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REPORT TO THE CONGRESS



*BY THE COMPTROLLER GENERAL
OF THE UNITED STATES*



Single Manager Needed To Obtain Cost And Fuel Savings In Spectrometric Oil Analysis Program

Department of Defense

Spectrometric oil analysis could greatly reduce maintenance costs and oil consumption in Department of Defense activities. Oil analysis has application to other Federal departments and agencies as well. So far, there has been little progress in the military services' oil analysis programs due to a lack of centralized management, which the Congress should question.

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AUG 27, 1975

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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-162313

To the President of the Senate and the
Speaker of the House of Representatives

This report concerns the large savings that can be obtained by improving the management and operation of the spectrometric oil analysis program. The Congress may be interested in the benefits to be attained by increasing the interservice use of oil laboratories and eliminating duplication. Also, the Congress may wish to question the Department of Defense about the military services' slow progress in achieving program objectives due to a lack of centralized management.

The report also covers matters of interest to those committees concerned with effectiveness of Armed Forces operations as well as those concerned with conservation of petroleum products. Further, since the oil analysis program has application for nondefense agencies, our findings should be of interest to those committees and members generally concerned with Government operations. Our review was made pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

We are sending copies of this report to the Director, Office of Management and Budget; the Secretary of Defense; and the Secretaries of the Army, Navy, and Air Force.

Acting

R. F. Kellum
Comptroller General
of the United States

*To: ...
Paper on Management*

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ABBREVIATIONS

DOD Department of Defense
GAO General Accounting Office
SOA spectrometric oil analysis

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D I G E S T

Nearly 3 years ago, the U.S. military services agreed to participate in a joint, or inter-service, program to predict--through spectrometric analysis--imminent failures on oil-lubricated mechanical equipment. Under the program

- oil analysis laboratories would provide as much interservice support as possible;
- uniform techniques and evaluation criteria would be used;
- data systems and forms would be standardized;
- spectrometric oil analysis would be used for aircraft, ground, and ship equipment when benefits in safety, economy, maintenance, or reliability could be obtained. (See p. 10.)

These objectives have not been met because the joint agreement did not provide for a central program manager with requisite authority to insure the success of the oil analysis program. (See p. 16.)

The Congress should question the Department of Defense about the program's accomplishments and its rationale for not appointing a single manager.

Since the program was begun on October 2, 1972,

- laboratories have provided little interservice support--less than 10 percent of the oil samples were analyzed for another service;
- laboratories have operated independently even though some were within a few miles of each other (see p. 11); and

--each service has spent time and money in developing its own evaluation criteria, laboratory manuals, and data systems, contrary to the joint agreement (see p. 14).

The services have developed limited applications of oil analysis for equipment other than aircraft. Some other test programs are being conducted, but aircraft equipment oil samples account for over 95 percent of the laboratory workload. Because these laboratories have underused capacities, oil analysis could be used for all sorts of equipment besides aircraft without a large investment in new laboratories or equipment. (See pp. 8 and 19.)

Private industry already has demonstrated that large savings can be obtained by using oil analysis for equipment such as trucks, buses, locomotives, compressors, and ships. (See p. 23.)

A Department of Defense study found that, under laboratory conditions, the oil change interval for generators could be extended from 100 to 300 hours by using oil analysis techniques. On the assumption that the current inventory of 26,000 generators would have an average use of 1,000 hours a year, the study estimated that extending the interval could save 670,000 gallons of oil and 250,000 oil filters, valued at about \$1.5 million each year. (See p. 25.)

The Secretary of Defense should provide direction to the military services to develop one cohesive oil analysis program. Specifically there should be a single manager having authority and sufficient responsibility to carry out the objectives that the military services themselves specified in the joint agreement.

The Department of Defense generally concurred in the findings and conclusion that dollar savings and improved equipment performance can be realized by improving the management and operation of the oil analysis program. It also agreed that the joint agreement for integration of service oil analysis programs had not been as effective as it could be.

The Department did not agree that there should be a single manager of the program. It believes that the Office of the Secretary should assist in developing and promoting a new joint service agreement to overcome program deficiencies pointed out in this report. (See app. I and pp. 31 and 32.)

A new joint service agreement will not insure an effective program. Various responsible oil analysis officials stated that if a new agreement does go into effect, they believe there will probably be some improvements at first; however, over an extended period of time, they doubted that the new agreement would be any more meaningful than previous ones. (See p. 18.)

CHAPTER 1

INTRODUCTION

Spectrometric oil analysis (SOA) is one of several techniques used by the public and private sectors to reduce the operating costs of aircraft, automobiles, ground equipment, and other mechanical devices which use oil as a lubricant. Within industry, other types of oil analysis are used besides SOA. However, because SOA is the predominant technique, we selected it for this review.

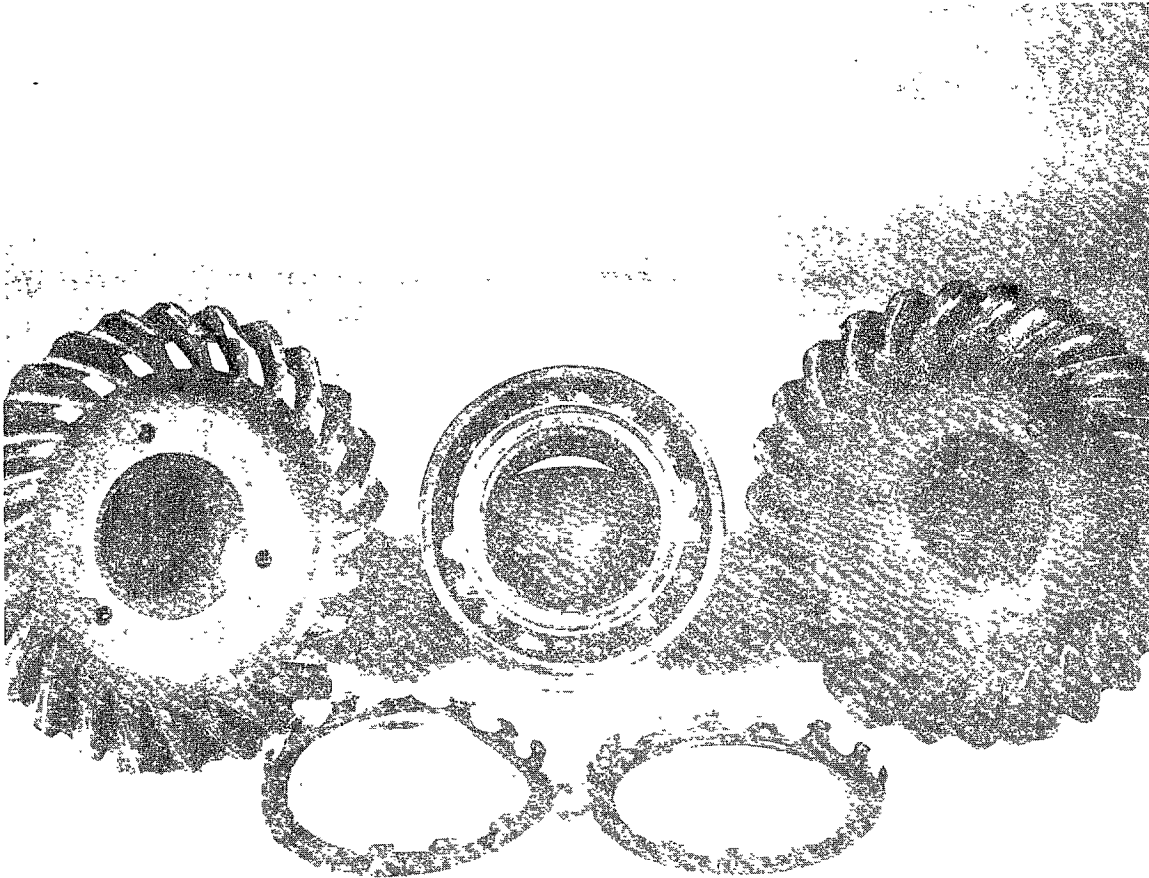
DESCRIPTION OF SPECTROMETRIC OIL ANALYSIS

SOA is a preventive maintenance tool used to predict-- and thus prevent--equipment failures. By measuring the concentration of worn metal particles suspended in used oil samples taken from equipment parts, SOA determines the degree of wear sustained by these parts. Such detection of equipment malfunctions before actual failures can greatly reduce maintenance costs and equipment downtime because the malfunctions can be corrected by limited maintenance rather than more expensive overhauls.

The photographs on pages 2 and 3 show damaged helicopter parts that were found by SOA.

The railroad industry conceived of SOA during the transition from steam to diesel locomotives in the 1940s. In 1955 the Navy began using SOA for military aircraft. The Army and the Air Force began using SOA in 1961 and 1964, respectively. Commercial users, in addition to using SOA for aircraft engines and parts, have used it for ground equipment, such as locomotives, buses, trucks, construction equipment, and industrial and production machinery.

SOA WEAR DETECTION

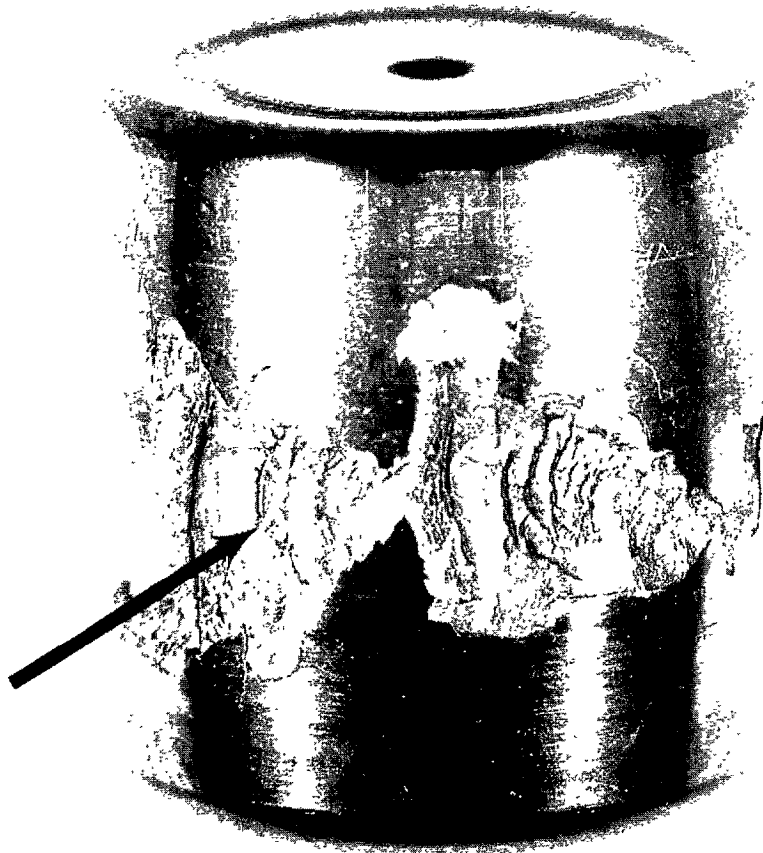


A failed bearing, a damaged input gear, and a damaged output gear from a helicopter. The photograph shows extensive damage to the ball raceways and bearing cages and damage to the gear teeth. This condition was found after SOA detected high iron and aluminum content.

COURTESY OF U.S. NAVY

SOA WEAR DETECTION

FATIGUE SPALLING



A roller from the planetary carrier gear box assembly (AFT transmission) from a helicopter of the presidential fleet. This condition was found after SOA detected high iron, silver, and copper content.

COURTESY OF U.S. NAVY

Two primary types of spectrometers are used:

- Atomic-absorption spectrometers, which are standard commercial equipment, burn a sample of solvent-diluted oil in a small burner and read the amount of a metal element in the oil.
- Emission spectrometers, which are built to military specifications, are more elaborate and about four times more expensive than the atomic-absorption type. They burn an oil sample between two carbon electrodes and read the amount of metal elements in the oil. Whereas atomic-absorption spectrometers can read only one metal element in each oil sample at a time, emission spectrometers can simultaneously read up to 20 elements in each sample.

The Navy currently has 36 SOA laboratories (19 shipboard and 17 at permanent land stations); the Army has 7. All of these laboratories use emission spectrometers. The Air Force has 112 laboratories equipped with 58 emission and 57 atomic-absorption spectrometers. All three services have reported beneficial results from using SOA as a preventive maintenance tool for aircraft engines and parts.

The spectrometer, which measures the amount of elemental contaminants, does not provide sufficient information on chemical compounds--particularly the organic type--to determine if the oil is still lubricating effectively.

Some organizations which use the emission spectrometer also perform additional tests on oil for such supplementary information. Two of the more important tests are:

Viscosity

- A measurement of the resistance of a fluid to flow at a particular temperature. This is one of the best methods of analyzing oil quickly. When the viscosity is lower than normal, fuel dilution can be suspected; when too high, a high solids or high carbon content is probably the cause. In either case, one of the first remedies is to change the oil and, possibly, the oil filter.

Differential infrared analysis

--Used to compare the chemical composition, degradation, and contamination of a used oil sample with a sample of unused oil.

In addition to the above tests, a new instrument--the Ferrograph analyzer--is being used to analyze worn metal particles and give an early warning of machine failure.

In this instrument, the sample of oil to be examined passes through a highly divergent magnetic field as it is running down a microscope slide with a specially treated surface. After the oil has been removed from the slide, the contaminant particles are found arranged according to size where they can be viewed easily. The large particles are not obscured by clusters of small ones, and the unique characteristics of the small particles can be determined. The shapes of the particles and the relationships between large and small particles indicate the type of wear processes occurring in the equipment and, possibly, the kind of part which is wearing.

CHAPTER 2

CURRENT STATUS AND EFFECTIVENESS

OF SPECTROMETRIC OIL ANALYSIS

PROGRAM HISTORY

In 1967 the Army, Navy, and Air Force entered into a triservice agreement to insure that the SOA program was systematically planned, developed, and managed as a coordinated program within the Department of Defense (DOD). The objectives were to be achieved by (1) standardizing techniques, terminology, procedures, policies, and equipment, (2) using standardized calibration samples, and (3) establishing SOA laboratories in optimal locations to facilitate interservice use wherever practicable.

In May 1969 DOD established a new program called the DOD Equipment Oil Analysis Program and directed the Navy to manage it. The DOD directive outlined 13 specific tasks to be accomplished by the Navy, established uniform oil sample intervals and standard response times for SOA results, and specifically identified the number of DOD laboratories to be authorized and DOD customers to be served by these laboratories.

In December 1971 DOD asked each of the services to evaluate the degree of compliance with the DOD directive. On the basis of the responses received, DOD concluded that the framework for joint participation had been established and that program direction was no longer needed. As a result, the directive which established the program was rescinded.

In place of the DOD directive, the services signed the Joint Agreement for the Interservice Equipment Oil Analysis Program, dated October 2, 1972. This agreement is still in effect.

GAO PRIOR REVIEW

As a result of a congressional request, we reviewed the SOA program established under the 1967 triservice agreement and found that it was ineffective because it did not assign authority and responsibility for insuring effective coordination.

In January 1968 we reported our observations to the Secretary, DOD, and recommended that his office review the program. A DOD ad hoc group studied the program and confirmed our observations. The group reported that

--there was a serious lack of uniform program management and

--interservice use of SOA equipment was almost nonexistent.

In an October 1970 report¹ to the Congress, we concluded that the program established by the May 1969 DOD directive would be a great improvement over the independent programs. However, in our review of SOA activities in 1971, we noted a lack of progress in implementing the DOD directive. This led DOD to evaluate this program, with the above-mentioned result--that is, the DOD program was no longer needed.

SERVICES' IMPLEMENTATION

All three services have obtained large cost savings by using SOA as a preventive maintenance tool for aircraft engines and parts.

--During fiscal year 1974, the Army analyzed 339,971 oil samples at a cost of approximately \$1.8 million. It estimated it saved about \$25.8 million in aircraft equipment replacement costs by preventing 187 potential part failures. This savings included the acquisition cost of 22 aircraft that could have been severely damaged had SOA not been used.

--Although the Navy could not provide any current data on cost savings, it estimated that during the 2-year period ended July 1, 1966, the value of aircraft and engines it saved totaled \$20.4 million.

¹"Savings From Joint Use of Spectrometric Oil Analysis Equipment by the Military Departments" (B-162313(1)).

--Air Force records indicated that about 100 overhauls a month were avoided by using SOA for aircraft equipment. The resulting cost savings amounted to \$12.8 million during 1973 and \$5.6 million during the first 6 months of 1974.

PROGRAM TODAY

Although the services have developed limited SOA applications for ground equipment and are conducting test programs, aircraft equipment oil samples account for over 95 percent of the SOA workload. The services' progress in extending SOA to other than aircraft equipment is summarized below.

--Since 1968 the Army has studied the inclusion of M-60 tank engines and transmissions in the SOA program. This inclusion was approved as expected in February 1975 and the Army is now studying the feasibility and cost benefits of including other equipment, such as self-propelled wheeled and tracked vehicles and watercraft. The Army also considered including heavy construction equipment in the program but concluded that this would be only marginally cost effective because of the equipment's low use.

--The Navy has applied SOA to some ship equipment and is running a pilot program on extending it to ship engines. Interim results from this program have led the Navy to consider extending the interval between oil changes on the engines of its Auxiliary Rescue Service ships from the manufacturer's recommended 250 engine hours to 1,500 engine hours. Navy officials believe that this change will result in annual savings of about 87,000 gallons of oil. Tests are still continuing on other ships to see if it is feasible to extend their oil change intervals. As to why SOA had not been applied to equipment other than aircraft earlier, a Navy official told us such application had a low priority and was not funded. He further stated that there has been little central direction for implementing an overall Navy program.

--In 1967 the Marine Corps conducted a test study to evaluate the practicality of using SOA for ground combat equipment. The study showed that SOA could provide benefits in improved combat readiness and reduced maintenance costs. However, due to several problems in the management, coordination, and methodology of the program, it was deferred until at least 1969 to allow for improvements. We were told no followup action was ever taken, however, because of low priority and nonavailability of funds.

--Air Force officials indicated that higher priority requirements to develop and improve aircraft applications of SOA, coupled with personnel limitations at the SOA program management level, have delayed extending SOA to ground equipment. They also said the Army is responsible for SOA ground equipment applications under the interservice agreement.

CHAPTER 3

NEED FOR CENTRALIZED PROGRAM MANAGEMENT

The Joint Agreement for the Interservice Equipment Oil Analysis Program has the following major objectives:

- SOA laboratories will provide as much interservice support as possible.
- Uniform analytical techniques and evaluation criteria will be applied to similar types of equipment monitored under the program.
- Data systems, forms, and procedures will be standardized as much as possible.
- SOA will be used for aircraft, ground, and ship equipment when benefits in safety, economy, maintenance, or reliability can be obtained.

To achieve a consolidated, coordinated, and standardized SOA program, the joint agreement assigned specific, individual responsibilities to the Army, Navy, and Air Force. Like the 1967 triservice agreement, however, the joint agreement did not provide for a central program manager with authority to insure that the services comply. As a result, little progress has been made toward achieving the program objectives. SOA laboratories have provided very little interservice support. In addition, each of the services has its own laboratory manual, evaluation criteria, and data collection system.

INTERSERVICE SUPPORT NEEDED

Under the 1969 DOD Equipment Oil Analysis Program, 107 Army, Navy, and Air Force laboratories were designated to handle the SOA workloads of DOD installations within their geographical areas. As mentioned on page 7, in 1971 we reported that progress toward interservice laboratory use was disappointing. The DOD directive which established the program was rescinded early in 1972. Since then the total number of laboratories has increased from 107 to 155--a 45-percent expansion. In addition, long-range plans call

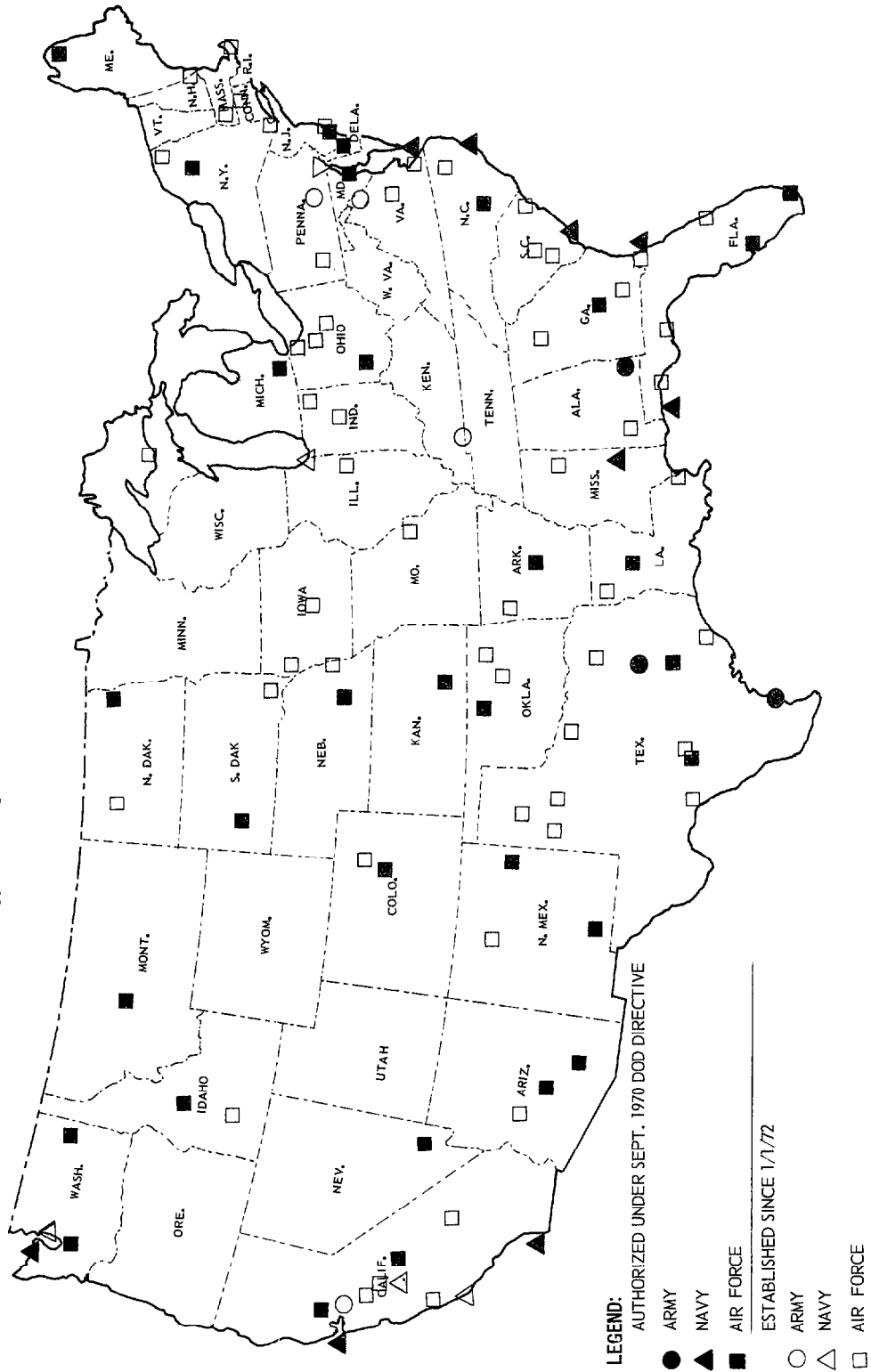
for a total of 166 laboratories by the end of fiscal year 1979. The map on page 12 shows the location of the laboratories in the continental United States, identifying those that have been established since the DOD directive was rescinded.

We found that most of the 155 service laboratories provided little or no interservice support. Less than 10 percent of the oil samples analyzed belong to another service. Indicating the trend toward decentralizing SOA, the Air Force program expanded from 6 area laboratories in 1964 to 112 base laboratories in 1974.

The lack of interservice support can even be found within the same or adjoining cities, as shown in the following examples:

- The Navy operates an SOA laboratory at the Jacksonville Naval Air Station, Jacksonville, Florida. The Air Force is establishing a laboratory at a Jacksonville Air National Guard unit about 26 miles from the air station. The Air National Guard unit has sent oil samples to the Navy laboratory in the past and has received the SOA results within a day. The Air Force, however, did not believe this response time was adequate. (See comment 1, p. 17.)
- The Navy and the Air Force operate laboratories at Norfolk and Langley, Virginia, respectively. Although the two installations are about 17 miles apart, the Air Force is buying a new spectrometer to modernize its Langley laboratory.
- The Navy and Air Force operate separate laboratories in the Philippines, Guam, and Hawaii. In Hawaii the laboratories are within a short distance of each other.
- In addition to the Navy and Air Force operating laboratories in close proximity to each other, the Navy has two laboratories only 5 miles apart in the Philippines.

**OIL ANALYSIS LABORATORIES OPERATED BY THE SERVICES
IN THE CONTINENTAL UNITED STATES**



All of the many reasons for the lack of interservice support relate to basic differences in the ways the services operate their SOA programs. The services gave the following explanations for not using other services' laboratories.

1. The Air Force does not believe that centralized laboratories, as proposed in the 1969 DOD oil analysis program, can respond to the needs of aircraft maintenance. The Air Force SOA program manager indicated that safety-of-flight considerations dictate the need for frequent oil sampling and rapid laboratory response for single-engine and/or fighter aircraft.

This requirement is supported to some extent by a contractor study which recommends that samples be taken after each flight for three models of fighter aircraft. The requirement for rapid response of these samples, according to an Air Force official, necessitates on-base SOA laboratories.

2. The Navy does not require such rapid response time as the Air Force. A Navy official told us that the Navy's objective is a response time of 3 days which, in most cases, can be met by mailing samples from outlying bases to existing Navy laboratories.

In one case, the Navy sends oil samples from Keflavik, Iceland, to its laboratory at Jacksonville, despite the existence of an Air Force laboratory at Keflavik. Navy officials stated that the Air Force laboratory at Keflavik has an atomic-absorption spectrometer which does not meet the accuracy or reproducibility criteria established for oil analysis certification. The monthly instrument correlation program has substantiated this conclusion. Thus, the Navy hesitates to use the Keflavik laboratory or any of the 56 other Air Force laboratories equipped with this type of spectrometer.

3. The Army operates seven SOA laboratories which serve Army installations in designated geographical areas. Samples are normally sent by mail. An Army official told us that the Army has reservations about using Air Force laboratories. Similar reservations were

expressed for using Navy laboratories. The primary concerns expressed relate to (1) reporting of analytical data and (2) inadequacies and inconsistencies in reporting systems.

The separateness of the services' individual SOA programs is also shown in the services' acquisition of new equipment without considering possible use of other services' laboratories. For example, before our review, the San Antonio Air Logistics Center had planned to procure 45 spectrometers to replace older instruments and to establish new laboratories. As a result of our questions about the need for laboratories planned at some locations, an Air Force official told us that Air Force headquarters reduced the procurement to 20 spectrometers and instructed the San Antonio center to provide acceptable justification for any additional spectrometers required. Center officials awarded a contract in February 1975 for 20 spectrometers at a cost of about \$974,000.

STANDARDIZED CRITERIA AND TECHNIQUES NEEDED

In addition to the services' stated reasons for the lack of interservice support, their independent development of evaluation criteria, laboratory manuals, and data collection systems has also been a deterrent. This lack of standardization, in our opinion, illustrates the need for centralized SOA program management.

Evaluation criteria

Evaluation criteria set forth the maintenance actions to be recommended on the basis of the worn metal concentrations and increasing concentration trends found in oil samples. Worn metal concentrations are expressed in parts per million by weight.

The Army, Air Force, and Navy laboratory manuals contain different evaluation criteria for common equipment items. Therefore, evaluations of the same oil sample could result in significantly different maintenance recommendations. In addition, the Air Force has recently paid about \$99,000 for a contractor study outlining refined evaluation criteria. The Air Force is currently evaluating this study

to determine the extent to which its criteria will be adopted for Air Force use. The Army, by means of a contract for about \$89,000, is currently refining its own evaluation criteria. Following are examples of the differing criteria:

--When the aluminum concentration in an oil sample from a J-85 engine reaches or exceeds six parts per million, the Air Force manual indicates that the engine should be considered "suspect" and the evaluator should make maintenance recommendations based upon his judgment and knowledge of the particular circumstances. The contractor study performed for the Air Force indicates that such equipment should be grounded and examined for a suspected discrepancy. According to the Navy manual, six parts per million of aluminum in a J-85 oil sample indicates either that the sample is normal or that another sample should be taken after an additional 5 hours of operation. Grounding of the equipment is not indicated under the Navy criteria until the aluminum concentration exceeds 15 parts per million and then only if the wear trend shows a large increase from the previous reading.

--Under Navy criteria, a 25-parts-per-million iron concentration in a sample from a J-85 engine requires, depending upon the trend indicated by prior samples, that a special sample be taken immediately or that the equipment be removed from service and an engineering investigation conducted. According to the Air Force manual, iron concentrations in the J-85 engine should be considered suspect when they reach 50 parts per million. The Air Force contractor study indicates that iron concentrations up to 30 parts per million are considered normal.

We did not attempt to determine whether the Air Force or the Navy has the better criteria. However, the variances in criteria indicate that the services need to get together, thereby improving aircraft safety and eliminating unnecessary maintenance and engine overhauls.

In addition to the benefits highlighted above, training would also be simplified if evaluation criteria could be standardized. Presently students at the oil analysis

training school are told to exercise special care in analysis because they must know and follow a separate laboratory manual and separate criteria for each service.

Data forms and data bank

Standardized forms and reporting procedures are a prerequisite to a common data collection system. But each of the services has developed its own forms and operates its own data bank. We were told that, because each service has its own forms, laboratories generally prefer to analyze all of one service's oil samples before starting to analyze those of another service. Lab personnel must also record the various services' results differently, use different evaluation criteria, and use different codes and data input methods. This sometimes delays response time, which further deters interservice support and cooperation. The use of standard forms, evaluation criteria, and data input would reduce processing time and would eliminate the need to assemble and analyze each service's samples individually.

According to a Navy official there is no doubt that a single system for collecting SOA data would be more cost effective than three separate systems. He stated that implementing a single data system would not be easy but that, because the joint agreement had been in effect for over 3 years, such a system was long overdue. He added that the single data system would also serve as a basis for objectively determining which of the evaluation techniques now used provides the best results.

CONCLUSIONS

The services' joint agreement to consolidate, coordinate, and standardize their SOA programs has not worked because no central program manager was established and given the authority to direct the overall program, including insuring compliance on the part of the services. As a result, the agreement has not achieved its stated objectives and the services have not taken advantage of SOA's full potential.

The services have not standardized the concepts, techniques, and procedures of their SOA programs. They disagree

on response time requirements and evaluation criteria and use different forms and data processing systems. As a result, there has been little interservice use of laboratories. We believe the services should coordinate their efforts and develop standard evaluation criteria for common equipment. Such standardization would reduce the costs of developing and refining criteria, permit more extensive interservice laboratory support, and facilitate training of laboratory personnel.

RECOMMENDATION

We recommend that the Secretary of Defense provide direction to the military services for development of one cohesive SOA program. Specifically, there should be a single manager of such a program and he should have the responsibility and authority to:

- Standardize criteria and techniques for SOA.
- Monitor the SOA program to insure maximum coordination and cooperation among the services.
- Provide overall program policy and guidance to insure that efforts are not duplicated.
- Extend SOA to all types of equipment, where it would be cost effective.
- Direct research, development, testing, and evaluation of SOA.

AGENCY COMMENTS AND OUR EVALUATION

The Acting Assistant Secretary of Defense (Installations and Logistics), in commenting for DOD on our recommendations, agreed that the 1972 joint agreement for integration of the SOA program had not been totally effective. He stated that the services are currently drafting and coordinating a new agreement which will more firmly establish goals, create a needed management structure that will include ties to the Joint Logistic Commanders, dictate the necessary mandatory joint meetings, and more appropriately

assign both individual and joint responsibilities. He also pointed out that DOD plans to closely monitor program integration and performance under the new joint agreement.

DOD also cited Air Force studies which reveal that earlier laboratory response time requirements were more stringent than necessary. Relaxing the response time should reduce the total Air Force laboratories to approximately 101 by the middle of fiscal year 1977. Also, the Air Force is in the process of revalidating its Jacksonville requirement with the aim of using the Navy laboratory at Jacksonville. Similarly, the Air Force intends to use an area concept at Langley, Oceana, and Norfolk.

DOD did not agree with our suggestion that there should be a single manager of the SOA program. DOD said that SOA is only one of many nondestructive tests and diagnostic procedures. A single manager of one could lead to a proliferation of single managers for each and every diagnostic tool and to many Office of the Secretary of Defense-managed programs whenever interservice support is a desired goal. DOD believes it is more appropriate for the Office of the Secretary of Defense to assist in developing and promoting a new joint service agreement which will overcome a number of current program deficiencies.

We agree with DOD that it may not be desirable to have a single manager for each and every diagnostic tool, non-destructive test, and diagnostic procedure; however, we suggest DOD consider having one single manager covering the various diagnostic systems, thereby eliminating the proliferation and achieving better use of the limited resources.

Various responsible SOA officials stated that if a new agreement does go into effect they believe there will probably be some improvements at first; however, over an extended period of time, they doubted that the new agreement would be any more meaningful than previous ones. To illustrate the current proliferation problems, they pointed out that even after GAO provided the services with copies of its preliminary report, one Army command was trying to independently develop its own SOA program without coordinating with the Army's SOA program manager, let alone any of the other services' managers.

CHAPTER 4

POTENTIAL SAVINGS FROM USING OIL ANALYSIS

FOR NONAIRCRAFT EQUIPMENT

Since the existing SOA laboratories have underused capacities, we believe SOA could be used for nonaircraft equipment without necessitating large expenditures for new laboratories or equipment. Navy land-based laboratories, for example, are used at 43 percent of capacity, while Air Force laboratories are used at 33 percent. Although Army laboratories are used at near-maximum capacity on an 8-hour shift basis, a second shift would provide the additional capacity. Otherwise, the Army could use the other services' laboratories, as discussed in chapter 3. Savings from extending SOA to nonaircraft equipment are discussed below.

REDUCED MAINTENANCE COSTS AND EXTENDED OIL CHANGE INTERVALS

Without SOA, the life expectancy of nonaircraft equipment is generally set arbitrarily by experience. The average life expectancy is often conservatively estimated to minimize equipment failure and, further, many items actually have a longer service life than average. Therefore, some equipment is overhauled or traded in before its service life has ended. SOA, however, can prevent equipment from being needlessly taken out of service. Thus, savings can be obtained in two ways--from the increased service life and from reduced maintenance costs. In addition, savings in capital investment are possible due to reduced requirements for vehicles in the maintenance pool. (Less downtime for maintenance means fewer vehicles are required.)

An illustration of effective SOA for nonaircraft equipment is shown on pages 20 to 22. For this illustration a manufacturer has established guidelines of normal wear for vital machine parts on a dozer, such as the engine, final drive, and transmission. These guidelines suggest the maximum parts-per-million level of specific elements.

The effect of lubricants can be seriously hampered if they become contaminated by other fluids used in the machine they serve or by excess silicon (dirt). Specifically, the wear analysis program depicted on these charts is looking

OIL ANALYSIS REPORT DOZER- ENGINE COMPARTMENT

MODEL DBH
SERIAL NO. 46A 18001
COMPARTMENT ENGINE
MACHINE APPLICATION DOZING

COMPANY ABC CONSTRUCTION
JOB SITE CEDAR RAPIDS
ATTN: JOHN SMITH
PHONE 319 - 363-7521

COPPER
 IRON
 CHROMIUM
 ALUMINIUM
 SILICONE

LAB CONTROL NO	DATE SAMPLE TAKEN	DATE SAMPLE RECEIVED	OILS OI MAKEUP OIL ADDED	SERVICE METER READING	HOURS MILES ON OIL	CU	FE	CR	AL	SI
						PPM	PPM	PPM	PPM	PPM
101	9-21	9-21	--	3950	INT.	7	40	3	6	15
165	10-15	10-17	45	4100	150	6	38	2	8	18
211	11-20	11-21	25	4265	165	4	25	1	3	12
270	1-5	1-5	18	4435	170	6	40	2	8	50
322	2-8	2-8	2	4465	30	1	8	1	2	4
419	3-15	3-17	14	4585	120	4	18	1	3	12
670	4-22	4-23	10	4735	150	12	26	1	6	11

DIAGNOSTIC COMMENTS

- #1 - HIGH OIL CONSUMPTION INDICATES REPAIR REQUIRED - PROBABLY RINGS & VALVES.
- #2 - HIGH SI INCREASED FE INDICATE TOP DIRT ENTRY - CHECK AIR INDUCTION SYSTEM.
- #3 - INCREASED AL INDICATES THAT FUEL PROBLEM IS CAUSING BEARING WEAR - CHECK FUEL NOZZLES & TIMING.

OIL ANALYSIS REPORT DOZER - LEFT FINAL DRIVE ASSEMBLY

MODEL DBH
SERIAL NO. 46A 18001
COMPARTMENT HYDRAULIC
MACHINE APPLICATION DOZING

COMPANY ABC CONSTRUCTION
JOB SITE CEDAR RAPIDS
ATTN: JOHN SMITH
PHONE 319 - 363-7521

COPPER
 IRON
 CHROMIUM
 ALUMINUM
 SILICONE

LAB CONTROL NO	DATE SAMPLE TAKEN	DATE SAMPLE RECEIVED	QTS OF MAKEUP OIL ADDED	SERVICE METER READING	HOURS MILES ON OIL	CU PPM	FE PPM	CR PPM	AL PPM	SI PPM
103	9-21	9-21	--	3950	INT.	3	12	1	8	18
213	11-20	11-21	2	4265	311	4	12	1	14	21
324	2-8	2-8	2	4465	511	4	14	2	16	21
672	4-22	4-23	0	4735	270	3	12	1	4	10

DIAGNOSTIC COMMENTS

- #1 - VALUES HIGH FOR HYDRAULIC SYSTEM. RESAMPLE.
- #2 - VALUES GETTING WORSE. CHECK WIPER AND OIL SEALS ON HYDRAULIC CYLINDERS. RESAMPLE IN 100 HOURS.
- #3 - MUST BE FIXED BEFORE MAJOR DAMAGE IS DONE. FIX, FLUSH SYSTEM, AND RESAMPLE.
- #4 - LOOKS A LOT BETTER. PROBLEM HAS BEEN SOLVED. RESAMPLE IN 250 HOURS.

OIL ANALYSIS REPORT DOZER - TRANSMISSION

MODEL _____ DBH _____ **COMPANY** _____ ABC CONSTRUCTION
SERIAL NO. _____ 46A 18001 **JOB SITE** _____ CEDAR RAPIDS
COMPARTMENT _____ TRANSMISSION **ATTN:** _____ JOHN SMITH
MACHINE APPLICATION _____ DOZING **PHONE** _____ 319 - 363-7521

COPPER
 IRON
 CHROMIUM
 ALUMINUM
 SILICONE

LAB CONTROL NO	DATE SAMPLE TAKEN	DATE SAMPLE RECEIVED	QTS OF MAKEUP OIL ADDED	SERVICE METER READING	HOURS METERS ON OIL	CU PPM	FE PPM	CR PPM	AL PPM	SI PPM
102	9-21	9-21	--	3950	INT.	620	130	1	4	15
212	11-20	11-21	2	4265	311	373	61	1	3	12
323	2-8	2-8	4	4465	511	440	52	1	3	13
671	4-22	4-23	0	4735	270	465	25	1	3	12

DIAGNOSTIC COMMENTS

- #1 - COOLER CORE LEAK. THIS MUST BE FIXED. DRAIN OIL AND RESAMPLE IN 150 HOURS.
- #2 - STILL HAVE A PROBLEM. CHECK TRANSMISSION PRESSURES. TRANSMISSION COULD BE SLIPPING CAUSING EXCESSIVE WEAR.
- #3 - LOOKS LIKE YOU FIXED COOLER CORE PROBLEM. RESAMPLE IN 150 HOURS (NOTE: RIGHT FINAL DRIVE SYSTEM).
- #4 - OIL IS DEFINITELY TRANSFERRING TO RIGHT FINAL DRIVE. NOTE OIL CONSUMPTION INCREASE. SUGGEST TRANSMISSION CHECKS. DRAIN, FLUSH, AND RESAMPLE.
- #5 - LOOKS LIKE PROBLEMS ARE CLEARING UP. RESAMPLE IN 300 HOURS.

for high contents of copper (Cu), iron (Fe), chromium (Cr), aluminum (Al), and silicon (Si). The diagnostic reports for the dozer parts are shown as follows:

--Engine, page 20.

--Final drive assembly, page 21.

--Transmission, page 22.

Private industry has benefitted from using SOA for such nonaircraft equipment as automobiles, truck engines, machine tools, surface ships, locomotives, tracked and wheeled vehicles, compressors, air-conditioners, buses, and generators. Following are examples of such benefits:

--A large construction contractor has used SOA since 1968 and currently monitors about 1,000 items of equipment, including earth-moving equipment, cranes, and generators. Recently, the company detected a transmission malfunction through SOA and corrected it for \$47 in parts and a small amount of in-house labor. If the transmission had been operated until it failed, a \$6,000 overhaul would have been required.

--A leading producer of heavy equipment provides SOA for the equipment it sells. SOA showed that two motor graders were developing rear main bearing failures which, if allowed to continue, could have damaged or destroyed the crankshaft. Repair costs for the two motor graders amounted to \$263.49, representing a savings of \$3,336.51.

--Through an SOA program, the railroads increased their locomotive oil change intervals from 30 days to the life of the engine. They reported savings of \$16 million to \$18 million a year in maintenance costs.

--A municipality put 205 vehicles on a 1-year SOA program, and an oil laboratory recommended a total of 485 oil changes. If the previous oil change intervals had been observed, the vehicles would have had 4,920 oil changes.

--One SOA program manager services a fleet of 185 trucks. Oil and oil filters were initially changed every 2 weeks but now are changed every 7 months, excluding those vehicles with mechanical problems. He estimates that the savings to the company, above the cost of the sampling, is \$96,000 per year. This pertains only to the savings in oil and filters.

As shown above SOA permits extending the interval between oil changes--in some instances very substantially. This saves on oil, maintenance manpower, and equipment downtime, while still protecting the equipment from excessive wear and failure.

SERVICE RECOGNITION

The services have recognized that savings can be obtained by extending oil change intervals for nonaircraft equipment. Although they have tried to extend these intervals, they have not generally done this with the type of factual and scientific help which SOA can provide.

In early 1974, to conserve fuels and lubricants, the Army arbitrarily doubled the oil change intervals for commercial and tactical wheeled vehicles, excluding engines under manufacturers' warranties. We estimate that the resulting savings could amount to \$1.3 million annually. However, since the intervals were extended arbitrarily instead of by using SOA, these savings could be offset by costly equipment damage due to undetected oil contamination and deterioration. For example, if an engine were faulty and started to wear, an arbitrarily extended oil change interval could compound the problem. In contrast, SOA could detect this problem and engine maintenance could preclude the failure.

In addition to the services' efforts, the Defense Department appointed a DOD Project Manager for Mobile Electric Power, who began a study of oil change intervals for generators during fiscal year 1972. The initial aim of the study was to find ways to reduce the cost of changing oil and filters. Later, when the energy crisis began, the study was redirected toward determining more effective use of fuels and lubricants. The results to date indicate that under laboratory conditions the oil change interval for

diesel engine generators could be extended from 100 to 300 hours. The study is being expanded to include testing under field conditions.

The oil and cost savings from extending oil change intervals depend on how much the generators are used. The DOD Project Manager assumed that the current DOD inventory of over 26,000 generators would have an average use of 1,000 hours a year each; therefore, an average of 10 oil changes a year would be required by each generator under the current oil change interval. He estimated that, by extending the interval to 300 hours, or 6 months, 670,000 gallons of oil and 250,000 oil filters, valued at about \$1.5 million, could be saved each year. It should be noted that these projected savings do not include the reduced maintenance labor costs for oil changes; the reduced logistics costs of procuring, storing, handling, and transporting the added oil and filters; and benefits accruing from less downtime of the equipment.

We recognize that savings such as those obtained from extending oil change intervals cannot be obtained without additional costs. For instance, one contractor said that, in addition to SOA, physical tests must be made to determine oil condition. Viscosity tests are an example. These tests measure the oil's resistance to flow; oil with too little viscosity has a decreased load-carrying ability while oil with too much viscosity causes increased friction and improper cooling. Another physical test is infrared analysis, which compares the chemical composition of used oil with that of unused oil and thereby detects (1) such oil contaminants as antifreeze and fuel and (2) depletion of various oil additives. The costs to the services for SOA and physical tests, in our opinion, will be more than offset by the savings from reduced maintenance costs and reduced oil and filter use. With such estimated annual savings as the \$1.3 million cited earlier from reduced oil and filter use by wheeled and tracked vehicles alone, the services could well afford to equip selected regional centers with the equipment needed for infrared and viscosity tests.

CONCLUSIONS

Very little progress has been made in using SOA on non-aircraft equipment despite the fact that existing laboratories have the capacity for increased workloads. We are not advocating that SOA is the best or only method of oil analysis. However, since the services already use SOA, we believe that extending its use to equipment other than aircraft would be cost effective. The services could better use their laboratories and, as private industry has already done, could greatly reduce maintenance costs and oil consumption. In today's environment, with the energy shortage and reduced military funding, such techniques as SOA should be carefully considered.

Oil changes at arbitrarily established operating-time or calendar intervals have a tendency to compound equipment problems due to undetected oil contamination and deterioration. In contrast, using such scientific methods as SOA prevents premature changing of oil, detects equipment problems before failures and thereby extends the life of the equipment.

RECOMMENDATION

We recommend that the Secretary of Defense require that SOA be extended to all types of equipment where it would be cost effective. Additional equipment as needed should be acquired only for key laboratories under a geographic regional concept.

AGENCY COMMENTS AND OUR EVALUATION

DOD stated that all three services had indicated active programs were underway to improve management of the SOA program and to expand the application of SOA to many different kinds of equipment.

We also provided our preliminary report to a number of nondefense agencies which might benefit from the use of SOA

and gave them an opportunity to comment. Those agencies that commented were:

- Federal Energy Administration.
- National Aeronautics and Space Administration.
- Department of Transportation.
- General Services Administration.
- United States Postal Service.
- Energy Research and Development Administration.

Although the Postal Service and General Services Administration did not believe the application of SOA to be cost effective to their vehicles, the opinion among the other agencies was that oil analysis usage by nondefense agencies appears to be feasible and desirable.

CHAPTER 5

SCOPE OF REVIEW

We examined regulations and operating procedures of each of the services. We reviewed the 1972 triservice agreement on SOA and the extent to which the services were complying with the agreement. Also we examined in detail documents relating to the use of laboratories, and we discussed with officials the effectiveness of SOA.

Our review included contacts with the following organizations.

Naval Air Systems Command
Naval Materiel Command
Naval Sea Systems Command
Naval Facilities Command
Office of Naval Research
Military Sealift Command
Headquarters, U.S. Marine Corps
Headquarters, Office of Naval Research
Headquarters, U.S. Air Force
(all in Washington D.C.)

Office of the Secretary of Defense (Installations
and Logistics)
 Directorate of Maintenance Policy and
 Director for Energy
Office of Management and Budget
Federal Energy Administration
U.S. Bureau of Mines
U.S. Department of Transportation
(all in Washington D.C.)

Army Materiel Command
Alexandria, Virginia

Naval Air Development Center
Warminster, Pennsylvania

San Antonio Air Logistics Center
San Antonio, Texas

Lexington Army Bluegrass Depot
Lexington, Kentucky

U.S. Army Oil Analysis Operators School
Fort Lee, Virginia

Mobile Electric Power--Department of Defense
Project Manager
Fort Belvoir, Virginia

Pensacola Naval Air Station
Pensacola, Florida

Roosevelt Roads Naval Station
Roosevelt Roads, Puerto Rico

U.S. Army Aviation Systems Command
St. Louis, Missouri

U.S. Army SOA Laboratory
Fort Campbell, Kentucky

U.S. Army Tank-Automotive Command
Warren, Michigan

Defense Construction Supply Center
Columbus, Ohio

H. B. Zachry Company
San Antonio, Texas

Caterpillar Tractor Company
Washington, D.C.

MTL Industries
Baltimore, Maryland

Naval Aviation Integrated Logistics Support Center
Patuxent River, Maryland

Analysts, Inc.
Linden, New Jersey

Spectron Caribe, Inc.
San Juan, Puerto Rico

Baird-Atomic, Inc.
Bedford, Massachusetts

Air Products and Chemical
Allentown, Pennsylvania

Mitre Corporation
McLean, Virginia

Cleveland Technical Center
Cleveland, Ohio

Oil International Laboratories
Cleveland, Ohio

Mobil Oil Company
New York, New York

Pan American Airlines
New York, New York

Eastern Airlines
Miami, Florida

National Airlines
Miami, Florida

American Airlines
Tulsa, Oklahoma



ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

INSTALLATIONS AND LOGISTICS

5 JUN 1975

Mr. Fred Shafer, Director
Logistics and Communications Division
United States General Accounting Office
Washington, D. C. 20548

Dear Mr. Shafer:

The Secretary of Defense has asked me to respond to your letter of April 3, 1975 and the General Accounting Office draft report on "Cost and Fuel Savings Realizable through Oil Analysis" (OSD Case 4066).

We generally concur with the findings and conclusion that dollar savings and improved equipment performance can be realized by improving the management and operation of DoD oil analysis programs. The DoD recognizes that oil analysis, as a maintenance diagnostic tool, has not been used to its maximum potential. This is especially true if testing techniques other than spectrometric analysis are included in the general spectrum of oil analysis programs.

A major inadequacy of spectrometric oil analysis is that the testing technique does not render any intelligence on contaminate particulate size or shape characterization. Acceptable contaminate threshold limits for small or large particles, for those from cutting wear, fatigue wear, or from normal wear would, and should, be different. Spectrometric oil analysis is further complicated by the influence of efficient filters installed in new machinery systems. The extent of the application of spectrometric oil analysis will decrease as finer filters are installed to increase bearing and gear life. Hence, the difficulty in establishing standards is understandable.


The 2 October 1972 joint agreement for integration of service oil analysis programs has not been totally effective. The Services are currently drafting and coordinating a new agreement which will more firmly establish goals, create a needed management structure which will include ties to the Joint Logistic Commanders, dictate the necessary mandatory joint meetings and more appropriately assign both individual and joint responsibilities. The DoD plans to closely monitor program integration and performance under the new joint agreement.

We do not advocate a single manager of this program at this time. Oil analysis is but one of many non-destructive tests and diagnostic procedures. A single manager of one could lead to a proliferation of single managers for each and every diagnostic tool and to many OSD managed programs whenever inter-Service support is a desired goal. We believe it is more appropriate for the Office of the Secretary of Defense to assist in developing and promoting a new joint service agreement which will overcome a number of current program deficiencies.

The questionable management practices that are highlighted in your report have been brought to the attention of the Services through distribution of the draft report. The Services generally concur with your findings. All three Services have indicated active programs are underway to improve management of the oil analysis program and to expand the application of oil analysis to many different kinds of equipment. For example, studies by the Air Force now reveal that earlier laboratory response time requirements were more stringent than necessary. Relaxing the response time should reduce the total Air Force laboratories to approximately 101 by mid-FY 77. Also, the Air Force is in the process of revalidating their Jacksonville requirement with the aim of utilizing the Navy laboratory at Jacksonville. Similarly, the Air Force intends to utilize an area concept at Langley, Oceana and Norfolk.

We appreciate your interest in reducing the cost of maintenance support through improving the management and operation of DoD oil analysis programs.

Sincerely,



JOHN J. BENNETT
Acting Assistant Secretary of Defense
(Installations and Logistics)



FEDERAL ENERGY ADMINISTRATION

WASHINGTON, D. C. 20461

JUN 10 1975

OFFICE OF THE ADMINISTRATOR

Mr. Monte Canfield, Jr.
Director
Office of Special Programs
U.S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Canfield:

This is in response to your letter of April 2 requesting the Federal Energy Administration to review the draft report entitled, "Cost and Fuel Savings Realizable Through Oil Analysis", (code 947108) prepared by the General Accounting Office.

Although the report focused on the applications of spectrometric oil analysis within the Department of Defense, you indicated that this or similar techniques might be productively applied by other federal agencies.

Oil analysis clearly can be applied effectively to large fleets of both aircraft and heavy-duty land and sea equipment. The draft report cited several instances where oil analysis had been successfully used by construction or large trucking firms. In the examples cited, oil analysis resulted in a significant reduction in the consumption of lubricants and provided an early warning of equipment failure.

Both the Postal Service and the General Services Administration have examined the possible application of oil analysis techniques to federally owned vehicles. In 1955, the Postal Service initiated a program under which oil analyses were performed for all postal vehicles on a regular basis. The program was terminated in the early 1960's, however, after it was determined that oil analysis was unable to reduce--and in fact resulted in some increase in--vehicle maintenance costs. Furthermore, the Postal Service determined that the cost of the oil analysis program, including the time spent drawing samples, was significantly higher than initially anticipated. These higher

costs far outweighed the savings achieved in lubricating oil. The General Services Administration has not instituted an oil analysis program, but has conducted oil analyses in conjunction with its Dual Fuel Program. A recent review by GSA concluded that oil analysis still could not be justified on a cost basis for general vehicle applications.

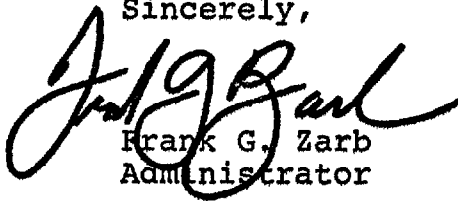
The Federal Energy Administration has not conducted an indepth analysis of the current applications of oil analysis. However, some general conclusions can be made. First, oil analysis can be an extremely useful tool in federal efforts to lower maintenance costs for major equipment, including aircraft, ships, and heavy-duty diesel engines. Second, oil analysis has been successfully applied by the private sector in those areas where cost savings are realizable. Third, even though dramatic reductions in the consumption of lubricating oils have been achieved through the use of oil analysis for certain types of equipment, this technology currently does not hold significant potential for major energy savings nationwide.

In 1973, the United States consumed about 155,000 barrels per day of lubricating oils and probably less than 50% of this volume was consumed in the type of equipment likely to benefit from oil analysis. Assuming that one third of this amount might be saved if oil analyses were applied more widely, results in estimated savings of about 25,000 barrels per day or less than .2% of total U. S. petroleum consumption. While these estimates reveal that expanded use of oil analysis could have only a minor impact on total energy demand, we do not want to suggest that even these small savings should be ignored. The efforts of the Department of Defense with respect to oil analysis should be encouraged, but the primary justification for the application of oil analysis should remain cost savings and not energy savings. Civilian federal agencies operate about 9,000 trucks that weigh more than three tons each. While there may be many factors which would argue against the use of oil analysis for these vehicles, they do represent a potential for further federal applications of this technology. Again, the decision to implement oil analysis for these vehicles must be based solely on cost savings, not the energy savings

that might ensue.

The Federal Energy Administration will continue to work with the Department of Defense, General Services Administration and other Federal agencies in encouraging the use of oil analysis where appropriate.

Sincerely,

A handwritten signature in black ink, appearing to read "Frank G. Zarb". The signature is stylized and cursive, with the first letters of the first and last names being prominent and capitalized. It is positioned above the printed name and title.

Frank G. Zarb
Administrator



OFFICE OF THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

ASSISTANT SECRETARY
FOR ADMINISTRATION

JUNE 6, 1975

Mr. Henry Eschwege
Director
Resources and Economic Development
Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Eschwege:

This is in response to your letter dated April 3, 1975, requesting the Department's comments on the General Accounting Office (GAO) draft report on cost and fuel savings realizable through oil analysis. The GAO found that spectrometric oil analysis is beneficial and its use could greatly reduce maintenance and oil consumption. The report addresses the Department of Defense activities, but GAO believes that oil analysis has application to non-defense agencies as well. The Department agrees with this conclusion.

I have enclosed two copies of the Department's reply.

Sincerely,

A handwritten signature in black ink, appearing to read 'William S. Heffelfinger'.

William S. Heffelfinger

Enclosure
(two copies)

DEPARTMENT OF TRANSPORTATION REPLYTOGAO DRAFT REPORT OF APRIL 3, 1975ONCOST AND FUEL SAVINGS REALIZABLE THROUGH OIL ANALYSISSummary of GAO Findings and Recommendations

The report is directed at the Department of Defense (DOD). The Joint Army/Navy/Air Force agreement to consolidate, coordinate, and standardize their oil analysis programs has not worked, because no central program manager was established or was given the authority to direct the overall program. Consequently, stated objectives have not been achieved, and the services have not taken advantage of spectrometric oil analysis' (SOA) full potential.

Very little progress has been made in using SOA for non-aircraft equipment despite the fact that existing laboratories have the capacity for increased workloads. The General Accounting Office (GAO) does not advocate that SOA is the best or only method of oil analysis. However, since the military services already use SOA, GAO believes that extending its use to equipment other than aircraft would be cost effective. The services could better utilize their laboratories and, as private industry has already done, could greatly reduce maintenance costs and oil consumption. In today's environment, with the energy shortage and reduced military funding, such techniques as SOA should be given careful consideration. In addition, GAO believes that oil analysis has application to non-defense agencies.

Summary of Department of Transportation Position

The report points up areas for significant savings in maintenance costs and fuel consumption of oil lubricated machinery and equipment through the use of SOA. The U. S. Coast Guard does have an oil analysis program and it is explained below in the Department's comments. In addition, the Federal Aviation Administration has an interest in SOA as it relates to the aviation industry.

Department of Transportation CommentsU. S. Coast Guard

The Coast Guard has an oil analysis program for spectrometric analysis for wear metals and physical tests for determining the condition of the oil for retention in service. The equipments monitored by this program are:

- Propulsion diesel engines of 150 HP and greater.
- Reduction gears of 500 HP and greater.
- Diesel engine prime movers for generators of 20 KW and greater.
- All shipboard steam and gas turbines.
- Other systems as directed by District Commanders such as controllable pitch propellers, cranes, steering systems, etc.
- R1820-76 Engine in HU-16
- T58-GE-5 Engine in HH-3F
- T58-GE-8B Engine in HH-52A
- T-56-7 Engine in C-130B
- T-56-15 Engine in C-130H
- All aircraft gear boxes

Laboratory services are furnished to the Coast Guard by DOD operated Spectrometric Oil Analysis Program (SOAP) laboratories (USAF, USA and USN). Procedural instructions, sampling methods and special sample requirements, forms usage and supply/procurement actions are specified by the technical orders applicable to the particular laboratories. The following technical orders are prescribed as applicable to Coast Guard units by current agency directives:

- Department of the Army Technical Bulletin TB 55-6650-300-15, Spectrometric Oil Analysis.
- Department of the Air Force T.O. 42B2-1-9, Spectrometric Oil Analysis Program.

- Navy Material Instruction P-4730, Spectrometric Oil Analysis.
- Navy Material Instruction 4731.1, Navy Oil Analysis Program (NOAP)

Navy laboratories have been assigned to process oil samples from Coast Guard equipment. Non-aircraft equipment in the 1st through 9th Coast Guard Districts is received by the NOAP Laboratory at Charleston Naval Shipyard, and the 11th through 17th Coast Guard Districts by the NOAP Laboratory at Lualualie, Hawaii. Analysis of Aircraft samples are primarily accomplished at the Navy laboratories at North Island and Norfolk, although some local support is obtained at DOD laboratories more proximate to distant concentrations of aircraft (e.g., Corpus Christy, TX; Elmendorf, Alaska).

Laboratory services furnished to the Coast Guard are funded on a reimbursable basis by Commandant (G-E). Total annual samples are approximately 35,000 involving reimbursement in the amount of \$125,000.

The Coast Guard commenced using Navy services in FY 1975 for non-aircraft equipment. For the preceding five years commercial services were used under term contracts. The change to the Navy was made in order to provide the continuity so essential for a program of this nature.

There are several areas in the report which the Coast Guard feels should be expanded. These are:

- a. The oil analysis is only as good as the laboratory technician doing the test or interpreting the results. From the report it is evident that interpretations vary according to the Service performing the analysis.
- b. Additives which are added to oil to give it special properties are depleted after some period of time. The Coast Guard is not sure if the depletion of the additives would show up in tests such as infrared analysis. This should be examined.

The Coast Guard's concept of maintenance does rely heavily on oil analysis as an analytical tool to maximize operating hours and it is our intention to continue to use the services provided under the SOAP's available to us within DOD. Since the Coast Guard does participate on a reimbursable basis and specify applicable

equipments through our engineering support managers, it is believed they should consider the authority of a single SOAP manager to "extend oil analysis to all types of equipment where it is cost effective" as advisory and subject to review by its engineering staff.

Federal Aviation Administration

The Federal Aviation Administration's comments concern the adoption of an oil analysis program by some air carriers in their maintenance programs. In addition, reports available to the National Business Aircraft Association indicate that some form of SOA is used on 25% of their fleet (approximately 1,000 airplanes).

Analysis of oil condition for engine lubricated components is and can be beneficial. To accomplish this, however, requires proper sampling intervals, rapid analysis of samples and specific metal deterioration limits before action should be taken to remove operating engines from service. Since failure experience on any particular engine design can vary widely with aircraft usage, maintenance, and environment, it is understandable that different acceptability criteria will evolve if no optimization guidelines are established. For example, common acceptability criteria for aircraft with common engines and similar usage should be readily attainable. Criteria which are too severe should be discernible from records of premature engine removals and excessive overhaul costs. Where criteria require sampling after each flight, it would appear that some basic engine design changes are warranted unless the engine happens to be nearing the end of its useful life, in which case the central authority should establish guidelines pertinent to the continuation of service and continuation of SOA sampling. Likewise, a single-engine aircraft would normally require a more extensive sampling program than multi-engine aircraft; however, the frequency of sampling should be related to the overall reliability of the engine as well as its relative maturity. Very new engines may require higher sampling rates to establish criteria, and very old engines would require higher sampling rates to prevent failures. Since failure of an engine on a multi-engine aircraft would seldom result in the loss of the aircraft as it would with a single-engine aircraft, a different frequency rate for sampling would be appropriate for multi-engine aircraft.

SOA has been found to be most useful in reciprocating engines, gearboxes and helicopter transmissions, where there is a relatively high degree of metal-to-metal contact. The gas turbine engine does not lend itself well to this type of single analysis for a determination of engine condition.

The cost effectiveness of an oil analysis program is also an important criterion. This aspect was considered by many air taxi operators and it was concluded that the costs involved outweighed the positive results achieved, particularly with the advent of the turbine engine. Further, with regard to the effectiveness of extended oil change intervals, it is believed that GAO should contact engine manufacturers to determine their reasons for recommending oil change intervals. It may well be that the arbitrary extension of oil change intervals could contribute to a reduction in long-term life for an engine. It may be false economy to measure the short-term savings in oil, oil filters, and maintenance costs if significant reductions in long-term life force early replacement and higher failure rates.

William P. Davis JUN 6 1975
Deputy Assistant Secretary for Administration



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546



Apr 24 1975

REPLY TO
ATTN OF

RWM

Mr. R. W. Gutmann
Director, Procurement and
Systems Acquisition Division
U. S. General Accounting Office
Washington, DC 20548

Dear Mr. Gutmann:

The enclosed comments are offered in response to your letter of April 3 to Dr. Fletcher on the subject of cost and fuel savings realizable through oil analysis. You will note that Spectrometric Oil Analysis (SOA) is an established procedure which is being widely used by the commercial airline industry. Additional usage by those non-defense agencies which operate fleets of vehicles or large banks of heavy-duty equipment appears to be feasible and desirable. Simpler lubricant-monitoring procedures are likely to be more satisfactory for less-standardized equipment because of the absence of the economies of scale needed to institute SOA.

Sincerely,

A handwritten signature in cursive script, appearing to read "Duward L. Crow".

Duward L. Crow
Assistant Administrator for
DOD and Interagency Affairs

Enclosure

Comments on Draft GAO Report of the Congress,
"Cost and Fuel Savings Realizable Through Oil Analysis,"
April 1975

NASA has reviewed the subject draft and concurs with the technical evaluation of Spectrometric Oil Analysis (SOA) therein. This agency is not sufficiently familiar with internal operational procedures of the military services, which are the subject of the greater part of the report, to offer its comments on those procedures.

In brief, SOA is now a proven and established procedure for monitoring wear of high cost, heavy duty mechanical components. It is best used as a key part of a comprehensive lubrication control system, along with other procedures which are also described in the report. It can result in a substantial reduction in usage of lubricants. More importantly, it can anticipate and prevent most wear failures.

SOA was adopted by the Naval Air Systems Command in the 1960's, although it had previously been used by the railroads. It has since been accepted by the other military air services as well as by commercial airlines. NASA has kept abreast of this latter usage, as demonstrated by the following extract from a September 1972 report by a group of its lubrication experts. (The report was based upon visits to maintenance depots of American Airlines in Tulsa, Trans-World Airlines in Kansas City, United Airlines in San Francisco, Western Airlines in Los Angeles and Continental Airlines in Los Angeles):

"Engine condition monitoring is vital to 'on-condition' maintenance procedures. SOA is generally considered a very reliable indicator of engine conditions. American Airlines experience indicates 90% reliability in predicting maintenance requirements and TWA has somewhat better experience (95%). TWA considers that their monitoring SOA eliminates 88% of unscheduled removals. United (which depends primarily on time scheduled rather than "on condition" maintenance) does not use SOA, but the other airlines visited consider it a valuable tool."

It appears likely that SOA could be useful to truck and bus fleet operators, power companies, machine shops, paper mills, textile mills, printing plants, etc. A few non-defense government agencies, such as the Government Printing Office and the Postal Service, fit in these categories (NASA has no knowledge of what procedures these agencies already use). Several other agencies, including NASA, own and operate a substantial amount of mechanical equipment. Application of SOA procedures to such equipment, while possible, would not be economical in most cases. The cost of training operators,

setting standards, establishing laboratories, or making arrangements with existing defense laboratories, and otherwise "gearing up" for each piece of equipment would have to be balanced against lubricant savings and the reduction of down time. A more complete analysis of the economies of using SOA could be made in each case, if desired. However, such simpler procedures as periodic oil changes, measurement of oil consumption rates and drain plug checks are probably adequate where economies of scale do not apply.



A. M. Lovelace
Associate Administrator for
Aeronautics & Space Technology

Date: April 23, 1975



THE POSTMASTER GENERAL
Washington, DC 20260

MAY 14, 1975

Mr. Victor L. Lowe
Director, General Government
Division
United States General Accounting
Office
Washington, D. C. 20548

Dear Mr. Lowe:

Thank you for inviting our comments on the draft of your report to the Congress on cost and fuel savings realizable through oil analysis.

The Postal Service used engine oil analysis for more than four years in the late '50's and early '60's, but the technique did not prove cost effective. It was our experience that by the time the oil analysis reports warned us of a problem, the harm had already been done. The failed parts illustrated in the draft report, for example, are already beyond the point of safe operation.

In addition, we do not believe oil analysis would be helpful in determining oil drain periods. At present, oil change intervals for our 1/4 ton and 1/2 ton vehicles, 84.6% of our total fleet, have been established at twice a year for low mileage vehicles and three times a year for high mileage ones. Engine failures related to lubrication amount to less than one-tenth of one percent per year. We do not believe that the use of oil analysis could improve our lubrication intervals sufficiently to provide enough savings in fuel, lubricants and repairs to pay for the cost of oil sampling and analysis.



UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

JUNE 2, 1975

Mr. Henry Eschwege, Director
U. S. General Accounting Office
441 G Street, N.W.
Washington, D.C. 20548

Dear Mr. Eschwege:

We have reviewed the draft report, "Cost and Fuel Savings Realizable Through Oil Analysis", as you requested.

We would favor placing additional emphasis in the report on the potential for conserving oil as a resource. Also, if it is your intent for the report to stimulate the use of oil analysis by non-defense agencies you might consider:

- expanding the descriptive coverage to include methods other than Spectrometric Oil Analysis (this would also make the report's coverage more consistent with its title).
- adding a bibliography of technical sources on the subject.
- making it clearer whether GAO believes that it would be desirable to expand non-defense agency use of DOD oil analysis facilities. If this is feasible, non-defense agencies will need information about each available facility such as a point of contact and an indication of the type and extent of services available, and cost ranges for the various services.

We would like to distribute a copy of the final report to each of our field offices so we will need 35 copies.

Sincerely,

M. C. Greer
Controller

CC: Ralph Carlone, GAO



Spectrometric oil analysis is essential for very large diesel engines which may suffer serious damage from acid corrosion and for aircraft engines, from a safety standpoint. But we do not believe the technique is cost effective for a fleet such as ours. If any information is developed which indicates that the Spectrometric oil analysis technique is desirable in a fleet such as ours, we would of course be most anxious to receive that information and reconsider our position.

Sincerely,



Benjamin F. Bailar

UNITED STATES OF AMERICA
GENERAL SERVICES ADMINISTRATION
WASHINGTON, DC 20405



MAY 30 1975

Honorable Elmer B. Staats
Comptroller General of the United States
General Accounting Office
Washington, D. C. 20548

Dear Mr. Staats:

Thank you for your letter of April 3, 1975, transmitting your draft report "Cost and Fuel Savings Realizable Through Oil Analysis."

Most vehicles in the Federal fleet are normally sold after 60,000 miles before a major overhaul is required. Since our incidence of engine replacement has been minimal (none involved oil problems), application of spectrometric oil analysis to vehicles in the fleet would not be cost effective. If we determine in the future that cost savings could be achieved through oil analysis, we will certainly institute such a program.

We appreciate the opportunity to comment on your draft report.

Sincerely,

Dwight A. In...
Dwight A. In...
Acting Administrator

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PRINCIPAL OFFICIALS OF
THE DEPARTMENT OF DEFENSE AND THE
DEPARTMENTS OF THE ARMY, NAVY, AND AIR FORCE
RESPONSIBLE FOR ADMINISTERING THE ACTIVITIES
DISCUSSED IN THIS REPORT

	<u>Tenure of office</u>	
	<u>From</u>	<u>To</u>
<u>DEPARTMENT OF DEFENSE</u>		
SECRETARY OF DEFENSE:		
James R. Schlesinger	July 1973	Present
William P. Clements, Jr. (acting)	Apr. 1973	July 1973
Elliot L. Richardson	Jan. 1973	Apr. 1973
DEPUTY SECRETARY OF DEFENSE:		
William P. Clements, Jr.	Jan. 1973	Present
Kenneth Rush	Feb. 1972	Jan. 1973
ASSISTANT SECRETARY OF DEFENSE (INSTALLATIONS AND LOGISTICS):		
John J. Bennett (acting)	Apr. 1975	Present
Arthur I. Mendolia	Apr. 1973	Mar. 1975
Hugh McCullough (acting)	Feb. 1973	Apr. 1973
<u>DEPARTMENT OF THE ARMY</u>		
SECRETARY OF THE ARMY:		
Howard Callaway	May 1973	Present
Robert F. Froehlke	July 1971	May 1973
UNDER SECRETARY OF THE ARMY:		
Norman R. Augustine	May 1975	Present
Herman R. Staudt	Oct. 1973	Apr. 1975
Vacant	June 1973	Oct. 1973
Kenneth F. Belieu	Aug. 1971	June 1973

<u>Tenure of office</u>	
<u>From</u>	<u>To</u>

DEPARTMENT OF THE ARMY (continued)

ASSISTANT SECRETARY OF THE ARMY
(INSTALLATIONS AND LOGISTICS):

Harold L. Brownman	Oct. 1974	Present
Edwin Griener	Aug. 1974	Sept. 1974
Edwin Griener (acting)	May 1974	Aug. 1974
Vincent P. Huggard (acting)	Apr. 1973	Apr. 1974

DEPARTMENT OF THE NAVY

SECRETARY OF THE NAVY:

J. William Middendorf II	June 1974	Present
J. William Middendorf II (acting)	Apr. 1974	June 1974
John W. Warner (acting)	May 1972	Apr. 1974

UNDER SECRETARY OF THE NAVY:

David S. Potter	Aug. 1974	Present
Vacant	June 1974	Aug. 1974
J. William Middendorf II	June 1973	June 1974
Frank Sanders	May 1972	June 1973

ASSISTANT SECRETARY OF THE NAVY
(INSTALLATIONS AND LOGISTICS):

Jack L. Bowers	June 1973	Present
Charles L. Ill	July 1971	May 1973

DEPARTMENT OF THE AIR FORCE

SECRETARY OF THE AIR FORCE:

Dr. John L. McLucas	July 1973	Present
Dr. Robert C. Seamans, Jr.	Jan. 1969	July 1973

<u>Tenure of office</u>	
<u>From</u>	<u>To</u>

DEPARTMENT OF THE AIR FORCE (continued)

ASSISTANT SECRETARY OF THE AIR FORCE
(INSTALLATIONS AND LOGISTICS):

Frank A. Shrontz	Oct. 1973	Present
Richard J. Keegan (acting)	Aug. 1973	Sept. 1973
Lewis E. Turner (acting)	Jan. 1973	Aug. 1973

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