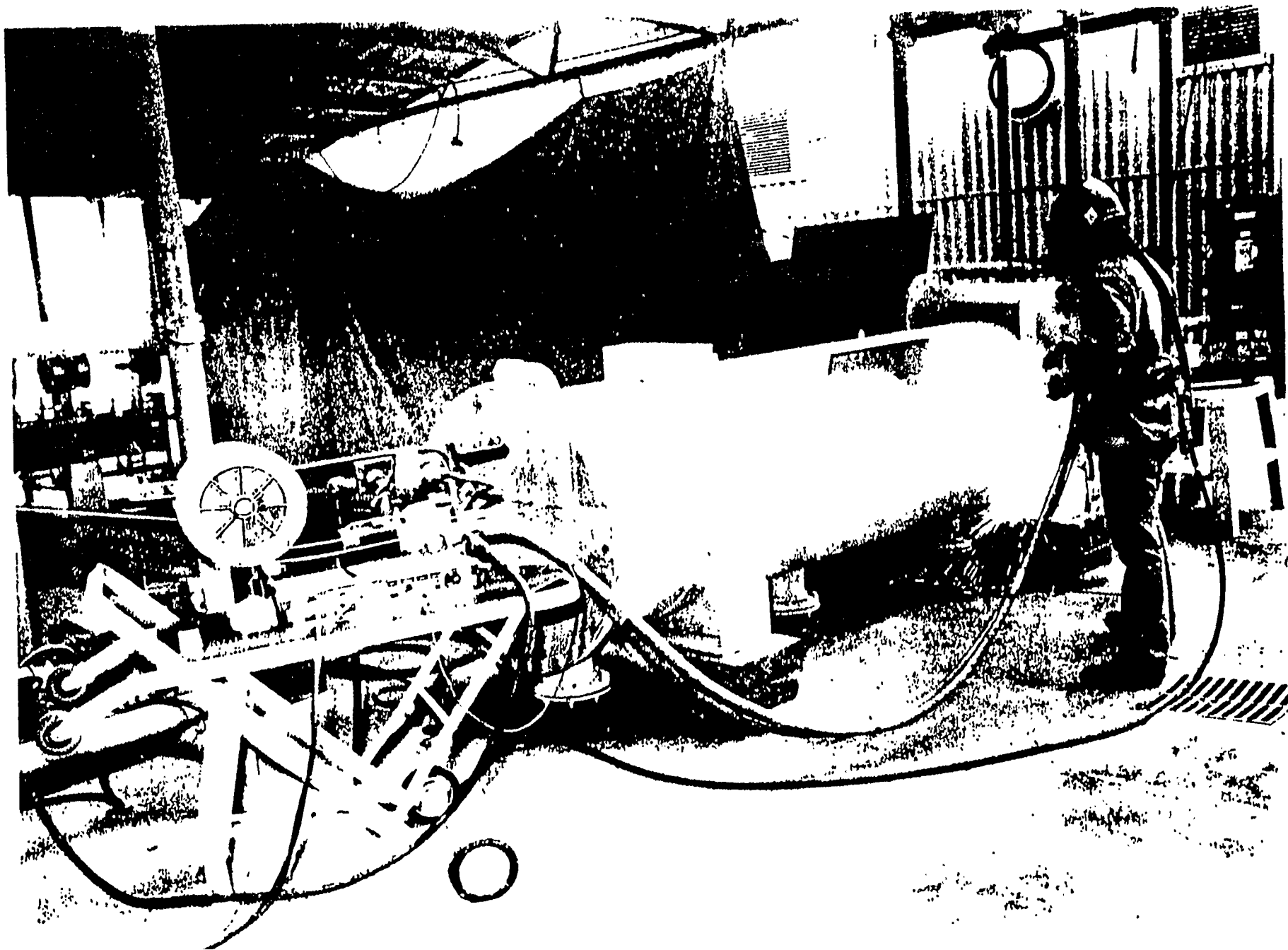


VALVES (THERMAL SPRAY COATED)



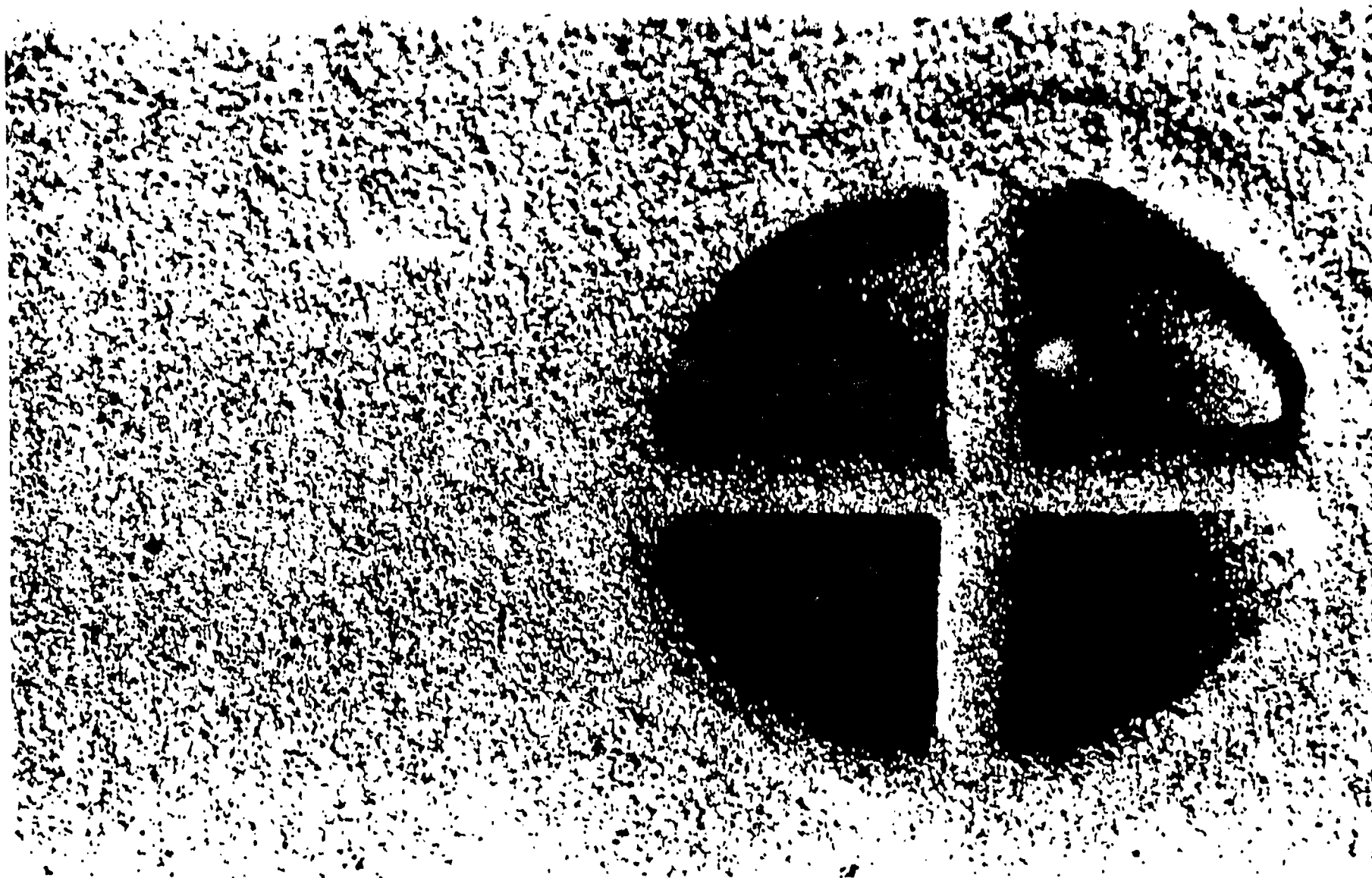
CORRODED VALVE





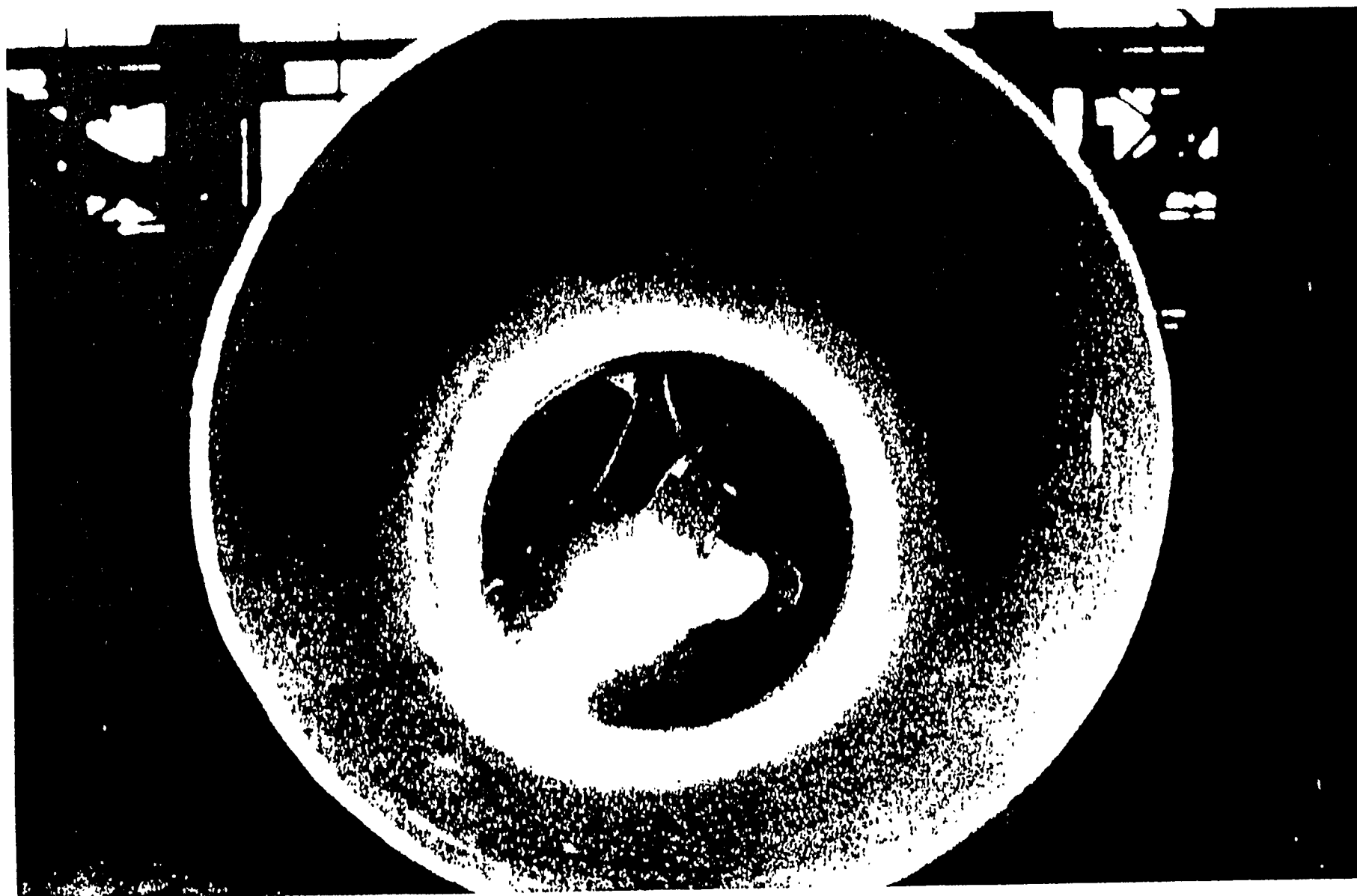


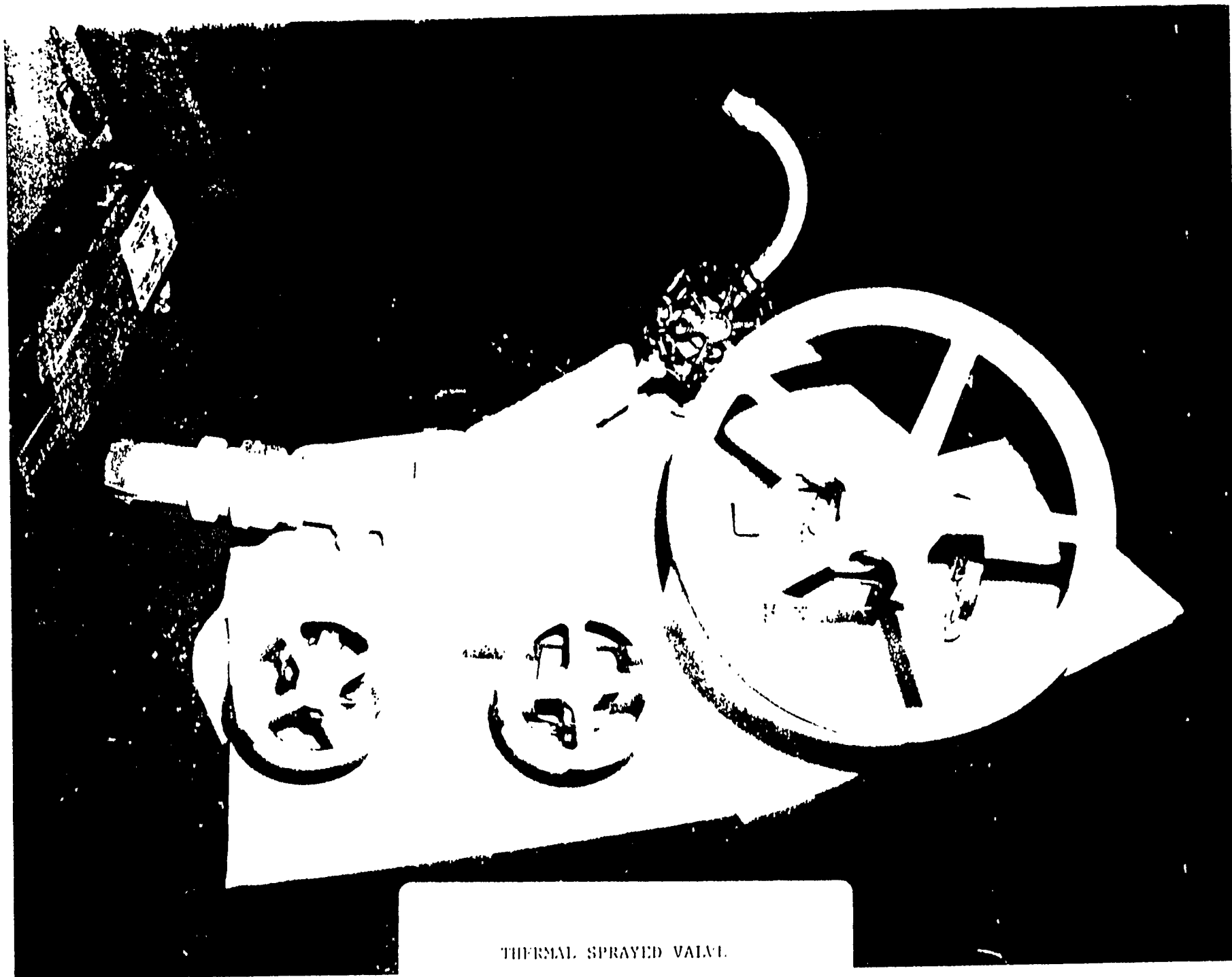
CONDENSER (THERMAL SPRAY COMPLETE)





WIDE-ANGLE SPEAKING





THERMAL SPRAYED VALVE

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