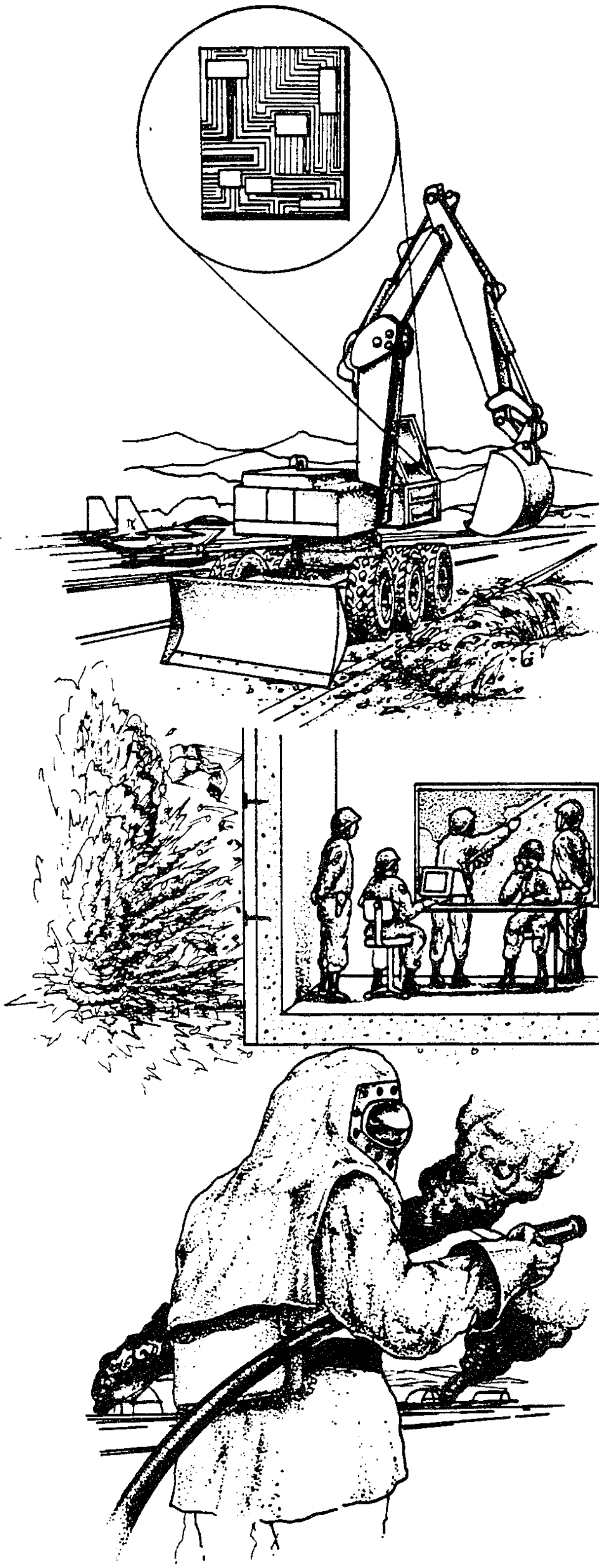

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AIR FORCE WASTE PETROLEUM, OIL, AND LUBRICANTS UTILIZATION AS BOILER FUEL

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FINAL REPORT

JANUARY 1992 - DECEMBER 1992

ENGINEERING RESEARCH DIVISION
Air Force Civil Engineering Support Agency
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13. ABSTRACT *(Maximum 200 words)*

This interim report documents the effort spent between January and December 1992. Work concentrated on literature search and survey, summarizing the data of the rate, variety, and management of waste POL generated at each Air Force base; studying DOD and commercial efforts to utilize waste POL as boiler fuel; conducting an economic incentive study; identify the environmental regulatory compliance issues; and identify and purchase of equipment. The literature review and the economic incentive study show that utilizing waste POLs as boiler fuel is possible and economically sound. Waste POL can be burned in a variety of boilers and burner types in blends with virgin boiler fuel up to 100 percent waste POL or as a fuel supplement in a coal-fired boilers. Concerns for undesirable emissions and ash residue include: (1) lead and other heavy metals; (2) inorganic elements such as sulfur, nitrogen, chlorine, bromine, and fluorine; and (3) organic elements such as antifreeze, halides, and solvents. Extra care is required at the collection points to minimize the contamination of waste POL by halogens, low flash point fuels and solvents, solids, and water. The surveys sent out to the Air Force Major Commands proved inadequate. Data received were incomplete and inaccurate. Lack of manpower and time at the individual bases contributed to the inaccuracy of the data.

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EXECUTIVE SUMMARY

A. OBJECTIVE

The objective of this interim report is to document the findings of the Phase I effort. The findings include : (1) Rate, variety, and management of waste POL generated at Air Force bases; (2) The economic incentives of using waste POL as boiler fuel; (3) Department of Defense and commercial sector activities; (4) The environmental and operational effects reported in the literature; and (5) Environmental regulations.

B. BACKGROUND

Because of the growing complexity and diversity of Air Force activities, millions of gallons of used POL are generated at Air Force bases. The quantity and variety of the used POL are functions of the mission of the individual Air Force base. In general, the waste POL includes lubricating oils, calibration fluid, antifreeze, transmission fluid, JP4, JP5, JP8, diesel, gasoline, and halogens.

Another source of used oil is the multi millions dollar stockpile of the automotive lubricants supplied by Battenfeld Grease & Oil and Battenfeld America to the Defense Logistics Agency. These lubricants are deficient in essential additives and are labeled unusable. Direction has been given to the individual services to utilize their used oil as boiler fuel while meeting local air quality restrictions.

Used POLs, in particular crankcase oils, are highly contaminated. During usage they get contaminated by wear metals, lead and other heavy metals, oxidation products, and carbonaceous particles. The most serious contamination may occur during handling and storage. Contaminants include water, acid, halogens, and low flash point liquid such as gasoline or solvents. Burning used POL in boilers may cause serious emission problems. However, because of its heating properties, viscosity, and flash point, the Air Force used POL represents a potentially valuable source of energy if it can be properly utilized for heating in existing boilers at Air Force bases.

C. SCOPE

This report covers literature review, results of surveys sent to the Air Force and Airline Industry, economic incentives study, and environmental regulations for used POL burning.

D. RESULTS

The literature review and the economic incentive study show that utilizing used POLs as boiler fuel is possible and economically sound. used POL can be burned in a variety of boilers and burner types in blends with virgin boiler fuel up to 100 percent used POL or as a fuel supplement in coal-fired boilers. Concerns for undesirable emissions and ash residue include: (1) lead and other heavy metals; (2) inorganic elements such as sulfur, nitrogen, chlorine, bromine, and fluorine; and (3) organic elements such as antifreeze, halides, and solvents. Extra care is required at the collection points to minimize the contamination of used POL by halogens, low flash point fuels and solvents, solids, and water.

The used POL surveys sent out to the Air Force Major Commands proved inadequate. Data received were incomplete and inaccurate. Lack of manpower and time at the individual bases and the reorganization of the major commands contributed to the inaccuracy of the data.

E. RECOMMENDATION

The Phase II is proposed in two parts. The first involves visitation to selected Air Force bases to collect information on used POL generation and management; boilers and burners, fuel usage; and environmental requirements. The second involves the laboratory testing program to investigate the burning of used POL and virgin fuel blends as well as the concerns of undesirable emission.

PREFACE

This report was prepared by the Air Force Civil Engineering Support Agency (AFCESA), Research, Development, and Acquisition Division, Air Base Operability and Repair (RACO) and Applied Research Associates (ARA). ARA efforts were performed under SETA Contract Number F08635-C-88-0067.

This report summarizes work done between January 1992 and November 1992. Mr Reza Salavani was the AFCESA Project Officer.

This report has been reviewed by the Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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SECTION I

INTRODUCTION

A. OBJECTIVE

The principal objective of this effort is to investigate the feasibility of utilizing Air Force generated used Petroleum, Oils, and Lubricants (POL) as boiler fuel. To achieve this objective, the effort was directed to study the following: (1) rate, variety, and management of used POL generated at Air Force bases; (2) economic incentives; (3) environmental and operational effects; and (4) methods to allow environmentally clean and efficient burning of waste POL.

B. BACKGROUND

The growing complexity and diversity of the Air Force activities have contributed to the increase in quantities and varieties of the generated used POL. The quantity and variety of the waste POL depend on the individual Air Force base mission. In general, the used POL includes lubricating oils, calibration fluid, antifreeze, transmission fluid, JP4, JP5, JP8, diesel, gasoline, and halogens.

Another source of used oil is the multimillion dollar stockpile of automotive lubricants supplied by Battenfeld Grease & Oil and Battenfeld America to the Defense Logistics Agency. These lubricants are deficient in essential additives and are labeled unusable. Direction has been given to the individual services to utilize their used oil stockpile as boiler fuel while meeting local air quality restrictions.

Used oils, in particular crankcase oils, are highly contaminated. During usage they get contaminated by wear metals, lead and other heavy metals, oxidation products, and carbonaceous particles. The most serious contamination may occur during handling and storage from water, acid, halogens, solids, garbage, and low-flashpoint liquids such as gasoline or solvents.

Because of its heating properties, viscosity, and flashpoint, Air Force used POL represents a potentially valuable source of energy that could reduce Air Force energy expenditures if properly utilized for heating in existing boilers at Air Force bases.

C. SCOPE

The research effort was designed to provide guidance to the base civil engineers and the boiler operators to allow safe, efficient, and environmentally clean burning of the waste oils operation in existing boiler systems.

To achieve the objective, the effort was divided into two phases. The first phase studied the following: (1) rate, variety, and management of waste POL generated at each AF bases; (2) economic incentives; (3) department of Defense and commercial sector activities; and (4) environmental issues and requirements. The first phase effort is detailed in this interim report. In the second phase the laboratory testing is to be conducted to study the environmental and operational effects, and to engineer methods to allow environmentally clean and efficient burning of used POL.

SECTION II

LITERATURE SURVEY

A. GENERAL

Numerous publications deal with used oil issues such as contamination, recycling, use as boiler fuel, and environmental impact. In 1970, the American Petroleum Institute (API) [1] investigated the extent of residues and particulate emission during the burning of used crankcase oil and virgin boiler oil blends. The study concluded that blends of used crankcase oil and virgin boiler oil can be safely burned in mixtures up to 25 percent by volume used oil. The test runs during this study were relatively short and in a follow-up work [2] API recommended a 5 percent mixture to reduce long-term burner fouling and unscheduled maintenance.

The assessment of used oil burning as fuels [3], funded by the Environmental Protection Agency (EPA), raised concerns about the undesirable emissions and ash residue from the following sources in the used POL : (1) lead and other metals; (2) inorganic elements such as sulfur, nitrogen, chlorine, and bromine; (3) organic elements such as gasoline, glycol antifreeze, halides, and other solvents; and (4) polychlorinated biphenyls (PCB). The study compiled results of 11 tests on burning used POL in boilers. The main conclusions of these tests can be summarized as follows:

(1) Used oil can be burned in a variety of boilers and burner types in blends with fuel oils up to 100 percent used oil or as a fuel supplement in a coal-fired boilers.

(2) Combustion problems such as ignition, stability, burner fouling, higher particulate emissions, and furnace deposits can be expected. However, these problems can be overcome. Hawaiian Electric Company has burned used lubricating oils in concentrations ranging up to 7 percent by volume for several years with no boiler deterioration or unusual maintenance problems.

(3) Lead emission can be a problem. 20 to 100 percent of the lead in used oil is expected to be emitted. Lead not emitted during normal combustion will be emitted during soot blowing.

Because lead is found in used oil mainly as ash constituent, moderate amounts of lead and other ash can be removed by sitting in tanks, simultaneously with water separation. During combustion organic, halides are converted primarily to hydrochloric, hydrobromic, and hydrofluoric acids. Metal halides salts may also be emitted, either unchanged from those present in the waste oil or formed by reaction of cations with halide acids. When the EPA study was conducted, no regulations of halide emission existed. However, current regulations include restrictions on chlorides emission.

Lubricating oils are generally grouped into four categories: (1) Petroleum-based oils;

(2) Synthetic oils; (3) Animal oils; and (4) Vegetable oils. Air Force waste lubricating oils consist of petroleum-based and synthetic oils. Petroleum-based lubricating oils are classified by generic attributes of the petroleum crude from which they are derived. The classifications are : (1) Naphthenic or Coastal (asphaltic); (2) Paraffinic or Pennsylvania; (3) Intermediate or Mid-continent. The bulk of hydrocarbons found in lubricating oils are naphthenics. The natural properties of these oils have proven insufficient for use in modern applications and additives to provide the desired service characteristics are added. Additives function as detergents, oxidation inhibitors, rust inhibitors, ignition inhibitors, antifoamantion, and others. With use, these additives undergo formulation changes which alter the oil desired properties.

Used lubricating oils, in particular, crankcase oils, are highly contaminated. During usage POLs get contaminated by wear metals, lead and other heavy metals, oxidation products, and carbonaceous particles. The most serious contamination may occur during handling and storage which include water, acid, halogens, and low-flashpoint liquids such as gasoline or solvents. Factors affecting the contamination level of lubricating oils include length of drain intervals, extent of fuel leakage into oil, engine operating conditions, and climate. These factors affect the rate of chemical and physical reactions in the oil and dictate the oil's metal profile.

Large quantities of used POL are routinely generated at Air Force installations. Contaminated jet fuel (JP-4, JP-5, and JP-8), turbine and lubricant oils, and hydraulic fluids are generated during aircraft activities and maintenance. Used calibration fluid is also generated during laboratory activities, while used crankcase oil and diesel fuel are generated from vehicles maintenance. Another source of used POL is the several millions of dollars stockpile of Battenfeld lubricants labeled unusable. These lubricants are deficient in essential additives.

B. BATTENFELD LUBRICANTS

The Department of Defense purchased wholesale stocks of automotive lubricants manufactured by Battenfeld Grease and Oil of New York and Battenfeld-America. The Army's Materials, Fuels, and Lubricants Directorate investigated the quality of the Battenfeld lubricants after an unusual number of engine replacements and maintenance deficiencies occurred at Fort Bliss, Texas [4]. These lubricants included engine oils procured against Military Specifications MIL-L-2104, MIL-L46152, and MIL-L-21260 and gear lubricants procured against MIL-L-2105. Elemental analyses for additive content and selected chemical/physical properties were conducted on 22 lots of Battenfeld products representing five different government contracts over a 3 year period. The investigation found 21 lots deficient in additives. The lubricants underwent varying degrees of formulation changes which made them unsuitable for their original applications.

The main additives in the engine oils are zinc, phosphorus, calcium, and magnesium while additives in the gear lubricants are sulfur and phosphorus. Sulfur can be found in all lubricate oils which is contributed by the base stock. The heating values of Battenfeld oils are not reported in the Military Specifications. However, based on their gravity, the heating values of these oils range between 18,800 and 19,400 BTU/lb which are similar to #2 heating oil.

C. DEPARTMENT OF DEFENSE STUDIES

1. Air Force Investigations

Two Air Force funded efforts were reviewed. The two efforts experimentally investigated the use of used POL as boiler fuel [5,6]. The first was conducted in 1972 by Esso Research and Engineering Company of New Jersey and was funded by AFWL. The other effort was conducted in 1976 by the Water and Solid Wastes Division, Environics Directorate, Air Force Civil Engineering Center.

a. AFWL Funded Work [5]. The experimental program was executed at TRW Combustion Test Site in Redondo Beach, California using a York-Shipley Model SPH-53-50-N6 dual fuel boiler. The boiler is a 50 BHp horizontal fire-tube boiler equipped with an air atomized burner. The burner control was modified to allow for simultaneous firing of natural gas and oil. This effort examined the feasibility of using the following used POL as boiler fuel in 5 percent blends with #2 and #6 oil :

(1) Waste aviation piston-engine oil (MIL-L-22851);
(2) Mixtures of piston-engine oil, synthetic turbine lube (MIL-L-7808), and hydraulic fluid (MIL-L-5606);
(3) Mixtures of piston-engine oil, synthetic turbine lube, hydraulic fluid, and Stoddard solvent (PD-680);
(4) JP-4; and
(5) JP-4 contaminated with Avgas.

The mixtures were formulated in a drum and mixed with industrial mixer. Used aviation piston-engine oil and hydraulic fluid were obtained from Kirtland AFB, NM while waste turbine oil was supplied by Tinker AFB, OK. Samples of the used piston-engine oil, synthetic turbine lube, and hydraulic fluid were analyzed to determine API gravity, ash content, metals (wear), metal (trace), bottoms sediment and wear, sulfur, nitrogen, distillation, and heating value. The analyses indicated that the waste POLs used in this study were free of contamination from other POLs.

The study monitored the stack gas for oxides of nitrogen (NOx), nitric oxide (NO), nitrogen (N2), sulfur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2), oxygen (O2), and hydrocarbons (HC). The study concluded the following:

(1) Used aviation piston-engine oil, used hydraulic fluid, and used synthetic turbine oil are compatible with #2 and #6 heating oil and can be burned simultaneously with natural gas.

(2) The use of used POLs, as described in the report, produced no noticeable degradation in boiler system hardware, no corrosion or erosion effects were observed.

(3) Total particulate loading in stack gases are well below local air quality limits. SO_2, NOx, CO2, HC, and CO emission remained at acceptable levels.

b. Air Force Civil Engineering Center Funded Work [6]. The long-term effects of used POL combustion such as corrosion and concentration of emissions were investigated at three Air Force bases with variety of boiler capacities and fuel sources. These bases included:

(1) Loring AFB, Maine: the test was conducted using a 63 MBtu/hr hot water water-tube boiler manufactured by WICKES Boiler Company. The boiler is a double-drum, bent tube "R" type with four burners rated at 1200 lb/hr #2 heating oil. The burners are steam-atomized burners manufactured by PEABODY Company.

(2) Seymour Johnson AFB, North Carolina : The boiler used in this study is manufactured by BIGELOW Company and produces saturated steam. It is rated at 19.3 MBtu/hr and equipped with a POWER FLAME burner air and heat atomized burner rated at 1034 lb/hr #5 heating oil.

(3) McConnell AFB, Kansas : The test boiler is manufactured by KEWANEE Boiler Corporation. The unit is a fire-tube boiler rated at 8.74 MBtu/hr and equipped with a single dual-fuel (#2 heating oil and natural gas) burner rated at 100 gal/hr #2 heating oil. The burner is ARC-134 rotary cup manufactured by Ray Oil Burner Company.

The report gives a used POL handling system design with variations to accommodate the three facilities at the three bases. The handling system injected the used POL into the virgin fuel line near the burner to deliver the blended fuel to the boiler. The study covered a range of blends of used JP-4, lubricating oils, and solvents with #2 heating oil, #5 heating oil, and natural gas. The blends, given in percent by volume, consisted of the following:

(1) A 50 percent JP-4 and 50 percent lubricating oils and solvents mixture in blends of 4 percent of the mixture and #2 oil and 11 percent mixture and #5 oil.

(2) Blends of 6 percent JP-4 in #5 oil and 16 percent JP-4 in #2 oil blend.

(3) Blends of lubricating oils and solvents at 2 percent in #5 oil blend, 16 percent in natural gas, and 26 percent in #2 oil.

The study measured CO_2, O_2, NOx, hydrocarbon, lead, and iron in stack gases and stack gas temperature. At the time of this study, only particulate and NOx were subject to regulation. The study concluded that (1) sulfur dioxide emission was not affected by burning used POL and virgin fuel blends; (2) long-term combustion of waste POL had no noticeable effect on boiler operation; (3) the separation of solvents and used lubricating oil is highly recommended; and 4) if a reciprocating pump is used to deliver fuel to burners, enough length of fuel line should be used to damp the pulsating effect on flame behavior.

Unfortunately, the excess air used in the test runs ranged between 40 to 186, percent far exceeding the 3 to 10 percent excess air suggested by the boiler manufacturers, thereby leaving the test results in doubt. The used POL handling system engineered in this study is useful and can be implemented in modifying boiler facilities to use waste POL. Seymour-Johnson AFB stopped burning used POL in 1985, after erratic flame and hot spots problems could not be solved.

2. Navy Investigations

In 1972, ESSO Research and Engineering Company under a contract with Naval Supply Systems Command conducted studies on oily waste (water contaminated by oils) generated at Naval shore facilities [7-13]. Under a contract with Naval Facilities Engineering Command, Exxon Research and Engineering Company (formerly ESSO) in 1974 conducted a series of studies on oily wastes generated at 17 Navy bases [14-31]. The generated data during these studies formulated the bases for two studies conducted by Civil Engineering Laboratory, Naval Construction Battalion Center [32-33]. The first of these studies dealt with laboratory testing of used POL firing in fire tube boiler while the second conducted a field test at the Naval Weapons Center, China Lake, California.

a. Laboratory and Field Testing Study [32]. The laboratory facility used was an 80 Bhp Scotch dry-back firetube boiler equipped with a steam atomized burner employing a Delavan nozzle. The primary measurements were the continuous monitoring of stack gas emissions. This included NO, CO, O_2, CO_2,and smoke. SO_2 was not measured, assuming that all sulfur in the fuel would oxidize to sulfur dioxide. The tested used POL consisted of randomly selected shipments. The usec POL consisted of used lube oil from diesel service shop (heavy oil), ship's waste oil (light), and water-contaminated JP-5 (Navy aircraft fuel, light). The used POL was fired in blends of # 2 heating oil (light), and # 6 heating oil (heavy). The study concluded that:

(1) No apparent problems were encountered in fuel miscibility, pumping, or firing with all waste-fuel blends.

(2) Fairly clean firing was achieved with all blends which included relatively clean nozzle tips, stack gases, and boiler gas-side heat transfer surfaces.

(3) Stable combustion was not achieved by steam atomizing of #2 heating oil and JP-5 blends, but was achieved using pressure atomized nozzle.

(4) Straight waste lubricating oils may be satisfactorily fired. The high content of ash in waste lubricating oil may result in increasing maintenance and/or decreasing efficiency due to ash accumulation of heat transfer surfaces.

(5) Other than relatively high ash accumulation when firing blends of high concentration of lubrication oil, no apparent emission problem was encountered.

b. Field Testing At China Lake [33]. The test facility is located at Plant no. 1, Building 00032, NWC, China Lake, CA. It consists of three water-tube boilers, each rated capacity is 20,700 lb/hr of saturated steam at 125 psi. The tested boiler was equipped with a single steam-atomized burner designed for # 6 heating oil. Oil blending was performed in a 450 gallon tank. The waste POL used in this study was a mixture of waste POL generated at various facilities at NWC which contained a large amount of water. The water was removed before the waste POL was used and the remaining oil was circulated to insure that the mixture was homogeneous. The elemental analysis of the waste POL showed that the waste oil mixture was slightly heavier, more viscous, and contained more ash than # 2 heating oil. The heating value of the waste mixture was similar to that of # 2 heating oil. However, <u>one striking difference was reported, the waste oil mixture flash point was below room temperature</u>. Test runs were performed with blends containing 0 to 100 percent waste oil mixtures. Stack gas emissions were measured for CO, CO_2, O_2, and NO. Test results showed no operational or environmental problems.

D. COMMERCIAL SECTOR EXPERIENCE

A number of long-term commercial operations proved the feasibility of burning used oil and fuel mixtures in boilers. In 1972 the Hawaiian Electric Company successfully burned a blend of crankcase oil and boiler fuel oil in one of its generating stations in Pearl Harbor [34]. The combustion of the blend did not affect boiler operation or maintenance and met the local emission standard at that time. Burning used automotive oil in coal fired boilers was demonstrated by Allied Chemical Corporation [35]. At its Solvay Plant in New York State, Allied Chemical mixed used automotive oil with pulverized coal before injecting it into the boiler. The use of used oil in this manner reduced air emission problems. Carrier Corporation, Syracuse, New York, demonstrated in 1972 the feasibility of burning used hydraulic fluid, machine tool lubricants, and compressor oil blended with #5 and #6 fuel oils in oil-fired boilers [36]. Carrier used a pre filtration and settling of the used oils mixture prior to blending and estimated a 2-year payback on the investment.

SECTION III

USED POL UTILIZATION SURVEY

A. GENERAL

To gain from the experience of the private sector in utilizing used POL, the airline industry, utility companies, and the chemical industry were targeted as potential used POL users. A questionnaire was sent to seven airline companies. Only US Air, United Airlines, and Delta Air Lines Inc. responded. The TWA letter never delivered and was returned eventually by the post office. The questionnaire is given in Appendix A.

Allied Chemical was cited in one of the reports as one company utilizing used oil at one of its facilities in New York State. However, the effort spent to collect information on this operation was fruitless. Allied Signal replaced Allied Chemical and no one knew what activities took place during the Allied Chemical times. In the utility industry, Carolina Power and Light utilizes waste oil in coal fired boilers in two locations in Norty Carolina, Sutton Power Plant and Cape Fear Power Plant.

In mid 1991, AFCESA/RACO sent out a questionnaire to all major commands in the Air Force. The questionnaire form is shown in Appendix A. All but TAC, SAC, and USAFE responded, and not all bases responded in each command. Furthermore, 1991 was not the best year for questionnaires due to Desert Shield and Desert Storm. Many bases participated in these efforts, and the reduced manpower and equipment affected both the used POL generation rate and questionnaire responses. Also, the consolidation and reorganization efforts in the Air Force promted SAC and TAC not to respone to the questionaires. Although the questionnaire had specific questions, the responses varied in details and in number of questions answered. However, the responses showed the variety of used POL generated on Air Force bases and methods of storage. Also, it showed the interest of the different bases in utilizing used POL as boiler fuel.

To overcome the usual inaccuracies generated by questionnaires, it is recommended that a few bases be selected and surveyed on site. Trips will be planned in the second phase of this study to visit these bases and to talk to boiler facilities managers. This approach will produce accurate data of waste POL generation and management and will provide one-on-one discussions to define the environmental and operational requirements, and boiler facility modification needs for waste POL burning.

B. AIR FORCE SURVEY

The Air Force survey is summarized in Table 1 by major command. The used POL reported in this table represents the total of jet fuels, diesel, lubrication oils, calibration fluids, and hydraulic fluids. Other waste such as paint thinners, halogens, and acids are not included.

Figures 1 through 4 show the estimated distribution of the generated used POL among the Air Force bases responded to the questionnaire. From these figures it is clear that the varieties and generation rates of waste POLs differ from one base to another, even within a major command, making it necessary to study each base as an individual case. This necessitated the selection of a few bases per major command for the economic incentive study. These bases will be investigated during the second phase of this project. The selection of these bases was based on the following factors: 1) base interest in the project; 2) variety and generation rate of waste POL ; and 3) base geographical location.

TABLE 1 : ESTIMATED USED POL GENERATED ANNUALLY BY VARIOUS AIR FORCE BASES

Command **Base *(state)*:**	**Used POL *(gpy)***	**Method of Dispose**	**Currently BurnWaste**
ATC			
Chanute AFB (Illinois)	12,410	Pay($0.1/gal)	No
Columbus AFB (Mississippi)	14,600	Give away	No
Goodfellow AFB (Texas)	3,270	Give away	No
Keasler AFB (Mississippi)	10,800	Sell ($0.06/gal)	No
Lackland AFB (Texas)	25,184	Sell ($0.05/gal)	No
Laughlin AFB(Texas)	7,000	Sell ($0.02/gal)	No
Mather AFB (California)	16,000	Donate	No
Randolph AFB (Texas)	10,550	Sell ($0.05/gal)	No
Reese AFB (Texas)	11,150	Give away	No
Sheppard AFB (Texas)	13,760	Pay($0.0004/gal Sell,	No
Vance AFB (Oklahoma)	13,138	Pay&Give	No
Williams AFB (Arizona)	14,290	Pay ($1.25/gal)	No
AFMC			
Hill AFB (Utah)	25,685	Sell ($0.03/gal)	No
Kelly AFB (Texas)	178,000	Burn, Pay ($0.55/gal)	Yes
Newark AFB (New Jersey)	1,425	Pay ($3.00/gal)	No
Robins AFB (Georgia)	128,606	Sell & Pay	No
Tinker AFB (Oklahoma)	179,416	Sell ($0.3/gal)	No
WP AFB (Ohio)	143,000	Sell ($0.03/gal)	No
AMC			
Altus AFB (Oklahoma)	14,511		No
Charleston AFB (South Carolina)	13,265		No
Dover AFB (Delaware)	44,268		No
Hurlburt FLD (Florida)	19,328		No
Kirtland AFB (New Mexico)	43,206		No
Lajes AB (Azores)	21,161		No
Little Rock AFB (Arkansas)	25,192		No
McChord AFB (WA)	22,220		No
McGuire AFB (New Jersey)	30,033		No
Norton AFB (California)	26,529		No
Pope AFB (North Carolina)	48,079		No
Scott AFB (Illinois)	1,375		No
Travis AFB (California)	20,703		No
PACAF			
Hickam AFB (Hawaii)	21,000	Burn	Yes
King Salmon Airport (Alaska)	2,500	Burn	Yes
Kadena AB (Japan)	26,743	Sell ($0.01/gal)	No
Yokota AB (Japan)	18,050	Give away	No

Some of the bases are burning used POL in their boilers. For example, at Kelly AFB (Texas), used calibration fluid is being burned in two of the three, six million BTU/hr, boilers that supply steam to the base kitchen. Kelly AFB produces about 150,000 gallons of waste calibration fluid every year. The properties of calibration fluid are similar to those of JP-5 but with lower lubricity. JP-5 is used by the Navy to fuel fleets' boilers. During a visit to Kelly the following condition were found:

(1) Waste is burned without mixing with virgin boiler fuel;

(2) Due to the low lubricity of calibration fluid, burner pumps were replaced with centrifugal pumps and diaphragm pumps are used to deliver the fuel from storage tank to the burner pumps;

(3) The waste calibration fluid does not have many contaminants. However, burning the lubrication fluid in these boilers produced silica oxides (sand) which deposited on the firebox water-tube wall. According to the boiler facility operator, the silica did not stick to these surfaces; but because these boilers are not equipped with soot blowers, the wastes will be treated with a chlorine compound to prevent silica oxides from forming.

(4) The local environmental authority permits the burning of used POL that contains less than 20 ppm chlorine.

The comparison between the generated used and the boiler fuel used for the selected bases is shown in Figures 5 through 8. The main boiler fuels are #2 heating oil and natural gas. In these figures natural gas is represented in #2 oil equivalent gallons based on the total heating value of natural gas used per year and the oil heating value per gallon. In a few cases #2 heating oil is used as a backup fuel with natural gas as the primary fuel. Replacing natural gas with used POL may be a problem since natural gas is used so that local air quality requirements are met. These figures show that used POL can replace #2 heating oil in amount ranges from 1percent to 60 percent, resulting in sizable savings.

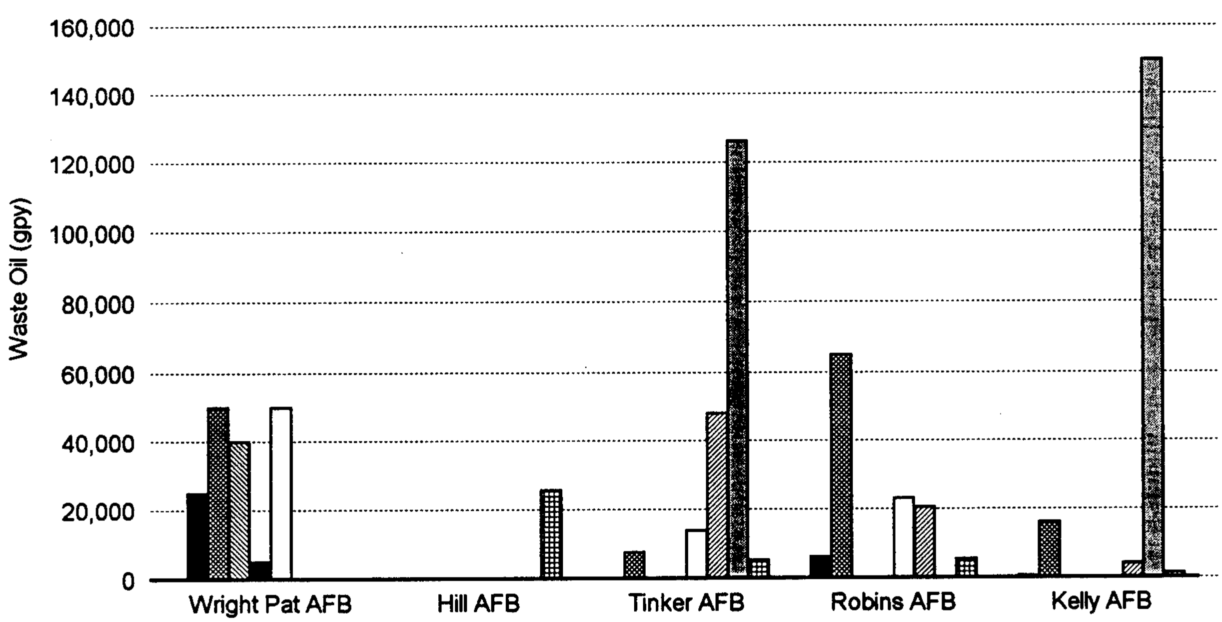


Figure 1: Air Force Materiel Command (AFMC) Used POL Generation (■ Diesel ▩ JP-4 ▧ JP-8 ■ JP-5 □ Lube. Oil ▨ Hyd. Oil ▩ Calib. Fluid ▦ Mix)

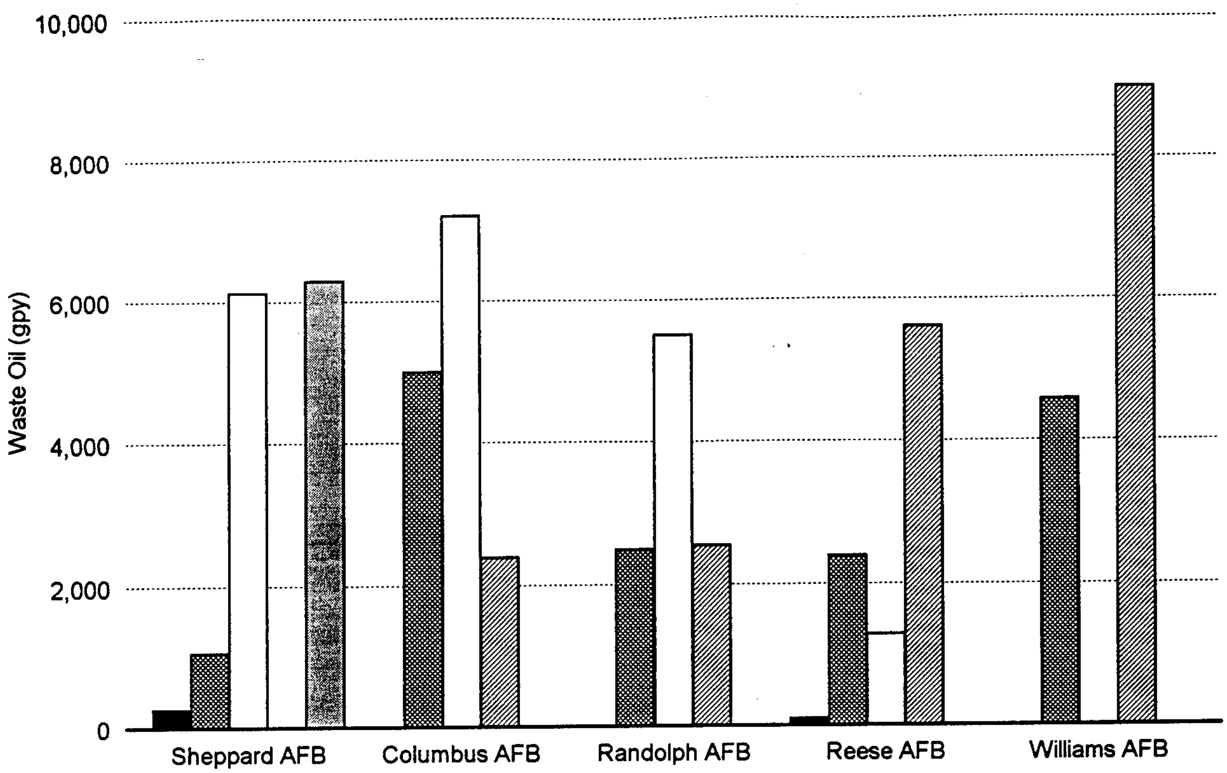


Figure 2: Air Training Command (ATC) Used POL Generation (■ Diesel ▩ JP-4 □ Lube. Oil ▨ Hyd. Oil ▩ Synth. Oil)

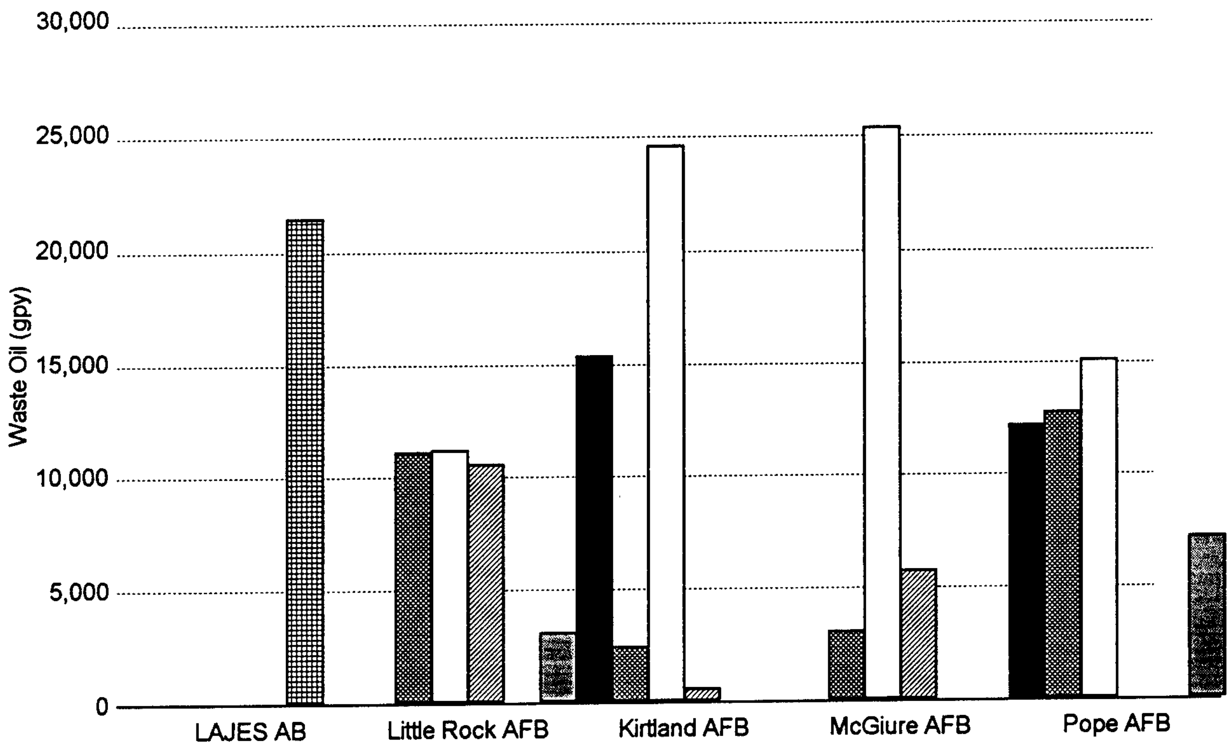


Figure 3: Air Mobility Command (AMC) Used POL Generation (■ Diesel ▩ JP-4 □ Lube. Oil ▨ Hyd. Oil ▦ Mix ▩ Synth. Oil)

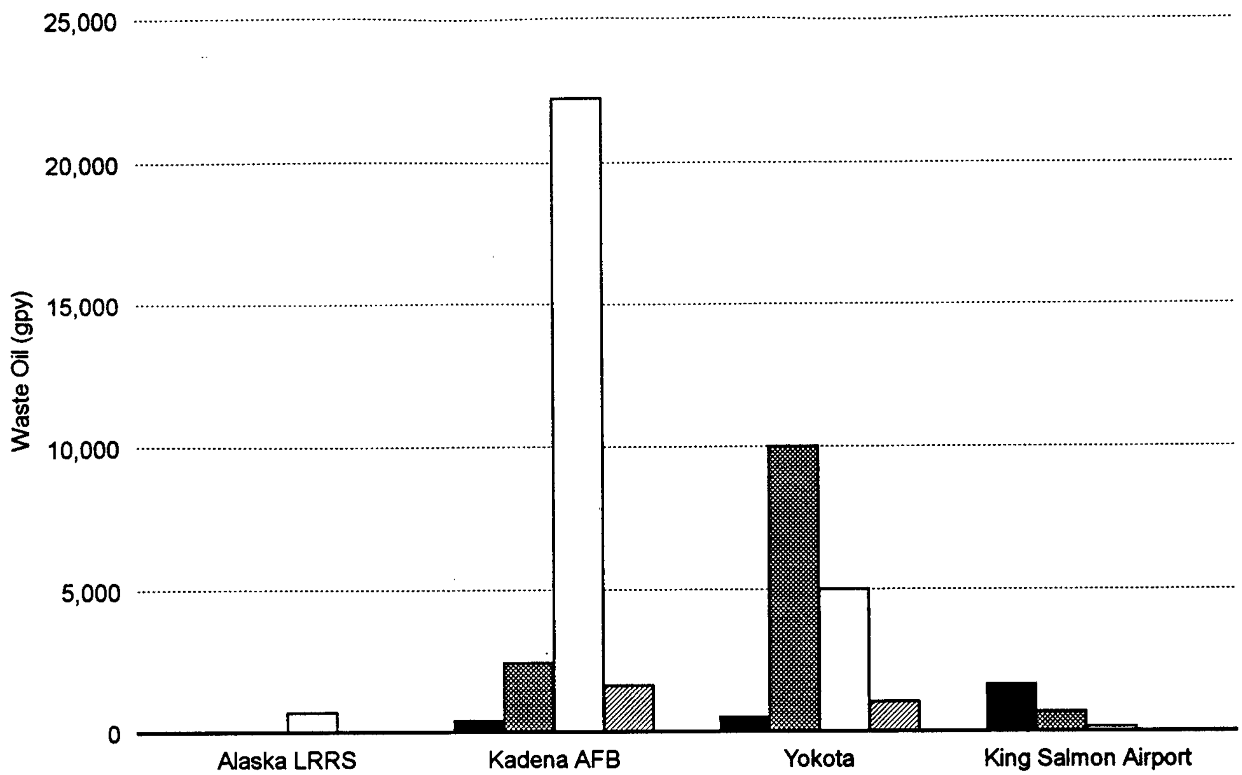


Figure 4: Pacific Air Force (PACAF) Command Used POL Generation (Diesel JP-4 Lube. Oil Hyd. Oil)

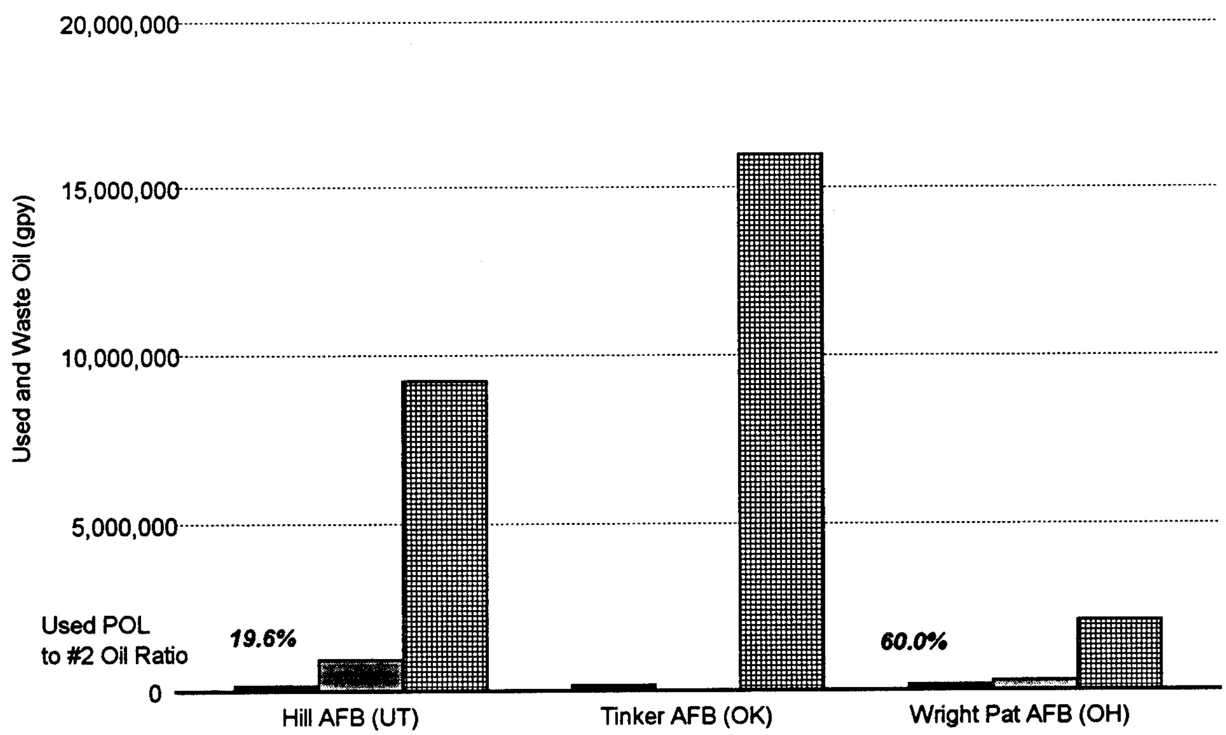


Figure 5: Comparison of Used POL Generated and Fuel Use for Air Force Materiel Command (AFMC) Selected Bases (Used Oil Oil #2 Nat. Gas)

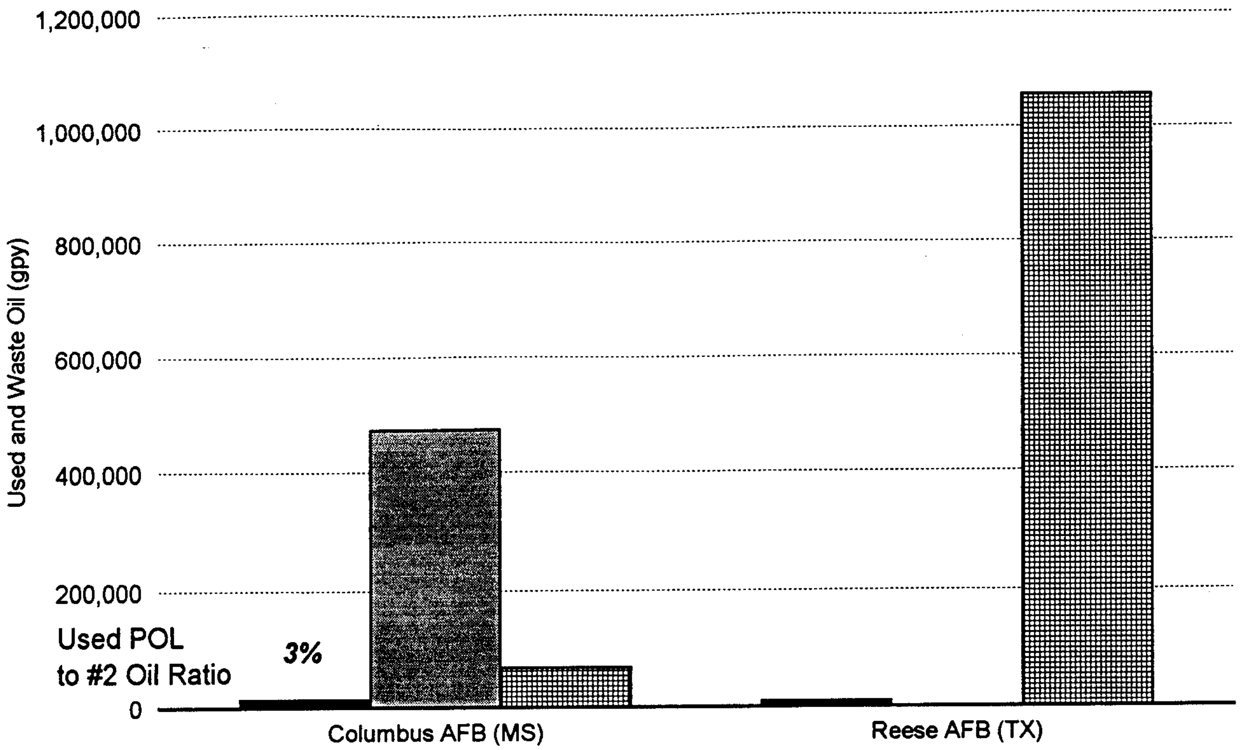


Figure 6: Comparison of Used POL Generated and Fuel Use for Air Training Command (ATC) Selected Bases (Used Oil Oil #2 Nat. Gas)

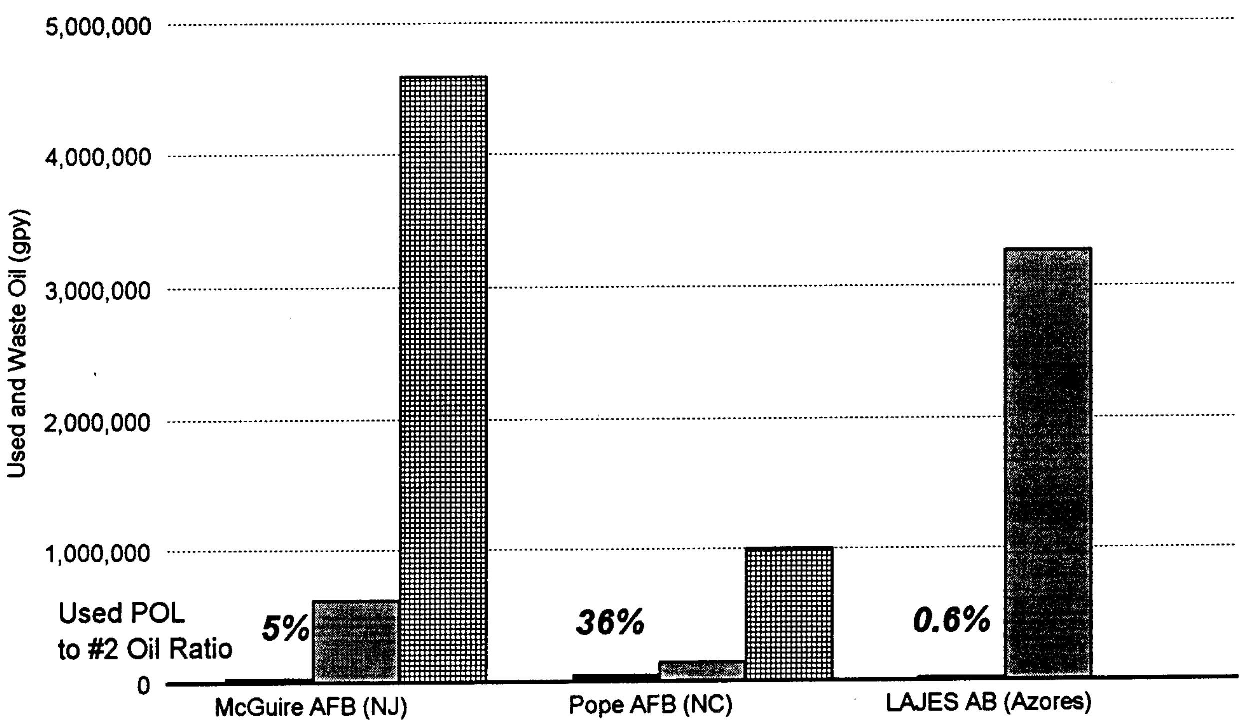


Figure 7: Comparison of Used POL Generated and Fuel Use for Air Mobility Command (AMC) Selected Bases (Used Oil Oil #2 Nat. Gas)

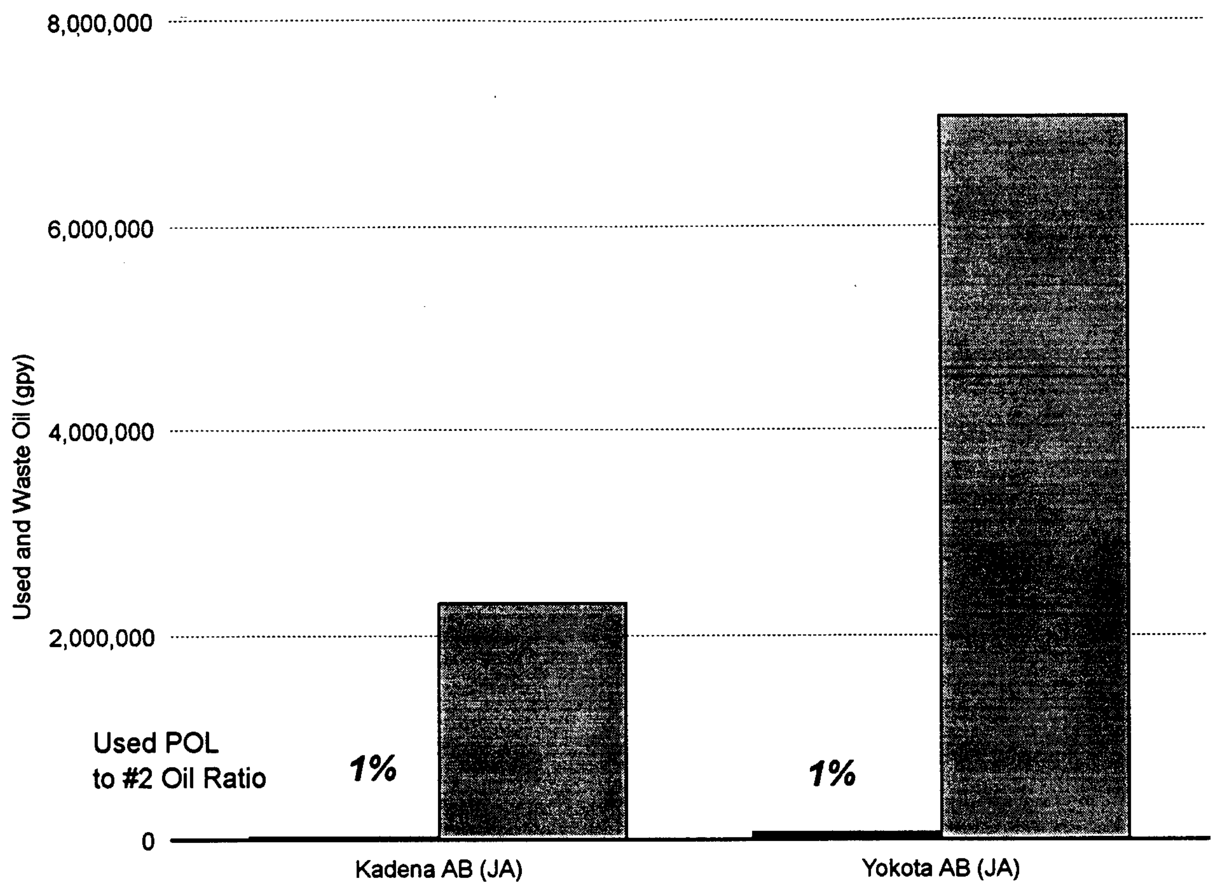


Figure 8: Comparison of Used POL Generated and Fuel Use for Pacific Air Force (PACAF) Command Selected Bases (■ Used Oil ▩ Oil #2)

C. COMMERCIAL SECTOR SURVEY

1. Airline Industry Utilization of Waste POL

US Air, United Airlines, and DELTA Air Lines responded to our questionnaire. Their responses are summarized in the following paragraphs.

a. US Air. The airline company generates 141,931 gallons of used POL per year. Only waste Jet fuel is blended with boiler fuel and burned, used turbine oil, ground vehicles lube oil, and hydraulic fluid are recycled at a cost to US Air of $ 0.27 to 1.35 per gallon. US Air response is summarized as follows.

US Air point of contact is: Mr Kenneth A. Wiseman
Facilities Director
US Air
National Airport
Washington D.C. 20001

TYPE OF USED OIL	AMOUNT (gpy)	PRESENT DISPOSAL METHOD (i.e. burn, recycle, sell, pay to dispode, etc.)	COST ($/gal)
a) Turbine Lube Oil	73,496	recycle	0.27 - 1.35
b) Ground Vehicle Engine Oil	49,600	recycle	0.27 - 1.35
c) Hydraulic Fluid	14,835	recycle	0.27 - 1.35
d) Diesel Fuel	0		
e) Jet Fuel	4,000	fuel blending	

b. United Airlines. United Airline answered the questionnaire very briefly, citing a lack of manpower. However, they have begun plumbing some of their storage facilities to reclaim the jet fuel tank sump product. The jet fuel sumps are filtered and used in diesel ground equipment. Other petroleum waste oil and products are disposed of by a licensed petroleum waste hauler.

United point of contact is: Mr William E. Thompson
Sr. Staff Representative
United Airlines
PO Box 66100
Chicago, IL 60666

c. DELTA Air Lines. DELTA generates 58,500 gallons of used oil per year. Of this amount, 5,850 gallons as jet fuel. Waste and virgin jet fuel are blended with #2 heating oil and burned in four fire-tube and six water-tube boilers. The yearly maintenance cost is about $ 1,200 while yearly savings totals $ 27,000. The DELTA response is summarized as follows.

TYPE OF USED OIL	AMOUNT (gpy)	PRESENT DISPOSAL METHOD (i.e. burn, recycle, sell, pay to dispode, etc.)	COST ($/gal)
a) Turbine Lube Oil	11,700	recycle/pay	0.18
b) Ground Vehicle Engine Oil	11,700	recycle/pay	0.18
c) Hydraulic Fluid	14,040	recycle/pay	0.18
d) Diesel Fuel	5,850	recycle/pay	0.18
e) Jet Fuel	5,850	Blend for reuse	
f) Gasoline-Water	9,360	recycle/pay	0.18

DELTA point of contact is : Mr Dave Allison
DELTA Air Lines
Dept 594, TOC - 1
Hartsfield International Airport
Atlanta, GA 30320

2. Carolina Power and Light

The used oil program at Carolina Power and Light (CP&L) is successfully running at two powerplants in North Carolina. CP&L is burning used lube oil from its car fleet, transformer oil, and turbine oil in the coal-fired boilers at Sutton and Cape Fear Power Plants. The program easily meets the air control permit. The major contamination occurs during collection. These contaminants include cloth, tennis shoes, and other objects not related to the function and original use of the waste oil. The contamination with these objects shows the need for a waste POL management program.

SECTION IV

ECONOMIC INCENTIVE

A. GENERAL

The economic incentive study was conducted on selected Air Force bases to determine the economic feasibility of the use of used POL as boiler fuel. Since there are factors which vary from boiler facility to boiler facility, several assumptions were made. These assumptions include:

(1) The cost of used POL transportation from point of collection to point of use is assumed at $0.10 per gallon.
(2) The cost of preparing a boiler facility to receive, store, and burn used POL is assumed at $ 20,000 for 200 Bhp boilers equipped with oil burners.
(3) Virgin oil cost is taken from the Base Consumption Report dated June 29, 1992.
(4) Halogen, paint thinner, and other low flash point liquids are excluded. Only waste aviation fuels, diesel, lubricating oils, hydraulic fluids, and calibration fluids are considered in this study.

This study can serve as a tool for the managers of the individual boiler facilities to determine the suitability of their installations to burn used POL.

B. METHOD OF CALCULATION

The calculation procedure is divided into costs and savings and losses steps. Currently, Air Force bases pay to dispose waste POL, sell it, or donate it. Disposing the used POL is counted as savings if the base pays to dispose, while counted as costs if the base sells the used POL. The costs here are: (1) the cost of modifying the boiler installation to allow for storage and use of the used oil; (2) the cost of delivering the used POL to the boiler location; and (3) the loss of revenue from selling to dispose the used POL. The savings are: (1) the savings in virgin boiler fuel cost; and (2) the cost of disposing used POL.

1. Cost of Modification

The waste POL piping scheme designed by Fink and Jackson [6] was evaluated and its present today cost was determined at $20,000. Modifications to the Fink and Jackson design may be needed to modify certain boiler facilities. However, for the purpose of completing the economic study, the cost of that design was used.

2. Savings and Losses

When waste POL is used in place of the virgin fuel, the cost of the replaced fuel, adjusted to the difference in the heating values of waste POL and virgin fuel, is treated as savings. The virgin fuel cost was taken from the Base Consumption Report dated June 29, 1992. The ratio of waste POL heating value to that of the virgin fuel was assumed to be 0.9.

For those cases where natural gas is the primary fuel, the price of an equivalent gallon of oil #2 was calculated based on the heating values of natural gas and oil #2. The Air Force Survey showed that the bases either sell, pay, or give to dispose of their waste POL. In few cases the base donates the waste POL to local schools or universities. In the case of selling the waste POL to be recycled the income from that sale is treated as losses while the cost of paying to dispose is treated as savings.

3. Calculation Steps

a. Nomenclature:

- β Ratio of used POL heating value to that of virgin fuel
- N Number of gallons per year of waste POL that can be utilized.
- X Cost/income of disposing of used POL.
- Y Cost of retrofit.
- Z Cost of virgin fuel per gallon.
- C Net cost.
- S Net savings

b. Net Costs :

C1 = Cost of modification per year (using 20 years amortization) = Y/20
C2 = Cost of used POL delivery (\$ 0.1 per gallon) = 0.1 x N

C = Net Cost = C1 + C2 = Y/20 + 0.1 x N

c. Net Savings :

S1 = Saving in fuel cost = N x Z xβ
S2 = Savings (+)/losses (-) from paying/selling to dispose used POL = ± N x X

S = Net Savings = S1 + S2 = (N x Z x β) + (± N x X)

d. Net Value :

Net Value = Net Savings - Net Cost

e. Payoff Period :

Payoff Period in months = 12 x (Y/Net Savings)

C. ECONOMIC INCENTIVES FOR THE SELECTED BASES

1. Air Force Materiel Command (AFMC)

Table 2 summarizes the rate and type of fuels usage and the rate of used POL generated on the AFMC selected bases.

TABLE 2: AFMC SELECTED BASES ENERGY USE AND WASTE GENERATED IN 1991

Base		gpy in (1000)	Fuel	Price● ($/gal)	Waste Disposing		
					Sell ($ /gal)	Donate	Pay ($ /gal)
Hill AFB (Utah)	Use	955	Oil # 2	1.04			
	Generate	188	waste		0.037		
Tinker AFB (Oklahoma)	Use	17 16,000	Oil # 2 N.Gas	0.65 0.34			
	Generate	180	waste		0.037		
WP AFB (Ohio)	Use	287 2,121	Oil # 2 N.Gas	1.04 0.51			
	Generate	170	waste		0.037		

● the price of equivalent gallon of natural gas was used to calculate the net savings

The results of the economic incentives calculations are :

a. Hill AFB (Utah) :

Net Cost = $ 19,750.00 / year
Net Savings = $ 178,312.00 / year
Net Value = $ 158,562.00 / year
Payoff Period = $ 1.35 months

b. Tinker AFB (Oklahoma) :

Net Cost = $ 18,942.00 / year
Net Savings = $ 51,313.00 / year
Net Value = $ 32,371.00 / year
Payoff Period = $ 4.68 months

c. Wright Patterson AFB (Ohio) :

Net Cost = $ 18,000.00 / year
Net Savings = $ 162,860.00 / year
Net Value = $ 144,860.00 / year
Payoff Period = $ 1.47 months

2. Air Force Training Command (ATC)

Table 3 summarizes the rate and type of fuels usage and the rate of used POL generated on the ATC selected bases. The results of the economic incentives calculations are:

a. Reese AFB (Texas) :

Net Cost = $ 1,940.00 / year
Net Savings = $ 3,840.00 / year

Net Value = $ 1,900.00 / year
Payoff Period = $ 5.20 years

b. Lajes AB (Azores Island) :

Net Cost = $ 3,116.00 / year
Net Savings = $ 20,907.00 / year
Net Value = $ 17,791.00 / year
Payoff Period = $ 12.00 months

TABLE 3 : ATC SELECTED BASES ENERGY USE AND WASTE GENERATED IN 1991

Base		gpy* in (1000)	Fuel	Price● ($ /gal)	Waste Disposing		
					Sell ($ /gal)	Donate	Pay ($ /gal)
Columbus AFB (Missouri)	Use	473	Oil # 2	1.04			
	Generate	15.	Waste			0.00	
Reese AFB (Texas)	Use	0.064 1,056 3.264	Oil # 2 N.Gas Propa.	1.08 0.43 1.31			
	Generate	9.400	Waste			0.00	

* for natural gas it is an equivalent gallons based on heating values.
● the price of equivalent gallon of natural gas was used to calculate the net savings.

3. Air Mobility Command (AMC)

Table 4 summarizes the rate and type of fuels usage and the rate of used POL generated on the AMC selected bases.

TABLE 4 : AMC SELECTED BASES ENERGY USE AND WASTE GENERATED IN 1991

Base		gpy * in (1000)	Fuel	Price● ($ /gal)	Waste Disposing		
					Sell ($ /gal)	Donate / Give Away	Pay ($ /gal)
Lajes AB (Azores)	Use	3.267	Oil # 2	1.04			
	Generate	21.161	Waste		‡		
McGuire AFB (New Jersey)	Use	616.207	Oil # 2	0.94			
	Generate	30.033	Waste			0.00	
Pope AFB (N. Carolina)	Use	139.743 1,005	Oil # 2 N.Gas	1.04 0.76			
	Generate	51	Waste			0.00	

* for natural gas it is an equivalent gallons based on heating values.
● the price of equivalent gallon of natural gas was used to calculate the net savings.
‡ no data on cost of disposing and assumed zero.

The results of the economic incentives calculations are:

a. McGuire AFB (New Jersey) :

Net Cost = $ 4,003.00 / year
Net Savings = $ 26,819.00 / year
Net Value = $ 22,819.00 / year
Payoff Period = $ 8.90 months

b. Pope AFB (North Carolina) :

Net Cost = $ 6,100.00 / year
Net Savings = $ 50,388.00 / year
Net Value = $ 44,288.00 / year
Payoff Period = $ 4.70 months

4. Pacific Air Force Command (PACAF)

Table 5 summarizes the rate and type of fuels usage and the rate of used POL generated on the PACAF selected bases.

TABLE 5 : PACAF SELECTED BASES ENERGY USE AND WASTE GENERATED IN 1991

Base		gpy * in (1000)	Fuel	Price● ($ /gal)	Waste Disposing		
					Sell ($ /gal)	Donate	Pay ($ /gal)
Kadena AB (Japan)	Use	2,678	Oil # 2	1.04			
	Generate	27	Waste		0.01		
Yokota AB (Japan)	Use	7.061	Oil # 2	1.04			
	Generate	72	waste		0.00		

* for natural gas it is an equivalent gallons based on heating values.
● the price of equivalent gallon of natural gas was used to calculate the net savings.

The results of the economic incentives calculations are:

a. Kadena AB (Japan) :

Net Cost = $ 3,674.00 / year
Net Savings = $ 26,743.00 / year
Net Value = $ 22,480.00 / year
Payoff Period = $ 9.2 months

b. Yokota AB (Japan) :

Net Cost = $ 8,205.00 / year

Net Savings =	$	70,500.00 / year
Net Value =	$	62,295.00 / year
Payoff Period =	$	3.4 months

The incentive study shows all but one of the selected bases with payoff period of one year or less. The payoff period for Reese AFB, Texas is about five years. Wright Patterson AFB, Ohio and Hill AFB, Utah are the highest in savings and the least in the payoff period. Bases such as Wright Patterson AFB could save 60 percent of its oil #2 usage, Hill AFB could save 20 percent of its oil #2 usage, and Pope AFB in North Carolina could save 36 percent of its oil #2 usage. These three bases have short payoff period and are good candidates for the second phase of this study.

SECTION V

ENVIRONMENTAL REGULATORY COMPLIANCE

A. GENERAL

In order to burn used POL as boiler fuel, the facility must comply with all federal and state requirements for facilities burning used petroleum. This section will identify sources of federal and state regulations for burning used petroleum products, specific federal emissions restrictions, and regulatory bodies that enforce ambient air quality criteria. Specific federal laws applying to disposal of used petroleum by combustion in heating boilers will be reviewed. Sources to obtain state laws that further restrict emission levels over the federal levels will also be identified. Finally, an outline of individual tasks that must be accomplished at the base level will be identified to comply with the regulations discussed below.

B. OVERVIEW OF SOURCES FOR REGULATION AND COMPLIANCE

1. Motive for Creation of Regulations

In the late 1960's, the Federal Government recognized the harm unregulated manufacturers, waste disposal companies, and municipalities were exacting on the well-being of the public through polluting the environment. Local and state governments adopted inconsistent environmental regulations. Therefore, federal regulations were adopted to provide minimum acceptable standards to protect the environment from the pollution resulting from collecting, storing, transporting, and disposing waste materials generated by industry, utilities, municipalities, and the public at large.

2. Federal Sources of Regulations

The federal regulations enacted by Congress to protect the environment are contained in the Code of Federal Regulations, Title 40 (40 CFR) "Protection of Environment." Through 40 CFR, each state and territory is compelled to enact laws and regulations enforcing the environmental protection criteria contained in this document. Title 40 CFR also gives the individual states the authority to further restrict emission of pollutants within state boundaries. The burning of used oil in all communities throughout the United States and its territories is regulated by these Federal laws.

3. State Sources of Regulations

The 40 CFR mandated states to comply with the requirements contained within it. One of the most powerful regulations required states to enact legislation that enforces the minimum restrictions. Subsequently, state legislatures passed laws through their Administrative Codes forcing activities within the state to comply with the EPA minimums. Many states have gone further by enacting stricter standards than those written in 40 CFR.

4. Relevant Parts of 40 CFR

Title 40 CFR is composed of two Chapters, the first of which is relevant to burning used petroleum products. This Chapter, Environmental Protection Agency (EPA), contains the federal regulations and criteria pertaining to protecting the environment. Subchapters A, C, and I provide restrictions concerning the burning of used petroleum products. Subchapter A - General contains administrative information on the management structure of the EPA , limits of its authority, and its responsibilities to the public. Subchapter C - Air Programs implements the Clean Air Act (CAA) and all of its amendments since it was first enacted in 1971. Subchapter I - Solid Waste[1] implements the Resource Conservation and Recovery Act (RCRA) and its amendments since it was first enacted by Congress. Portions of these Subchapters are pertinent to burning used petroleum products. An in-depth review of the relevant sections of these Subchapters follow.

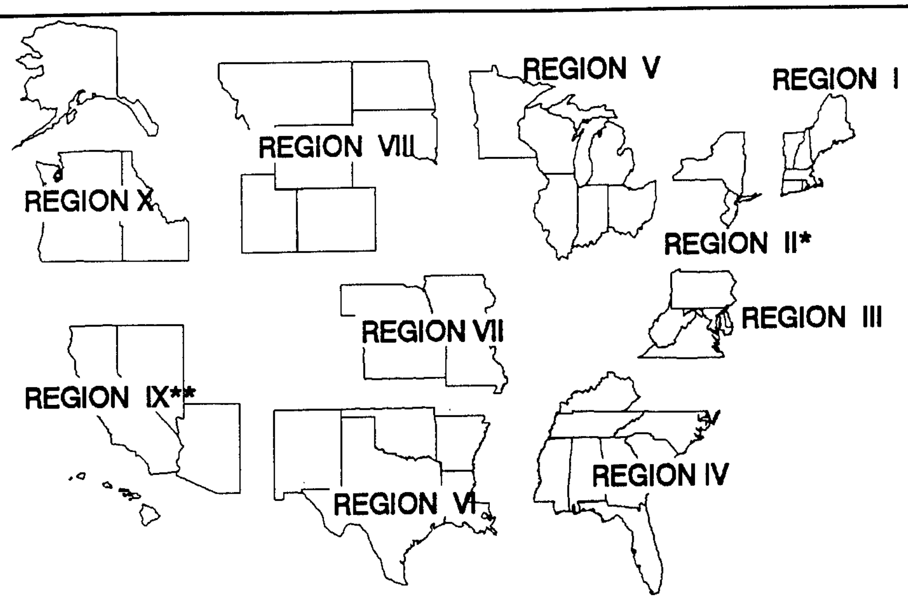
C. MANAGEMENT STRUCTURE OF THE EPA: SUBCHAPTER A - GENERAL

The National Environmental Policy Act of 1969 was enacted through 40 CFR which created the EPA. Knowing that a central administration would be cumbersome in dealing with all 50 states and the several territories, the NEPA established ten regions within the United States and its territories (Figure 9). Each region reviews actions being contemplated by a member state or territory that may impact the environment and/or other regions. The regions also act as impartial mediators over environmental disputes between the states and between regions.

Region I:	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
Region II:	New Jersey, New York, Puerto Rico, Virgin Islands
Region III:	Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia
Region IV:	Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee
Region V:	Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin
Region VI:	Arkansas, Louisiana, New Mexico, Oklahoma, Texas
Region VII:	Iowa, Kansas, Missouri, Nebraska
Region VIII:	Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming
Region IX:	Arizona, California, Hawaii, Nevada, American Samoa, Trust Territories of the Pacific Islands, Guam, Wake Island, Northern Marinas

[1]By EPA definition, waste petroleum is classified as a solid waste.

Region X: Alaska, Idaho, Oregon, Washington



*Includes the territories of Puerto Rico and Virgin Islands
**Includes the territories of Amercan Samoa, Trust Territories of the Pacific Islands, Guam, Wake Island, Northern Marianas

Figure 9 : EPA Regions Within the United States.

D. AMBIENT AIR QUALITY: SUBCHAPTER C - AIR PROGRAMS

1. General

This Subchapter implements the federal regulations mandating compliance with the CAA of 1971and the major amendments made in 1977 and 1990. Upon initial passage it required the individual states and territories to develop air quality maintenance programs and established National Ambient Air Quality Standards (NAAQS) on specific pollutants. It also regulates all major industrial plants that have a potential of releasing criteria pollutants to the atmosphere. And finally, it establishes emission sampling methods and calculation techniques to determine compliance with the emission limitations.

2. State Implementation Plans and the CAA

The CAA requires each state to submit plans to the EPA detailing its compliance with the regulations contained within the CAA and any of its amendments. The plans are referred throughout 40 CFR as State Air Quality Implementation Plans, or SIPs. The initial SIPs were formally submitted to the EPA for review and approval on a state-by-state basis in the early-to-mid 1970's. They gave specifics on how the state would comply with the EPA-established NAAQS. The states periodically update their SIPs to incorporate amendments to the CAA passed by Congress. These updates also request status changes on industries within the state as they come in compliance with the CAA and its amendments.

The CAA was written and NAAQS established to regulate the emission of air pollutants to the atmosphere. These pollutants, known as criteria pollutants, are sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate under 10 microns in diameter (PT-10 or PT_{10}), carbon monoxide (CO), airborne lead (Pb), and, just recently added, ozone (O_3). The emission level of criteria pollutants is regulated for each industrial category. These are regulated through the CAA and various state SIPs. Combustion of used petroleum for energy recovery must meet the emission restrictions contained in the CAA and state SIPs.

The approval process of individual State's air quality implementation plans is detailed in [38]. Each Subpart of this Part deals with a single state. It identifies the name of the plan as referred to by the state, the date the plan was submitted, and the EPA exceptions to the plan. Exceptions contrary to federal statutes or favoring one industry over another within the state are disapproved. Exceptions approved include schedules for industries or pollution sources within the state to come into compliance with newly established ambient air quality standards [39]. Changes to an individual state's SIP are submitted to the EPA when deemed necessary by the state. The EPA implements these changes through official evaluations that are recorded in the federal register. The next annual publication of 40 CFR is then amended with the changes as recorded in the federal register.

3. Air Quality Maintenance Areas (AQMA)

The AQMAs were developed through the cooperation of adjoining states and have been designated as Air Quality Control Regions (AQCR). If the AQCR is within state boundaries, it is an Intrastate AQCR. If the AQCR crosses state boundaries, it is an Interstate AQCR. Currently, there are 247 AQCRs [40]. Each AQCR is staffed with individuals responsible for the air quality within that region. Various states have different names for this body of individuals: Air Pollution Control Board, Air Quality Maintenance Board, Air Pollution Maintenance Control District, etc. Each of these bodies recommends emission limits for activities within its jurisdiction to the state for incorporation into the SIP. They also report to the state results of local ambient air sampling tests and on the compliance of potential polluters with the NAAQS and local standards imposed through state law. This gives the states the information they need to exercise their responsibility and authority in enforcing the NAAQS [41] and state standards.

State and Local Air Monitoring Stations (SLAMS) are set up around states in networks to collect historical ambient air quality data. These data are used to determine future regulations for the different areas being monitored. Detailed requirements for establishing SLAMS are in [42]. This applies to any state or local air pollution control agency, Indian reservation governing bodies, and/or owners or operators of new pollution sources. These may be required also at Air Force bases that burn used oil.

4. NAAQS

The NAAQS set primary and secondary standards of airborne criteria pollutants and the EPA has developed standard methods to determine compliance. If any region of the country exceeds the maximum limits on any one of these pollutants, the area is referred to as a "non-attainment" area for that pollutant. Nonattainment areas then come under special rules and laws regarding air pollution sources until the area can once again maintain the established NAAQS. The primary and secondary standards can be found in [43] and are condensed in Table 6.

Acceptable methods for measuring criteria pollutants are detailed in [44]. Other methods may be used to obtain the data used to determine air quality. However, these alternate methods must be evaluated and approved by the EPA prior to using them in establishing attainment of the NAAQS.

TABLE 6 : NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Standard	Measurement Period
SO_x	80 μg/m^3 (0.03 ppm) 345 μg/m^3 (0.14 ppm)	annual mean maximum concentration in any 24 hour period not exceeded more than 1/yr
PM-10	150 μg/m^3 (0.06 ppm) 50 μg/m^3 (0.02 ppm)	24 hour average concentration annual arithmetic mean
NO_x	100 μg/m^3 (0.053 ppm)	annual arithmetic mean
CO	10 mg/m^3 (9 ppm) 40 mg/m^3 (36 ppm)	eight hour average not exceeded more than 1/yr eight hour average not exceeded more than 1/yr
O_3	235 μg/m^3 (0.12 ppm)	hourly average not exceeded more than 1/yr
Pb	1.5 μg/m^3	quarterly average arithmetic mean

Alternate methods to determine air quality can replace the ones detailed in [48]. EPA acceptance requirements for alternate methods are identified in [45] . These can include either automatic or manual emission sampling techniques. Reference [45] also gives procedures to follow for the EPA to approve an alternate method for general or specific use. These methods are referred to as "reference" methods [44]. An alternate method approved by the EPA for use is termed an "equivalent" method. While a proposed method for determining air quality is under evaluation by the EPA, it is referred to as a "candidate" method. Reference and equivalent methods may be used interchangeably for determining air quality. Reference [45] restricts candidate methods to the plant/area under current evaluation for complying with the NAAQS.

5. Performance Requirements for Stationary Sources.

a. General . Stationary sources of air pollution must meet emission criteria set forth in [46]. This Part identifies performance requirements for any new source and identifies schedules for existing sources to conform to the stated criteria. In addition, states can be given the authority to implement and enforce emission standards for new stationary sources located within the state's jurisdiction. Reference [47] identifies which states have been given this authority based on individual pollutants.

The EPA will assist owners / operators of new stationary sources with developing the lowest reasonable cost for the new source to comply with EPA requirements. A database is kept by the EPA on how recently established (new) sources are controlling pollution. This is known as the Best Available Control Technology / Lowest Allowable Emissions Rates (BACT/LAER) database and is managed through the EPA's Clearinghouse in Raleigh, North Carolina. Each new source of air pollution is required to submit its emissions control method to the EPA.

Reference [47] also contains all the requirements for keeping records and notifying the local, state, and federal agencies of the schedule for construction, operation, and testing of a new plant (new source). Existing plants making physical or operational changes affecting the amount or type of emissions generated are also regulated by this Part. Requirements detailing emission control performance tests, availability of emission data to the public, and instructions on complying with maintenance requirements are in this Part. Requirements for monitoring emissions for specific criteria pollutants and modification and reconstruction actions on existing facilities are located within this Part.

b. Steam Generating Units. By definition, the EPA includes all boilers as steam-generating units. In the EPA list of priorities of major pollution source categories, steam generating units rank 11th in a list of 59 types of sources. These sources include municipal waste combusters, incinerators, cement plants, acid plants, metal smelters, and pulp and paper mills. Standards for monitoring and controlling these emission sources are identified in [48], Subparts C through VVV.

Subpart D of Reference [48] details the emission standards for industrial and commercial boilers based on design heat input capacity and date construction started on the units. These three categories are (1) fossil-fuel-fired units rated at 73.25 million watts (250 million Btu/hr) and above in which construction started after August 17, 1971, (2) industrial and commercial units rated between 29.30 million and 73.25 million watts (100 million and 250 million Btu/hr) in which construction or modifications started after June 19, 1984, and (3) small commercial units rated between 2.93 million and 29.30 million watts (10 million and 100 million Btu/hr) in which construction or modifications started after June 9, 1989. The size of the majority of boilers in the Air Force fall into categories 2 and 3 with most of these in category (3). (Boilers in category (1) are typically large utility boilers used to operate steam turbines to produce electricity.) By EPA definitions, changing the type of fuel normally burned in a boiler constitutes a modification to the boiler. Therefore, boilers in categories (2) and (3) that begin burning used oil would fall under the EPA emission requirements.

c. Emission Restrictions.

(1) Category 2 Boiler Emission Restrictions.

(a) SO_2[2]. Fuel oil-fired units cannot emit gases composed of over 10% of the potential SO_2 formed from the combustion of the fuel nor can the emissions contain over 340 ng/J (0.8 lb/MBtu) of SO_2. If the facility operates at less than 30 percent of its annual capacity, then it is restricted to 215 ng/J (0.5 lb/MBtu) of sulphur dioxide emitted. The facility is in compliance if it meets the above standard when calculations are based on a 30-day

[2] 40 CFR, section 60.42b.

rolling average. These emission limits apply at all times including periods of startup, shutdown, and malfunctions. During periods of malfunction or maintenance of the SO_2 control system, the facility may burn fuel containing no more than 0.5 percent by weight of sulphur or fuel that has an emission rate of SO_2 of less than 215 ng/J (very low sulphur fuel oil).

(b) Particulate Matter[3]. Emission of particulate matter with exhaust gases is restricted to 43 ng/J (0.1 lb/MBtu) or less, as long as the facility uses conventional or emerging technology to control sulphur dioxide emissions. The gases discharged are also limited to 20 percent opacity on a 6-minute average except for one 6-minute period per hour of not more than 27 percent opacity. Particulate and opacity limits apply at all times except during periods of startup, shutdown, or malfunction.

(c) NO_x[4]. Limits on emission of NO_x are dependent on the heat release rate of the boiler and on the type of fuel oil normally used. The release rate is restricted to 43 ng/J (0.10 lb/MBtu) for boilers with a heat release rate of 730,000 J/s-m^3 (70,000 Btu/hr-ft^3) or less (low heat release rate) and burning No. 2 heating oil or diesel fuel. The allowable release rate doubles to 86 ng/J (0.20 lb/MBtu) for boilers with a heat release rate of over 730,000 J/s-m^3 (70,000 Btu/hr-ft^3) (high heat release rate). If used oil and virgin fuel oil blends are used, the boiler owner/operator may petition the EPA to establish NO_x emission limits for the specific facility. The owner/operator must also demonstrate that the destruction of the used oil by combustion precludes the boiler from meeting the NO_x emission standards. The boiler must still comply with the above limits until approval is granted by the EPA and when using only virgin fuel oil. The emission standards for the boiler apply at al times including startup, shutdown, or malfunctions. Compliance is determined through a 30-day rolling average.

(2) Category 3 Boiler Emission Restrictions.

(a) SO_2[5]. Restrictions on SO_2 emissions for boilers in this category are 215 ng/J (0.50 lb/MBtu) heat input. As an alternative, no restrictions on SO_2 emissions apply if the boiler fuel only contains sulphur equal to or less than 0.5% by weight. Compliance with emission restrictions is determined on a 30-day rolling average. However, if only fuel containing 0.5% sulphur by weight is used, compliance may be determined, based on the fuel supplier's certification on sulphur content of the fuel.

(b) Particulate Matter[6]. Restrictions on particulate matter only apply to those boilers rated at 8.7 MW (30 MBTU/hr) heat input and higher and only restricts opacity. No emissions may display greater than 20 percent opacity on a 6-minute average except for one 6-minute period per hour of not more than 27 percent opacity. This standard applies at all times except during startup, shutdown, and periods of malfunction.

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[3] 40 CFR, section 60.43b.

[4] 40 CFR, section 60.44b.

[5] 40 CFR, section 60.42c.

[6] 40 CFR, section 60.43c.

(c) NO_x. There are no Federal emission limits for NO_x at this time for boilers of this size.

d. Control of Criteria Pollutants.

(1) General. Monitoring criteria pollutants in boilers burning fuel oil can be accomplished in two ways: (1) continuous monitoring of the final emissions from the boiler smokestack, or (2) fuel sampling to determine the fuel's potential for producing pollutants. If continuous monitoring is elected, Reference [49] gives methods to use to evaluate the boiler's production of SO_2, NO_x, and either oxygen or carbon dioxide. If fuel sampling is elected, the boiler owner/operator uses fuel sampling pollution potential to show that combustion would meet the standards in Reference [48].

(2) Emission Sampling and Calculation of Concentrations.

(a) SO_2 Emissions. Method 6 in Reference [50] gives the sampling technique and calculations required to determine SO_2 concentrations during the initial boiler performance testing. The method is based on chemically separating the SO_2 from the exhaust gases and mixing it with a fluid. The fluid is analyzed in a laboratory for its SO_2 concentration using the barium-thorin titration techniques. Results give SO_2 concentration in milligrams per dry standard cubic meter (mg/sdcm) of exhaust gas. The sampling train and chemical analysis techniques are detailed completely.

Three alternate methods are also explained: 6A, 6B, and 6C. Method 6A is the same as Method 6 except the CO_2 and moisture concentrations and emission rates are also determined. Method 6B differs from 6 and 6A by providing the daily average emissions of SO_2 and CO_2. Method 6C is used for continuous monitoring of the emissions for SO_2 compliance and uses ultraviolet, nondispersive infrared, or fluorescence analyzers. Methods 6, 6A, and 6B are mainly used for performance testing to show that emissions will remain below the levels allowed. Method 6C is typically used for those sources that may be emitting close to the limits and therefore require continuous monitoring. Results give SO_2 concentration in mg/sdcm and emission rates in ng/J and CO_2 concentration in percent.

(b) NO_x Emissions. Method 7 in Reference [49] gives the sampling technique and calculations required to determine NO_x concentrations during the initial boiler performance testing. The method is based on mixing enough oxygen with the emission sample to change any remaining NO to NO_2. The sample is analyzed in a laboratory using the phenoldissulphonic acid procedure explained in Reference [50]. Results give NO_2 concentration in milligrams per dry standard cubic meter (mg/sdcm) of exhaust gas. The sampling train and chemicals required are detailed completely. This method will determine the NO_x concentration ranging from 2 to 400 mg/sdcm without diluting the sample.

Five alternate methods are also explained: 7A, 7B, 7C, 7D, and 7E. Only Methods 7A, 7C, 7D, and 7E are applicable to boilers. Method 7A is similar to 7 in sampling and sample recovery techniques. However, an ion chromatograph is used to determine NO_2 concentration. Detection range is 125 to 1,250 mg/dscm, which is higher than Method 7. Method 7C is similar to Method 6 in sampling and sample recovery. However, in the laboratory the NO and NO_2 are oxidized to NO_2 and NO_3, and then the NO_3 is reduced to NO_2

with cadmium. The sample is then analyzed calorimetrically for its NO_2 content. The lower limit of detection is 13 mg/sdcm and no upper limit has been established. Method 7D is very similar to 7C except the NO_x is all changed to NO_3. The quantity of NO_3 in the sample is then determined through ion chromatography. Method 7E is used for continuous emission sampling when required by the regulations. The gas sample is passed through a chemiluminescent analyzer that determines NO_x concentration. Results of all four alternate methods are in mg/sdcm.

(c) PM-10 Emissions and Opacity. Method 5 of Reference [49] gives the sampling technique and calculations required to determine PM-10 concentrations during the initial boiler performance testing. The method extracts an emission sample and traps the particulate matter on glass wool filters. The quantity of particulate is determined by the difference in the weight of the glass wool after the filtering process resulting in a value measured in g/sdcm.

Reference [49] also gives the two methods used to determine opacity of emissions. Method 9 is subjective because it involves an individual trained to determine opacity and the observation of the smoke plume being evaluated. The method contains specific guidance on qualifying individuals to determine opacity and the equipment used for the qualification procedures. It also contains direct requirements on plume observation and recording. An alternate method provides quantitative data to determine opacity. Using this method, opacity is determined using a mobile ruby laser and can be used night or day, in sunny or cloudy conditions. This alternate method and Method 9 results are expressed in percent opacity and can be directly compared with the criteria in Reference [48].

(d) SO_2, NO_x, and PM-10 Analyses. Method 19 maintains the calculation methods to determine emission compliance with the minimums in Reference [48]. The calculations require a known value for percent oxygen or, alternately, percent carbon dioxide in the sample. It details the manipulation of the concentration as reported in mg/sdcm to ng/J on an hourly or daily basis. Equations 19-1 through 19-9 [48] are used to determine the emission rate in ng/J. Only one of these equations is used and is selected based on three criteria: (1) O_2 or CO_2 based F factor, which is the ratio of gas volume of the products of combustion to the heat content of the fuel (Reference [49], Table 19-1), (2) dry or wet basis for the pollutant, and (3) dry or wet basis for either O_2 or CO_2. If a combination of fuels are burned simultaneously, such as virgin oil and used oil, Equation 19-18 is used to calculate the fractional F factor for each fuel. If the 24-hour or 30-day annual averages are required, they are calculated using Equation 19-19 for hourly based data or Equation 19-20 for other than hourly data. The results from these calculations can be compared directly with the maximum criteria pollutant emissions in Reference [48].

D. RESPONSIBILITIES OF OTHER FEDERAL AGENCIES

1. General

The federal government has not been blind to its own contributions to spoiling the environment. The passage of NEPA held federal agencies accountable for their future actions as they related to the environment. In addition, in 1977 it went further to require these agencies to observe all local environmental regulations. This obviously had a huge impact on the Air Force bases located in proactive environmental states such as California.

2. National Environmental Policy Act (NEPA)

The NEPA was established in 1969 and implemented through Executive Orders 11514 and 11991 (Reference [52]). These orders required all federal agencies to consider the ramifications of their proposed actions on the environment. The agency involved must also examine alternatives to the proposed actions and develop them so that they will stand up to the general public's scrutiny and understanding. It must also minimize the adverse effects the proposed action may have on the environment and, not just restore, but enhance the environmental quality.

3. 1977 Clean Air Act Amendment

The passage of the 1977 amendment to the Clean Air Act (42 USC 7476(c)) put further restrictions on Federal agencies. This amendment required all federal agencies to comply with any restrictions placed on emissions as identified in the local SIP and as approved by the EPA. However, compliance is only required if the proposed action would have "a significant direct or indirect impact " that adversely affects air quality (Reference [52]). The body making the significant impact determination is not clear.

4. Air Force Responsibility

Since the Air Force is a federal agency, it must comply with all of the restrictions outlined above. Therefore, each Air Force base must comply with the federal and state restrictions on emissions. The restrictions are dictated by the AQCR in which the base is located and as implemented through the SIP. Table 7 identifies the AQCR in which each AFB is located.

E. SUBCHAPTER I - SOLID WASTE

1. General

The RCRA regulates the methods of collecting, storing, transporting, and disposing hazardous waste materials. Petroleum products alone, if mishandled, pose a danger to the environment if mishandled. Used and waste petroleum products pose an additional hazard because of the change in chemical content and physical characteristics that may have occurred during use and subsequent collection.

TABLE 7 : AIR FORCE BASES AND AQCR.

EPA Region	State	Air Force Base [County] (Major Command)	40 CFR Part 81 Designation (Paragraph #)	AQCR No.
I	Maine	*Loring [Aroostook] (ACC)	Aroostook (81.179)	108
	Massachusetts	Hanscom [Middlesex] (AFMC)	Metropolitan Boston (81.19)	119
II	New Jersey	McGuire [Burlington] (AMC)	Metropoliton Philidelphia (81.15)	45
	New York	Griffiss [Oneida] (AAC)	Central New York (81.127)	158
		Plattsburgh [Clinton](AMC)	Champlain Valley (81.48)	159
III	Delaware	Dover [Kent] (AMC)	Southern Delaware (81.178)	46
	D.C.	Bolling (AFDW)	National Capital (81.12)	47
	Maryland	Andrews[Prince Georges] (AMC)	National Capital (81.12)	47
	Virginia	Langley [Hampton Roads] (ACC)	Hampton Roads (81.93)	223
IV	Alabama	Gunter [Elmore] (AU)	Columbus-Phenix City (81.58)	2
		Maxwell [Montgomery] (AU)	Columbus-Phenix City (81.58)	2
	Florida	Eglin [Okaloosa] (AFMC)	Mobile-Pensacola-Panama City-Southern Mississippi (81.68)	5
		Homestead [Dade] (ACC)	Southeast Florida (81.49)	50
		Hurlburt [Okaloosa] (AMC)	Mobile-Pensacola-Panama City-Southern Mississippi (81.68)	5
		*MacDill [Hillsborough] (ACC)	West Central Florida (81.96)	52
		Patrick [Brevard](SPACECOM)	Central Florida (81.95)	48
		Tyndall [Bay] (ACC)	Mobile-Pensacola-Panama City-Southern Mississippi (81.68)	52
	Georgia	Moody [Lowndes] (ACC)	Southwest Georgia (81.238)	59
		Robins [Houston] (AFMC)	Central Georgia (81.236)	54
	Mississippi	Columbus [Lowndes] (ATC)	Northeast Mississippi (81.62)	135
		Keesler [Harrison] (ATC)	Mobile-Pensacola-Panama City-Southern Mississippi (81.68)	52
	North Carolina	Pope [Cumberland] (AMC)	Sandhills (81.151)	169
		Seymour Johnson [Wayne] (ACC)	Southern Coastal Plains (81.170)	170
	South Carolina	Charleston [Charleston] (AMC)	Charleston (81.112)	199
		*Myrtle Beach [Horry] (ACC)	Georgetown (81.111)	203
		Shaw [Sumter] (ACC)	Camden-Sumter (81.110)	198
	Tennessee	Arnold [Coffee] (AFMC)	Tennessee River Valley-Cumberland Mountains (81.72)	7
V	Illinois	*Chanute [Champaign] (ATC)	East Central Illinois (81.263)	66
		Scott [St Clair] (AMC)	Metropolitan St. Louis (81.18)	70
	Indiana	*Grissom [Miami] (AMC)	Wabash Valley (81.218)	84
	Michigan	K.I. Sawyer [Marquette] (ACC)	Upper Michigan (81.197)	126
		*Wurtsmith [Iosco] (ACC)	Central Michigan (81.195)	122
	Ohio	Newark [Licking] (AFMC)	Metropolitan Columbus (81.200)	176
		Wright-Patterson [Greene](AFMC)	Dayton (81.34)	173
VI	Arkansas	*Eaker [Mississippi] (ACC)	Northeast Arkansas (81.139)	20
		Little Rock [Lonoke] (AMC)	Central Arkansas (81.138)	16
	Louisiana	Barksdale [Bossier] (ACC)	Shreveport-Texarkana-Tyler (81.94)	22
		*England [Rapides] (ACC)	Southern Louisiana-Southeast Texas (81.53)	106
	New Mexico	Cannon [Curry](ACC)	Pecos-Permian Basin (81.242)	155
		Holloman [Otero] (ACC)	El Paso-Las Cruces-Alamogordo (81.82)	153
		Kirtland [Bernalillo] (AMC)	Albuquerque-Mid Rio Grande (81.83)	152
	Oklahoma	Altus [Jackson City] (AMC)	Southwestern Oklahoma (81.125)	189
		Tinker [Oklahoma] (AFMC)	Central Oklahoma (81.47)	184
		Vance [Garfield] (ATC)	North Central Oklahoma (81.124)	185
	Texas	*Bergstrom [Travis] (ACC)	Austin-Waco (81.134)	212
		Brooks [Bexar] (AFMC)	Metropolitan San Antonio (81.40)	217
		*Carswell[TarrantorParker](ACC	Metropolitan Dallas-Fort Worth (81.39)	215
		Dyess [Taylor] (ACC)	Abilene-Wichita Falls (81.132)	210
		Goodfellow [Tom Green] (ATC)	Midland-Odessa-San Angelo (81.137)	218
		Kelly [Bexar] (AFMC)	Metropolitan San Antonio (81.40)	217
		Lackland [Bexar] (ATC)	Metropolitan San Antonio (81.40)	217
		Laughlin [Val Verde] (ATC)	Metropolitan San Antonio (81.40)	217
		Randolph [Bexar] (ATC)	Metropolitan San Antonio (81.40)	217
		Reese [Lubbock] (ATC)	Amarillo-Lubbock (81.133)	211
		Sheppard [Witchita] (ATC)	Abilene-Wichita Falls (81.132)	210

TABLE 7 : AIR FORCE BASES AND AQCR. (concluded)

VII	Kansas	McConnell [Sedgwick] (ACC)	South Central Kansas (81.253)	99
	Missouri	Whiteman [Johnson] (ACC)	Southwest Missouri (81.118)	139
	Nebraska	Offutt [Sarpy] (ACC)	Metropolitan Omaha-Council Bluffs (81.50)	85
VIII	Colorado	Cheyenne Mt. [El Paso] (SPACECOM)	San Isabel (81.175)	38
		Falcon [El Paso] (SPACECOM)	San Isabel (81.175)	38
		*Lowry [Denver] (ATC)	Metropolitan Denver (81.16)	36
		Peterson [El Paso] (SPACECOM)	San Isabel (81.175)	38
		USAF Academy [El Paso] (USAFA)	San Isabel (81.175)	38
	Montana	Malmstrom [Cascade] (AMC)	Great Falls (81.141)	168
	North Dakota	Grand Forks [Grand Forks] (ACC)	North Dakota (No designation)	172
		Minot [Ward] (ACC)	North Dakota (No designation)	172
	South Dakota	Ellsworth [Meade] (ACC)	Black Hills-Rapid City (81.214)	205
	Utah	Hill [Davis] (AFMC)	Wasatch Front (81.52)	220
	Wyoming	F.E. Warren [Laramie] (ACC)	Metropolitan Cheyenne (81.89)	242
IX	Arizona	Davis-Monthan [Pima] (ACC)	Pima Intrastate (81.269)	nd
		Luke [Maricopa] (ACC)	Maricopa (81.36)	15
		*Williams [Maricopa] (ATC)	Maricopa (81.36)	15
	Califonia	Beale [Yuba] (ACC)	Sacramento Valley (81.163)	28
		*Castle [Merced] (ACC)	San Joaquin Valley (81.165)	31
		Edwards [Kern] (AFMC)	Southeast Desert (81.167)	33
		*George [San Bernadino] (ACC)	Southeast Desert (81.167)	33
		Los Angeles [Los Angeles] (AFMC)	Metropolitan Los Angeles (81.17)	24
		March [Los Angeles] (AMC)	Metropolitan Los Angeles (81.17)	24
		*Mather [Sacramento] (AFMC)	Sacramento Valley (81.163)	28
		McClellan [Sacramento] (AFMC)	Sacramento Valley (81.163)	28
		*Norton [Los Angeles] (AMC)	Metropolitan Los Angeles (81.17)	24
		Onizuka [San Mateo] (SPACECOM)	San Francisco Bay Area (81.21)	30
		Travis [Solano] (AMC)	San Francisco Bay Area (81.21)	30
		Vandenberg [Santa Barbara] (SPACECOM)	South Central Coast (81.166)	32
	Hawaii	Hickam [Honolulu] (PACAF)	State of Hawaii (81.76)	60
		Wheeler [Honolulu] (PACAF)	State of Hawaii (81.76)	60
	Nevada	Nellis [Clark] (ACC)	Mohave-Yuma (81.268)	13
	Guam	Andersen(PACAF)	Guam (No designation)	246
X	Alaska	Eielson [Fairbanks Northstar] (PACAF)	South Central Alaska (81.247)	10
		Elmendorf [Anchorage] (PACAF)	Cook Inlet (81.54)	8
		Shemya (PACAF)	South Central Alaska (81.247)	10
	Idaho	Mountain Home [Elmore] (ACC)	Idaho (No designation)	63
	Washington	Fairchild [Spokane] (ACC)	Eastern Washington-Northern Idaho (81.100)	62
		McChord [Pierce] (AMC)	Puget Sound (81.32)	229

*These Air Force bases are scheduled to close by 1995.

Industry has recognized that much of the used and waste petroleum products could be safely used as an energy source. However, during some processes in which petroleum is used as a lubricant, heavy metals may migrate into the oil, thereby increasing the amount of heavy metals. These heavy metals end up in the ash left over from the combustion process and may be in such high concentrations as to make the ash a hazardous waste. The EPA established regulations in 1985 that apply specifically to collecting, storing, transporting, and burning of these waste petroleum products to allow safe energy recovery. These regulations also provide safe disposal of the ash products that would otherwise end up in landfills.

2. Used Oil as a Heating Source

a. RCRA and Used Petroleum. In 1985, RCRA established special rules for collecting, storing, transporting, and burning used petroleum for energy recovery. These rules are established in Reference [54]. In RCRA terminology, waste petroleum, or "used oil" is separated into two categories. The used oil is either "off-specification" or not. An off-specification used oil exceeds any one or more of the levels of specific hazardous chemicals or flash point identified in Table 8. Even though the threshold level of total halogens is 4,000 ppm, if the used oil contains more than 1,000 ppm total halogens it is automatically considered to have been mixed with a hazardous waste. The burning of this oil would then be subject to controls in Reference [54] , unless the presumption that the used oil had been mixed with hazardous wastes can be refuted. A synopsis of the rules applicable to the Air Force follow.

3. The Air Force and Burning Used Oils

Since the Air Force will burn the used and waste oils on the Air Force base where they are produced, the burning is regulated under Reference [55]. The boilers used must produce electric power, steam, or heated or cooled air (Reference [56]). If only a specified waste or used oil is burned, the Air Force is required only to obtain an analysis that shows the used oil meets the specification and they must keep a record of the analyses for three years. If the waste oil is determined to be "off-specification", then this oil may still be burned. However, the burner must notify the EPA stating the location and general description of the base's used oil management activities (Reference [57]). This "off-specification" used oil also must not have been blended with any hazardous waste identified under Reference [58].

F. SOURCES FOR OBTAINING FURTHER RESTRICTIONS

With the continuing changes in the environment, the laws regulating the environment are always changing. Title 40 CFR changes are relatively easy to keep up with since each change is published daily in the Federal Register. Also, once a year Title 40 CFR is published with all the changes of the previous year incorporated. Keeping up with state and local laws is another matter. The EPA does not keep track of state requirements that are more stringent than those in 40 CFR. When the EPA reviews the revised SIPs submitted by the individual states, the EPA only publishes whether it approves the SIP, as discussed previously.

TABLE 8 : SPECIFIED CHARACTERISTICS OF USED OIL.

Constituent/Property	Allowable Level
Arsenic	5 ppm maximum
Cadmium	2 ppm maximum
Chromium	10 ppm maximum
Lead	100 ppm maximum
Flash Point	100 °F minimum
Total Halogens	4,000 ppm maximum

In 1972, the United States Army Corps of Engineers Construction Engineering Research Laboratory created a tracking mechanism for all federal and state regulations governing many environmental concerns. The database was turned over to the Department of Urban and Regional Planning, University of Illinois at Urbana, Illinois. The database, now called the Computer-aided Environmental Legislative Data System (CELDS), is actively maintained on a regular basis by individuals employed by the University of Illinois. The database is updated twice a month with all the changes to the federal and state regulations.

Changes to the federal and state regulations are actively sought after. The Federal Register is examined daily for changes in the EPA rules. Changes in state laws are obtained directly from the agency responsible within the state. The staff maintaining the database routinely contacts state environmental officials to identify any pending legislation that may impact environmental law within the state. Once the legislation is passed and made law, the database is updated during one of the bimonthly updates. The CELDS database can be accessed on-line through any terminal with a modem. Or, the staff maintaining CELDS will do the research as requested. Both methods cost a modest fee.

G. SUMMARY

Procedures for complying with federal and state regulations on burning used oils are not difficult to identify. Each Air Force Base has an environmental planning section responsible for keeping abreast of federal, state, and local laws that protect the environment. This section is the best place to gain the most recent information on the local environmental laws and restrictions on burning used oils. Accessing the CELDS database and searching for relevant information should also be accomplished to back up the requirements identified at the base level.

In burning used petroleum for energy recovery, the base must comply with the emission restrictions in Subpart D of Reference [46] and with any supplemental restrictions applied at the state level. The base must also comply with the handling and burning requirements for used oil and its combustion by-products set forth in Reference [53]. State requirements on burning must also be met.

Emission restriction compliance at each regulated boiler burning used oil is through sampling and testing. Either the emissions themselves or the fuel may be analyzed. If the boiler fuel is natural gas, diesel fuel, or heating oil No.2, SO_2 and NO_x scrubbers will not be necessary. However, if the boilers use residual heating fuels such as Nos. 4, 5, or 6, then SO_2 and NO_x, scrubbers may have to be added to the system. Heating oils Nos. 4, 5, and 6 usually contain a sulphur content that produces emissions with high levels of SO_2. In any case, emission levels of SO_2 and NO_x must remain below the limits identified previously. If continuous monitoring of the emissions and analyses is elected, use Method 19, Equation (19-19) of Reference [51] to demonstrate compliance. Equation (19-19) takes the hourly average pollutant rate and averages them over a 30-day cycle. If no change in operation is made to existing boilers it is normal for a state to reference the federal emission criteria in their individual SIPs. Also, the base must comply with any permitting requirements from the local AQCR. Permitting can be relatively painless in areas where the NAAQS is always attained. Permitting may be quite restrictive in non-attainment areas. It is highly unlikely that the AQCR will require an air monitoring station be installed. Reference [44] contains all of the reference methods to determine quantities of criteria pollutants in the emissions. These may be necessary during an initial test of the system to demonstrate that emission criteria are being met.

The base must also comply with the restrictions on collecting and burning the used oil contained in Reference [53]. Chemical analyses of the used petroleum for heavy metals before it is burned will most probably be required. An analysis for sulphur content could also be completed at the same time. Knowing the weight percent of sulphur, the mixture ratio for virgin fuel-oil to waste oil could be determined to keep the mixture sulphur content below the 0.5 percent weight content allowed. It is very important to have the ability to vary the mixture ratios. It is unlikely that two different batches of waste oil will have the same chemical makeup.

From a federal viewpoint, Reference [46] provides the regulations on emission restrictions. Reference [49] provides methods to monitor emissions for compliance. The best available technology for controlling emissions for new stationary sources can be determined through the EPA BACT/LAER database. Burning used oils for energy recovery is regulated by Reference [53] E as long as the used oils have not been blended with hazardous wastes to where the mixture would then be classified a hazardous waste.

From a state viewpoint, if the state has chosen to more closely regulate its environment, the state's administrative code and laws identify stricter standards than the EPA's. The state typically restricts allowable emissions in areas that have a high industrial base and may even restrict emissions from specific corporate sources. The state is prompted by the EPA to create these regulations so that these industrialized areas will not exceed the NAAQS. If the NAAQS are exceeded, federal regulatory action promulgated by the EPA may then take precedence over state actions.

SECTION VI

CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The conclusions of this effort have been drawn from the literature reviews and the economic incentives study along with the used POL surveys. They are summarized below:

(1) Used POL can be burned in a variety of boiler and burner types in blends with fuel oils up to 100 percent used POL or as a fuel supplement in a coal-fired boilers.

(2) Combustion problems such as ignition, stability, burner fouling, higher particulate emissions, and furnace deposits can be expected. However, these problems can be overcome.

(3) Undesirable emissions and ash residue from the following sources in the used POL can be expected: (a) lead and other metals; (b) inorganic elements such as sulfur, nitrogen, chlorine, and bromine; (c) organic elements such as gasoline, glycol antifreeze, halides, and other solvents; and (d) polychlorinated biphenyl (PCB).

(4) Lead emission can be a problem. 20 to 100 percent of the lead in used oil is expected to be emitted. Lead not emitted during normal combustion will be emitted during soot blowing. Because lead is found in used oil mainly as ash constituent, moderate amounts of lead, other ash, as well as water can be removed by allowing them to settle.

(5) During combustion, organic halides are converted primarily to hydrochloric, hydrobromic, and hydrofluoric acids. Metal halides salts may also be emitted, either unchanged from those present in the waste oil or formed by reaction of cations with halide acids. Current EPA regulations include restrictions on halides emission.

(6) Additive deficient Battenfeld lubricant stockpile could a good source of energy for the Air Force.

(7) The technical feasibility of burning used POLs in boilers for heat recovery has been demonstrated. There are several successful used POL programs at Air Force bases and in the commercial sector. Kelly AFB, TX, burns used calibration fluid with no significant problems while CP&L burns used oil in coal-fired boilers.

(8) Studies which have investigated operational effects of used POL are limited in scope and do not cover current environmental concerns. The operational results of some of these studies are inconclusive. Seymour Johnson AFB, NC, canceled its used POL program in 1985, ten years after Fink and Jackson [6] completed their investigation. The cancellation was due to erratic flame and hot spots.

(9) Some Air Force bases have the potential to reduce the oil #2 usage for up to 60 percent, a $163,000 savings per year per base.

B. RECOMMENDATIONS

Previous investigations demonstrated the technical feasibility of burning used POLs in boilers for heat recovery. However, because of the limited scope of these studies, a testing program is proposed to address issues pertaining to Air Force operations. The following is recommended for phase II effort:

1. Bases Selection and Visitation

A few bases for survey and review will be selected. The selected bases will be visited to collect information on used POL generation and management; boiler facilities type and size, fuel usage, facility modification requirements, and environmental restrictions. The selected bases would generate reasonable quantities of contaminated jet fuel, used synthetic lube oil, and used petroleum based oil.

2. Test program

A test program is to be conducted at WL/FIVCO Energy Laboratory, Boiler Facility, Tyndall AFB. The boiler facility includes a 30 Bhp water tube boiler which produces saturated steam at 150 psi and is equipped with a dual fuel burner. The burner is capable of burning propane and # 2 heating oil and uses steam to atomize the fuel oil. The testing program will investigate the burning of used POL and virgin fuel blends for up to 100 percent used POL as well as the concerns of undesirable emission. The blends will include the following:

(a) Blends of used synthetic oil and virgin fuel oil.
(b) Blends of used petroleum based oil and virgin fuel oil.
(c) Blends of contaminated jet fuel and virgin fuel oil.
(d) Burning used synthetic oil, petroleum based oil, and contaminated jet fuel in blends that are similar in heating value and physical and thermodynamic properties to the virgin fuel oil.
(e) If possible, burning the used and contaminated POL with propane.

The emission characteristics, such as NOx, SO_2, total hydrocarbon, CO_2, lead, iron, and chlorine will be measured. Boiler tubes will be inspected and deposited soot will be analyzed for lead and other contaminants. Measurements to determine boiler performance will be also collected. These measurements include steam flow rate and pressure, feedwater temperature, and fuel consumption rate.

Samples of the fuel blends will be analyzed to determine their elemental composition. The elemental analysis is required for the boiler performance calculations. It will also be used to determine the ratio of emitted contaminants to those left in the soot. Test records will be kept on system performance including downtime (if any) and reasons for shutdown, chemical analysis data, emission levels, boiler performance, and operational characteristics.

REFERENCES

[1] "Used Oil Disposal," American Petroleum Institute, Final Report, Publication No. 4036, August 1970.

[2] "Waste Oil Roundup No. 2," American Petroleum Institute, Final Report, Publication No. 1582, April 1973.

[3] "Used Oil Burning As A Fuel," Environmental Protection Agency, Final Report, EPA 530/SW-892, Vol. I & II, 1980.

[4] Letter Report 90-1, Department of the Army, Materials, Fuel, and Lubricants Division, US Army Belvoir Research, Development, and Engineering Center, Fort Belvoir, Virginia 22060-5606.

[5] Lieberman, Martin, "Combustion and Heat Recovery of Air Force Waste Petroleum Oils and Lubricants," AFWL-TR-73-244, February 1974.

[6] Fink, Patrick T. and Jackson, Jerry W.,"Waste POL Disposal Through Energy Recovery," Final Report, AFCEC-TR-76-2, 1976.

[7] SSO Research and Engineering Company, Final Contract Report No. GRUS.1EAD.72: "Research of oily wastes, San Diego area," by R.H. Salvesen et al. Linden, N.J., Naval Supply Systems Command, Oct 1972. (Contract No. N00600-72-C-0761).

[8] SSO Research and Engineering Company, Final Contract Report No. GRUS.2EAD.72: "Research of oily wastes, Norfolk area," by R.H. Salvesen et al. Linden, N.J., Naval Supply Systems Command, Jan 1973. (Contract No. N00600-72-C-0761).

[9] SSO Research and Engineering Company, Final Contract Report No. GRUS.3EAD.72: "Research of oily wastes, Pearl Harbor area," by R.H. Salvesen et al. Linden, N.J., Feb 1973. (Contract No. N00600-72-C-0761).

[10] SSO Research and Engineering Company, Final Contract Report No. GRUS.5EAD.73: "Research of oily wastes, Pugent Sound area," by R.H. Salvesen et al. Linden, N.J., Jun 1973. (Contract No. N00600-72-C-0761).

[11] SSO Research and Engineering Company, Final Contract Report No. GRUS.6EAD.73: "Research of oily wastes, Charleston, S.C.," by A. Beerbower et al. Linden N.J., Jun 1973. (Contract No. N00600-72-C-0761).

[12] SSO Research and Engineering Company, Final Contract Report No. GRUS.7EAD.73: "Research of oily wastes, Jacksonville area Naval facilities," by S.M. Fruh et al. Linden, N.J., Jun 1973. (Contract No. N00600-72-C-0761)

[13] SSO Research and Engineering Company, Final Contract Report No. GRUS.9EAD.73: "Research of oily wastes, Los Angeles-Long Beach area Naval facilities," by S.M. Fruh

et al. Linden, N.J., Jun 1973. (Contract No. N00600-72-C-0761).

[14] Exxon Research and Engineering Company, Report No. GRUS.1DJE.74: "Oily wastes handling and disposal, U.S. Naval Submarine Base, New London, Conn," by S.M. Fruh and A.R. Garabrant. Linden, N.J., Naval Facilities Engineering Command, Aug 1974. (Contract No. N00025-74-C-0001).

[15] Exxon Research and Engineering Company, Report No. GRUS.2DJE.74: "Oily wastes handling and disposal, U.S. Naval Air Station, Brunswick, Maine," by S.M. Fruh and A.R. Garabrant. Linden, N.J., Naval Facilities Engineering Command, Jul 1974. (Contract No. N00025-74-C-0001).

[16] Exxon Research and Engineering Company, Report No. GRUS.3DJE.74: "Oily wastes handling and disposal, Portsmouth Naval Shipyard, Kittery, Maine," by S.M. Fruh and A.R. Garabrant. Linden, N.J., Naval Facilities Engineering Command, Jul 1974. (Contract No. N00025-74-C-0001).

[17] Exxon Research and Engineering Company, Report No. GRUS.4DJE.74: "Oily wastes handling and disposal, U.S. Naval Shipyard, Philadelphia, Penn.,"by a A.R. Garabrant. Linden, N.J., Naval Facilities Engineering Command, Nov 1974. (Contract No. N00025-74-C-0001).

[18] Exxon Research and Engineering Company, Report No. GRUS.5DJE.74: "Oily wastes handling and disposal, U.S. Naval Station, Roosevelt Roads, Puerto Rico," by S.M. Fruh and J.M. Ferraro. Linden, N.J., Naval Facilities Engineering Command, Nov 1974. (Contract No. N00025-74-C-0001).

[19] Exxon Research and Engineering Company, Report No. GRUS.6DJE.74: "Oily wastes handling and disposal, U.S. Naval Air Station, Pensacola, Fla.," by J.M. Ferraro and S.M. Fruh. Linden, N.J., Naval Facilities Engineering Command, Nov 1974. (Contract No. N00025-74-C-0001).

[20] Exxon Research and Engineering Company, Report No. GRUS.7DJE.74: "Oily wastes handling and disposal, U.S. Naval Air Station, Bermuda," by A.R. Garabrant. Linden, N.J., Naval Facilities Engineering Command, Nov 1974. (Contract No. N00025-74-C-0001).

[21] Exxon Research and Engineering Company, Report No. GRUS.8DJE.75: "Oily wastes handling and disposal, U.S. Naval Station, Adak, Alaska," by S.M. Fruh. Linden, N.J., Naval Facilities Engineering Command, Mar 1975. (Contract No. N00025-74-C-0001).

[22] Exxon Research and Engineering Company, Report No. GRUS.10DJE.75: "Oily wastes handling and disposal, U.S. Naval Construction Battalion Center, Port Hueneme, Calif.," by S.M. Fruh and A.R. Garabrant. Linden, N.J., Naval Facilities Engineering Command, Mar 1975. (Contract No. N00025-74-C-0001).

[23] Exxon Research and Engineering Company, Report No. GRUS.12DJE.75: "Oily wastes handling and disposal, U.S. Naval Air Test Center, Patuxent River, Md.," by R.H. Salvesen. Linden, N.J., Naval Facilities Engineering Command, Mar 1975. (Contract No. N00025-74-C-0001).

[24] Exxon Research and Engineering Company, Report No. GRUS.13DJE.75: "Oily wastes handling and disposal, U.S. Naval Base Guantanamo Bay, Cuba," by J.M. Ferraro. Linden, N.J., Naval Facilities Engineering Command, Mar 1975. (Contract No. N00025-74-C-0001).

[25] Exxon Research and Engineering Company, Report No. GRUS.14DJE.75: "Oily wastes handling and disposal, U.S. Naval Activities, Italy," by S.M. Fruh. Linden, N.J., Naval Facilities Engineering Command, May 1975. (Contract No. N00025-74-C-0001).

[26] Exxon Research and Engineering Company, Report No. GRUS.15DJE.75: "Oily wastes handling and disposal, U.S. Naval Support Activity, Athens, Greece," by S.M. Fruh. Linden, N.J., Naval Facilities Engineering Command, May 1975. (Contract No. N00025-74-C-0001).

[27] Exxon Research and Engineering Company, Report No. GRUS.16DJE.75: "Oily wastes handling and disposal, U.S. Navy Activities, Spain," by J.M. Ferraro and A.R. Garabrant. Linden, N.J., Naval Facilities Engineering Command, May 1975. (Contract No. N00025-74-C-0001).

[28] Exxon Research and Engineering Company, Report No. GRUS.17DJE.75: "Oily wastes handling and disposal, U.S. Naval Activities, Canal Zone," by J.M. Ferraro and S.M. Fruh. Linden, N.J., Naval Facilities Engineering Command, May 1975. (Contract No. N00025-74-C-0001).

[29] Exxon Research and Engineering Company, Report No. GRUS.17DJE.75: "Oily wastes handling and disposal, U.S. Naval Activities, Canal Zone," by J.M. Ferraro and S.M. Fruh. Linden, N.J., Naval Facilities Engineering Command, May 1975. (Contract No. N00025-74-C-0001).

[30] Exxon Research and Engineering Company, Report No. GRUS.18DJE.77: "Oily wastes handling and disposal, U.S. Naval Air Facility, Atsugi, Japan," by J.M. Ferraro and S.M. Fruh. Linden, N.J., Naval Facilities Engineering Command, May 1975. (Contract No. N00025-74-C-0001).

[31] Exxon Research and Engineering Company, Report No. GRUS.20DJE.77: "Oily wastes handling and disposal, U.S. Naval Station, Midway Island," by J.M. Ferraro and S.M. Fruh. Linden, N.J., Naval Facilities Engineering Command, Oct 1977. (Contract No. N00025-74-C-0001).

[32] Fu, T.T., Chapler, R.S.,"Utilization of Navy-Generated Waste Oils As Boiler Fuel - Economic Analysis and Laboratory Testing," Final Technical Note, TN no. N-1570, February 1980.

[33] Fu, T.T., Chapler, R.S.,"Waste Oils Boiler Firing Demonstration at NWC, China Lake, CA," Final Technical Note, TN no. N-1580, June 1980.

[34] "Hawiian Utility Has Good Result Burnibg Waste Oil," Platt's Oilgram News Service, 50, No 220, November 1972.

[35] Porrello, Joseph A., "Allied Uses Up Old Auto Oil," Syracuse Herald American, January

1972.

[36] "Low Cost System Reaches Waste Oil For Boilers," POWER, August 1972.

[37] Approval and promulgation of implementation plans, Code of Federal Regulations, Title 40, Part 52, July 1991.

[38] Approval and promulgation of implementation plans, Code of Federal Regulations, Title 40, Part 52, Sections 52.50 - 52.62, July 1991.

[39] Designation of areas for air quality planning purposes, Code of Federal Regulations, Title 40, Part 81, Sections 81.11 - 81.275, July 1991.

[40] Requirements for preparation, adoption, and submittal of implementation plans, Code of Federal Regulations, Title 40, Part 51, Sections 51.40 - 51.63, July 1991.

[41] Ambient air quality surveillance, Code of Federal Regulations, Title 40, Part 58, July 1991.

[42] National primary and secondary ambient air quality standards, Code of Federal Regulations, Title 40, Part 50, July 1991.

[43] Ambient air monitoring reference and equivalent methods, Code of Federal Regulations, Title 40, Part 53, Sections 53.20 - 53.23, July 1991.

[44] National primary and secondary ambient air quality standards, Code of Federal Regulations, Title 40, Part 50, Appendices A, B, G, and J, July 1991.

[45] Ambient air monitoring reference and equivalent methods, Code of Federal Regulations, Title 40, Part 53, Sections 53.2 - 53.16, July 1991.

[46] Standards of performance for new stationary sources, Code of Federal Regulations, Title 40, Part 60, July 1991.

[47] Standards of performance for new stationary sources, Code of Federal Regulations, Title 40, Part 60, Section 60.4(b), July 1991.

[48] Standards of performance for new stationary sources, Code of Federal Regulations, Title 40, Part 60, Section 60.4(b), July 1991.

[49] Standards of performance for new stationary sources, Code of Federal Regulations, Title 40, Part 60, Appendix A, July 1991.

[50] ASTM D 1608 - 60

[51] Procedures for implementing the requirements of the Council on Environmental Quality on the National Environmental Policy Act, Code of Federal Regulations, Title 40, Part 6, Section 6.1, July 1991.

[52] Procedures for implementing the requirements of the Council on Environmental Quality

on the National Environmental Policy Act, Code of Federal Regulations, Title 40, Part 6, Section 6.303, July 1991.

[53] Standards for the management of specific hazardous wastes and specific types of hazardous waste management facilities, Code of Federal Regulations, Title 40, Part 266, Subpart E, July 1991.

[54] Standards for the management of specific hazardous wastes and specific types of hazardous waste management facilities, Code of Federal Regulations, Title 40, Part 266, Subpart D, July 1991.

[55] Standards for the management of specific hazardous wastes and specific types of hazardous waste management facilities, Code of Federal Regulations, Title 40, Part 266, Section 266.44, July 1991.

[56] Standards for the management of specific hazardous wastes and specific types of hazardous waste management facilities, Code of Federal Regulations, Title 40, Part 266, Section 266.41 (b), July 1991.

[57] Standards for the management of specific hazardous wastes and specific types of hazardous waste management facilities, Code of Federal Regulations, Title 40, Part 266, Section 266.44 (b), July 1991.

[58] Standards for the management of specific hazardous wastes and specific types of hazardous waste management facilities, Code of Federal Regulations, Title 40, Part 266, Subpart C, July 1991.

APPENDIX A

AIR FORCE SURVEY

USED POL QUESTIONNAIRE

MAJCOM ____________   POINT OF CONTACT ____________________
TELEPHONE ____________________

INSTALLATION __________   POINT OF CONTACT ____________________
TELEPHONE ____________________

1. Amount of waste POL generated annually:

TYPE	AMOUNT (gal)	PRESENT METHOD OF DISPOSAL (i.e., burn, recycle on base, sell, pay to dispose, etc.)	COST ($/gal)
TURBINE LUBE			
AVIA. PISTON OIL			
CRANKCASE OIL			
JP-4			
JP-5			
JP-8			
DIESEL			
OTHER			

a. How do you store each waste product?

2. If you presently burn waste POL:

TYPE WASTE	TYPE BOILER	TYPE BURNER	PRIMARY FUEL	MIXTURE RATIO

a. Provide details on set up (i.e., mixing tanks, metering equipment, pumps, etc.):

3. Known EPA emissions requirements for your boilers:

4. What information would you need to burn your waste POL in your boilers?

5. Would you want this capability?

AIRLINES COMPANIES QUESTIONNAIRE

WASTE PETROLEUM, OILS, AND LUBRICANTS (POL) QUESTIONNAIRE

COMPANY:______________________ POINT OF CONTACT:______________________

LOCATION:______________________ TELEPHONE #:______________________

____

Note: Please answer as many questions as possible unless you feel a question is not applicable (write N/A) or the information is privileged. We will hold your responses in strictest confidence. Feel free to attach any supporting documentation.

1. Amount of waste oil, lubricants, and fuel generated annually:

TYPE OF WASTE OIL	AMOUNT (gal)	PRESENT DISPOSAL METHOD (i.e. burn, recycle, sell, pay to dispose, etc.)	COST ($/gal)
a) Turbine lube oil			
b) Ground vehicle engine oil			
c) Hydraulic fuel			
d) Diesel fuel			
e) Jet A			
f) Other (specify)			

2. How is each waste product stored? (separated-tanks, combined-tanks, waste-disposal company tanks/tank trailers, etc.)

3. If you contract to dispose/recondition/recycle the waste oil from #1, please provide information on the firm.

FIRM NAME:______________________ POINT OF CONTACT:______________________

ADDRESS:______________________ TELEPHONE #:______________________

____

4. If you presently burn any of the waste oil in #1, please provide details:

TYPE OF WASTE OIL	TYPE & SIZE TYPE BOILER	PRIMARY BURNER	MIXTURE FUEL	RATIO

5. If possible, provide details on the waste oil burning set up (i.e. mixing tanks, metering equipment, pumps, pollution control/abatement equipment, special piping arrangements, etc.) Attach drawings if available.

6. Who designed the oil burning capability?
   In-house engineering
   Contract (provide name/location/point of contact if possible)

7. What emissions are being recorded:

8. What is the rough cost incurred to establish and maintain this capability?

   Design: $________ Equipment: $________ Ops/Maint: $________/year

9. What are your projected savings from this operation? $_________/year

10. Do you foresee any near-term changes (next five years) in local or EPA emissions requirements that will impact your operation in burning waste oil?
    YES NO

    a. If yes, what are the expected changes?

    b. If changes to your current procedures or equipment are anticipated, do you plan to make the changes and continue burning your waste oil?
       YES NO

11. Would your company like to further discuss your waste oil burning operations with our engineers? YES NO

12. Do you know of any other aviation-related companies currently burning waste POLs? YES NO

FIRMNAME:____________________ POINT OF CONTACT: ____________________

ADDRESS:____________________ TELEPHONE #: ____________________

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AIRLINES COMPANIES CONTACTED

American Airlines
Maintenance & Engineering
Dallas-Fort Worth International Airport
PO Box 619616
Dallas, TX 75261-9616

Delta Airlines
Engineering and Technical Services
Hartsfield-Atlanta International Airport
Atlanta, GA 30320

Northwest Airlines
Maintenance & Engineering Dept.
Minneapolis-St Paul International Airport
St Paul, MN 55111

Southwest Airlines
Energy/Provisioning
Box 37611 Love Field
Dallas, TX 75235

Trans World Airlines
Ground Operations Support & Control
605 Third Ave
New York, NY 10158

United Airlines
Facilities & Airport Affairs
Box 66100
Chicago, IL 60666

US Air
Properties & Facilities
National Airport
Washington, D.C. 20001

APPENDIX B

BOILER PACKAGE SPECIFICATIONS

A. SCOPE

The requested boiler package will be used for research purposes. The dimensions of this package shall not exceed eight (8) feet high, seven (7) feet wide, and eighteen (18) feet long.

The boiler package shall include one (1) 30 Bhp water-tube steam boiler (1035 lb/hr) at 150 psig operating pressure and 200 psig design pressure. The boiler package shall be equipped with a steam atomization dual fuel (Oil #2 and propane) fully modulated burner. Boiler, feedwater system, heat exchanger, and all other components shall be mounted on a common steel skid. The boiler package is a closed system where the generated steam will condensate in the heat exchanger system and return back to the feedwater system. The heat exchanger will be the boiler's variable load. The boiler package design shall meet the Industrial Risk Insurer's recommendations for dual fuel boilers. All interconnecting piping and electrical shall be included to allow total automatic operation of entire system.

B. BOILER PACKAGE EQUIPMENT

The Boiler Package shall be completely assembled and tested as an integral package. The boiler package shall be equipped with control cabinet, switches and lights, a full complement of controls, including dual fuel shutoff valves, pressure controls, and fire eye programming combustion control. It shall include the following items all of which are to be mounted on the skid :

1. Boiler

The recommended boiler is manufactured by International Boiler Works (IBW) model # BF30D-12 or equivalent. The requested boiler is a thirty (30) Bhp and shall have the following design specifications:

a. The boiler shall be of the type O. The unit shall be with a tangent tube furnace including a water cooled insulation and casing, designed for pressurized firing; heavy structural steel base, trim, burner(s), controls and appurtenances. The unit shall be hydrostatically tested and stamped by a recognized boiler insurance company all in accordance with the ASME code.

b. The steam generator shall be designed to develop 1035 pounds of steam per hour continuously at 150 psig from feedwater at 212°F when firing No. 2 oil or propane gas. The boiler shall be designed to maintain a minimum of 80 percent efficiency. Stack temperatures shall not fall below dew point in order to prevent corrosion.

c. All boiler tubes shall be easily removable with standard tools without requiring expanding or welding at the attachment to the drums. Tube removal and replacement shall be readily accomplished from the sides of the boiler.

d. Boiler shall have a downcomer at the front and one downcomer at the rear outside the flue gas section to provide positive circulation throughout the boiler. Boiler shall have an inspection opening in each drum end.

e. The boiler shall have an access panel to the furnace and an observation port located at the rear. A front flame observation port shall be provided at burner enclosure.

f. The entire inner casing and combustion chamber access door shall be easily removed and replaced for inspection and maintenance. A round smoke outlet shall be located at the rear of boiler.

g. The boiler shall be equipped with an integral, factory installed steam separation system within the upper drum. The steam separation system shall insure that the moisture content of the saturated steam leaving the unit shall not exceed one-half of one percent. Bottom blowdown connection shall be provided such that the blowdown effluent shall be drawn from the center of the lower drum.

h. The boiler shall be equipped with stack temperature gauge.

i. The boiler shall be equipped with a rear access door for soot and ash cleaning.

j. The boiler shall be equipped with the following controls, trims, and accessories :

(1) Operating Pressure Control;
(2) Modulating Pressure Control;
(3) Water Level Gauge Glass and ISO Valves;
(4) Water Column Blowdown Valves;
(5) UL Approval;
(6) High Limit Pressure Control;
(7) Steam pressure Gauge;
(8) Auxiliary LWCO;
(9) Feedwater temperature gauge;
(10) Stack temperature gauge;
(11) Safety valves, size, and quantity shall be in strict accordance with ASME Code requirements;
(12) Steam gauge, complete with syphon and cock;
(13) Water column complete with red line gauge glass, tri-cocks (for high pressure steam only), and drain valve;
(14) Feedwater pump control of the probe type to automatically activate feedwater pump for makeup water;
(15) Primary low water cutoff of the probe type to stop burner operation when water falls below its set level; and

2. Burner

The recommended burner is a WEBSTER model JB1-C-05-R7795-M.10-MS or equivalent. The burner is a fully modulated dual fuel burner designed to fire No. 2 oil and propane gas and to use steam to atomize No. 2 oil.

a. The burner shall be capable of burning No. 2 oil and propane gas. The burner shall use steam to atomize No. 2 oil. The burner shall be arranged to operate automatically with full modulation for at least 3-to-1 turndown ratio and proven low fire start.

b. The burner shall be equipped with a potentiometer for manual flame adjustment.

c. The burner shall be equipped to allow cold startup using gas and easily switched over to steam atomized No. 2 oil operation. Operational procedures to switch between the two fuels shall be provided.

d. The burner shall be equipped with electric ignition. The ignition system shall be factory-mounted.

e. Oil pump and assembly shall be furnished with oil strainer, oil relief valve, and fuel return line.

f. The burner unit shall be equipped with necessary controls and safety devices to operate shutdown automatically. The combustion safety control shall be of the electronic type with positive, timed programming sequences, and with safety lockout control in the event of a flame failure.

g. The burner control cabinet shall be mounted on the boiler and shall contain the necessary fuses, motor contractors, and control circuit. The control cabinet shall also contain the electronic flame safeguard and programmer, control circuit switch, necessary switching relays and indicating lights, all wired to a numbered terminal strip.

h. Burner controls and accessories :

(1) Motor, Fan, and Air Inlet Control;
(2) Control Cabinet, Switch and Light;
(3) UV Flame Scanner;
(4) Pilot Solenoid Valve;
(5) Pilot Ignition Transformer;
(6) Oil Valves and Pressurizing Medium;
(7) Air Flow Switch;
(8) Flame Safety Control;
(9) Motor Starter;
(10) Proven Gas Pilot;
(11) Pilot Regulator and Valve; and

3. Feedwater/Makeup Tank

The recommended feedwater tank is York-Shipley model 40S-2 or equivalent. It shall be equipped with level gauge, float level controller, temperature makeup control valve, thermometer, sparger, and all necessary interconnecting piping and connections.

4. Steam-to-Water Heat Exchanger.

The recommended heat exchanger is Sentry model B4-30 or equivalent.

a. The purpose of the heat exchanger is to load the boiler and to allow the boiler operator to modulate boiler load up to 100 percent of the boiler capacity by changing cooling water flow rate. The modulation shall match the burner turndown ratio.

b. The heat exchanger package shall be equipped to handle the difference in the pressure between the boiler pressure and feedwater tank pressure with no loss of condensate.

c. The heat exchanger system shall NOT use more than 20 gpm of 80 F cooling water or temperature rise not to exceed 30^{o}F.

d. The heat exchanger shall be an integrated part of the skid mounted boiler package.

e. Heat exchanger shall be furnished with cooling water flow gauge and inlet and outlet temperature gauges.

5. One Steam Trap

The recommended steam trap is NICHOLSON model NFT250 or similar.

6. One Manual By-Pass Feeder Chemical Injection System.

Including mixing chamber and valves for controlling oxygen levels and boiler scale. The recommended system is Claypool Pump & Machinery Co. model 6-1/2-10 1.5 gal or equivalent.

7. One Boiler Feedwater Pump

To be coupled with approximately 3-HP electric motors, 3,500 RPM, Totally Enclosed Fan Cooled (TEFC), rating of 1/60/208. The recommended feedwater pump is GRUNDFOS model 2CR-100U or equivalent.

8. One Sample Cooler

The recommended cooler is NEPTUNE model # SC316-10 or equivalent, with copper tubes. The purpose of the sample cooler will be to take samples from the boiler feedwater line.

9. One Blowdown Tank

The recommended tank is Penn Separator Corp model A14B-A5D or equivalent. A 25 gallon capacity tank with drain valve and associate equipment for both upper and bottom blowdowns.

10. Air Vent Valves. One automatic and one manual air vent valves.

11. Accessories.

a. Electrical requirements. 208 volts, 1-phase, 60 Hertz and 115 volts, 1-phase, 60 Hertz. All the necessary conduit and wiring shall be installed to electrically integrate the whole system within a single electrical control panel. All 208 volt electrical devices shall be mounted in a separate panel. All panels shall meet the requirements of NEMA 4 or better.

b. All the structural steel, as a minimum, shall be sandblasted and painted with a coat of zinc based primer.

c. The package shall include the necessary piping, fittings, and valves to integrate all components. All inlet and outlet pipe connections shall be screwed or flanged mounted at the edge of the skid.

d. Each of the steam and feedwater high pressure lines shall be insulated.

e. Each of the steam, feedwater, and condensate lines shall have bypass tees installed and equipped with valves to allow measurement sensors isolation. Length of the bypass will be determined based on the offeror design drawings. Two (2) tees and three (4) valves are required for each bypass.

f. Lifting lugs shall be provided to facilitate rigging.

C. DRAWINGS AND DATA SHEETS

One week after the date of award, the successful bidder shall submit detailed draft engineering drawings and data sheets of the boiler package for government approval. Final design drawings shall be submitted and approved prior to shipping the boiler package. The approval process for each of the initial and final design drawing and data sheets will take two weeks. These drawings and data sheets are:

1. Detailed Process Flow and Instrumentation Diagram;
2. Structural Steel and Foundation Loads;
3. Detailed arrangement of piping and components;
4. Electric Wiring Data and control block diagram;
5. Electrical design drawings for a complete installation;
6. Instruments and Equipment Spec Sheets; and
7. Operation manual.

D. INSTALLATION, SYSTEM CHECKOUTS, AND PERSONNEL TRAINING

The boiler package shall be delivered ready for hookups. The Government will connect makeup water, cooling water, and fuels to the boiler-package-skid-edge-mounted connections. Also, the Government will connect all electrical services to the electrical panels mounted on the boiler package. The offeror shall be responsible for start-up and verification of operability only.

The system verification of operability shall be proved by an acceptance test based on ASME PTC 4.1 procedures. The acceptance test shall prove that all components will work together at all loads and conditions and to achieve : 1) Boiler maximum continuous rating; and 2) Air emission standards.

Two days of on site startup service and instruction of our operating personnel are required.

E. CLARIFICATION STATEMENT

If the bidder selects to propose equipment other than the recommended, the bidder shall state the differences clearly if any.

F. BOILER PACKAGE COST BREAKDOWN

The offeror shall provide an itemized cost list for the following items as a minimum requirement. Material, engineering, and labor cost shall be included as a combined cost for each item.

1. Boiler (including burner)
2. Heat Exchanger
3. Feedwater Tank
4. Feedwater Pumps
5. Manual Chemical By-pass Feeder
6. Sample Cooler
7. Blowdown Tank Assembly
8. Steel Skid
9. System Checkouts and Personnel Training
10. Delivery & Shipping
11. Fee
12. Total Cost

APPENDIX C

EQUIPMENT PURCHASES

A. GENERAL

Several major components of the laboratory setup were purchased using Government purchase orders (Form 9). These components include: (1) Boiler system; (2) Stack emission monitoring for Oxygen, NOx, and Total Hydrocarbon; (3) Flash point tester; and (4) Viscosity meter. Other stack emission and testing equipment and control and monitoring system will be purchased in the second phase. It is envisioned that the following equipment will be purchased:

1. Stack emission monitoring for opacity, heavy metals, and inorganic elements.
2. Elemental analysis equipment.
3. Control and monitoring system components.

B. PURCHASED EQUIPMENT

1. Boiler Package

The boiler package consists of a 30 Bhp water-tube boiler manufactured by International Boiler Works model # BF30D-12, equipped with a fully modulated dual fuel steam atomized WEBSTER burner model # JB1-C-05. The burner is capable of burning propane or oil # 2 with a turn down ration of 3-to-1. The boiler package is equipped with a steam-to-water heat exchanger to load the boiler, a condensate tank, feedwater pump, chemical by-pass feeder, sample cooler , and blowdown tank. The boiler package is a skid mounted system ready for hookups. The Boiler Package Specifications document that was used by the Tyndall Contracting Office is given in Appendix B.

2. Emission Monitoring System

The purchased emission monitoring system is a HORIBA ENDA-F1400 stack gas analyzer. The analyzer is an EPA compliant with sensors to measure Oxygen (O_2) in two ranges (0-10 percent and 0-25 percent), NOx in two ranges (0-100 and 0-500 ppm), and Total Hydrocarbon (THC) in two ranges (0-100 and 0-500 ppm) on dry bases. The system has the capability of automatic calibration. The analyzer measures NOx and THC using Cross Flow Modulated Non-dispersive infrared (NDIR) analyzers, while measures O_2 using magnetopneumatic analyzer.

3. Flash Point Tester

Pensky-Martens closed type gas-heated flash point tester. The tester can be used in determining the flash point of fuel oils, cutback asphalt, and other viscous materials and suspensions. It is confined to ASTM standards E-134, D-93, IP 34, and DIN 51376.

4. Viscosity Meter

The rotary viscometer can measure viscosities from 10 to 1,000,000 centipoise with accuracy of +/- 1 percent.