FM 10-67-2
HEADQUARTERS
DEPARTMENT OF THE ARMY

PETROLEUM LABORATORY TESTING AND OPERATIONS

DISTRIBUTION RESTRICTION:

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED.

By Order of the Secretary of the Army:

DENNIS J. REIMER
General, United States Army
Chief of Staff

Official:

JOEL B. HUDSON
Administrative Assistant to the
Secretary of the Army
03165

DISTRIBUTION:

Active Army, Army National Guard, and U.S. Army Reserve: To be distributed in accordance with the initial distribution number 115480, requirements for FM 10-67-2.

Field Manual
No. 10-67-2

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 2 April 1997

PETROLEUM LABORATORY TESTING AND OPERATIONS

Table of Contents

		Page
PREFACE		ix
CHAPTER 1	ENVIRONMENTAL RESPONSIBILITIES	1-1
Section I	ENVIRONMENTAL PROTECTION STEWARDSHIP	1-1
	Scope of Environmental Responsibility	1-1
	Environmental Protection Stewardship Goals	1-1
	Role of Environmental Protection Stewardship in Leadership	1-2
	Environmental Responsibilities of Personnel	1-2
Section II	HAZARDOUS MATERIALS	1-3
	General	1-3
	Hazardous Waste	1-3
	Hazardous Materials	1-4
	Hazardous Materials Management	1-4
CHAPTER 2	PETROLEUM PRODUCTS	2-1
Section I	PETROLEUM-BASE LIQUID PROPELLANTS AND FUELS	2-1
	Crude Petroleum	2-1
	Types of Petroleum Products	2-1
	Petroleum-Base Liquid Propellants and Fuels Category	2-1
Section II	FUEL OILS	2-3
	Burner Fuels	2-3
	Kerosene	2-4

DISTRIBUTION RESTRICTION: Approved for public release; distribution is unlimited.

*This publication supersedes FM 10-70, 9 May 1983, and FM 10-72, 11 August 1986.

Section III	LUBRICATING OILS AND GREASES	2-4
	Purpose	2-4
	Lubricating Oils	2-4
	Requirements	2-5
	Lubricating Greases	2-6
	Classification of Greases	2-6
	Grease Requirements	2-6
	Properties of Grease	2-6
	Miscellaneous Products	2-6
CHAPTER 3	PETROLEUM QUALITY	3-1
Section I	PETROLEUM INSPECTION PROCEDURES	3-1
	General	3-1
	Quality Control	3-1
	Quality Assurance	3-1
	Quality Surveillance	3-1
Section II	QUALITY ASSURANCE	3-2
	Quality Assurance Program Administrators	3-2
	Quality Assurance Representative Responsibilities	3-2
	Quality Assurance Inspections and Acceptance	3-2
	Quality Assurance Inspection of Contractor Facilities	3-3
	Quality Assurance Inspections of Storage and Transfer Facilities	3-3
	Quality Assurance Inspection of Tankers and Barges	3-4
	Quality Assurance Inspection of Tank Cars and Tank Vehicles	3-4
	Quality Assurance Measurements and Documentation	3-5
Section III	QUALITY SURVEILLANCE	3-6
	Quality Surveillance Program Administrators	3-6
	Petroleum Quality Surveillance And Technical Assistance Program	3-6
	Correlation Programs	3-7
	Quality Surveillance During Storage, Loading and Unloading Operations	3-8
	Quality Surveillance During Storage Operations	3-8
	Quality Surveillance During Tanker and Barge Loading Operations	3-8
	Quality Surveillance During Jet Fuel or Kerosene Loading Operations	3-9
	Quality Surveillance During Tanker and Barge Unloading Operations	3-9
	Quality Surveillance During Tank Cars and Tank Vehicle Loading and Unloading Operations	3-10
	Quality Surveillance During Pipeline Operations	3-10
Section IV	CLEANLINESS STANDARDS FOR AVIATION FUELS	3-11
	General	3-11
	Filter/Separators	3-11
	Solid Contamination	3-12
	Water Contamination	3-12
	Testing Effluent Samples for Water	3-14

CHAPTER 4	PETROLEUM LABORATORY PERSONNEL, FACILITIES, AND TESTING EQUIPMENT	4-1
Section I	PETROLEUM LABORATORY PERSONNEL	4-1
	Petroleum Laboratory Officer	4-1
	Petroleum Laboratory Specialist	4-1
	Duties of Petroleum Laboratory Specialist	4-1
Section II	PETROLEUM LABORATORIES	4-2
	General	4-2
	CONUS Army Laboratory Facilities	4-2
	OCONUS Laboratories	4-2
	Types of Laboratories	4-2
	Base Petroleum Laboratory	4-3
	Modular Base Petroleum Laboratory	4-3
	Mobile Petroleum Laboratory	4-3
	Airmobile Petroleum Laboratory	4-3
	Petroleum Quality Analysis System	4-7
Section III	TEST KITS	4-7
	General	4-7
	Aviation Fuel contamination Test Kit	4-7
	Sampling and Gaging Kit	4-9
	Ground Fuels Contamination Test Kit	4-9
	Captured Fuels Test Kit	4-9
	Aqua-Glo Test Kit	4-9
Section IV	LABORATORY EQUIPMENT MAINTENANCE AND SUPPLY	4-11
	Maintenance	4-11
	Calibration	4-11
	Calibration of Test Kits	4-11
	A-Level Calibration Procedures	4-11
	C-Level Calibration Procedures	4-11
	Supply	4-12
	Inventories	4-12
	Prescribed Load List	4-12
Section V	EQUIPMENT PUBLICATIONS AND FORMS	4-12
	General	4-12
	DODISS	4-12
	DD Form 1425	4-13
	Requisition Processing	4-13
CHAPTER 5	ESTABLISHING PETROLEUM TESTING FACILITIES IN THE THEATER	5-1

Section I	DEPLOYMENT OF PETROLEUM TESTING FACILITIES	5-1
	Preparation for Shipment	5-1
	Shipping Documents	5-1
	Request Channels and Format	5-1
	Request Approval	5-2
Section II	PETROLEUM LABORATORY AREA REQUIREMENTS	5-2
	General	5-2
	Environmental Considerations	5-2
	Laboratory Site Selection	5-3
	Petroleum Base Laboratory Requirements	5-3
	Modular Base Laboratory Requirements	5-3
	Mobile Laboratory Requirements	5-3
	Airmobile Laboratory Requirements	5-4
	Ground Fuels Test Kit Requirements	5-4
	Test Kit Requirements	5-4
Section III	NBC ENVIRONMENT	5-4
	NBC Threat Considerations	5-4
	Nuclear Effects	5-4
	Preparation of Site	5-5
	Laboratory NBC Protection Procedures	5-5
	NBC Defense Fundamentals	5-5
	NBC Operations	5-6
	Nuclear Attack	5-6
	Biological Attack	5-6
	Chemical Attack	5-7
	Operations in a Contaminated Environment	5-7
	Laboratory SOP	5-7
	Training	5-8
	Destruction of Army Laboratories	5-8
CHAPTER 6	PERFORMING QUALITY SURVEILLANCE IN THE THEATER	6-1
Section I	PETROLEUM QUALITY SURVEILLANCE IN THE DEVELOPED THEATER	6-1
	Description of the System	6-1
	Base Petroleum Laboratory	6-1
	Mobile Petroleum Laboratory	6-1
	Airmobile Petroleum Laboratory	6-1
	Test Kits	6-1
	Testing Requirements	6-2
	Procurement of Petroleum Products	6-2
	Standardization Agreements	6-2
	Channels of Communication	6-2
	Laboratory Requirements	6-2
	Quality Surveillance Mission	6-2

Section II	PETROLEUM QUALITY SURVEILLANCE IN THE UNDEVELOPED THEATER	6-5
	Description of the System	6-5
	Testing Requirement	6-5
	Procurement of Petroleum Products	6-6
	Commandeered/Captured Petroleum Products	6-6
	Channels of Communication	6-6
	Laboratory Requirements	6-6
	Additional Requirements	6-6
	Time-Phased Laboratories	6-7
CHAPTER 7	INTRODUCTION TO CHEMISTRY FOR THE PETROLEUM LABORATORY	7-1
Section I	MATTER	7-1
	General	7-1
	Definition	7-1
	Quantity of Matter	7-2
Section II	REAGENTS AND SOLUTIONS	7-4
	General	7-4
	Equations	7-4
	Reagents	7-4
	Solutions	7-4
	Factors Affecting Solubility	7-4
	Concentrations of Solutions	7-5
	Preparing Solutions	7-5
	Primary Standards	7-5
	Secondary Standards	7-6
	Standardization	7-6
	Titration	7-6
	Standardization by Titration	7-6
	pH Scale	7-7
	Indicators	7-7
Section III	BALANCES AND WEIGHING	7-8
	General	7-8
	Analytical Balance	7-8
	The Harvard Trip Balance	7-9
	Triple Beam Balance	7-10
CHAPTER 8	EVALUATING PETROLEUM PRODUCTS	8-1
Section I	PROPERTIES OF PETROLEUM PRODUCTS	8-1
	Critical Properties	8-1
	API Gravity	8-1
	Appearance/Workmanship	8-1
	Aqua-Glo Water Test	8-1

	Ash Content	8-2
	Carbon Residue	8-2
	Cleveland Open Cup Flash Point	8-2
	Cloud Point	8-3
	Color	8-3
	Cone Penetration of Grease	8-3
	Copper Corrosion	8-4
	Distillation	8-4
	Dropping Point of Grease	8-6
	Existent Gum	8-6
	Freezing Point	8-6
	Fuel System Icing Inhibitor	8-6
	Ignition Quality of Diesel Fuels	8-7
	Kinematic Viscosity	8-7
	Lead in Fuels	8-8
	Neutralization Number	8-8
	Oxidation Stability and Potential Gum	8-9
	Particulate Contaminant in Aviation Fuel	8-9
	Pensky-Martens Flash Point	8-9
	Pour Point of Petroleum Oils	8-10
	Precipitation Number	8-10
	Reid Vapor Pressure	8-10
	Smoke Point	8-10
	Sulfur in Petroleum Products	8-10
	Tag Closed Cup Flash Test	8-11
	Thermal Stability	8-11
	Water and Sediment	8-11
	Water Reaction	8-12
	Water Separation Characteristics	8-12
	Conductivity	8-13
Section II	IDENTIFICATION OF UNKNOWN PRODUCTS	8-13
	General	8-13
	Classification by Gravity	8-13
	Light Distillates	8-14
	Heavy Distillates	8-15
	Group A Distillates	8-15
	Group B Distillates	8-15
	Group C Distillates	8-16
	Reports and Recommendations	8-16
Section III	PRODUCT RECLAMATION AND DISPOSITION	8-16
	General	8-16
	Factors Affecting Reclamation	8-17
	Reclamation Techniques	8-17
	Improving Critical Properties	8-17
	Approximating a Blending Ratio	8-18
	Downgrading and Regrading	8-18

	Disposition Procedures	8-19
CHAPTER 9	SAMPLERS AND SMAPLING PROCEDURES	9-1
	General	9-1
	Types of Samples	9-1
	Samplers	9-1
	Sample Containers	9-5
	Sampling Procedures	9-5
	Special Procedures for Millipore Testing	9-8
CHAPTER 10	PETROLEUM LABORATORY OPERATIONS	10-1
Section I	SAFETY DURING LABORATORY OPERATIONS	10-1
	General Precautions	10-1
	Preventing Fires	10-2
	Modular, Mobile and AirMobile Laboratories	10-2
	Fire Extinguishers	10-3
	Types of Fire Extinguishers	10-3
	Methods of Extinguishing Petroleum Fires	10-4
	Handling Chemicals	10-5
	Substitute Solvents	10-7
	Handling Excess Chemicals	10-7
	Handling Solutions	10-7
	Controlling Pressure and Vacuum	10-8
	Controlling Fumes	10-9
	Electrical Safety	10-9
Section II	LABORATORY ANALYSIS REPORTING	10-10
	General	10-10
	Petroleum Sample Tag	10-10
	Petroleum Laboratory Analysis Report	10-10
	Testing	10-12
Section III	STANDARD PUBLICATIONS AND FORMS	10-13
	General	10-13
	Military Standardization Handbook for Fuels, Lubricants, and Related Products	10-13
	Federal Test Method Standard No. 791	10-13
	ASTM Standards 23, 24, 25, and 27	10-13
	DFSCH 4120.1 Reference List of Specifications and Standards	10-14
	DOD Manual 4140.25-M Procedures for the Management of Petroleum	10-14
	AR 715-27, Petroleum Procurement of Quality Assurance Manual	10-14
	Forms	10-14

APPENDIX A	PETROLEUM LABORATORIES	A-1
APPENDIX B	TEST MAN-HOURS FOR TYPE OF FUEL	B-1
APPENDIX C	CONVERSION CHARTS	C-1
APPENDIX D	POSSIBLE CAUSES OF CONTAMINATION/DETERIORATION	D-1
GLOSSARY		Glossary-1
REFERENCES		References-1
INDEX		Index-1

PREFACE

Purpose and Scope

This manual is a guide for commanders, staff officers, and other personnel concerned with planning, organizing, and carrying out petroleum QS testing in a theater of operations.

The doctrine in this manual concerns operations in a tactical theater and may not relate directly to normal peacetime garrison operations. Doctrine for the development and operation of theater petroleum testing facilities is discussed separately for an improved and unimproved theater of operations. The systems described are applicable to both conventional, and NBC warfare.

This manual is a consolidation of FMs 10-70 and 10-72. It addresses certain environmental issues to be considered in planning petroleum laboratory operations. It provides information concerning the types of petroleum products, and their uses by the military; petroleum quality; the various laboratories and test kits available for implementing quality surveillance in the theater; and the deployment and establishment of these facilities. The final chapters of this manual address basic chemistry used in the laboratory, along with the properties of petroleum, testing methods; samplers and sampling procedures; and general petroleum laboratory operations. This manual is not intended to be the only source of information on the operation of petroleum testing facilities. It does not cover individual items of testing equipment and their maintenance or the internal operation of testing facilities. In addition to this manual, it is necessary to have publications such as those listed in the references in order to provide an adequate petroleum QS program.

User Information

The proponent of this publication is HQ USATRADOC. You are encouraged to submit recommended changes and comments to improve this manual. Make sure you key your comments to the exact page, paragraph, and line of the text in which the change is recommended. Provide reasons for each comment to ensure understanding and complete evaluation. Write your comments on a DA Form 2028 (Recommended Changes to Publications and Blank Forms) or in a letter, and send them to

Training Directorate
Quartermaster Training Division
ATTN ATCL AQ
801 Lee Avenue
Fort Lee, VA 23801-1713

Unless otherwise stated, whenever the masculine gender is used, both men and women are included.

CHAPTER 1

ENVIRONMENTAL RESPONSIBILITIES

Section I. Environmental Protection Stewardship

The Army environmental vision is to be a national leader in environmental and natural resource stewardship for present and future generations as an integral part of our mission.

SCOPE OF ENVIRONMENTAL RESPONSIBILITY

We must take care of the environment (that is, practice environmental protection stewardship). The definition of stewardship is taking care of property while also caring about the rights of others. We must plan our operations without harming the environment. Good environmental protection stewardship lets leaders take care of soldiers and their families. It also saves resources vital to combat readiness. The Army's environmental concerns include the following.

- The Army has the huge task of reducing the environmental impact on its installations and units throughout the US and the world. Within CONUS, the Army owns 20 million acres of land (an area about half the size of Virginia). This shows the vastness of this task. Each area of our daily operation has some effect on the environment.
- The Army is renewing its emphasis on taking care of the environment. Petroleum units by their nature have a huge impact on the environment. It is critical for the leaders and soldiers in these units to follow safe, legal environmental practices. By doing so, they protect their health and the health of those around them. They also prevent long term environmental damage that can lead to fines and other legal actions.

ENVIRONMENTAL PROTECTION STEWARDSHIP GOALS

The Army no longer just complies with laws, they want to be a leader in environmental protection. To do this , the Army has set goals for its leaders. These goals include:

- Compliance. Ensure that all Army sites (CONUS, OCONUS) attain and sustain compliance in the face of changing requirements.
- Restoration. Clean up contaminated sites as quickly as resources permit to protect human health and environment.
- Prevention. Adopt and implement integration management approaches, procedures, and operations in all Army mission areas to minimize all environmental contamination and pollution. Do not receive a notice or violation or a fine for not following local, state, and federal environmental regulations.
- Conservation. Conserve, protect, and enhance environmental, natural and cultural resources, using all practical means consistent with missions, so that present and future generations may use and enjoy them.
- Planning. Consider the environment in the planning and decision making process, and initiate environmental planning early in the mission.
- NEPA. Integrate all NEPA procedures into operations.

ROLE OF ENVIRONMENTAL PROTECTION STEWARDSHIP IN LEADERSHIP

A leader who cares for the environment also cares for his people. He does this by reducing or eliminating undue health risks. He saves resources (soldiers or money) vital to his mission. He keeps training areas in excellent condition for training far into the future. He preserves cultural artifacts for study by future generations. He also teaches the basic moral duty of soldiers to protect and preserve the United States of America and its allies.

ENVIRONMENTAL RESPONSIBILITIES OF PERSONNEL

Personnel at all levels must protect our environment. This includes soldiers, NCOs, officers, and unit commanders.

Soldiers' Responsibilities. In addition to specific environmental precautions a soldier must enforce in his duty performance, he is responsible for adhering to the following general practices.

- Follow installation environmental policies, unit SOPs, ARs, and environmental laws and regulations.
- Make sound decisions in everyday activities.
- Advise the chain of command on techniques to ensure environmental regulations are followed.
- Identify the environmental risks in individual and team tasks.
- Support the Army recycling program.
- Report HM and HW spills immediately.

NCO's Responsibilities. The NCO makes decisions that can impact on the environment. Some of the environmental standards he must practice are listed below.

- Always consider the environment in day-to-day decisions.
- Make sure soldiers know the Army's environmental ethic.
- Train soldiers to be good environmental stewards.
- Be committed to environmental protection.
- Identify environmental risk associated with tasks.
- Plan and conduct environmentally sustainable actions and training.
- Protect the environment during training and other activities.
- Analyze the influence of the environment on your mission.
- Integrate environmental considerations into unit activities.
- Train peers and soldiers to identify the environmental effects of plans, actions, and missions.
- Counsel soldiers on the importance of protecting the environment and the results of not complying with environmental laws.
- Incorporate environmental considerations in AARs.
- Support the Army recycling program.
- Report HM and HW spills immediately.

Officer's Responsibilities. The officer is responsible for the welfare of his troops as well as the environment. His actions should reflect the following objectives.

- Build an environmental ethic in soldiers.
- Train and counsel subordinate leaders on stewardship.
- Lead by example.
- Enforce compliance with laws and regulations.
- Always consider the environment in making day-to-day decisions.
- Make sure subordinates know the Army's environmental ethic.
- Train subordinates to be good environmental stewards.
- Commit subordinate leaders to protect the environment.
- Analyze the influence of the environment on the mission.
- Integrate environmental considerations into unit activities, to include identifying the environmental risks associated with unit tasks.

Unit Commander's Responsibilities. The commander must build an environmental ethic in his soldiers. The commander sets the tone for environmental compliance. He is totally responsible for complying with all applicable environmental laws in the unit. Commanders train their subordinates on stewardship and counsel them on doing what is right. They must lead by example and enforce compliance with laws. Some of their responsibilities are listed below.

- Consider the environment in making daily decisions.
- Know about the NEPA, HM, HW, HAZCOM efforts, and spill contingencies.
- Commit subordinates to environmental protection.
- Make sure officers and NCOs know the environmental ethic and train them to be good environmental stewards.
- Counsel officers and NCOs on the importance of protecting the environment and the results of violating laws.
- Ensure officers and NCOs comply with requirements when reporting hazardous substance spills.
- Ensure environmental concerns are addressed throughout the training.
- Identify and assess the environmental consequences of proposed programs and activities.
- Plan and conduct training that complies with environmental laws, including marking areas as “off-limits” during training exercises.
- Discuss environmental concerns during briefings, meeting, and AARs.
- Establish and sustain unit environmental awareness training.
- Appoint an environmental compliance officer and a HW coordinator (the same person can serve both positions). These appointments ensure environmental compliance occurs at the unit level.
- Ensure the unit SOP covers environmental considerations, conservation, natural resources, and spill procedures.
- Support the Army pollution prevention/recycling program.
- Report HM and waste spills immediately.
- Conduct environmental self-assessment or internal environmental compliance assessments.
- Meet with key installation environmental POCs.

Appointed Personnel's Responsibilities. These personnel are appointed by the commander and should receive formal training. Some of their responsibilities are listed below.

- Act as an advisor on environmental regulatory compliance during training, operations, and logistics functions.
- Serve as the commander’s eyes and ears for environmental matters.
- Be the liaison between the unit and higher headquarters who are responsible for managing the environmental compliance programs and providing information on training requirements certifications that unit personnel need.

Section II. Hazardous Materials

GENERAL

Petroleum laboratory operations include the storage, use, and disposal of chemicals and petroleum products that are identified as hazardous to the environment. Proper use and control of these materials is necessary to protect the environment. Environmental pollutants discussed in this section are hazardous wastes and hazardous materials.

HAZARDOUS WASTE

Hazardous waste is defined as any material left from a process, or resulting from maintenance, which poses a threat to human health or the environment. Spent chemicals and fuel samples fall into this category. Purchasing less hazardous or non-hazardous materials reduces the volume of hazardous waste that will require disposal.

Collection Points. Each base or unit shall establish a hazardous waste collection point. The hazardous waste shall be properly classified as to the potential for harm to individuals or the environment. Waste oil, spent fuel, samples, solvents, spent lab chemicals, and acids will be properly labeled and packaged for accumulation and handling. Personnel will deliver the identified waste, properly packaged and identified, to designated collection points. The DLA, or its designated agent, is responsible for designating pick-up collection points and evacuating the hazardous waste disposal site.

HAZARDOUS MATERIALS

Hazardous material is defined as any material which, when taken internally, inhaled, or applied to (to come in contact with) the skin, may cause death or serious injury. Some examples are: flammable liquids and gases, corrosives, oxidizers, explosives, and toxins. Many of these substances are used by petroleum laboratory personnel. Proper handling and storing of chemicals is discussed in Chapter 10. It is also mandatory to store and maintain them IAW appropriate directives. Personnel should be trained in spill prevention and control. For spills beyond your immediate capability, coordinate with the nearest battalion for assistance from the spill response team. Any environmental incident, accident or hazardous materials spill must be reported for follow-up and accountability procedures.

HAZARDOUS MATERIALS MANAGEMENT

At a minimum, a petroleum laboratory hazardous materials management plan should include:

- Supervision of the procurement, use, storage, and disposal of the materials as required by AR 200-1 and federal and state requirements.
- Establishment of proper procedures to protect public health and the welfare of the persons who are potentially exposed to these materials.
- Availability of required MSDSs for each type of chemical procured for laboratory operations.
- Proper storage for hazardous materials, to reduce the need for corrective actions.

CHAPTER 2

PETROLEUM PRODUCTS

Section I. Petroleum-Base Liquid Propellants and Fuels

CRUDE PETROLEUM

Crude petroleum is a mixture of many complex hydrocarbons, all of which have different boiling points. By the process of distillation, the various hydrocarbon compounds in crude oil can be separated physically into groups of hydrocarbons having similar boiling ranges. These groups of hydrocarbons are known as fractions or cuts. The common fractions yielded from crude oil include: butanes and lighter cuts; straight-run gasoline cut; naphtha cut; kerosene cut; gas and lube oil cut; and residue cut. The quantity (percentage) of each cut, per barrel, varies according to the geographic origin of the crude oil. After the initial separation process into fractions or cuts, there are additional refining processes necessary to produce finished petroleum products for use by the consumer.

TYPES OF PETROLEUM PRODUCTS

Petroleum products are grouped into four main categories: (1) petroleum-base liquid propellants and fuels; (2) fuel oils; (3) cutting, lubricating, and hydraulic oils and greases; and (4) miscellaneous chemical specialties. These categories are discussed in the following paragraphs. Specifications listed in these paragraphs can be obtained from the Department of the Navy, Navy Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

PETROLEUM-BASE LIQUID PROPELLANTS AND FUELS CATEGORY

Petroleum-base liquid propellants and fuels include aviation gasoline, automotive gasoline, jet or turbine fuels, and diesel fuel. These propellants and fuels are discussed below.

Aviation Gasoline. AVGAS is the fuel used in all piston aircraft engines. The most important properties of aviation gasoline are: volatility; knock value; vapor pressure; stability; and solvent or corrosion properties. Some of the characteristics of aviation gasoline are listed below.

- They are mixtures of hydrocarbons that boil in the approximate range of 90°-338°F.
- They have a gravity range of about 66°-72° API.
- Gasoline hydrocarbon molecules have approximately 5 to 9 carbon atoms (C_5 - C_9). (Those hydrocarbons with fewer carbons are normally gases.)

Producing a satisfactory fuel for aircraft and for all gasoline-driven piston engines is largely a matter of blending and controlling the proportions of various hydrocarbons. Sometimes the process includes altering the structures of the hydrocarbons. AVGAS is manufactured according to ASTM specification D 910. The gasolines are manufactured in three grades: 80 (red or clear and containing no lead); 100/130 (green); 100/130LL (blue).

Motor Gasoline. During the refining process, MOGAS is derived from that fraction of crude oil within a boiling range of 90°- 420°F. The components in MOGAS do not have to be controlled within the same narrow limits as AVGAS. In MOGAS more of the valuable aromatics can be used, and more alkenes and alkanes are acceptable than in MOGAS due to less restrictive stor-

age requirements. MOGAS differs from AVGAS mainly in volatility and antiknock properties. They also differ in vapor pressure. Because of these differences, the use of MOGAS in aircraft is unsafe unless both the aircraft engine and the aircraft itself have been adapted for its use. Two types of MOGAS are discussed below:

- Commercial MOGAS is supplied under the ASTM specification D 4814. The specification covers special, regular, and premium grades in classes A, B, C, D and E to suit climatic conditions. Additionally, ASTM D 4814 covers oxygenated gasoline blends which are required in certain geographical regions of the United States to reduce CO_2. Gasohol is gasoline with 10 percent (by volume) ethanol. It is used as an alternate fuel and supplied in the same grades and classes as commercial gasoline. Gasohol is intended for use where long-term storage is not anticipated. It is procured under CID A-A-52530.
- Combat MOGAS is suitable for use in all gasoline engines, other than aircraft, under all conditions of service. Gasoline in this category is supplied under specification MIL-G-3056 in type I for use at all temperatures above 0°F (-18°C) and in type II for use where the mean temperature is consistently below 32°F (0°C).

Jet or Turbine Fuels. Jet or turbine fuels required for jet aircraft engines are obtained from special kerosene and gasoline fractions of crude oil. Fuel used in jet aircraft engines, should contain the properties listed below.

- The fuel must contain as much heat energy as possible both per unit weight and per unit volume.
- Combustion properties, which are related both to chemical composition and volatility, must be as good as possible.
- The fuel must have a low freezing point due to the low temperature encountered by jet aircraft flying at high altitudes for long periods of time.

Other areas of consideration are listed below.

- Loss of fuel in flight by evaporation.
- The fuel should be non-corrosive.
- The fuel should not clog fuel filters.
- The fuel should not produce vapor lock or slugging. (Slugging is the loss of liquid fuel from the vents owing to the pulling action of escaping vapors.)

JP-4, JP-5, JP-7, JP-8, JET A-1. Available jet or turbine fuels are: JP-4, JP-5, JP-7, JP-8 and JET A-1. A primary consideration in the development of any petroleum fuel is its availability in relation to other needed fuels, all of which must come from the same batch of crude oil. Generally, gasoline producers cannot produce as much jet or turbine fuel as gasoline because a barrel of crude oil contains about twice as much material in the gasoline range as in the jet-diesel range. These fuels are discussed below.

- JP-4 fuel is a wide-cut, gasoline base jet fuel procured under MIL-T-5624. The use of JP-4 is limited to geographical regions where extreme cold weather conditions exist. The boiling point for this particular type of gasoline base fuel is in the approximate range of 120° to 500°F, and it has low vapor pressure (2.0 to 3.0 psi, Reid). JP-4 is not the preferred fuel because of the inherent ignition hazards in this cut of fuel. Jet fuel supplied under MIL-T-5624 may be required to contain 0.10 to 0.15 percent by volume of FSII. The FSII used in JP-4 is DIEGME and must conform to MIL-I-85470. JP-4 may contain a SDA. Currently there are two that have been approved, ASA-3 and STADIS 450. These SDAs increase the conductivity of the fuel and allow static electricity to dissipate rapidly. Because the additives are surfactants, the WSIM test is not run on JP-4 containing an SDA. The additives are usually blended in a concentration of 1.0 part per million. This yields a conductivity rating of 200-600 pS/m or 200 to 600 CUs. The API gravity range for JP-4 is from 45.0 to 57.0.
- JP-5 is a narrow-cut, kerosene-base jet fuel procured under MIL-T-5624. It was originally developed for use by aircraft carrier planes where a safer fuel than JP-4 was required for storage aboard the carrier, and is now used by all sea-based aircraft. The boiling point for this cut of fuel

is within a range of 400° to 600°F. It has a high flash point, (140°F) and the vapor pressure is less than 1 psi. Since JP-5 is supplied under MIL-T-5624, it also must contain a FSII. Because of its high flash point the preferred FSII in JP-5 is DIEGME, with a required concentration level of 0.15 to 0.20 percent by volume. DIEGME shall conform to MIL-I-85470. The API gravity range for JP-5 is from 36.0 to 48.0.

- JP-7, a thermally stable fuel, is a kerosene-base fuel procured under MIL-T-38219. It is used by the Air Force for specific application in which higher thermal stability is required. It is not intended for general acquisition, but is a limited production item for use only in engines that require this product.
- JP-8 is a kerosene base aviation turbine fuel procured under MIL-T-83133. Development of JP-8 is a result of battlefield damage that had shown JP-8 was inherently a safer fuel (for example, less susceptible to ignition and sustained fires). Also, JP-8 is essentially identical to JET A-1 and would be commercially available worldwide. The API gravity range for JP-8 is from 37.0 to 51.0. JP-8 is JET A (CONUS) or JET A-1 (OCONUS) combined with the additives: FSII, SDA and Corrosive Inhibitor. JP-8 has been established as the single fuel for the battlefield by DOD directive. JP-8 is used in both aviation turbine engines and compression ignition engines.
- JET A (CONUS) and JET A-1 (OCONUS) aviation turbine fuel is essentially identical to JP-8 except it does not contain the three additives required in JP-8. JET A/JET A-1 is the standard fuel used by commercial airlines worldwide. It is procured under ASTM D 1655.

Diesel Fuel. Diesel fuel can be classified in either the petroleum-base liquid propellants and fuels category or the fuel oils category. It is used in diesel engines and depends on the heat of compression of an air charge for ignition. Diesel fuel is graded according to its use. DFM is procured for use on ships under military specification MIL-F-16884. Diesel fuels used in certain turbine and compression-ignition engines are procured under the Commercial Item Description A-A-52557 in Grade Low Sulfur No. 1-D (DL1) and Grade Low Sulfur No. 2-D (DL2). Diesel fuels may also be used in place of light burner fuels. Diesel fuel properties that have considerable influence on the performance and reliability of a diesel engine are listed below.

- Ignition quality.
- Volatility.
- Tendency to form carbon deposits on engine parts.
- Viscosity.
- Sulfur content.
- Ash and sediment.
- Flash point.
- Pour point.
- Acidity.

Section II. Fuel Oils

BURNER FUELS

Burner fuels are used in boilers or furnaces to generate power or heat. These liquid fuels have several advantages over solid fuels. These advantages are:

- Greater heating value on a weight or volume basis so that less storage space is required.
- More efficient combustion because of better contact between fuel and air under conditions of use and an almost complete absence of ash.
- Greater ease of handling and firing.

- Greater heat input for a given combustion space.

Classes of Burner Fuels. Two classes of burner fuels: military and commercial, are discussed below.

- Military burner fuels are procured under military specification, MIL-F-859, in grade Navy Special for use in steam-powered vessels. Specifications for these fuels are not exacting, but compatibility is sometimes of concern to the user. Different lots of fuel procured on a worldwide basis must be compatible because some burner fuels, stable when stored separately, may not be stable in combination.
- Commercial burner fuels are procured under ASTM Specification D 396 and are intended for general heating purposes. There are seven grades established in this class of burner fuels: No. 1, No. 2, No. 4, No. 4 (light) No. 5 (light), No. 5 (heavy) and No. 6. These fuel oils differ chiefly in viscosity and gravity and in types of burners required for use. Some fuels require preheating before combustion takes place, and burners used with these fuels must have preheaters.

KEROSENE

Kerosene is used by the military services as an illuminating oil, for space heating and for other general purposes such as cleaning tools and equipment. It is supplied under ASTM Specification D 3699 in grade K-1 (low sulfur, mandatory for use in nonflue connected burner appliances) and grade K-2 (for other burner applications). Good quality kerosene boils in the approximate range of 300° to 572°F. Thus, there is an absence of heavy ends or extremely high boiling point fractions that interfere with clean burning in lamps or complete vaporization in stoves. Also, the absence of light ends or very low boiling point fractions gives the kerosene a relatively high flash point to secure safety in handling, storage, and burning.

Section III. Lubricating Oils and Greases

PURPOSE

The primary purpose of any lubricant is to reduce friction, which would eliminate metal-to-metal contact. Lubricating oils provide a film that permits surfaces to glide over each other with less friction. Therefore, lubrication is essential to prevent wear in any mechanical device where there are surfaces rubbing against each other. Oils are also used to clean, seal, and cool the equipment. The selection of the proper lubricating oil for a given application depends upon the design of the equipment and the condition under which the equipment is to be operated.

LUBRICATING OILS

Many lubricating oils are produced from the light and heavy lubricant fractions of crude oil. Some are made from steam or vacuum distillates, some from residual stocks, and some from blends of distillates and residuals. Distillate stocks contain substances in the approximate (C_{25} - C_{40}) range; residual stocks contain substances in the (C_{50} - C_{80}) range. These oils boil in the range of 300° to 1,000° F. The nature of these oils varies from spindle oils, which are only a little more viscous than kerosene, to highly viscous and heat-resistant aircraft engine oils. Generally, topped crudes are subjected to vacuum distillation to separate the various lubricant cuts. Refining removes most of the undesirable components such as wax, asphalt, and oxidizable impurities. After refining, stocks are blended and compounded with fatty materials, as necessary to achieve desired results. Various additives are blended in to delay oxidation and formation of acids and suppress crystallization of wax. This blending process also lowers the pour point, promotes oiliness, strengthens the lubricating

film, reduces foaming, improves the viscosity index, and supplies a detergent and dispersant quality to the lubricant. Increased use of synthetic base oils will lessen the demand for petroleum base lubricants.

REQUIREMENTS

Lubricating oils used by the military are too numerous to list in this publication. The ARMYLOG/FEDLOG has a complete list of petroleum products and identifies the appropriate specifications. A great volume of lubricating oils is included in three important categories: military symbol oils, crankcase oils, and gear oils. Selected large volume oils procured in these categories are shown in Table 2-1. (All of the oils listed there have petroleum bases except the last two, which have synthetic bases.) Table 2-2 lists the SAE numbers and military symbol equivalents of various lubricating oils.

Table 2-1. Lubricating oils and specifications

Specification	Product
MIL-L-2104	OE/HDO-30, OE/HDO-40, and OE/HDO 15/40multi-weight oils
MIL-L-2105	GO-80/90, and GO-85/140
MIL L-6081	MS 1005 and MS 1010
MIL-L-6082	MS 1080,1100 and1120
MIL-L-9000	MS 9250
MIL-L-17331	MS 2190 TEP
MIL-L-53074	MS 5190, 5230
MIL-H-17672	MS 2075TH, 2110TH, 2135TH
MIL-L-7808	Symbol LGT (Synthetic Base)
MIL-L-23699	Lubricating Oil, Aircraft, Turbine (Synthetic Base)

Table 2-2. SAE numbers and military symbol equivalent

SAE No.	Military Symbol Oils
10W	OE/HDO-10, 1010
20W	2075, 2110
30	2190 TEP, 9250, 1065, OE/H00-30, 2135, 6075
40	OE/HDO-40, OE/HDO 15-40
50	1100, GO 80/90
140	5190, GO 85-140
250	5230

LUBRICATING GREASES

In general, grease should not be used where oil will perform the necessary lubrication. There are conditions however when grease is a more suitable lubricant. Grease is used in bearings, which, because of their nature, are unable to retain oil. Grease is also used in inaccessible bearings where the grease is applied by grease cups. Under dirty atmospheric conditions, the use of grease is advisable as it seals the ends of the bearings and thus prevents dust and dirt from entering the bearings. Also, it is preferred in food processing plants and paper and textile mills where drip and splatter must be avoided.

CLASSIFICATION OF GREASES

Greases are classified according to their soap base or thickener. These, in turn, govern the properties and application of the lubricant in a general way. The soaps used are derived from fatty animal or vegetable oils such as tallow or cottonseed. New greases include: disperses of soap in nonpetroleum liquids, and nonstop thickeners in petroleum oils. A third type of grease, nonpetroleum-nonsoap, consists of such substances as silicone liquids thickened with alkyl ureas. General classes of greases are as follows:

- Calcium Base Grease. Calcium base greases containing low viscosity oils are cup greases. Those containing slightly more viscous oils are pressure gun greases. These are used in relatively slow moving bearings. The greases are water resistant, but they do not retain consistency well at high temperatures.
- Sodium Base Grease. Sodium base greases, containing the more viscous oils, will hold up in situations where high temperatures can be expected. They are soluble in water. These greases are used in gears and in faster moving bearings.
- Lithium Base Grease. Lithium base greases are water resistant and possess good low temperature characteristics. They are more costly than calcium and sodium base greases and their use is often restricted to low volume applications.
- Aluminum Base Grease. Aluminum base greases are water resistant and retain consistency well at moderate temperatures. They combine the characteristics of both calcium and sodium base greases. Aluminum base greases are used for gears, for reciprocating parts, and for the lubrication of equipment used in food and textile mills.
- Barium Base Grease. Barium base greases are water resistant and can be used at high temperatures.
- Mixed Base Grease. Mixed base greases are used where calcium or sodium base greases cannot be used. Mixed base greases are used on high-speed, anti-friction bearings under wet conditions and for the lubrication of steam-heated calendar rolls in paper and textile mills.

GREASE REQUIREMENTS

Some of the large volume greases used by the Army include industrial, general-purpose grease, (supplied under federal specification VV-G-632); automotive and artillery grease, (supplied under military specification MIL-G-10924); and ball and roller bearing grease, (supplied under specification DOD-G-24508).

PROPERTIES OF GREASE

Essential properties of greases include appearance, penetration (worked), stability, corrosion, resistance to aqueous solutions, dropping point, fuel resistance, odor, free acidity, oxidation, and oil separation.

MISCELLANEOUS PRODUCTS

The following petroleum products are categorized in the miscellaneous category:

- Paraffin waxes and petrolatum (used in packing and sealing rations, and for dipping munitions to prevent rust and corrosion).
- Cutting oils (used as cooling mediums and lubricants for specific machine operations).
- Solvents (used as paint thinners and for cleaning metal surfaces and bearings, also used in the dry cleaning of clothes).
- Insulating oils (used as insulating and cooling medium for certain transformers).
- Asphalt (used for airstrips and for roofing).

- Medicinal products.
- Fungicides and insecticides.

CHAPTER 3

PETROLEUM QUALITY

Section I. Petroleum Inspection Procedures

GENERAL

Providing quality fuel requires inspection at the point of purchase, monitoring quality during storage, and ensuring quality while distributing fuel to users. A series of inspection procedures, laboratories, and testing kits are an integral part of Army doctrine and force structure. These procedures ensure that the petroleum products used by the US Army are of the highest quality, meet the required performance standards, and can be used for their intended purpose. Inspecting and testing are necessary to ensure that only acceptable products are offered to the government by the contractor. Laboratory technicians must be aware of the need for painstaking and conscientious work to preserve life and property. These petroleum inspection procedures are divided into three distinct areas: quality control, quality assurance, and quality surveillance.

QUALITY CONTROL

QC is the inspection procedure performed by refinery personnel to monitor the production of a particular petroleum product. QC, as distinguished from QS, involves the manufacturer's inspection of the handling, step-by-step processing, and finishing of materials. It also involves the final inspection and testing of end products to ensure that contract materials are acceptable. As the US government does not currently operate any refineries, an in-depth discussion of QC procedures is not included in this FM.

QUALITY ASSURANCE

Military petroleum products are usually procured under federal or military specifications. QA is a contract administration function performed by the Government in determining whether contractors fulfill contract requirements and specifications of petroleum products and related services. QA ends and QS begins when the QAR accepts the product. Acceptance of the product represents the transfer of ownership from contractor to Government.

QUALITY SURVEILLANCE

QS includes all the measures used to determine and maintain the quality of government-owned petroleum products to the degree necessary to ensure that such products are suitable for their intended use. The purpose of QS is to ensure that products meet quality standards after acceptance from the contractor and still meet quality standards after transfer between government agencies or issue to users. QS is complete when the product is consumed or transferred to another agency or service. Until transfer or consumption, it is the responsibility of the owning service or agency to ensure product quality.

Section II. Quality Assurance

QUALITY ASSURANCE PROGRAM ADMINISTRATORS

The QA program ensures that the military services obtain products that conform to government specifications. The agencies and personnel responsible for QA are described below.

DLA. The DLA administers the QA program. In CONUS, the DLA delegates procurement inspection and acceptance responsibilities to the DCMC. OCONUS activities are delegated to the DCMCI. The DCMC subdivides procurement responsibilities into DFRs to aid in administration. AR 715-27 and DOD Manual 4140.25-M describe the policies and procedures used by Army activities and personnel for procurement inspection worldwide.

Contractor. The contractor is responsible for controlling the quality of his products during manufacture and storage so he can provide the government only those products that meet specifications IAW DLAM 4155.1 (AR 715-27). He must maintain an effective QC program, that covers testing, sampling, blending, packaging, sealing, marking, and loading of petroleum products. The contractor must perform all inspection tests on finished products required by the contract and specifications and maintain a satisfactory system of records and reports.

QAR. Government personnel responsible for administering QA at the contractor sites are known as QARs. QAR responsibilities are described below.

- Administer an IQUE of the contractor facilities to ensure that the contractor has in effect a QC system.
- Determine minimum verification testing acceptable for quality products.
- Verify that required tests are performed for compliance with specifications.
- Obtain quality data from the contractor to determine products as acceptable.

QAR RESPONSIBILITIES

The QAR's functional responsibility is fulfilled when the product is accepted and ownership transfers to the government. At this time, QS begins. The QAR is usually assigned responsibility for product inspection at the field inspection office in which the product is manufactured or procured. However, if requested, the QAR may provide assistance to areas outside of their jurisdiction. In some cases, it may be to the government's advantage to have the inspection performed by an activity other than the assigned one. In this case, requesting personnel should submit rationale for reassignment action to the appropriate DCMCI agency.

QUALITY ASSURANCE INSPECTIONS AND ACCEPTANCE

Standards and methods used in performing procurement QA inspection on petroleum items are developed, established, and distributed by the DCMCI. The procurement QA inspection ensures that the military services obtain products that conform to government specifications. QA inspections for acceptance can be performed at the FOB origin or FOB destination.

FOB Origin. When specified as a FOB origin contract, QA inspection is performed at the FOB origin. The product should receive a type A test IAW AR 715-27 and MIL-HDBK-200. If the product is in compliance with all the terms of the contract, it is accepted by the government representative. When products are accepted at origin or any point other than destination, they are not reinspected at their destination for QA compliance. When the product reaches its destination, receiving locations may perform general examinations to determine that the supplies are in conformity with

the contract. They should check the type and kind of product, whether or not it is contaminated, or the volumes are correct. If the product appears to be other than that ordered, or if samples fail to meet requirements, further testing is performed and the receiving activity will contact the DCMCI to request inspection assistance and guidance.

FOB Destination. When specified as a FOB destination contract, QA inspection is performed at the FOB destination to determine compliance with the contract. Title passes to the government at the receiving activity when the product is accepted. Acceptance is based on a determination of quantity and verification of enough quality characteristics, as prescribed by MIL-HDBK-200

QUALITY ASSURANCE INSPECTION OF CONTRACTOR FACILITIES

An important aspect of QA is the inspection of contractor facilities and equipment used to manufacture and transport petroleum products.

Policy. It is DLA policy to accept only those supplies and services that fully conform, in all respects, to the contract requirements. The offer of nonconforming supplies or services to the government for acceptance should be the exception, and contractors should be discouraged from submitting requests for waivers. When a waiver request occurs, the QAR will initially review and evaluate it and forward it to the field administration office. The field administration office will then contact the appropriate office given in DLAM 4155.1 (AR 715-27). When an exception to a specification is included in the original contract or incorporated as a change, that exception will be clearly indicated on DD Form 250 series document, (Material Inspection and Receiving Reports).

Preaward Survey. The QAR may make a preaward survey of the contractor's facilities or may assist in making the survey. The purpose of the survey is to ensure that the contractor has the necessary facilities and the uncommitted capability to produce materials of the quality and in the quantities needed to fulfill the government contract. The contractor will be expected to include a quality program to ensure products are of acceptable standards. If inadequacies are evident during surveillance of contractor facilities, the inspector will record those instances of noncompliance and request corrective actions IAW DLAM 8200.2.

QUALITY ASSURANCE INSPECTIONS OF STORAGE AND TRANSFER FACILITIES

The QAR ensures that refining or terminal tanks used to store contractor-furnished or government-owned products are adequate. Consideration is given to the following:

- The amount and extent of corrosion and other contaminants present in the facilities..
- Provisions for control of water bottoms.
- Location and arrangement of suction lines and water drawoffs.
- Provisions for QC of government-owned products.
- Availability of tank calibration tables.

Transfer Lines. The QAR verifies that acceptable products designated for shipment or transfer are moved through completely segregated systems. If this is not possible, the system must be properly protected by blind or blank flanges; or open bleeder valves between double line valves in transfer lines and manifolds. Common transfer lines (non-segregated) should be displaced with the product being shipped or transferred.

Government Furnished Equipment. If the government furnishes transportation equipment, the title for the product passes to the government when the product passes through the loading orifice of the equipment. Therefore, the contractor is not responsible if the product is contaminated by unsuitable transportation equipment unless the extent of the contamination clearly indicates that contractor personnel failed to inspect the interior

of the equipment. See QA inspection of tankers and barges for inspection procedures.

Commercial Pipelines. Contractor-owned products for government use may be moved in commercial pipelines. When using this arrangement, the supply contract states that the product will be inspected at origin and accepted at destination. The product may also be tested at destination if it can be received in terminal tankage before delivery to the government.

QUALITY ASSURANCE INSPECTIONS OF TANKERS AND BARGES

The QAR must personally inspect the tanker or barge before it is loaded to make sure it is in an acceptable condition to receive cargo. The contractor is not responsible for the product once it has passed the outboard hose connections of the vessel. When a tanker or barge is scheduled for a multiple port loading, the QAR at the first loading port inspects all cargo tanks, if possible. For the tanker or barge to pass the inspection, all the cargo tanks must be approved for loading. Representatives at subsequent loading points are advised of the results of the inspection at the first loading port. Tanks not inspected at the first loading port should be inspected at a subsequent port and accepted or rejected. Tanks previously inspected and accepted, but not loaded, may be rejected at a subsequent port if the conditions appear to warrant this action. Regardless of pressure or protests, representatives must not expedite vessel movements at the expense of quality or quantity determinations. The following actions are required during inspections of tankers and barges..

- The QAR may require that samples of rust be taken from selected cargo tanks and tested with the product being loaded, or a similar solvent. This test is performed to determine the effect upon the corrosiveness and gum characteristics. The rust is pulverized and added to a sample of the product to be loaded, or a similar solvent, in proportions of 1 gram of rust per 100 milliliters of the liquid. After the mixture has been shaken vigorously for at least 1 minute, it is filtered free of rust and examined for color, corrosion, and residue, as required by the product specifications.
- Loading plans are reviewed to ensure they are workable. Consideration must be given to bulkheads, lines, tank capacities, ship's trim, and other factors. If cargoes are split, the QAR makes sure the vessel is structurally suitable for handling two or more grades of product simultaneously without contamination. The representative also ensures that the bulkheads are secure and that the vessel has double valve separation or line blanks.

QUALITY ASSURANCE INSPECTIONS OF TANK CARS AND TANK VEHICLES

The QAR ensures that the contractor performs specific inspections of tank cars and tank vehicles. The contractor must inspect all tank cars and tank vehicles before loading to ensure they are suitable to receive and transport the product. Any tank car or tank vehicle that is not acceptable for loading is rejected. Any tank car or tank truck, received by the contractor from a military activity, which contains a product in excess of 200 gallons, will be reported by the QAR to the responsible supply officer. The following actions are required during inspections of tank cars and tank vehicles.

- The contractor must sample and test any residue remaining in the conveyance from a previous haul to determine whether a new product can be loaded on top of the residue. If the residue cannot be identified, the conveyance is rejected. The incompatible residue must be drained and the conveyance flushed or cleaned as needed.
- The contractor must maintain filtering devices in tank cars, tank vehicles, and small container filling lines. He must make periodic inspections of this equipment, keep records of the inspections, and make needed repairs or replacements to the equipment, when necessary.
- The contractor must check loaded conveyances for water and sediment. Any free water must be removed before shipment, except for jet fuels and lubricating oils, in which case the conveyance will be rejected.

- The contractor must ensure the product in the discharge manifold of a loaded tank vehicle is the same grade and color as that loaded.
- The contractor must perform applicable tests on representative samples taken from each loaded conveyance to ensure the product has not been adversely affected.
- The contractor is responsible for maintaining records of test results and retaining samples.

- The contractor must seal the domes of the tank cars and all openings of the tank vehicles, with numbered seals, after the conveyance has been loaded.

QUALITY ASSURANCE MEASUREMENTS AND DOCUMENTATION

The QAR ensures that the contractor performs all quantity measurements according to the ASTM methods listed in the contract. Volume correction to gallons at 60°F is required for:

- All product volume measured in storage tanks, prior to receipt.
- Residual fuels and lubricating oils measured in tank trucks. Residual fuels for this purpose are products with a viscosity equal to or greater than a regular (not light) No. 4 fuel oil (ASTM D 396).
- All other volumes of fuel and fuel oil deliveries that equal or exceed 3,500 gallons, unless not required per contract provision.

Products Shipped By Tanker or Barge. The quantities of products shipped from or received by a tanker or barge, for FOB origin, shall be determined (at contractor's option) by shore tank or shipping tank measurements or calibrated meters. A government representative may be present to witness measurement. For FOB destination, quantities shall be determined (at Government's option) on basis of receiving (shore) tank measurements or calibrated meter if the facility is so equipped. A contractor representative may be present to witness the delivery measurement.

Products Shipped By Tank Car. Quantities shipped by tank car are determined from rated shell capacity or net weight of contents; quantities shipped by tank vehicle are determined from vehicle shell calibration tables, net weight of contents, or calibrated meters.

Product Shipped by Pipeline. Quantities moved by pipeline are determined by use of calibrated meters or by tank gages at the point of origin, unless otherwise provided by contract.

Products in Contractor Terminals. Quantities of government-owned products in contractor terminals are inventoried and reported as required by contract. Quantities of government-owned products in commercial pipelines are reported separately. Inventories are witnessed and certified by the QAR.

Losses. The QAR assists departmental activities in investigating the loss of government-owned products. Losses connected with shipping are reported on SF 361 (Discrepancy in Shipment Report). Losses connected with government-owned products in the custody of contractors or in the custody of the government are reported on DA Form 4697 (Department of the Army Report Survey).

Inspection Documentation. The QAR ensures that the contractor has prepared the required inspection documents before the QAR completes it. These documents include DD Form 250 (Material Inspection and Receiving Report) and DD Form 250-1 (Tanker/Barge Material Inspection and Receiving Report). DD Form 250 is used to document receipts of contractor shipments of DLA-owned bulk fuel, by over-land transport or pipeline to DFSPs. DD Form 250-1 is used to document shipments and receipts of bulk fuel

transported by ocean tankers and barges. Samples of these forms are included in Chapter 10.

Section III. Quality Surveillance

QUALITY SURVEILLANCE PROGRAM ADMINISTRATORS

QS begins when petroleum products are accepted by the government. It applies to all petroleum-related products, and is the responsibility of all personnel who handle them. Testing products in the supply system is necessary to confirm that petroleum products are satisfactory for their intended use. The Quality Surveillance Handbook for Fuels, Lubricants, and Related Products (MIL-HDBK-200) sets forth procedures and requirements used by the military departments and the DLA. Agencies and personnel responsible for QS programs and procedures are described below.

- The USAPC, New Cumberland Army Depot, New Cumberland, PA, is responsible for developing, coordinating, and monitoring CONUS QS programs as described in AR 710-2. This activity is under the staff supervision of the AMC and the operational control of the TROSCOM. Besides the USAPC laboratories, other laboratories that have a limited quality surveillance capability are located at Fort Hood, Tx; Fort Lee, VA; Fort Campbell, KY; Fort Bragg, NC; Fort Stewart and Fort Benning, GA; and Fort Rucker, AL. Upon request, USAPC will provide assistance to overseas commanders in coordinating QS and technical assistance programs.
- In the theater, the JPO is responsible for ensuring that an adequate QS program is maintained within major commands. In a large theater, there may be requirements for a SAPO or offices to assist the JPO in monitoring the petroleum system in the areas of responsibility. Overseas laboratory facilities will be provided and maintained for testing fuels and lubricants per joint regulation AR 700-36 (AFR 74-16, NASUPINST 4730.1D, MCO P4760.1A, DLAR 4155.29).
- Ultimately, QS is the responsibility of every agency in the supply system that transports, stores, distributes, or issues petroleum products. Owning agencies are responsible for establishing and maintaining a QS program as prescribed by MIL-HDBK-200. The organization's commander must ensure that facilities are available and adequate to test the various petroleum products. He is also responsible for informing the JPO or SAPO, DFR, or DFSC when any petroleum product, except pipeline interface product, does not meet deterioration limits.

PETROLEUM QUALITY SURVEILLANCE AND TECHNICAL ASSISTANCE PROGRAM

The Petroleum Quality Surveillance and Technical Assistance Program consists of multiple programs designed to assist commanders in the receipt, storage, and issue of quality petroleum products. CONUS commanders will provide necessary information, equipment, and personnel available within their resources to assist the coordinating USAPC in accomplishing the requirements of these programs. The total program consists of the following elements listed below.

- Quality Surveillance Program.
- Petroleum Technical Assistance Program.
- Operational Surveillance Program.
- Air Pollution Abatement Program.
- Petroleum Laboratory Certification.
- Engineering Technical Review Program.

- Underground Storage Tank Program.

Quality Surveillance Program. The Quality Surveillance Program is conducted to ensure the quality of petroleum products supplied from commercial sources directly to US Army, ARNG, and USAR units, and maintain the quality of Army-owned petroleum. It will be conducted on all bulk petroleum, and packaged products at the frequencies established in MIL-HDBK-200. It can be conducted more frequently, if desired, for closer surveillance or when directed by USAPC. It will be established worldwide for both bulk and packaged products. Samples are taken from delivery conveyances, and commercial product sources, IAW DA PAM 710-2-1, for each contract, (including local purchases) totaling more than 10,000 gallons annually.

- In CONUS, USAPC will establish a CONUS sampling schedule. Although the USAPC is not responsible for QA, petroleum products are tested upon receipt from the contractor to establish a base line for future testing. Upon request, the USAPC will provide to the submitting activity detailed sampling instruction, advise the submitting activity of the test results, and determine if additional QS samples need testing.
- In OCONUS, commanders will establish a sampling schedule at the frequencies established in MIL-HDBK-200 or more frequently, if desired, under the guidance of the JPO.

Petroleum Technical Assistance Program. The petroleum technical assistance program is conducted in conjunction with MACOMs and administered by the USAPC to provide technical assistance to commanders in solving petroleum problems. Commanders may request help from a technical assistance team to resolve problems on receiving, storage, handling, usage, QS, supply, and distribution of petroleum products. Commanders may also obtain assistance with the design, construction, maintenance, and repair of petroleum facilities and dispensing equipment. The Technical Assistance Program is conducted in CONUS by USAPC. Upon request, USAPC will provide assistance to overseas commands.

Operational Surveillance Program. The operational surveillance program is designed to provide essential QS services to commanders of US Army and National Guard installations as well as Army Reserve units. It ensures delivery of acceptable products for use in military equipment by applying proper handling and control measures. It enables the collection and reuse of products to the maximum extent possible.

Air Pollution Abatement Program. The APAP provides a testing service to CONUS commanders for compliance with air pollution abatement standards established by law and implemented by AR 200-1.

Petroleum Laboratory Certification. All TDA and TOE petroleum testing laboratories must be certified. Certification will include a review of facilities, equipment, methods, and personnel qualifications. The USAPC is responsible for certifying all CONUS-based labs and for providing the personnel necessary to certify OCONUS laboratory facilities. Laboratories shall not perform testing for the purposes of determining suitability or disposition of petroleum products unless they are certified.

Engineer Technical Review Program. Plans for new construction, modifications, or upgrading of petroleum facilities are submitted to the USAPC for review or technical assistance. All facilities must meet all the requirements of applicable regulations and safety considerations.

Underground Storage Tank Program. This program establishes underground storage tank standards as required by law. The UST program applies to all CONUS Army and ARNG installations and USAR units that operate underground storage tanks. OCONUS units must comply with substantive requirements of federal regulations for USTs, plus the more stringent of Army or host nation requirements.

CORRELATION PROGRAMS

In addition to the Quality Surveillance and Technical Assistance Program, correlation programs exist to provide efficiency checks on certified laboratory facilities. Samples from the same cut of fuel are sent to all laboratories for testing. The results obtained from each laboratory are tabulated. Individual laboratory test results that deviate from the majority can be an indicator that the testing facility and/or equipment is substandard or personnel are not adequately trained. Results are reported to the laboratory with guidance for corrective action. Specific guidance on the correlation program is found in the appropriate command's instructions that cover POL. The USAPC administers the CONUS correlation programs. Theater-wide correlation programs are usually administered by the JPO.

QUALITY SURVEILLANCE DURING STORAGE, LOADING AND UNLOADING OPERATIONS

The petroleum laboratory technician, assigned to a base, mobile, or airmobile laboratory, provides laboratory testing support to surrounding units by performing prescribed tests on petroleum samples submitted IAW MIL-HDBK-200. He also provides laboratory testing on any samples submitted of questionable quality. The test results are documented and provided to the supported units with recommendations, when necessary. They perform the technical evaluation necessary for QS. The majority of information contained in this FM addresses the duties and responsibilities associated with the operation and maintenance of a base, mobile or airmobile laboratory. However, the QAR implements QS in petroleum storage and distribution operations. Minimum procedures required for proper quality surveillance of storage operations are discussed below.

QUALITY SURVEILLANCE DURING STORAGE OPERATIONS

QS of storage operations requires the following procedures.

- Store only one kind of fuel in a tank to maintain fuel quality. If it is necessary to store another type of fuel in a tank, the tank must be cleaned before pumping in the new fuel.
- Inspect storage tanks IAW MIL-STD-457. Establish a card file to record the inspection results and establish tank cleaning schedules.
- Segregate products and grades in separate systems when possible and identify lines and facilities as prescribed in CFR, Title 29-Labor. Protect the product by using blind or blank flanges or open bleeder valves between double line valves, or by removing a section of pipe. Segregation by a single valve is not sufficient.
- Consolidate on-specification stocks. This will keep storage tanks filled for shipments or issues and keep other tanks empty for receipt of new products. It will also reduce breathing and evaporation losses, reduce the number of tank switches in batching operations, and allow necessary time for settling and testing of new stocks before using.
- Receive on-specification products into partly filled tanks if necessary, but do not add new stocks of doubtful quality. Be sure that the fresh product received into a partly filled tank is the same product and of equal or better quality than the old product.
- Refer to MIL-HDBK-200 for the minimum settling time requirements for petroleum products before using.
- Bulk fuel tanks should be drained of water after each product receipt and at a minimum of weekly, thereafter. Do not maintain water bottoms unless specifically authorized by the appropriate technical authority.
- Sample and test dormant stocks as prescribed in quality surveillance tables in MIL-HDBK-200.
- In instances where water bottoms cannot be completely removed, the water layer should be checked monthly. Check for the presence of hydrogen sulfide that sometimes forms as a result of bacterial action in sulfates present in the water. Hydrogen sulfide is corrosive and will cause the product to fail the copper corrosion requirement of the specification.

- Water checks should be made daily in issue tanks and weekly in static tanks or each time a tank is gaged. If water is found, it should be drained as soon as possible.

QUALITY SURVEILLANCE DURING TANKER AND BARGE LOADING OPERATIONS

A barge is any vessel with less than a 30,000 barrel capacity. A tanker is any vessel with over a 30,000 barrel capacity. Minimum procedures required for proper QS in tanker and barge loading operations are as follows.

- Tankers and barges should be used for one-product service when possible. Otherwise, a tanker or barge should be used for clean products or for black products only.
- Any vessel with greater than a 30,000 gallon capacity, is inspected by tank entry and prepared IAW AR 715-27, Table II (Guide for Preparation of Cargo Tanks).

- By referring to the ship's log, the government representative must verify that minimum procedures listed in DLAM 4155.1 (AR 715-27) were followed to prepare cargo tanks for change of product.
- The government representative reviews the cargo layout plan. He verifies that split cargoes are properly separated to prevent intermingling.
- Cargo tanks that have been ballasted with salt water must be stripped and wiped dry before loading. Any water in the tank or lines needs to be removed.
- The quality of the product in shore tanks and all lines used in loading must meet specifications. Approximately 2,000 to 5,000 barrels or at least line fill, should be pumped into one center cargo tank in the vessel. The ship's officer should then switch the loading to another tank and continue loading. A sample should be drawn from the first tank and tests performed to determine if the quality of the product being loaded is satisfactory. Further sampling and testing are conducted at the discretion of the representative. If at any time there is an indication of contamination, the loading operation is stopped until the cause and extent of the contamination is determined.

QUALITY SURVEILLANCE DURING JET FUEL OR KEROSENE LOADING OPERATIONS

When jet fuel or kerosene is loaded, minimum QS procedures are enforced. They are described below.

- Before loading, all lines are dropped and water removed from the cargo tanks.
- Initial loading will be at a rate not more than 3 feet per second (about 1,500 barrels per hour through a 1/2-inch line) through loading lines into the cargo tanks until the discharge outlet has been covered by at least three feet of the product. Thereafter, the normal loading rate is resumed. The loading rate will not exceed the sum of the allowable rates for the individual tanks being filled. If turbulence or splashing occurs in a cargo tank after the discharge outlet is covered by the specified 3 feet of product, the reduced loading rate should be applied until the turbulence ceases.
- When a cargo tank is filled, ullages, water soundings, temperatures, and samples should not be taken until 30 minutes after flow has ceased to allow static charge to dissipate. Quality spot checks can be made 30 minutes after cessation of flow. Whether the tank is being completely filled or just partially filled the same waiting restrictions apply before sampling is permitted.
- If strapping tables are available, on-board quantities are estimated for comparison with quantities delivered from shore tanks. The representative enters quantities shipped on DD Form 250-1 and testifies as to quality of product loaded. If ship and shore corrected quantity figures differ by more than ± 0.5 percent, investigate the difference by regaging, checking seals, or other actions. Enter results of investigation on DD Form 250-1 in the REMARKS block. The ± 0.5 percent figure must be tempered with the known loading history of the ship.

QUALITY SURVEILLANCE DURING TANKER AND BARGE UNLOADING OPERATIONS

The following QS procedures are recommended when unloading tankers and barges.

- All level samples are taken from cargo tanks, and the receiving checks are performed as prescribed by the QS table in MIL-HDBK-200 before discharging begins. Verify all seals shown on the document. If the API gravity of any tank differs by ± 0.5 percent API from the loading API gravity, isolate that tank until its quality is verified. Other prescribed tests are performed on composite samples. However, discharging operations should not be delayed further if the receiving checks are favorable.
- Ullages, water soundings, and temperatures of cargo tanks are taken. If strapping tables are available, quantities on board are compared with quantities obtained at the loading point. Any deficiencies in the quantity or quality of the product at the loading point are noted.
- Gages, water measurements, and temperatures of shore tanks are taken before and after discharging. Final gages must be done as soon as possible but cannot be started until tanks have settled for 30 minutes to dissipate static electricity. After the initial 30 minute wait, gages can be repeated at 15 minute intervals until the two are constant. Final quantity figures are entered on DD Form 250-1 before vessel departure.
- Checks must be made to verify that shore and pier lines are empty or full before and after discharge.
- Cargo tanks are inspected after discharging. If strapping tables are available, quantities discharged and those remaining are compared with quantities delivered to shore tanks.
- Shore tanks are sampled and post discharge tests are performed after settling a minimum of 2 hours or 1 hour per foot in depth, if time permits.
- Any product received that does not conform to established use limits is reported to the JPO.

QUALITY SURVEILLANCE DURING TANK CAR AND TANK VEHICLE LOADING AND UNLOADING OPERATIONS

Minimum procedures required for proper QS in tank car and tank vehicle loading and unloading operations are described below.

- Refer to MIL HDBK 200, Table V, for instructions when internal inspection or sampling show the need for cleaning tanks.
- When possible, store the same product repetitively in tank cars and tank vehicles to reduce the need for cleaning and to prevent contamination.
- Verify that minimum procedures listed in AR 715-27 have been followed if the product is changed.
- Inspect the interior and mechanical condition of tank cars and tank vehicles to be sure they are in condition to receive the product to be loaded.
- Verify that the products in storage tanks have been checked for shipment tests prescribed in the applicable QS table in MIL- HDBK-200.
- Ensure that qualified filter/separators have been installed in the supply lines from fuel storage tanks to loading racks.
- Placard each vehicle as prescribed in CFR, Title 49-Transportation. Do not split-load tank vehicles because of mixing in common discharge systems. Ensure that the vehicles have required markings and placards IAW AR 55-355 and applicable DOT regulations.
- Check the loaded tank cars and tank vehicles for shipment tests prescribed by the applicable quality surveillance table in MIL-HDBK-200. Perform a visual check on loaded conveyances for water and ensure that it is removed if present. Also check for grade and color of product in discharge systems of tank vehicles.
- Secure dome covers and attach serial numbered seals to the domes and outlets immediately after checking the contents. Seal any place where cargo can be removed. Enter API gravity and all seal numbers on the documents.
- Check seals at destination and perform receiving checks prescribed by the QS table before unloading. If water is present, remove it. If API gravity is more than ± 0.5 of the loaded gravity, hold the shipment and notify the laboratory as soon as possible (DLAM 4155.1/AR 715-27).

Fuels that have a cloudy appearance or an unusual color should not be accepted until laboratory test(s) indicate they are suitable for use.

- Be sure that a tank car or vehicle discharges into the storage tank intended to receive the product. If the contents are transferred to another tank vehicle, be sure that the receiving vehicle is in the proper condition to receive the product with no danger of contamination.

QUALITY SURVEILLANCE DURING PIPELINE OPERATIONS

QARs exercise QS over all movement in government-owned and commercial multi-product pipelines to maintain the quality and quantity of products owned by the government.

Commercial Pipelines. Government-owned products moved in commercial pipelines are inspected as prescribed by the supply contract and commercial tariffs. The inspection of pipeline operations generally include:

- Handling of batches (cycling, pumping rates, progress checks at test points).
- Generation, handling, and evaluation of interfacial mixtures.
- Cutting of batches into receiving tankage.
- Verification of product quality in receiving tankage.
- Use of corrosion inhibitors.
- Periodic checks of government-owned products for solid's content.

The military department having physical possession of the products is responsible for establishing and maintaining an adequate QS program in compliance with MIL-HDBK-200. Army personnel responsible for QS of multiproduct pipeline operations are required to follow these minimum procedures:

- Refer to AR 715-27 for proper sequence of batches and recommended cut points, for computation of volume of interfaces, and for recommended batch change records.
- Verify quality of product in pipeline receiving tankage after receipt. Select identification test IAW MIL-HDBK-200.
- Plan tank switches and necessary valve operations in exact compliance with the pumping order for better control of the interface formed when a new batch is pumped into the line.
- See that necessary velocity and pressure for turbulent flow is maintained. See that the pressure is maintained in every part of the line that must be shut down.
- Check color or gravity, depending on the product, in all batch changes at each successive terminal or checkpoint for the dispatcher's information as he follows the progress of batches and makes deliveries from the line.
- Make deliveries at intermediate terminals and to branch pipelines by means of heart cuts.
- Remove interfaces from the pipeline at the last takeoff point for each product to simplify handling and to prevent formation of new interfaces.
- Observe proper batch sequence to form interfaces that can be cut into one or both of the adjacent products. Segregate any interface that cannot be so disposed of.
- Test the segregated interfacial material to determine what products, if any, it can be blended with and in what proportions. The petroleum laboratory determines the disposition.
- Check samples from all storage tanks after receipts from the pipeline, (particularly those from tanks that have received part or all of an interface) to ensure that the product is within use limits.
- Earmark the contents of a tank found to be just within use limits after receipt of an interface, for early issue or shipment.. Avoid cutting a second interface into such a tank before it has been emptied.
- Perform ASTM D 2276 to determine particulate contamination in petroleum products

Section IV. Cleanliness Standards for Aviation Fuels

GENERAL

Aviation fuels require special handling and surveillance. QM units are primarily responsible for QS during the receipt, storage, and distribution of bulk petroleum products in a theater of operations. However, the handling and surveillance of a product at unit level is the responsibility of that unit. The aviation unit has the operational responsibility for ensuring the aviation fuel receives the required special surveillance.

FILTER/SEPARATORS

Filters/separators remove solid contaminants and entrained water from liquid fuels. Generally, filter/separators used by the military, use identical filter elements and canisters that meet the requirements of Military Specification MIL-F-52308. When fuels are provided by one military service to another, the filtering done in connection with storing, distributing, and dispensing must meet the requirements of the supported unit. To ensure quality, all fuel must be filtered, regardless of the type of product.

Use of Filter/Separators. Aviation fuel must be kept free of solid and water contamination before using. At a fuel system supply point, filter/separators should be installed on the delivery side between the discharge pump assembly and the receiving side of the dispensing facilities. Aviation fuels must be passed through an approved filter/separator of suitable capability before it is delivered to any receiving unit. It must also pass through a filter/separator before being put into any refueling vehicle. Finally, the fuel is again passed through a qualified filter/separator before being dispensed to an aircraft.

Replacement of Filter Elements. The effectiveness of filtration is indicated by the amount of pressure differential across the filter/separator. The effectiveness of filtration of aviation fuels should be determined after filter elements are initially installed or changed, and every month thereafter, by following the procedure described in ASTM D 2276. The appropriate TM for each filter separator should be checked for information on the replacement of filters. The pressure differential with clean, new element(s) is usually 2.5 psi or less. The filter elements should be changed for the following reasons:

- The pressure differential drops suddenly, indicating probable rupture, or it exceeds maximum pressure differential specified for the separator.
- The reading on the pressure differential indicator is in the red (35 psi and above).
- Laboratory analysis of two successive samples finds that too much water or particulate matter is getting through the filter/separator.
- A conversion is being made from pumping a lower grade product to a higher grade one.
- A DOD standard filter element, NSN 4330-00-983-0998, that has been in use for 24 months should be changed.
- A filter change is made when converting from any fuel to jet fuel.
- Twenty-four months has elapsed or an inspection shows they are ruptured or not properly installed.

SOLID CONTAMINATION

Solid contamination consists of both suspended particles and sediment that may come from any of the following sources: sand or dirt, dust from the air, metal from repair or wear, plasticixers from hose liners, lint, or black (magnetic) and red (non-magnetic) iron oxides. The size of particles and the amount are of critical importance because of small clearances in aircraft and diesel equipment. Fine particles are less than 10 microns in size. A micron is 0.001 millimeter, or 1/25.400 of an inch. These particles are not ordinarily visible to the unaided eye. Thus, a fuel without visible solids is not necessarily acceptable.. Fine particles less than 5 microns in size cannot be removed readily

by settling. Coarse particles are 10 microns or larger, and these can be detected visually. Such contamination settles out fairly easily, and all of it can be separated by adequate filtration. For additional information on contamination, see Table 3-1.

WATER CONTAMINATION

Water may be present in the dissolved state or in the free (emulsified) state. Water dissolved in fuel is similar to moisture in the atmosphere. Dissolved water cannot be detected visually, nor can it be removed by filter/separators. Small quantities of water do not harm the fuel if the water remains a solution. However, it separates readily when the fuel cools to a temperature lower than that at which the water went into the solution. Dissolved water becomes free water when it separates from the fuel.

Free Water. Free water may appear in the form of a cloud or haze. It may also appear as an emulsion. It may appear in the form of droplets clinging to the side of containers, or in larger quantities on the bottoms of containers. Free water is undesirable because it causes icing, corrosion, and malfunctioning of aircraft accessories. Free water in gasoline, diesel fuel, and turbine fuel can be removed easily by settling and by adequate filter/separators.

Table 3-1. Contamination table

Contaminant	Appearance	Characteristics	Effects on Aircraft
Water:			
Dissolved Water	Not visible	Fresh water only; separates as cloud when fuel cools.	None, as long as it remains in solution; see free water.
Free water	Light or heavy cloud; droplets clinging to sides of container; or large amounts on bottom of container.	Fresh water or salt water.	Icing of fuel system, erratic gage readings; large amounts can cause flame-out; salt water corrodes fuel system components.
Solid matter			
Rust	Red or black powder, rouge, or grains; may appear as dye-like material in fuel.	Red (Fe203) non-magnetic; Black (Fe304) magnetic; often comprises 70-90 percent of total solids.	Causes sticking, sluggish or general malfunction of fuel controls, flow dividers, pumps, nozzles,
Sand or dust	Crystalline, granular, or glass-like.	Often comprises 0-20 percent of total solids.	Same as rust.
Aluminum, cadium or magnesium.	White or gray powder or paste.	Sometimes sticky or gelatinous when wet; sometimes comprises 0-10 percent of total solids.	Same as rust; and may reduce fight range and high altitude performance.
Emulsions:			
Water-in-fuel	Light or heavy cloud.	Finely divided drops of water in fuel; same as free water cloud; usually settles out at about the same rate as free water.	
Fuel-in-water	Reddish, grayish, or	Finely divided drops of	Same as free water and

	blackish; sticky material variously described as gelatinous or gummy; often appears as fibrous or stringy material in clear or cloudy fuel.	fuel in water; often contains rust that stabilizes the emulsion; adheres to materials normally in contact with fuel; emulsion may persist for indefinite period; contains 50-70 percent water, and 30-50 percent fuel.	sediment or suspended matter; quickly causes filter plugging and erratic readings in fuel quantity probes.
Miscellaneous Interfacial matter Air bubbles	 Lacy bubbles or scum in interface; resembles jelly fish. Cloud in fuel	 Result of bacterial action on sulfates in fresh water; H2S may be generated. Easily dissipated	 Same as free water; deposits of matter may be left in fuel tanks. None.

TESTING EFFLUENT SAMPLES FOR WATER.

Samples from aircraft refueling vehicles should be tested daily on site using the Aqua-Glo series II/III ultraviolet detector kit, to determine the amount of water in the fuel. Also, aviation fuel should be visually examined each time a sample is analyzed for solids. Visual inspection procedures are described below.

- Step 1- Fill a clean 1-liter bottle from the effluent stream and note appearance of fuel. Record appearance as clear and bright, hazy, or cloudy.
- Step 2- Observe samples appearing clear and bright for the presence of minute droplets of water when sampling.
- Step 3- Allow the sample to stand for 15 minutes and repeat step 2 above. Record the presence of any droplets.

CHAPTER 4

PETROLEUM LABORATORY PERSONNEL, FACILITIES, AND TESTING EQUIPMENT

Section I. Petroleum Laboratory Personnel

PETROLEUM LABORATORY OFFICER

The petroleum officer, 92F, 0-2, commands or exercises staff responsibilities for units engaged in petroleum operations. He directs the acquisition, storage, inspection, testing, issue and distribution of petroleum products and water. Specific to the petroleum laboratories, his responsibilities include:

- Determine QS requirements.
- Perform and direct QS at points of procurement and throughout the petroleum distribution system.
- Direct base or mobile laboratory operations in testing procedures.
- Supervise performance of standard physical and chemical tests.
- Evaluate test results to ensure products meet federal and military specifications.
- Recommend disposition of off-specification or captured petroleum products.

PETROLEUM LABORATORY SPECIALIST

The petroleum laboratory specialist supervises or conducts laboratory tests on POL. The tests are performed IAW ASTM test methods and the products are evaluated IAW military and federal specifications. At the ascending skill levels, the laboratory specialist is responsible for identifying sources and types of contamination and deterioration, recommending reclamation and disposition, planning and implementing QS operations, and performing QA/QS as a OAR/OSR. At all skill levels, the laboratory specialist is responsible for adherence to fire and safety procedures and compliance with all governing environmental regulations.

DUTIES OF PETROLEUM LABORATORY SPECIALIST

Skill Level 1. Specific responsibilities of the petroleum laboratory specialist at skill level 1 are described below.

- Receives samples and conducts tests on petroleum products.
- Reports findings IAW ASTM test methods.
- Evaluates test results with specification requirements and makes recommendations regarding product disposition.
- Applies fire prevention and safety control procedures in handling volatile POL products.
- Applies principles of OHSA and EPA regulations for possible violations of environmental control laws.

Skill Level 2. Specific responsibilities of the petroleum laboratory specialist at skill level 2 are described below.

- Identifies sources and types of contamination and deterioration. Makes recommendations for reclamation and disposition.
- Furnishes required QS reports to higher HQ.
- Performs organizational and preventive maintenance and calibration on laboratory equipment.
- Performs fire and safety inspections.

- Applies principles of OSHA and EPA regulations for possible violations of environmental control laws.

Skill Level 3. Specific responsibilities of the petroleum laboratory specialist at skill level 3 are described below.

- Plans and organizes petroleum laboratory activities.
- Establishes files and technical references and specifications.
- Prepares and reviews administrative and technical reports.
- Supervises all supply activities and coordinates activities with POL storage and distribution.
- Assists in establishment and supervision of QS programs.
- Ensures adherence to laboratory fire and safety procedures.
- Applies principles of OHSA and EPA regulations for possible violations of environmental control laws.

Skill Level 4. Specific responsibilities of the petroleum laboratory specialist at skill level 4 are described below.

- Performs staff and advisory duties by assisting and planning quality assurance, surveillance operations, and programs.
- Inspects contractor facilities to ensure compliance with all provisions of the contract.
- Coordinates special testing of POL products, including troubleshooting of differences in results among laboratories
- Applies principles of OSHA and EPA regulations for possible violations of environmental control laws.

Section II. Petroleum Laboratories

GENERAL

Petroleum facilities and testing equipment used to perform QS in a theater of operations includes several types of laboratories and a series of test kits. The Army inventory includes base labs, modular base labs, mobile labs and airmobile labs. It also includes aviation fuel contamination test kits, ground fuels test kits, captured fuels test kits, sampling and gauging kits, and aqua glo test kits. Actual needs for QS equipment/facilities will vary depending on the structure of the units deployed, location within the theater, urgency, and other considerations.

CONUS ARMY LABORATORY FACILITIES

Facilities established to perform QS testing of Army-owned stocks in depots and commercial terminals are located as stated below. Other laboratory facilities that can perform most petroleum tests are at Fort Rucker, AL, Fort Bragg, NC, Fort Stewart, GA, and Fort Lee, VA.

The states located east of the Mississippi River are served by the Chief, Army Petroleum Center, Field Office, East, New Cumberland, PA, 17070. The states located west of the Mississippi River, are served by the Chief, Army Petroleum Center, Field Office West. Tracy, CA 95376.

OCONUS LABORATORIES

Laboratory facilities overseas are designated by AR 700-36 as area laboratories. These facilities are responsible for QS testing for all military services in their geographic area of responsibility.

TYPES OF LABORATORIES

The Army has petroleum laboratories which provide increasing capability in both testing scope and output. These laboratories are staffed by petroleum laboratory specialists and are assigned to petroleum units or platoons. The different types of

laboratories are: Base Petroleum Laboratory, Modular Base Petroleum Laboratory, Mobile Petroleum Laboratory, Airmobile Petroleum Laboratory, and Petroleum Quality Analysis System. Capabilities of existing laboratories, described below, are listed in Table 4-1, page 4-4. See Appendix A for illustrations of the mobile and airmobile petroleum laboratories.

BASE PETROLEUM LABORATORY (LIN: N83225)

The Base Petroleum Laboratory will be replaced by the Modular Base Petroleum Laboratory. The Base Petroleum Laboratory, is used to perform all type A, B and C tests on petroleum products, such as gasoline, diesel fuel, kerosene, lubricating oils and greases.

MODULAR BASE PETROLEUM LABORATORY (LIN: Z56271)

The MBPL consists of one mobile petroleum laboratory and a second semi-trailer containing test equipment, water supply, power distribution, and environmental control systems. The MBPL will fill the need to have a rapidly deployable base laboratory and will augment the mobile laboratories in theaters where fixed facilities do not exist. The MBPL is capable of performing all tests required by MIL-HDBK-200 on fuels and lubricants. This includes all required A-level tests, IAW approved ASTM procedures, federal test methods, and related standard petroleum procedures. The physical layout of the MBPL permits all of its test equipment, documentation, and supplies to be mounted or stored in the laboratory during operations or movement, without impeding personnel movement within the MBPL. The MBPL is powered by a 60 kw generator. This generator is capable of sustaining operations for a minimum of 20 hours. It can operate a self-contained water supply system to provide for emergency showers, eyewash, and to flush accidental spills of chemicals, (minimum of 50 gallons). It also maintains component devices in a clean, uncontaminated state after initial installment. The MBPL is also equipped with a computer for semi-automated data collection and reporting. The MBPL is a deployable, major test facility. It is allocated to a petroleum group, and normally will be employed in EAC in the COMMZ.

MOBILE PETROLEUM LABORATORY (LIN: 3800).

The mobile petroleum laboratory is a self-contained unit housed in either an M-822 or M-971 semi-trailer van. It is used to perform qualitative and quantitative tests on petroleum products in the field. Laboratory personnel can perform B-1, B-2, B-3, and C type tests on fuels; modified type A tests on fuels; and modified type B-2 tests on packaged lubricants, greases, and related fluids. The laboratory requires only an external power source, a water supply, and a waste water disposal facility when in operation. The laboratory is C-141 deployable with landing gear and dolly removed. This facility can be allocated to a Quartermaster Petroleum Supply Battalion, a Petroleum Pipeline and Terminal Operating Battalion, and a Corps or EAC area. TM 5-6640-215-13 and TM 10-6640-215-23P contain the operating and maintenance data for this laboratory.

AIRMOBILE PETROLEUM LABORATORY (LIN: L33184)

The airmobile petroleum laboratory is a self-contained unit which only needs an external power source, a water supply, and a waste-water disposal facility when in operation. The laboratory is essentially an S-280 B/G military shelter that has been modified to accommodate all of the equipment, apparatus, instruments, and supplies needed to support fuel quality testing in the forward areas. It can perform a variety of critical tests in the field, on aviation and diesel fuel. It is designed for rapid movement by ground or air and for quick on-site setup. It is air deployable by C-130 or larger aircraft or CH-47 helicopter, either by internal or sling loading. This facility is allocated to a Main Support Battalion to provide divisional support. TM 10-6640-216-13&P contains the operating and maintenance data for this laboratory.

Table4-1. Capabilities of petroleum laboratories

Test	Test Method	Base/Modular Base Petroleum Laboratory LIN L83275 LIN Z56271	Mobile Petroleum Laboratory LIN L33800	Airmobile Petroleum Laboratory LIN L33184
D 56	Flash Point by Tag Closed Tester	X	X	
D 86	Distillation of Petroleum Products	X	X	X
D 91	Precipitation Number of Lubricating Oils	X	X	
D 92	Flash and Fire Point by Cleveland Open Cup	X	X	
D 93	Flash Point by Pensk e-Martens Closed Tester	X	X	X
D 94	Saponification Number by Petroleum Products	X	X	
D-95	Water in Petroleum Products and Bituminous Materials by Distillation	X	X	
D 96	Water and Sediment in Crude Oils	X		
D 97	Pour Point of Petroleum Oils	X	X	
D 129	Sulfur in Petroleum Products (General Bomb Method)	X		
D 130	Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test	X	X	X
D 156	Saybolt Color of Petroleum Products (Saybolt Chromometer Method)	X		
D 189	Conradson Carbon Residue of Petroleum Products	X	X	
D 217	Cone Penetration of Lubricating Grease	X	X	
D 287	API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)	X	X	X
D 322	Gasoline Diluent in Used Gasoline Engine Oils by Distillation	X	X	
D 323	Vapor Pressure of Petroleum Products (Reid Method)	X	X	X
D 341	Viscosity-Temperature Charts for Liquid Petroleum Products	X	X	
D 381	Existent Gum in Fuels by Jet Evaporation	X	X	
D 445	Kinematic Viscosity of Transparent and Opaque Liquid (and the Calculation of Dynamic Viscosities)	X	X	
D 446	Films Deposited from Bituminous Emulsions	X	X	
D 473	Sediment in Crude and Fuel Oils by Extraction	X	X	
D 482	Ash from Petroleum Products	X	X	

Table 4-1. Capabilities of petroleum laboratories (continued)

Test	Test Method	Base/Modular Base Petroleum Laboratory LIN L83275 LIN Z56251	Mobile Petroleum Laboratory LIN L33800	Airmobile Petroleum Laboratory LIN L33184
D 524	Ramsbottom Carbon Residue of Petroleum Products	X		
D 525	Oxidation Stability of Gasoline (Induction Period Method)	X	X	
D 526	Lead in Gasoline, Gravimetric Method.	X	X	
D 566	Dropping Point of Lubricating Grease	X	X	
D 611	Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents	X	X	
D 873	Oxidation Stability of Aviation Fuels (Potential Residue Method)	X	X	
D 874	Sulfated Ash from Lubricating Oils and Additives	X	X	
D 892	Foaming Characteristics of Lubricating Oils	X	X	
D 893	Insoluble in Used Lubricating Oils	X	X	
D 942	Oxidation Stability of Lubrication Greases by the Oxygen Bomb	X	X	
D 974	Neutralization Number by Color-Indicator Titration	X	X	
D 976	Calculated Cetane Index of Distillate Fuels	X	X	X
D 1012	Aniline Point and Mixed Aniline of Hydrocarbon Solvents	X	X	
D 1085	Gaging Petroleum and Petroleum Products	X	X	X
D 1086	Measuring the Temperature of Petroleum and Petroleum Products	X	X	X
D 1094	Water Reaction of Aviation Fuels	X	X	X
D 1218	Refractive Index and Refractive Dispersion of Hydrocarbon Liquids	X		
D 1250	Petroleum Measurement Tables	X	X	X
D 1266	Sulfur in Petroleum Products (Lamp Method)	X		
D 1275	Test for Corrosive Sulfur in Electrical Insulating Oil	X		
D 1287	ph of Antifreeze, Antirust and Coolants	X	X	
D 1298	Density, Relative Density (Specific Gravity) or API Gravity of Crude Petroleum and Liquid Petroleum Product by Hydrometer Method	X	X	
D 1332	Smoke Point of Aviation Turbine Fuels	X		

Table 4-1. Capabilities of petroleum laboratories (Continued)

Test	Test Method	Base/Modular Base Petroleum Laboratory LIN L83275 LIN Z56251	Mobile Petroleum Laboratory LIN L33800	Airmobile Petroleum Laboratory LIN L33184
D 1796	Water and Sediment in Crude Oils and Fuel Oils by Centrifuge	X	X	
D 2270	Calculating Viscosity Index from Kinematic Viscosity	X	X	
D 2273	Trace Sediment in Lubricating Oils	X	X	
D 2276	Particulate Contaminant in Aviation Fuels by Line Sampling	X	X	X
D 2386	Freezing Point of Aviation Fuels	X	X	
D 2392	Color of Dyed Aviation Gasoline	X	X	
D 2500	Cloud Point of Petroleum Oils	X	X	
D 2547	Lead in Gasoline, Volumetric Chromate Method	X	X	
D 2550	Separation Characteristics of Aviation Turbine Fuels (WSIM)	X	X	
D 2624	Electrical Conductivity of Aviation and Distilled Fuels using a Static Dissipator	X	X	X
D 2709	Water and Sediment in Distillate Fuels by Centrifuge	X	X	
D 3240	Undissolved Water in Aviation Turbine Fuels	X	X	X
D 3241	Thermal Oxidation Stability of Aviation Turbine Fuels (JFTOT Procedure)	X	X	
D 3703	Determination of Peroxide Content of Aviation Turbine Fuels	X		
D 3948	Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer	X	X	
D 4057	Manual Sampling of Petroleum and Petroleum Products	X	X	X
D 5006	Measure of Fuel System Icing Inhibitors (Ether Type) in Aviation	X	X	X
FTMS 5101	Neutrality (Qualitative)	X	X	
FTMS 5327.3	Determination of Fuel System Icing Inhibitor (FSII) in Hydrocarbon Fuels	X	X	X
FTMS 5329	Humidity Cabinet Protection	X	X	
FTMS 5330	Visual Colorimetric Determination of FSII in Hydrocarbon Fuels	X	X	
FTMS 5340	Inhibitor in Hydrocarbon Fuels/B2	X	X	X
FTMS 5415	Resistance of Greases to Aqueous Solutions	X	X	

PETROLEUM QUALITY ANALYSIS SYSTEM (LIN: Z48700)

Research is being conducted for future development of the PQAS. The PQAS will include modern analytical instrumentation and communications equipment mounted on a highly mobile flatform. It will be capable of performing rapid analysis and quality testing of mobility fuels from COMMZ to areas forward of the FSB. It will eventually replace the petroleum Air Mobile Laboratory, a highly mobile laboratory equipped with communications and capable of operating independently throughout the theater.

Section III. Test Kits

GENERAL

Various test kits are used throughout the theater of operations to provide limited QS of fuels. The kits are designed to provide a final check on fuel quality and include only tests that indicate the most common forms of fuel contamination such as inclusion of water and sediment and commingling. Also, most kits include equipment which allows the user to sample and measure the fuel's volume. Test kits provide daily testing at the brigade and battalion levels. If there is any doubt about the quality of the product tested, a sample should be submitted to the supporting laboratory. Capabilities of the various petroleum test kits described below, are listed in Table 4-2, page 4-8

AVIATION FUEL CONTAMINATION TEST KIT (LIN: T05741)

The aviation fuel contamination kit is designed to provide a final check on aviation fuel just before fueling of an aircraft. It is a one-person, portable kit consisting of components and testing equipment capable of performing the Particulate Contamination Test on aviation gasoline and turbine fuel; the API gravity and temperature tests;
and determining free water content in aviation fuel samples (Aqua-Glo series). Particulate contamination can be performed by color method or the match weight method. The match weight monitor method is an alternate to ASTM D 2276. The color rating can be made in the field by visual analysis, and does not require stringent laboratory procedures. The match weight method must be sent to a laboratory for analysis. This kit is primarily used by aviation companies and can be operated by the fuel truck operator. TM 5-6630-218-10 contains the operating and maintenance data for this test kit (see Figure 4-1).

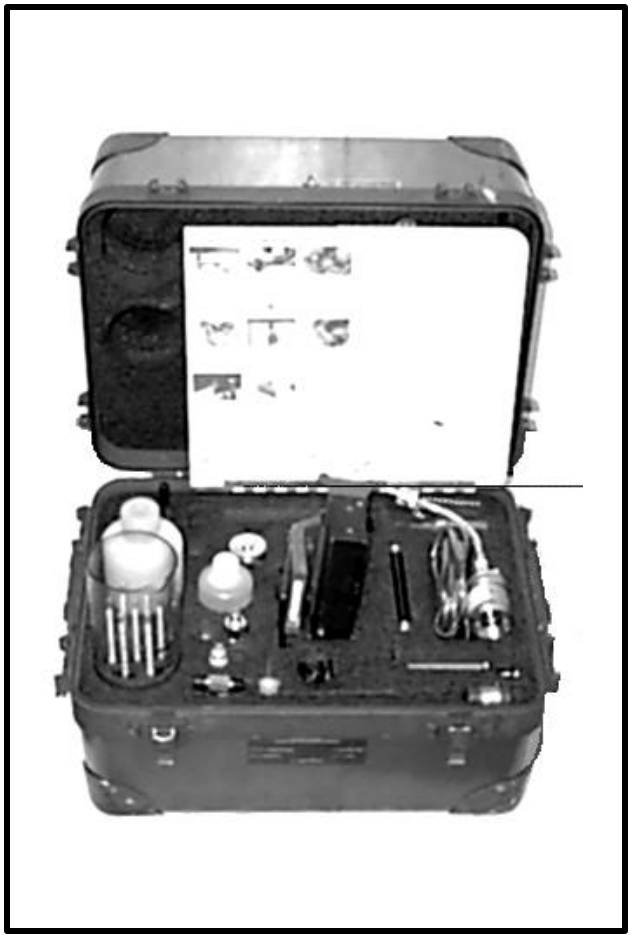


Figure 4-1. Aviation Fuel Contamination test kit

Table 4-2. Capabilities of petroleum testing kits

Test	Test Method	Ground Fuels Petroleum Test Kit LIN W05673	Sampling and Gaging Kit LIN W02115	Aviation Fuel Contamination Test Kit LIN T05741	AquaGlo Test Kit Series II/III LIN G04106
D 86	Distillation of Petroleum Products	X			
D 93	Flash Point by Pensky-Martens Closed Tester	X			
D 270	Sampling Petroleum and Petroleum Products	X	X		
D 287	API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)	X	X	X	
D 1085	Gaging Petroleum and Petroleum Products	X	X	X	
D 1086	Measuring the Temperature of Petroleum and Petroleum Products	X			
D 1250	Petroleum Measurement Tables	X			
D 1298	Density, Relative Density (Specific Gravity), Or API Gravity of Crude Petroleum And Liquid Petroleum products by Hydrometer Method	X	X	X	
D 2276	Particulate Contamination in Aviation Turbine Fuels			X	
D 3240	Undissolved Water in Aviation Turbine Fuels			X	X
D 4057	Manual Sampling of Petroleum and Petroleum Products		X	X	

SAMPLING AND GAGING KIT (LIN: W02115)

The sampling and gaging kit has the capability to determine the API gravity of fuels. This test provides the user with an indication of product type or a check for commingling of fuels. TM 10-6640-230 contains the operating and maintenance data for this test kit (see Figure 4-2).

Figure 4-2. Sampling andGaging test kit

GROUND FUELS CONTAMINATION TEST KIT (LIN: W05673)

The ground fuels contamination test kit is designed specifically to test diesel fuels and motor gasoline to be used in ground equipment (see Figure 4-3, page 4-10). The ground fuels test kit has the capability to accurately determine if commingling has occurred. Because this kit is supplemented by separate Aqua-Glo and Millipore test equipment, it can determine contamination of the fuel by water and particulate matter. TM 10-6630-247 contains the operating and maintenance data for this kit

CAPTURED FUELS TEST KIT (LIN: P95280)

The captured fuels test kit is a compact, portable kit intended for use by field soldiers. It can determine if a fuel of opportunity (captured or unknown) is suitable for use in diesel or gas turbine engines. Determination is by approximate measurement of specific gravity, viscosity, and visual contamination. Fuel sample size to perform the test is less than 300 milliliters. All tests are combined in a single tester. Fuel is considered suitable only if all three tests have given "GO" readings. Operational time to perform the test should not exceed ten minutes. TM 10-4320-314 contains the operating and maintenance data for this kit.

AQUA-GLO TEST KIT (LIN: G04106)

The Aqua-Glo III water detector/mini monitor contamination test kit is used to detect and measure the amount of undissolved water in kerosene-type jet fuels. The Aqua-Glo Series III has a new light source, and is capable of operating on AC power or battery packs.

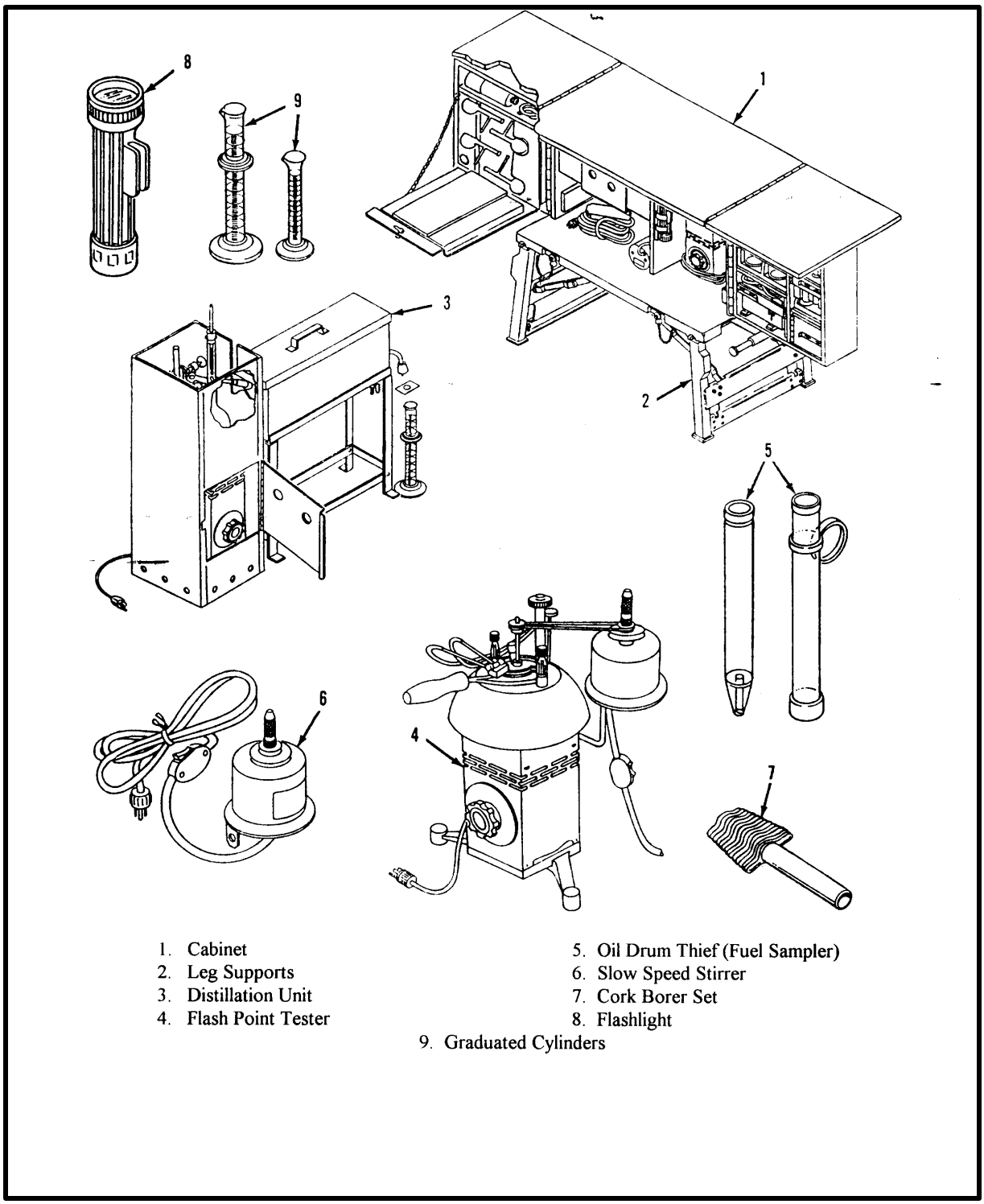


Figure 4-3. Ground Fuels Contamination test kit

Section IV. Laboratory Equipment Maintenance and Supply

MAINTENANCE

Instructions for maintaining the laboratories and their special components are in the applicable TMs. Because maintenance personnel are not assigned to petroleum laboratories, all laboratory personnel must perform operator maintenance on the equipment. A maintenance schedule should be prepared detailing the maintenance to be performed on each piece of equipment. Suspense folders containing Schedule and Record DD Forms 314 (Preventive Maintenance) should be maintained. These folders are given to technicians in the laboratory to check the listed items and perform the required maintenance. A checklist format is satisfactory. The equipment in the laboratory, whether in use or not, should remain in a high state of readiness.

CALIBRATION

According to AR 750-25, all petroleum laboratory personnel are responsible to ensure all of the laboratory equipment listed in TB 43-180 is periodically calibrated. Calibration logs, though not required, have proven valuable in maintaining an equipment audit trail. They can then be used to schedule the C-level calibration workload within the laboratory and A-level calibration by the TMDE personnel.

CALIBRATIONOF TEST KITS

In addition to petroleum laboratory equipment, components of the test kits may also require calibration. The sampling and gaging kit contains an innage tape and bob that must be periodically calibrated. Kits that contain thermohydrometers or thermometers and hydrometers will need calibration. Personnel responsible for the operation of these kits should contact the nearest mobile or base petroleum laboratory for C-level calibration support. Most of the time, a one-for-one exchange of each item of equipment can be arranged. The captured fuels test kit does not require calibration.

A-LEVEL CALIBRATION PROCEDURES

A-level calibration is not performed by petroleum laboratory personnel. It is performed by personnel from a TMDE calibration center. Petroleum laboratories can either schedule a TMDE calibration laboratory team to perform A-level calibration on site or send the equipment to a TMDE calibration and repair center, or a combination of both. The method chosen depends on the regulations and policies within the specific command. Laboratories sending equipment for calibration must have at least two sets of the equipment on hand. Never turn in both sets at the same time. Rotate them to keep a calibrated set on hand. DA Form 2402 (Exchange Tag) is filled out and attached to each item of equipment that must be sent to a calibration facility. The sending petroleum laboratory files the bottom portion of the tag for accountability purposes.

C-LEVEL CALIBRATION PROCEDURES

C-level calibration (standardization) is performed at the petroleum laboratory by laboratory personnel using an A-level calibrated set of equipment. C-level calibration methods are listed in ASTM Volume 5.03, Series E (ASTM Method E1 for thermometers or E 100 for hydrometers). Once an item of equipment has passed C-level calibration, a completed DA Label 80 (US Army Calibrated Instrument) is either attached to the item of equipment or to the DD 314 and kept on file. Items of equipment which fail C-level calibration should have a DA Form 2417 (US Army Calibration System Rejected Instrument) attached so that they will not be used. These items of equipment, along with items of equipment being re-

turned from the A-level calibration facility, should be turned in for repair or disposal.

SUPPLY

Equipment requirements for petroleum laboratories are determined by TOE, TDA, TMs, military and federal specifications, and the current MIL-HDBK-200 These are used as guides to establish the basic requirements for the laboratory. Stocks have to be added to as new tests are adopted. This facilitates accomplishment of special test programs the laboratory is responsible for or involved in. Reviewing the current mission is the best way of determining required stock levels and for planning acquisition of new equipment or other required items.

Standard Items. Standard items are found in the 6600-series or 6800-series FSC lists or the USAPC supply catalog for petroleum laboratories. Many standard petroleum items are normally in short supply in the theater because they are not high-demand items. Requisitions should be submitted far in advance, and long delays should be expected because of surface shipment from distant points

Nonstandard Items. Nonstandard items are those not available in the military supply system. These items can normally be obtained from commercial company catalogs. These catalogs may be obtained directly from the company by sending a letter from the laboratory or the supply officer (S4).

INVENTORIES

One of the senior laboratory specialists is usually assigned the additional duty of laboratory supply chief. This individual should maintain a stock level control file or a current running inventory on all laboratory apparatus and chemicals required. Once a 100 percent inventory has been conducted, a current running inventory can be maintained by using a usage/breakage list and a periodic updating of the inventory. A 100 percent inventory is recommended on a quarterly basis.

PRESCRIBED LOAD LIST

Upon deployment of the mobile laboratories, the person in charge of ordering supplies must reorder all items of equipment listed in each of the laboratory's overpack content list. This ensures that replenishment of expendable supplies is accomplished before the overpack supplies are exhausted. A laboratory PLL must be developed based on actual demand data after the initial order. Subsequent requests for supplies will be based on the laboratory's PLL. The PLL is subject to change as the mission dictates.

Section V. Equipment Publications and Forms

GENERAL

Each laboratory is required to maintain a current library of specifications (military and federal), military standards, and other standardization documents as appropriate for the mission. Most documents can be ordered using the DODISS and DD Form 1425 (Specifications and Standards Requisition).

DODISS

DODISS is a cumulative alphabetical and numerical listing of specifications, standards and related standardization documents It is sorted by federal supply class and available for military activities from:

Commanding Officer
Naval Publications and Forms Center
ATTN: NPFC 105
5801 Tabor Avenue
Philadelphia, PA 19120-5099

The DODISS is in three parts. Part I is the DODISS alphabetical listing. It lists all active documents alphabetically by nomenclature, cross referenced to document number, document date, preparing activity, and custodians. Part II is the DODISS numerical listing. It lists all active documents in document number sequence by document type. Part III is the DODISS FSC listing. It lists all current documents in FSC sequence, cross referenced to document number, document date, preparing activity, and custodians.

DD FORM 1425

DD Form 1425 is available through the normal forms distribution system. It includes a self-addressed gummed label. Use of DD Form 1425 ensures faster service when requisitioning standardization documents. However, all requests will be honored without regard to the requisition form used. Military activities having a requirement for automatic distribution of standardization documents in specificFSCs should refer to DOD 4120.3-M.

REQUISITION PROCESSING

To expedite requisitions for special documents, be sure to follow these procedures:

- Indicate complete mailing address.
- Indicate desired quantity of each document.
- List each desired specification or standard by document symbol as shown in the DODISS.
- List federal specifications in alphabetical order and all others in numerical order. The following sequence is preferred: military specification, military standards, federal specifications, federal standards,QPLs and others.
- Limit the number of line items per request to five or less.
- All amendments and revisions will automatically be issued with the basic specification unless otherwise specified by the requester. For more information, refer to the introduction of the DODISS.

CHAPTER 5

ESTABLISHING PETROLEUM TESTING FACILITIES IN THE THEATER

Section I. Deployment of Petroleum Testing Facilities

PREPARATION FOR SHIPMENT

When petroleum testing facilities are prepared for shipment, the type of laboratory, its mission or purpose, and the mode of transportation need to be considered. Coordination of the major steps during the notification sequence (N + hour) should be set up by the laboratory's NCOIC. It should be based on the laboratory resources and the time factor in which these steps must be completed. The time factor may vary from 24 to 72 hours, depending on the mission and local SOP. Specific to the laboratory is the coordination of resources necessary to prepare the interior and exterior of the laboratory for movement in the specified time. Particular attention must be paid to the correct handling of the supplies used in a laboratory, many of which are classified as hazardous materials. Requirements for shipping hazardous materials by rail, road, water and nonmilitary aircraft are found in CFR 40 and 49, BOE Tariff Number 6000-B, and DOT regulations. For information on shipping hazardous materials by military aircraft, refer to TM 38-250. The laboratory NCOIC will use the appropriate reference for the mode of transportation to prepare the hazardous materials for shipment. Quantities per container (or package) of hazardous materials and types of packing material may change with each type of transportation.

SHIPPING DOCUMENTS

DD Form 1387-2 (Special Handling Data/Certification) is required for hazardous material shipped by military aircraft. Use this form for all shipments of hazardous laboratory material. See TM 38-250 for form preparation instructions and IAETA for commercial air and some military air hubs. This form helps personnel to rapidly identify, neutralize, and dispose of hazardous material in case of an accident. Refer to the local SOP and BOE 6000-B to prepare shipping papers according to TM 38-250. When a laboratory is shipped by air during tactical or contingency operations, a waiver is necessary. Waivers to packaging requirements must be requested according to TM 38-250.

REQUEST CHANNELS AND FORMAT

A request to ship by military aircraft should be submitted through channels to HQ, USAF, when Air Force aircraft are involved. For Army aircraft, shipment waivers are requested from:

Headquarters
Department of the Army
ATTN: DAPE-HRS
Washington, DC 20310-0001

The request must contain the following:

- The reason the shipment must be made.
- The reason other modes of transportation cannot be used.
- A statement that noncompatible items have been packed to prevent propagation of detonation or contamination (in case one item detonates or leaks).This does not apply to conditions present in aircraft crash. The statement should also include a brief description of tests or other basis on which such safety conclusions rest, and additional safety controls which must be exercised by the carrier.

- An estimate of propagation of detonation or contamination to be expected if the aircraft crashes.

- Date of movement, route, type of aircraft required (channel or special), specific cargo load configuration required (if requested) and a POC at origin and destination.

REQUEST APPROVAL

The office that has operational control of the aircraft, in coordination with safety personnel and other staff agencies, evaluates each request for waiver. If it approves the waiver, it will forward copies of the approved request to the requester and to the command having operational control of the aircraft. It will also advise the shipper, person, or office to be contacted at the origin base. The office requesting the waiver, on receipt of approval, arranges for the handling of the shipments at origin, in transit, and at destination bases.

Section II. Petroleum Laboratory Area Requirements

GENERAL

Some critical factors to consider in establishing petroleum laboratory operations include site selection and setup, assembly, and disassembly of the laboratory. Other areas of concern are environmental considerations, fire prevention, destruction of equipment to prevent enemy use, and defense in an NBC environment. Information on individual items of equipment and maintenance procedures can be found in the appropriate TMs.

ENVIRONMENTAL CONSIDERATIONS

We need to keep our commitment in protecting the environment. The following areas must be considered prior to occupancy of an area.

- Flora and Fauna Protection. Destruction of flora and fauna for bases and for minimum health and welfare and safety is permitted. Destruction and clearing of large areas, in excess of approximately 100 acres, must be approved through the operational chain-of-command with final approving authority resting with the joint operational commander. The affect on the environment should be weighed against the military advantage to be gained. The method for clearing operations must be coordinated and approved through the engineer and medical channels.
- Basing and conducting operations in the vicinity of archeological and historical buildings and areas should be minimized to protect such areas from war and war related damage.

Environmental protection measures must be implemented during operations and after departure from a site. The purpose of this record keeping is to document US stewardship of land and facilities during the contingency. This will preclude unsubstantiated claims against the US Government, and false detrimental publicity against the US armed forces.

- Unless it is detrimental to the success of the mission and operational effectiveness, all bases and installations (permanent and temporary) shall be operated IAW the governing environmental standards as determined by the DOD.
- When practicable, the initial environmental conditions of any location occupied by US forces as a base, will be documented. This documentation will include a description and condition of water sources, soil, flora, archeological/historical facilities, air quality, and other environmental considerations. This documentation will be forwarded through engineer channels to the component service engineer.
- Prior to departure and abandonment of a base, the current description and conditions of water sources, soil, flora, archeological/historical facilities, air quality and other environmental conditions will be documented. Also, users of the base during US occupancy will submit locations

of latrines, hazardous waste sites, landfills, maintenance activities, POL storage, and other possible environmentally hazardous activities through engineer channels to component service engineers.

- Initial and closeout base environmental conditions will be maintained at component service HQ for five years after conclusion of the contingency unless further directions are issued.

LABORATORY SITE SELECTION

Choosing a good laboratory site is critical to the safety and security of all personnel. Some of the physical characteristics to look for in selecting areas for all petroleum laboratories are:

- The site should be firm, reasonably level with well drained terrain, and relatively free of surface rocks and large stones.
- Avoid low areas because of the danger of vapors collecting in them.
- The selected site should be at least 500 feet away from other areas of operation.
- Choose a site near a stream, pond, or other established water source when possible, to provide a source for the laboratory's water system and as an aid in fire control.
- The selected site should be located near or on an access road.
- The site should provide adequate cover and concealment, or camouflage nets may be used.
- The site should be easily defended.
- Site should require the least amount of engineer support.

PETROLEUM BASE LABORATORY REQUIREMENTS

Since the Petroleum Base Laboratory is being replaced by the Modular Petroleum Base Laboratory, site requirements and preparations will not be discussed in this manual.

MODULAR BASE LABORATORY REQUIREMENTS

Area requirements for the proposed modular base petroleum laboratory will be sufficient to position two trailers, side by side. Each trailer is approximately 38 feet long by 8 feet wide. The selected site must also include space for generators, a sample storage area, a waste disposal area and administrative parking.

MOBILE LABORATORY REQUIREMENTS

The site for a mobile laboratory should be large enough to maneuver a trailer approximately 38 feet long and 8 feet wide. Areas for the trailer-mounted , 60-kilowatt generator; sample storage; waste disposal area; chemical overpack storage; and administrative vehicle parking must also be considered in the selected area.

- Initial Preparation, Equipment Inspection, and Test Equipment Operations. TM 10-6640-215-13 contains operator, unit and direct support maintenance instructions for the mobile laboratory. Refer to TM 10-6640-215-23P for list of spare and repair parts; special tools; special tests, measurement and diagnostic equipment (TMDE); and other special support equipment required for the performance of unit and direct support maintenance of the mobile laboratory.
- Operational Capability. Full operational capability of the mobile laboratory can be achieved within 12 to 16 hours from the time the laboratory arrives on site. This time is required for utility hookup, unpacking of test equipment, mixing of solutions, and bringing equipment and baths to operating temperatures.
- Sustainability. The mobile laboratory has a series of overpack boxes which contain the necessary replacement chemicals, glassware, and expendable supplies to provide for 60 to 90 days of sustainability without resupply. The increased sustainability allows for the time lag in the unde-

veloped theater that occurs while regular supply lines are being established. The BII (Basic Issue Items) List and Expendable/Durable Item List are found in TM 10-6640-215-13. The actual lengths of days depend on the work load experienced, the types of products tested, and the mission of the unit to which the laboratory is assigned.

AIRMOBILE LABORATORY REQUIREMENTS

The site for the airmobile laboratory should be large enough for a shelter 12 feet long by 7 feet wide. Include additional space for a trailer-mounted, 15 kw generator; overpack and sample storage; waste disposal area; and administrative vehicle parking.

- Initial Preparation, Equipment Inspection, and Test Operation. Initial preparation, equipment inspection, and test equipment operation is described in TM 5-6640-216-13&P. Full operational capability of the airmobile laboratory can be achieved within four to six hours of arrival at the site.
- Sustainability. As with the mobile laboratory, the airmobile laboratory includes overpack boxes which provide a 60 to 90-day sustainability factor. See SC 6640-97-CL-E01 for the content list.

GROUND FUELS TEST KIT REQUIREMENTS

The ground fuels test kit can be set up and operated in a space as small as 6 feet by 4 feet.

The test kit should be set up in a tent or shelter in order to protect test equipment from wind, dust, rain, or snow.

TEST KIT REQUIREMENTS

Except for the ground fuels test kit mentioned above, the remaining kits do not require any specific shelter for operation. The following kits are portable and housed in suitcase-type cases. See Chapter 4 for additional information on available test kits.

- The aviation fuel contamination test kit can be set up in 10 minutes. The kit is designed to transport enough expendable supplies to run 50 tests without replenishment.
- The Aqua-Glo test kit can be operated immediately. Supplies are sufficient to run 50 tests.
- The sampling and gauging kit can be operated immediately. There are approximately 120 days worth of expendable supplies included in the kit.
- The captured fuels test kit has immediate operational capability. Since it does not use any expendable supplies, its use is uninterrupted.

Section III. NBC Environment

NBC THREAT CONSIDERATIONS

Petroleum testing facilities are found throughout the theater of operations. It is probable that they will face some enemy activity either in the form of conventional or NBC weapons. NBC agents used by the enemy will depend on terrain, weather, location of other enemy units, and the desired effect. These weapons may be delivered by air, land, or sea and by indirect or direct fire. Laboratory facilities must be able to withstand an NBC-contaminated environment. Efforts to reduce the vulnerability of sites to NBC attack play a major role in improving survivability.

NUCLEAR EFFECTS

Understanding the effects of a nuclear blast is important in planning your defense against it. It can cause equipment damage as well as injury to personnel. The effects of a nuclear explosion include the following.

- The air blast can overturn or crush equipment and hurl debris.
- Thermal radiation can ignite combustible materials.
- Nuclear radiation can affect personnel, both after the explosion and through residual radiation.
- EMP can damage electrical equipment because it induces voltage in excess of normal operating levels.

PREPARATION OF SITE

Standard defense procedures in preparing a site for occupancy are listed below.

- Camouflage your position and equipment.
- Disperse equipment and areas of operation.
- Store chemicals properly. Store incompatible chemicals away from each other.
- Use containers to store equipment and supplies, if possible. Also, cover the equipment and supplies.
- Use terrain features to shield operations.
- Make sure first aid supplies are on hand.
- Construct fighting positions that have overhead cover.
- Follow communications security and operations security procedures.
- Make sure the operating area is free of debris.

LABORATORY NBC PROTECTION PROCEDURES

To further protect laboratory equipment and facilities from an NBC attack, some additional procedures are listed below.

- The test kits can be set up in a tent. The tent can be hardened by putting sandbags around the center pole and placing sandbags and dirt as far up the sides as possible.
- The airmobile and mobile laboratories are good shelters as long as doors, windows, vents, and cable access ports are closed. The earth is a good shielding material. Use natural terrain features to reduce blast effects. Wires and cable runs should be kept as short and straight as possible and, where practical, the cables and wires should be kept on the ground. Elevating them may increase the EMP-generated voltages and currents. Cover ground wires and cables with at least 1 inch of dirt to protect them against EMP. Power generators should be protected by piling sandbags or other suitable material around them. Entry and exit procedures should be established to limit the spread of contamination should it occur.
- The base laboratory follows the same NBC defense measures as the airmobile and mobile laboratories. A concrete building makes a better shelter than a wooden structure. Proper storage of chemicals, with incompatible groups stored as far apart as possible, will reduce the fire hazard in the area.

NBC DEFENSE FUNDAMENTALS

The three fundamentals of NBC defense are avoidance, protection, and decontamination. These can be applied to laboratory systems in the following manner.

- Contamination avoidance. Avoidance addresses individual and/or unit measures taken to avoid or minimize NBC attacks and reduce the effects of NBC hazards. FM 3-3 and FM 3-100 provide information on NBC avoidance measures. Avoidance techniques are accomplished by the use of cover, concealment, and dispersion. Good techniques will not only reduce detection by enemy forces, but they will also reduce the effects of thermal radiation. By taking advantage of any existing natural and manmade terrain features (for example, caves, ditches, ravines, culverts and tunnels) contamination can often be avoided.

- Protection. Protection consists of actions used to counter enemy firepower and maintain the health and morale of soldiers. Protection applies when contamination cannot be avoided. Positions should be hardened, all loose equipment should be immobilized by anchoring or tying it down, vital equipment should be protected or shielded, and proper MOPP levels should be employed. Fuel samples should be kept in a trench or pit with some type of covering. Shock-sensitive equipment should be shielded by cushioning it with padding material.
- Decontamination. Decontamination is the reduction or elimination of the contamination hazard. Decontamination is used to reduce or eliminate a hazardous contaminant. The NBC element of the unit to which the laboratory is assigned should be contacted for more up-to-date information on defense techniques and procedures.

NBC OPERATIONS

Operating procedures for laboratory facilities are discussed in Chapter 10. Laboratory NBC procedures should be coordinated with the NBC elements of the unit to which the laboratory is assigned to ensure information and techniques are current and comprehensive. For information on the NBC environment, refer to FMs 3-3, 3-4, 3-5, and 3-100. Laboratory facilities must be able to withstand an NBC-contaminated environment.

NUCLEAR ATTACK

Personnel need to know what to do during and after a nuclear attack. Soldiers should be trained to act without hesitation. Their initial actions must be automatic and instinctive.

During a Nuclear Attack. As a rule, a nuclear attack will be a surprise, that may also involve several attacks. Time to take protective action will be minimal in this situation. Soldiers should do the following:

- Troops must immediately drop face down.
- Close their eyes.
- Protect exposed skin as much as possible, by putting hands and arms under or near the body and keeping the helmet on.
- Remain face down until the second blast wind has passed.
- After the wind has passed, follow the unit NBC SOP.
- Be aware of a fallout hazard if the laboratory is downwind from the blast.

NUCWARN. If a nuclear attack is made on enemy positions by our forces, a NUCWARN message may be sent to nearby units. If you receive a NUCWARN message, follow these steps:

- Cease all testing.
- Move all hazardous and flammable chemicals from the laboratory to the storage room or place them in a container.
- Cover exposed equipment if time permits.
- Take personal weapons and evacuate the laboratory.

- Close all doors.
- Go to the prepared positions and wait for the explosion.
- Refer to the NBC SOP for more information.

After a Nuclear Attack. Protection must not stop when the attack ends. Soldiers should do the following:

- Stay calm.
- Check personnel for injuries and render self-aid/buddy-aid according to instructions in FM 21-11.
- Check the area for radiation and reduce the hazard with basic soldier skills decontamination.
- Check weapons and equipment damage.
- Use soapy water and brushes to wash the equipment and the outside of the laboratory.
- Mark the area of water runoff as "contaminated."
- Review the NBC SOP for other actions.

BIOLOGICAL ATTACK

Personnel must be aware of the actions to take before, during and after a biological attack.

Before a Biological Attack. Preparations for a biological attack can be accomplished long before the attack happens. Personal health maintenance, which includes up-to-date immunizations, good hygiene, area sanitation and physical conditioning willreduce the effects of the attack.

During a Biological Attack. There are no immediate methods of detecting a biological attack. When high probability indicators of a biological attack exist, immediate actions include:

- Put on the protective mask.
- Button up clothing for complete protection against living biological agent

After a Biological Attack. Because there are no devices to indicate when a biological hazard no longer exists, soldiers should do the following:

- Continue to wear the protective mask until authorized to remove it.
- Check personnel for symptoms of poisoning.
- Administer antidotes if needed.
- Check the area for contamination.
- Move personnel and equipment to a decontamination site, if one is available.
- Personally decontaminate equipment according to priority, if a site is not accessible.
- Mark the area of water runoff as "contaminated."
- Perform preventive maintenance checks and services on all equipment.
- Repair damage, if possible.
- Report status of equipment and personnel to higher headquarters.
- When possible, move the laboratory and personnel out of the contaminated area to continue operations.

CHEMICAL ATTACK

Personnel must be aware of the actions to take during and after a chemical attack.

During a Chemical Attack. Personnel must act quickly and without hesitation. If a chemical round explodes or an alarm signal is given, they should do the following.

- Cease testing.
- Don appropriate level MOPP.
- Identify the agent.
- Stay alert for more strikes.
- Refer to unit NBC SOP for additional procedures.

CHEMWARN. If a CHEMWARN is received, personnel should cover all exposed equipment, in the time allowed, before going to their covered positions.

After a Chemical Attack. Personnel actions following a chemical attack, are the same as those stated above for a biological attack.

OPERATIONS IN A CONTAMINATED ENVIRONMENT

If persistent chemical agents have been used or nuclear fallout or residual radiation is present, the area will remain contaminated after the attack has ended. Contact higher HQ to see if the mission should continue. If the unit must continue to test, decontaminate the inside of the laboratory, if needed. The outside of the laboratory should also be decontaminated, as much as possible. Set up a decontamination point near the entrance of the laboratory so personnel can decontaminate themselves before entering. The only hazard in the laboratory will probably be a vapor hazard. Protective masks should be worn at all times. Gloves should also be worn, when necessary. The laboratory officer or NCO in charge will determine what tests need to be done. Keep higher HQ informed of the status of the laboratory testing. The

laboratory should be continuously monitored for contamination.

LABORATORY SOP

The laboratory SOP must have an annex for NBC defense responsibilities and procedures. For helpful information in preparing the annex, see FMs 3-3, 3-4, 3-5, 3-100, and 25-50. Coordinate the annex with the NBC officer and NCO of the unit. Update the SOP to show any changes in policy. Make sure the annex covers the following areas:

- Alarms and warnings of NBC attack.
- Means of identification of personnel in MOPP 4.
- Method of communication to use while in MOPP 4.
- Actions for personnel to take in the laboratory before, during, and after an NBC attack.
- Maintenance and storage of NBC supplies and equipment.
- Positioning and protection of vehicles, supplies and equipment.
- Priorities of decontamination.
- Decontamination procedures.
- Operations in a contaminated environment.
- NBC 1 report.
- Procedures for special environments (arctic and jungle).

TRAINING

Training before an NBC attack is the means for survival. It is especially important for a biological attack, since there are no devices to indicate when a biological hazard is present. Good personal health habits, up- to -date immunizations, good area sanitation, and good physical conditioning are essential to survivability in the NBC environment. It is essential that laboratory personnel become proficient in those tasks outlined in FM 21-2.

DESTRUCTION OF ARMY LABORATORIES

Destruction of Army material is sometimes necessary to prevent enemy use. Only the commanding officer can order demolition. Once it is decided, destruction should be as complete as possible. However, the safety of personnel comes first and the degree of destruction should not jeopardize lives. Unless they are disabled, consideration should be given to transporting the mobile laboratory to a center for decontamination. Detailed procedures for destruction of the petroleum base laboratory are listed in TM 5-6640-214-14. Additional procedures for destruction of equipment can be found in TM 750-244-3.

CHAPTER 6

PERFORMING QUALITY SURVEILLANCE IN THE THEATER

Section I. Petroleum Quality Surveillance in the Developed Theater

DESCRIPTION OF THE SYSTEM

The procurement of petroleum products and their delivery to the developed theater are described in DOD 4140.25-M. Normally, time will be available to ensure that petroleum procured from host nation or CONUS based refineries meets US military specifications. Responsibility for ensuring the quality of fuels delivered to the theater lies with DFSC, JPO, and their subordinate agencies. The JPO is responsible to the developed theater commander for establishing and monitoring the theater QS program. The Army provides overland petroleum support to US land-based forces of all DOD components. Only when fuel is delivered to the consumer does it gain service identity. The theater Army commander normally delegates the authority to control the QS mission to the petroleum group commander. The petroleum group accomplishes the QS mission by supervising the testing of fuels throughout the theater. Testing facilities depend on testing requirements, criticality of the fuel, intended use of the fuel, and type of theater (developed or undeveloped). A description of these facilities and their capabilities can be found in Chapter 3.

BASE PETROLEUM LABORATORY

The base petroleum laboratory is normally found in the COMMZ at the base terminal of a petroleum pipeline and terminal operating battalion. It is under the control of the petroleum group.

MOBILE PETROLEUM LABORATORY

The mobile petroleum laboratory is contained in a 10-ton semi-trailer van. The van is air transportable. Because space is a limiting factor for the mobile petroleum laboratory, it cannot support as great a sample work load as the base laboratory. Mobile petroleum laboratories are found in the COMMZ and Corps attached to pipeline and terminal operating battalions and to petroleum supply battalions.

AIRMOBILE PETROLEUM LABORATORY

The airmobile petroleum laboratory is authorized for the airborne and air assault light divisions and the heavy division in the MSB.

TEST KITS

Aviation Fuel Contamination Test Kit. The aviation fuel contamination test kit is used by all units having a bulk aviation fuel refueling mission.

Ground Fuels Petroleum Test Kit. The ground fuels petroleum test kit provides a testing capability at the general support operating level and at the direct support level. The ground fuels test kit is normally located with units having a bulk petroleum storage, supply, and refueling mission.

Sampling and Gaging Kit. The sampling and gaging kit is found in the brigade forward supply

section of all divisions. It is used as a final check to ensure proper identification of products received from division main and corps support units.

Captured Fuels Test Kit. The captured fuels test kit is located with selected armor and mechanized infantry combat units to allow for testing and use of captured or commandeered fuels.

Aqua-Glo Test Kit. The Aqua-Glo test kit is used by personnel involved in aviation refueling operations.

TESTING REQUIREMENTS

The testing of DLA-owned and Army owned petroleum products in the developed theater in peacetime is described in MIL-HDBK-200. It provides a detailed breakdown of the types of tests required for each class of product. The handbook and Tables 6-1 through 6-3, beginning on page 6-3, provide guidance for testing in a tactical developed or undeveloped theater.

PROCUREMENT OF PETROLEUM PRODUCTS

Procurement in the developed theater is usually from friendly host nations. There is normally sufficient lead time to ensure that procured products meet US military specifications. Personnel with MOS 77L, E6 and E7, or MOS 77F, E8, should be requested by higher HQ to be QARs when the procurement mission requires support.

STANDARDIZATION AGREEMENTS

STANAGS, such as STANAG 3149, between nations of are used to provide minimum QS for petroleum products.

CHANNELS OF COMMUNICATION

Providing QS in a developed theater of operations requires good communication between higher HQ and QS testing facilities located in the theater. Such communication falls into two categories: command and technical. The command channel of communications for the petroleum organization in the theater of operations is discussed in FMs 10-67 and 10-602. The technical channel of communications provides for exchange of technical information. It is directed by the responsible JPO.

LABORATORY REQUIREMENTS

Laboratories in a developed theater in peacetime are designed to meet the QS testing mission of the theater. In the tactical developed theater, their design may not be adequate. Modifications to existing laboratories or construction of new ones may be required. Such construction requires coordination with the facilities' engineers. Facilities' engineers are responsible for providing the laboratory with water, electricity, drainage, waste disposal, equipment repair, and equipment calibration. These items are addressed when planning for modification of existing peacetime testing facilities. Equipment requiring calibration is placed on a regular schedule with the appropriate calibration teams. See Chapter 4 for additional information concerning equipment calibration. TB 43-180 provides calibration requirements for Army equipment . Normal operator standardization is carried out per the appropriate ASTM or FTMS test procedures. According to ASTM E 77, all petroleum laboratories must maintain a temperature of 73.4 °F ± 3.6 °F and humidity of 50 ± 5 percent. These requirements must be met to maintain equipment and to ensure the accuracy of testing.

QUALITY SURVEILLANCE MISSION

A number of factors (including fuel requirements, methods of supply, storage capability, and allied/joint services agreements) must be considered when determining the total QS work load within the theater. Laboratories maintain historical data on all testing performed. The data are analyzed to determine the number and types of tests performed. Appendix B is a guide for the number of man hours needed for each type of test.

Table 6-1. Test requirements for fuel

Action	Peacetime	Developed Theater	Undeveloped Theater
Procurement QA	Full specification testing according to current regulations (contractor or base laboratory)	Full specification testing, less anti-knock and Cetane ratings by test engines; if not available locally (contractor, base, or mobile laboratory).	Minimum emergency tests by mobile, airmobile, or contractor laboratory; if available, pending
Bulk Distribution QS (Wholesale)	According to MIL-HDBK-200, type B-1, B-2, B-3, or C tests. Refer to MIL-HDBK-200	According to Mil-HDBK-200, anti-knock and Cetane engine ratings. Refer to MIL-HDBK-200	Minimum emergency tests by mobile or airmobile laboratory or aviation fuel test kit. See Table 2-2.
Direct Support QS (Retail)	Refer to MIL_HDBK-200, Appendix B of this manual, and current FM or TM guidance.	Refer to current FM or TM. 1. Ground fuels test kit. 2. Aviation fuel contamination test kit.	Refer to current FM or TM. 1. Ground fuels test kit. 2. Aviation fuel contamination test kit.
Captured Fuel	1. Ground Fuels test kit. 2. Aviation fuel contamination test kit. NA	Not for contingency use. Withhold all captured stocks from use until either a base or mobile laboratory can certify usability by B-1 testing. For immediate consumption, test with captured fuels test kit.	Not for contingency use. Withhold all captured stocks from use until either a base or mobile laboratory can certify usability by B-1 testing. For immediate consumption, test with captured fuels test kit.

Table 6-2. Minimum procurement tests (QA) for fuels

Fuel	Test	Test Method Number
Motor Gasoline	Visual Appearance	ASTM D 4176
	Color	ASTM D 1500
	Specific Gravity	ASTM D 1298 or 287
	Distillation	ASTM D 86
	Reid Vapor Pressure	ASTM D 323
Diesel Fuel	Visual Appearance	ASTM D 4176
	Flash Point	ASTM D 93
	Distillation	ASTM D 86
	Specific Gravity	ASTM D 1298 or D 287
	Cetane Index	ASTM D 976
	Cloud Point	ASTM D 2500
	Particulates	ASTM D 2276
Turbine Fuels	Visual Appearance	ASTM D 4176
	Particulate	ASTM D 2276
	Distillation	ASTM D 86
	Copper Corrosion	ASTM D 130
	Reid Vapor Pressure	ASTM D 323
	Flash Point (JP-5 only)	ASTM D 93
	Fuel System Icing Inhibitor	FTMS 791 (Method 5327.3) or B-2 Test Kit
	Water Separation Index, Modified by Portable Separometer	ASTM D 3948
	Conductivity	ASTM D 2624
	Specific Gravity	ASTM D 1298 OR D 287
	Thermal Stability	ASTM D 3241
	Freezing Point	ASTM D 2386

Table 6-3. Test requirements for lubricants, hydraulic fluids, and related products

Action	Peacetime	Combat Developed Theater	Combat Undeveloped Theater
Procurement QA	Refer to current regulations	Full specification testing	Contractor or mobile laboratory reduced test schedule: Type B-2 tests.
QS	Refer to current regulations	No testing is required as long as container is received undamaged and product is within its shelf life. If containers are damaged or product is past its shelf life, forward samples to nearest base petroleum laboratory.	No testing is required as long as container is received undamaged and product is within its shelf life. If containers are damaged or product is past its shelf life, forward samples to nearest base petroleum laboratory.
Captured QC/QS Packaged Products	NA	Do not use. Send samples to nearest base petroleum laboratory for B-2 testing.	Do not use. Send samples to nearest base petroleum laboratory for B-2 testing.

Section II. Petroleum Quality Surveillance in the Undeveloped Theater

DESCRIPTION OF THE SYSTEM

A bulk petroleum QS program is critical in the undeveloped theater. Time may not be available to ensure fuels procured in the theater meet US military specifications. Some risks may have to be accepted to provide fuel in sufficient quantities to support the theater's operational plan. As a result, it is critical that petroleum testing be available early in the undeveloped theater buildup. The petroleum laboratory testing equipment must be capable of performing minimum bulk fuel tests. The DFSC, the JPO, and their subordinate organizations are responsible for ensuring quality fuel is available and delivered to the theater. The JPO is responsible to the theater commander for establishing and monitoring the theater QS program. The senior Army commander is responsible to the theater commander for establishing an Army QS program. Depending on how the undeveloped theater is structured, the senior Army commander may be a division, corps, or theater Army commander. As in the developed theater, all fuels which enter an Army-operated petroleum distribution system do not necessarily become Army-owned fuels. The Army, with the bulk fuel mission of supporting all DOD land-based forces, may be required to resupply other services with bulk petroleum.

TESTING REQUIREMENT

Testing of DLA-owned petroleum products in CONUS for supply into the undeveloped theater is described in MIL-HDBK-200. The type of petroleum testing facility and the manner in which it is employed are the same as in the developed theater.

PROCUREMENT OF PETROLEUM PRODUCTS

Fuels procured within an undeveloped theater will undergo a minimum of testing for general use. This testing may be done either at the refinery laboratory under the supervision of a QAR or by having samples sent to the nearest operational laboratory out of the country. Under emergency conditions, a mobile or airmobile laboratory may be required to perform tests indicated as minimum tests in MIL-HDBK-200. Personnel with MOS 77L, E6 and E7 or MOS 77F, E8, should be requested by higher HQ when procurement testing within the theater can be done at the refinery laboratory.

COMMANDEERED/CAPTURED PETROLEUM PRODUCTS

These products are obtained under emergency conditions. Units should only use this fuel for short periods of time and in extreme combat emergency. Personnel should identify the type of fuel (for example, diesel or gasoline) and have reasonable assurance that it is clean and free of sediment and water. Short-term use is dictated by battlefield conditions and is not measurable in hours or miles. Use of such fuels involves great risk to engine life and performance characteristics. Use should be discontinued when US products are available, unless the foreign fuel is approved for use by a petroleum laboratory. Units requiring long-term use (more than 48 hours or 100 miles) of these fuels must provide samples to a petroleum laboratory for analysis. Units must follow use or blending recommendations made by the petroleum laboratory.

CHANNELS OF COMMUNICATION

It is critical to maintain good communication between higher HQ, QS testing facilities, and units submitting samples. As in the developed theater, two channels of communication are command and technical. They function the same as they do in the developed theater.

LABORATORY REQUIREMENTS

Fuel requirements, methods of supply, storage capability, and allied joint service agreements are areas of concern in the undeveloped theater. Data on these areas are used as a basis for determining the number of types of units requiring QS laboratories. To determine the number of laboratories for the undeveloped theater, project a developed theater and the laboratories it requires. These laboratories are then time-phased into the theater with their respective petroleum unit. The types of testing performed will be different in the initial stages of the undeveloped theater. Factors affecting testing in the initial stages of the undeveloped theater are listed below.

- The number of coastal tankers required to lighter large ships.
- Initial installation of submarine pipelines and floating hose lines.
- Configuration of TPTs.
- Number of base TPTs required to supply the theater (a TPT has limited storage capacity).
- Number of collapsible tanks at intermediate and head terminals.
- Filling points for tank truck operations.

As the undeveloped theater matures and fixed petroleum distribution facilities are constructed, the types of testing performed become those required for a developed theater as discussed in Section I of this chapter.

ADDITIONAL REQUIREMENTS

Construction of base laboratories and placement of mobile or airmobile laboratories require planning. Factors affecting construction or placement of laboratories in the undeveloped tactical theater are facility support, climate, and terrain.

Facility Support. Placement of base laboratories in the undeveloped theater requires coordination with supporting engineers who are responsible for providing water, electricity, equipment repair,

drainage, waste disposal, and equipment calibration. These items are planned when projecting requirements for the undeveloped theater. Equipment requiring calibration is placed on a regular schedule with the appropriate calibration teams. TB 43-180 provides calibration requirements for Army equipment. Laboratory personnel (operators) must standardize the laboratory according to the appropriate ASTM or FTMS test procedures. Mobile and airmobile laboratories do not require engineer support during initial emplacement. However, for prolonged periods of deployment, obtain engineer support for electricity, water, wastewater disposal, and calibration of laboratory equipment.

Climate. The climate of an area affects the condition of a fuel. A hot climate ages fuel faster, causing accelerated deterioration. This deterioration may mean that more frequent testing must be performed.

Terrain. The terrain of the theater affects the mobility of laboratories. The base laboratory is not normally moved once it is established in the theater. The mobile petroleum laboratory is readily deployable. Moving the mobile laboratory over great distances is usually done by air. The petroleum airmobile laboratory is the most readily deployable of the three main laboratories. It can be loaded on a 5-ton, drop side truck. It can also be moved by CH-47 helicopter via sling load and it is transportable by any of the current cargo aircraft.

TIME-PHASED LABORATORIES

To ensure quality fuels are provided to the undeveloped theater, testing facilities capable of performing the minimum required tests must be available from the start of operations. The airmobile laboratory is the first testing facility time phased into the theater. It is placed with the first division ashore, assuming a pipeline is built. As the beachhead and the theater expand, the airmobile laboratory moves forward to support the division. Mobile laboratories are then moved to the head terminal in support of the petroleum supply battalion while additional mobile laboratories are deployed with the terminal and operating battalions. At the same time, a modular base laboratory will be constructed or established. Table 6-4 provides a guide for laboratories time-phased into the undeveloped theater.

Table 6-4. Petroleum laboratory timetable

Type of Laboratory	Transport Mode	Estimated Time (in hours)
Airmobile	Air	D through D+5
Mobile	Air or Surface	D+5 through D+60
Base	Surface	D+60 through D+90

CHAPTER 7

INTRODUCTION TO CHEMISTRY FOR THE PETROLEUM LABORATORY

Section I. Matter

GENERAL

Chemistry is a science that deals with the composition and properties of substances or matter, of which everything is composed. In the petroleum laboratory, the laboratory specialist will be responsible to identify chemical substances (perform qualitative analysis) and estimate quantities present (perform quantitative analysis) in their examination of fuel samples. This chapter addresses some of the basic terms, formulas, tests, and equipment they will use.

DEFINITION

Matter is anything that has mass and occupies space. The smallest unit or component of matter is an atom. There are over 100 different kinds of atoms in the world and all matter is made of one or more of these atoms. Since matter can be broken down into its component(s), in addition to classifying it by its current state (solid, liquid, or gas), it can also be classified according to its composition or components.

State. Matter classified by state may exist as a solid, having a definite shape and volume. It may exist as a liquid, having a definite volume but no definite shape. It may also exist as a gas, having no definite shape or volume. The state in which matter exists depends on the prevailing temperature and pressure conditions.

Composition. Matter classified according to its composition will fall into the following categories.

- Element. An element is matter that contains only one type of atom. Therefore, each kind of atom is called an element. Gold is an element since it is made only of gold atoms. The names of each of these known elements has been abbreviated with an approved symbol. All of the known elements are listed by their symbol in Figure 7-1, page 7-2.
- Compound. A compound is matter that is made up of two or more elements, that are chemically combined in a very definite proportion. Compounds can be broken apart. The abbreviation for a compound is called a formula. The formula shows the proportion in which the elements are combined in the compound. Rust is a compound. It is made from the elements iron and oxygen. Examples of other compounds and their formulas are shown in Table 7-1, page 7-2.
- Mixture. A mixture is matter that consists of either two or more elements or compounds (or both) blended together in any proportion. Unlike a compound, it usually absorbs all the properties of the ingredients that went into it. The constituents of a mixture can be separated and recovered by physical or mechanical methods. This is in contrast to compounds, whose constituents must be separated by a chemical process. The following are some types of mixtures:
- Homogeneous mixture. In a homogeneous mixture the composition and properties are the same.
- Heterogeneous mixture. In a heterogeneous mixture the various components are unlike.
- Emulsion. An emulsion is a mixture of very small droplets of a liquid in another liquid.

- Suspension. A suspension contains very small, solid particles dispersed within a liquid which does not dissolve them. The solid particles tend to settle upon standing.
- Solution. In a solution, the dispersed particles are single atoms, molecules, or ions and are too small to be seen even with high magnification.

QUANTITY OF MATTER

Laboratory personnel use the metric system to measure matter. See Appendix C for conversion charts for area, length, temperature, flow, weights, volume and force. Table 7-2, page 7-3 lists frequently used measurement units and prefixes used in the laboratory. Also, there are unique terms that chemists and laboratory personnel use to describe matter discussed in the following paragraphs.

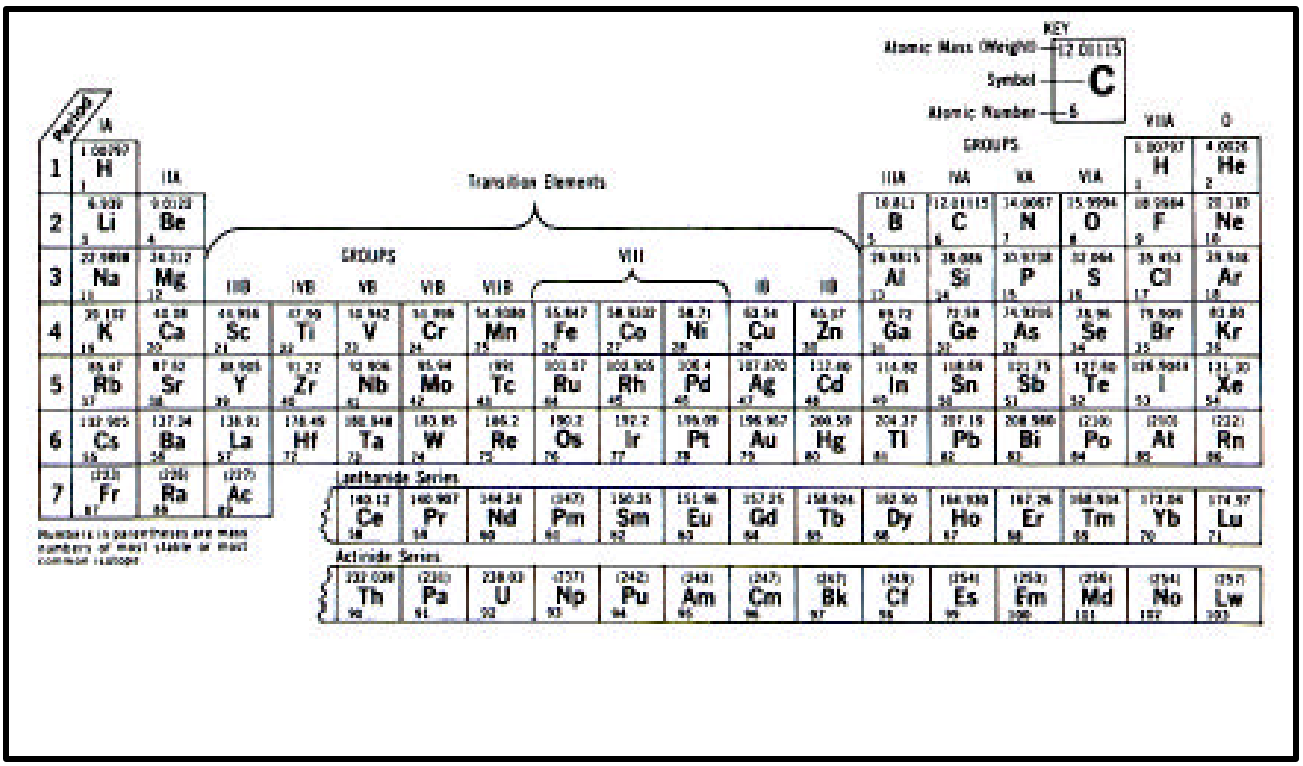


Figure 7-1. Periodic table of the elements

Table 7-1. Examples of components and formulas

Compound	Formula
Sodium chloride	NaCl
Methane	CH4
Sodium Oxide	Na_2O
Ethane	C_2H_6

Mole. The mole is a term used to describe a quantity of matter which is equal to 6.023 X 10E+23 particles (atoms, molecules, or ions) of that matter. It also works out to be the molecular weight of a substance, expressed in grams. The symbol for mole is mol.

Atomic Mass. The atomic mass (weight) of an element is provided in the periodic chart. This number represents two things: (1) the mass of an atom in atomic mass units and (2) more importantly, for the petroleum laboratory specialist, the weight, in grams, of one mole of atoms of an element.

Equivalent Weight. The equivalent weight is the weight of a substance, in grams, that would react with or displace one gram of hydrogen ions in a compound. The equivalent weight of a substance is found by dividing its molecular or formula weight by the total number of electrons its metallic component has lost in forming the compound (its total positive valence). For example, the equivalent weight of $MgCl_2$ is found by dividing its formula weight, 95 grams, by 2, since the magnesium atoms have each lost two electrons in forming the ionic bonds with chlorine. The equivalent weight of $MgCl_2$ is 47.5 grams.

Molecular or Formula Weight. The molecular or formula weight of a compound is the weight, in grams, of one mole of molecules of the compound. It is found by adding the atomic weights of all the constituent elements. For example, to determine the formula weight of magnesium chloride, ($MgCl_2$), do the following:

- Step 1. Refer to the periodic chart, for the atomic weight of magnesium. It is 24. There is one mole of these ions in one mole of $MgCl_2$.
- Step 2. Refer to the periodic chart for the atomic weight of chlorine. It is 35.5. $MgCl_2$ contains two moles of chlorine ions, so the atomic weight must be doubled.
- Step 3. To the weight on one mole of magnesium ions (24 grams), add the weight of two moles of chloride ions (71 grams) to arrive at the weight of one mole of $MgCl_2$ (95 grams).

MEW. The MEW is the equivalent weight divided by 1,000.

Molar Volume. Molar volume is a term associated with the measurement of gases. Gas volume varies with temperature and pressure. The molar volume of a gas is the volume occupied by one mole of its molecules under certain stated pressure and temperature conditions. For example, one mole of ideal gas will occupy a volume of 22.4 liters in a closed container at a temperature of 0° C (273° K) and a pressure of one atmosphere (760 millimeters of mercury).

Table 7-2. Metric system of measure

Property Of Matter Measured	Metric Unit Used	Metric Prefix	Stands For-
weight (mass)	gram		
volume	liter	milli-	$\frac{1}{1000}$
distance	meter	centi-	$\frac{1}{100}$
temperature	Celsius degree	kilo-	1000

Section II. Reagents and Solutions

GENERAL

The use of solutions is important in the daily analytical work performed in the petroleum laboratory. The laboratory technician must be able to prepare solutions of very accurately known concentrations. Some definitions and procedures associated with the preparation of these solutions are discussed below.

EQUATIONS

A chemical equation is used to represent the changes that occur when chemicals react or combine to form new compounds. An equation gives the qualitative nature of a reaction (what compounds or elements combine and what compounds are produced) and also describes the quantitative nature of a reaction (how much of each reactant is needed and how much of the products will be formed). An equation shows the formulas of the starting materials and products, the proportions in which the starting materials combine, and the proportions in which the products are formed. An equation is shorthand for a reaction. Although it does not tell everything, it is extremely useful for the solution of many chemical problems.

REAGENTS

A reagent is a chemical substance that is used for analyses because of its known reaction with other chemical substances. Such analyses are performed through observations of the effects of reagents on unknown substances. A qualitative analysis can identify an unknown when certain results are produced by a certain reagent. A quantitative analysis can then determine the amount of the substance present gravimetrically (by weighing) or volumetrically (by measuring volume).

SOLUTIONS

A solution is a homogenous mixture of two or more substances in which the mixed substances' particles are molecular in size and are uniformly distributed. The dissolved particles cannot be seen, do not settle out upon standing, and are easily removed by filtration. In the petroleum laboratory, the primary concern is in creating solutions in three ways. These three types of solutions involve dissolving gas in a liquid; dissolving solid in a liquid; and dissolving liquid in a liquid. Common terms used in the preparation of solutions are defined below.

- A solvent is the substance that does the dissolving.
- A solute is the substance that is dissolved or dispersed among the solvent particles.
- Solubility is a description of the degree to which a substance will dissolve in a particular solvent.

FACTORS AFFECTING SOLUBILITY

Petroleum laboratory technicians must create solutions for many of the chemical tests they do. It is important that they understand the factors that effect solubility, so they perform their job efficiently. The solubility of a solute and solvent depends on the following factors:

- The nature of the substances mixed is very significant. In general, the rule "like dissolves like" is true. This means that if the molecular structure of the solute and solvent particles is similar, they will probably exhibit an appreciable degree of solubility. For example, an aromatic compound is generally more soluble in benzene (another aromatic compound) than in water or ethanol.
- Temperature is another important consideration. The solubility of a solid solute in a liquid

solvent generally increases when the temperature of the solvent is increased. However, the solubility of a gas in a liquid decreases with increased temperature.

- Pressure is significant only in a gas-liquid type of solution. The solubility of a gas increases when the pressure increases.
- The speed with which a solid solute may be dissolved in a liquid solvent is increased by granulating or powdering the solid and by agitating or stirring the mixture.

CONCENTRATIONS OF SOLUTIONS

The concentration of a solution is a quantitative expression of the amount of solute that is dissolved in a certain amount of solvent. Technicians choose the particular expression for concentration depending on their intended use for the solution. Concentrations are expressed in any one of the following ways.

- Normality. Normality neutralizers acids and bases. A 1N solution contains one gram-equivalent weight of the solute per liter (1,000 ml) of solution.

$$\text{Normality} = \frac{\text{number of equivalent weights of solute}}{\text{liters of solution}}$$

- Molarity. Molarity determines volumes. A 1M solution contains one gram-molecular weight of solute per liter of solution.

$$\text{Molarity} = \frac{\text{molecular weights of solute}}{\text{liters of solution}}$$

- Molality. Molality is concerned with weights during the test. A 1M solution contains one gram-molecular weight of solute per 1,000 grams of solvent.

$$\text{Molality} = \frac{\text{molecular weights of solute}}{\text{1,000 grams of solvent}}$$

- Percent by Weight. This method describes grams of solute per 100 grams of solution.

$$\text{Percent by weight} = \frac{\text{weight of solute}}{\text{weight of solution}} \times 100\%$$

- Percent by Volume. This method describes the volume of solute per 100 volume units of solution.

$$\text{Percent by volume} = \frac{\text{volume of solute}}{\text{volume of solution}} \times 100\%$$

PREPARING SOLUTIONS

Calculations dealing with neutralization of acids and bases generally use normality. Acid/base neutralization chemical reactions are important in petroleum laboratory work, and are described later. For now, it is important to know that using the concept of normality makes it easy to determine the progress of these reactions, and to determine how much acid and base is needed to complete the reaction. Solutions of the same normality contain the same number of equivalent weights per unit volume. Equal volumes of solutions of equal normality are equivalent. Therefore, 10 milliliters of 1N KOH (a base) would neutralize 10 milliliters of any 1N acid solution, whether the acid be HC1 or H_2SO_4. Mathematically, the above statements are summarized by the following:

$$(ml_1)(N_1) = (ml_2)(N_2)$$

$$N_1 V_1 = N_2 V_2$$

PRIMARY STANDARDS

A primary standard is a known substance, with properties that make it useful, as a reference in standardization. The properties of a primary standard should include a high equivalent weight, usually greater than 50. It should be chemically stable and should not absorb atmospheric moisture readily. It also should react completely when neutralized. Primary standards are also rather weak acids and bases, which makes them safer to handle then secondary standards. Common primary standards are discussed below.

- KHP. This primary standard is used to standardize bases because it is acidic. It has an equivalent weight equal to its molecular weight (203.22 grams). Titration of KHP requires the use of phenophthalein indicator. Other primary standards that can be used to standardize bases are: $H_2C_2O_4$ (oxalic acid), $H_2C_2O_4.2H_2O$, C_6H_5COOH, and NH_2SO_3H.
- Na_2CO_3. Anhydrous sodium carbonate is used to standardize acids because it is basic. Its equivalent weight (53.00 grams) is equal to one-half its molecular weight (106.0 grams). Titration of Na_2CO_3 requires the use of methyl orange indicator, since the use of phenolphthalein would yield a false end point.
- Other primary standards that can be used to standardize acids are $KHCO_3$, Tl_2CO_3, $Na_2B_4O_7.10H_2O$, and $Na_2C_2O_4$.
- $H_2C_2O_4$ (oxalic acid), $H_2C_2O_4..2H_2O$ (oxalic acid dihydrate), C_6H_5COOH (benzoic acid), and NH2SO3H (sulfamic acid) may be used to standardize bases.

SECONDARY STANDARDS

Although secondary standards (substances commonly found in laboratories) can function just as well as a primary standard, they are called secondary standards because of certain characteristics that make them less desirable than primary standards. Foremost among these is the fact that substances typically used as secondary standards are strong acids and bases, making them extremely hazardous to handle. They also have low equivalent weights which means relatively high concentrations must be used to neutralize substances. The secondary standard should be of about the same normality as the solution to be standardized. Some examples are discussed below.

- Most strong acids, such as HC1 and H_2SO_4, can be used satisfactorily as secondary standards.
- The strong bases usually used as secondary standards are KOH and NaOH.

STANDARDIZATION

Standardization is the process of obtaining a standard solution. A standard solution is one whose concentration is known to the fourth decimal place. In general, standard solutions are either acidic or basic. An acidic solution is standardized with a base and a basic solution is standardized with an acid. When a solution is standardized, comparison is made of volumes of solution of known and unknown concentration which undergo a neutralization.

TITRATION

Titration is the process of determining the volume of reagent solution required to react with a solution of another substance. Titration measures the volumes of the unknown and standard solutions. Since the concentration of the standard is known, the concentration of the unknown may be calculated by applying these fundamental relationships

$$\text{Normality} = \frac{\text{number of milliequivalent weights}}{\text{number of milliliters of solution}}$$

$$\underset{\text{(Reactant 1)}}{\text{Number of milliequivalents}} = \underset{\text{(Reactant 2)}}{\text{number of milliequivalents}}$$

$$\text{Number of milliequivalents} = \text{normality x milliliters}$$

Substituting the above expression into relationship 2 leads to the relationship:

$$\underset{\text{(Reactant 1)}}{\text{Normality x milliliters}} = \underset{\text{(Reactant 2)}}{\text{Normality x milliliters}}$$

Or:

$$n_1 X ml_1 = N_2 X ml_2$$

These relationships enable further calculations to be made, dealing with the determination of the weight of substances reacting with the standard solution.

STANDARDIZATION BY TITRATION

Assume that a 0.1N solution of an acid is to be prepared and standardized. A quality of one liter is required. The following steps describe the procedure.

- Step 1. Select a basic primary standard for an acidic solution, usually sodium carbonate. Note from the container the milliequivalent weight and assay values.
- Step 2. Calculate the weight of primary standard required to neutralize about 40 milliliters of 0.1N acid with the use of the equation. DFP represents decimal fractional purity.

$$\text{weight needed (MG)} = \frac{\text{(N) (40ml) (MEW)}}{\text{DFP}}$$

- Step 3. Weigh a clean and dry Erlenmeyer flask on the analytical balance.
- Step 4. Add the grams of primary standard calculated in Step 2 above, and record the weight to the fourth decimal place.
- Step 5. Dissolve the primary standard in an unmeasured quantity of water.
- Step 6. Add two or three drops of methyl orange.
- Step 7. Using burets, titrate the solution in the flask with the acid solution to be standardized.
- Step 8. Repeat the titration procedures at least two more times.
- Step 9. For each titration, calculate the normality (to four decimal places) of the acid solution by using the following equation:

$$N = \frac{\text{(DFP) (weight of primary standard)}}{\text{(ml of acid) (MEW primary standard)}}$$

- Step 10. Obtain the average value of the acid's normality and label the standardized solution for identification. If any solution differs from the mean by $\pm$0.0005 N, rerun the titration process.

pH SCALE

The pH scale determines the acidic or basic range of a substance (see Figure 7-2, page 7-8). The scale has a range from one to fourteen, with seven being neutral. Acids have a pH of 1-6.999; bases have a pH of 7.001-14; and neutral is 7.000. When acids and bases are mixed together, the pH is altered. When an acid and base is mixed in equal proportions based on their normality, they will combine to become a salt based liquid or neutral substance. Characteristics of acids and bases are stated below.

- Acid characteristics include: turn blue litmus paper red, and have a pH less than 7.00.
- Base characteristics include: turn red litmus paper blue, and have a pH greater than 7.00.

INDICATORS

Indicators are dyes that change color or shade of color when the pH (degree of acidity or alkalinity) of a solution changes. Therefore, they can be used to indicate the concentration of hydrogen ions in solutions of acids and bases. They are also used in volumetric analysis to mark the end point of titration. Indicators used in the petroleum laboratory are as follows:

- Methyl Orange. This indicator has a pH range of 3.1 (red) to 4.4 (yellow-orange). It is also used in the presence of carbonate radicals (anything containing the CO_3 atom group such as TL_2 CO_3). The solution is made by dissolving 0.1 grams in 100 milliliters of distilled water. The end point is an orange-brown.
- Methyl purple. This indicator has a pH range of 4.8 (purple) to 5.4 (green). The change from purple to green is fast and is preceded by a change from purple to light gray. This indicator is also used in the lamp sulfur test and is prepared according to the test method.
- Paranitrophenol. This indicator has a pH range of 5.0 (colorless) to 7.0 (yellow-green). It is also used only when called for in ASTM test procedures. The solution is made by dissolving 0.5 grams of p-nitrophenol in 100 milliliters of distilled

water and filtering if necessary. The end point is pale yellow.

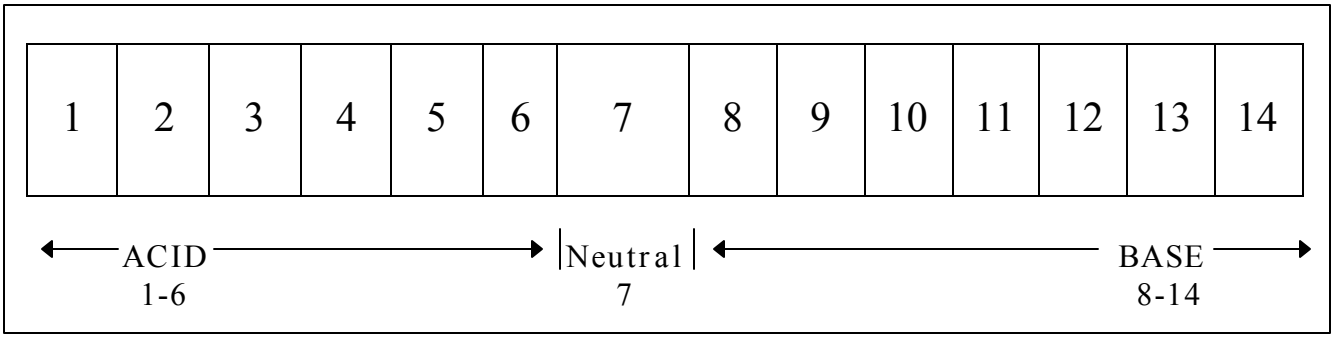


Figure 7-2. pH Scale

- Phenolphthalein. This indicator has a pH range of 8.0 (colorless) to 9.8 (red). It is also used in the absence of carbonate radicals. The solution is made by dissolving 1.0 grams in milliliters of 90 percent ethyl alcohol. The end point is faint black.

- P-Naphtholbenzein. This indicator has a pH range of 8.2 (amber) to 10.5 (blue). It will go from amber to olive green to clear green to bluish green to blue. This indicator is also used in the neutralization number test and is prepared according to the test method.

Section III. Balances and Weighing

GENERAL

Weighing is a necessary part of preparing solutions and is used in many tests in the laboratory. The petroleum laboratory has several types of balances for specific purposes.

ANALYTICAL BALANCE

The analytical balance is used for precision weighing (0.0001 gram) of small quantities. Figure 7-3 is a single-pan analytical balance with advanced features. Those features include: easy-to-read display, separate sealed keys and automatic calibration. General procedures for using this balance are listed on the following page. Again, the manufacturer's handbook should be available when using the balance

Figure 7-3. Analytical balance

Weighing Press the TARE to zero the display. Place the object(s) to be weighed on the pan. Read the displayed weight after the display is stable (i.e. when the no-motion symbol indicates stability by switching off or on).

Weighing-In Place a container on the pan. Press the TARE key or use a remote switch to zero the display. Fill the container until the target weight is reached. When mixing ingredients in a container press TARE after each addition.

Weighing-Out. Place a full container on the pan. Press TARE to zero the display. When anything is subsequently removed from the container the amount removed will be displayed as weight loss.

Weighing a Deviation. Place a reference or standard sample weight on the pan. Press TARE and then remove the weight, weight loss will be displayed. Now any sample weight placed on the pan will indicate its deviation from reference in terms of a positive or negative display. This function is useful in check-weighing operations.

THE HARVARD TRIP BALANCE

The Harvard trip balance, shown in Figure 7-4, page 7-10 is a precision balance used for weighing substances in the petroleum laboratory. It should be used on a reasonably flat and level surface. In this setting a very near balance should be attained with the beam and tare poises all the way to the left. Some of its operational features are discussed below.

Zeroing the Balance. If the scale does not balance at zero when set upon its working surface, adjust the knurled zero adjust knob at the right end of the beam. (It is also advisable to check the zero balance periodically since foreign material may accumulate on the plate or beams and cause a slight change in the balancing position)

Weighting. After a zero balance has been obtained, the specimen to be weighed is placed on the left platform of the balance. The poises are then moved to a position which will restore the scale to balance. The lower poise is moved to the right until the first notch is reached which causes the right platform of the scale to drop. The lower poise is then moved back one notch which will cause the right platform to again rise. The upper poise is then moved to the right until the scale is brought into balance. The resultant weight is then read directly from the beams by adding the amount indicated on the lower and upper beams.

Use of the Tare Poise. To use the tare poise, first slide the poise to an approximate balance position, and then rotate the poise to obtain final balance. An internal screw thread allows the tare poise to be precisely positioned in either direction by simply rotating it. (When the tare poise is not in use, it should be slid firmly to the left until it makes contact with a stop.)

Specific Gravity Determination. For the purpose of suspending specimens for immersion weightings, bent pins are provided near the bottom of the scale plate loops which are accessible from the underside of the scale base. The balance can be mounted on a Clamp and Rod Support. There is a half-inch clearance hole provided underneath the base that slips on over the end of the rod. The procedure for weighing a suspended specimen is the same as that for weighing a specimen on the scale platform.

Care and Maintenance. When the balance is not in use, be sure to remove the load from the weighing pan and to replace the rubber washers to lift the pivots off the bearings. Avoid storing the balance in a place where vibrations will be transmitted to it. Keep the balance clean at all times, being particularly careful not to let dirt accumulate in the vicinity of the bearings. Never lubricate the scale bearings. The bearings in these balances are high grade polished agate V-blocks and the knife

Figure 7-4. Harvard trip balance

edges are hardened, precision-ground steel. This type of bearing works best when clean and dry. Should the bearings become dirty, attempt to clean by blowing out with air blast. If this is unsuccessful, the bearing covers will have to be removed. In replacing the bearing covers, it is necessary that the hardened blue steel friction plate is replaced in the recess provided.

Cleaning Magnet Faces. From time to time, it is necessary to clean accumulated debris from the magnet faces. This is best done by inserting a piece of adhesive tape into the magnet slot and pressing it against the magnet face. This will pick up attracted material and prevent it from interfering with movement of the damper vane.

TRIPLE BEAM BALANCE

The triple beam balance is used when precise weighing is not required. For instance, it would be used when determining the approximate weight of tubes to be centrifuged. General instructions for using the triple beam balance, are provided in the following paragraphs. Figure 7-5, page is a photograph of the triple beam balance.

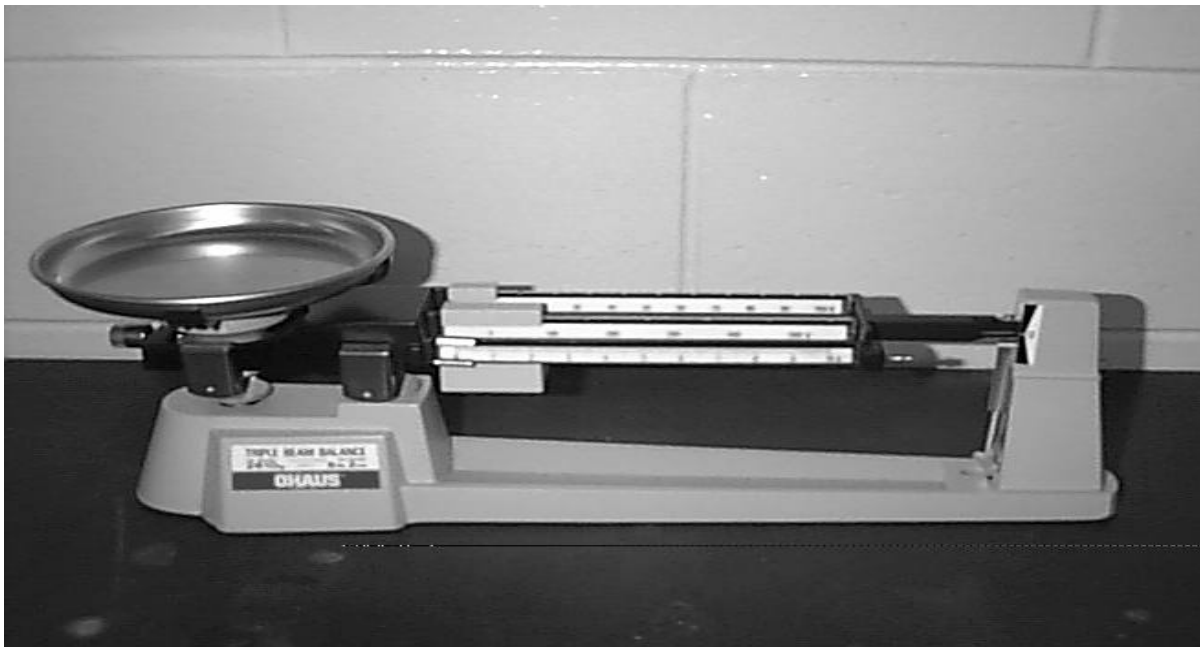


Figure 7-5. Triple beam balance

Leveling and Zero Balance. Select a reasonably flat and level surface on which to use the balance. The beam should be near a zero balance with all poises at zero, and the tare poise against its stop to the extreme left (tare models only). A final zero balance is attained by means of the knurled zero. Adjust the knob at the left end of the beam. Check the zero balance periodically since foreign material may accumulate on the plate or beams and cause a slight change in the balance position. Whenever the balance is moved, the zero balance must be rechecked, since it will be affected by a change in the inclination of the working surface.

Weighing. After obtaining a zero balance, place the substance to be weighed on the load receiving platform. Move the center poise to the first notch where it causes the beam pointer to drop, then move back one notch and the pointer will rise. On metric models, proceed by manipulating the rear poise in the same manner. Then slide the front poise to the position that brings the beam into balance. On avoirdupois models, proceed by sliding either the front or rear poise to the position that brings the beam into balance. The weight of the substance is then directly read by adding the values indicated by the poises. While not in use, the attachment weights store conveniently along the trough in the base of the balance.

Use of the Tare Poise. Slide the poise to an approximate balance position, and rotate the poise to obtain final balance. An internal screw thread allows the tare poise to be precisely positioned in either direction by simply rotating it. When the tare poise is not in use, it should be slid firmly to the left until it makes contact with a stop.

Care and Maintenance. Keep the balance clean at all times; do not let dirt accumulate in the vicinity of the bearings. Do not apply oil or any lubricant to the knives or bearings. Blowing the bearings out with a dry air blast is a very effective way of cleaning them and it is recommended that this be done periodically to maintain the utmost of sensitivity in the balance. From time to time, it is necessary to clean accumulated debris from the magnet face. This is best done by inserting a piece of adhesive tape into the magnet slot and pressing it against the magnet face. This will pick up attracted material and prevent it from interferring with movement of the damper vane. When transporting the balance, take care that it does not receive any sharp blows and is not subjected to unnecessary rough treatment. When the balance is not in use, be sure to remove the pad from the weighing pan.

CHAPTER 8

EVALUATING PETROLEUM PRODUCTS

Section I. Properties of Petroleum Products

CRITICAL PROPERTIES

The critical properties of a product determine the adequacy of that product for its intended use. When the critical properties of a product do not meet specification or use limits, the product must be reclaimed by downgrading, blending. filtering, dehydrating, or inhibiting. The following paragraphs describe critical properties and list tests performed on products to determine their suitability for use. See Appendix D for a table on probable causes of contamination / deterioration.

API GRAVITY (ASTM 287, D 1298)

Scope. These tests are run on all petroleum products, except greases, to determine their densities in terms of API gravity.

Significance. These tests are generally used as a quality control indicator, but some specifications have actual API gravity requirements. The scale was developed to eliminate the problem of working with decimals associated with specific gravity. An API gravity of 10 is equal to 1.000 specific gravity. As the API gravity goes up, its corresponding specific gravity goes down. API gravity is needed in order to select volume reduction factors to be used in fuel accounting procedures. When the API gravity of a product rises more than 0.5 (for example, MOGAS going from 59.5 to 60.1 API gravity), the cause is usually contamination by a lighter petroleum product. A drop in API gravity is generally caused by contamination with a heavier product. Results that vary more than 0.5 API indicate a problem, and further tests must be performed to determine the cause.

APPEARANCE/WORKMANSHIP

Scope. This is a visual test performed on a product to determine if it is homogeneous, clear, bright, separated, or otherwise different from what the product should look like.

Significance. Depending on the product, it will be clear (free of suspended matter or particles), bright (sparkle in transmitted light), homogeneous (uniformly mixed), separated (stratified or bleeding), or have visual sediment or water. To make these determinations, care should be taken that nothing is overlooked. Control of such contamination requires constant vigilance. Solid and liquid contamination can lead to restriction of fuel metering points, improper seating of inlet valves, corrosion, fuel line freezing, gel formation, filter plugging, or failure to lubricate. Product containing visual sediment and water should be allowed to settle and then filtered before use.

AQUA-GLO WATER TEST (ASTM D 3240)

Scope This test is run on aviation fuels and selected ground fuels to detect harmful levels of water contamination.

Significance. Water can become a petroleum contaminant at any stage from the refinery to ultimate use. Extreme care must be taken to eliminate it from fuel. Water in aviation fuels can freeze and form ice at altitudes above 8,500 feet. The resulting ice can clog on-board fuel filters and prevent fuel flow to the engine. For this reason,

water is generally limited to 10 parts per million, maximum. If the result is higher, a resample should be taken and tested. If a resample fails, the fuel distribution system should be evaluated for proper settling times and filter elements checked. Water in diesel fuels can cause severe corrosion in cylinders and stop a diesel engine. Fuel line freezes can occur in ground equipment as well as in aircraft. Current Army policy dictates that ground fuels be filtered before use.

ASH CONTENT (ASTM D 482 AND D 874)

Scope. These tests are performed to determine the amount of ash-forming materials present in fuel oils and lubricating oils.

Significance. The plain ash test (D 482) is run on fuel oils and non-additive lubricating oils to detect contamination by inorganic matter, such as rust, sand, or metallic salts. These contaminants can abrade metal surfaces, and in the case of fuel oils, clog injection nozzles and form deposits. The sulfated ash test (D 874) is run on additive-type lubricating oils to determine the amount of additive present. Test results usually show sulfated ash in the range of 0.8 to 1.5 percent. If periodic testing reveals a decrease in percentage, additive loss is indicated. If tests on distillate fuels reveal contamination by inorganic matter, the fuels can usually be reclaimed by allowing them to settle and then filtering them. If tests on non-additive lubricating oils show contamination, the oils should be disposed of as directed. If tests on additive-type lubricating oils show loss of additive, the oils can usually be reclaimed by blending.

CARBON RESIDUE (ASTM D 189 AND D 524)

Scope. These tests are performed on distillate fuels, lubricating oils, and residual fuel oils.

Significance. The type of carbon residue resulting from the tests indicates the base of crude oil used in the refining process. A product derived from a paraffin base crude produces a H&F residue, and a product derived from an asphalt or naphthalene base crude produces a L&F residue. Paraffin base products produce little carbon residue, generally in the range of 0.01 to 0.5 percent. Asphalt and napthene base products produce residue in the range of 0.1 to 30 percent. The tests are useful in detecting residual contamination in distillate products. When residual contamination is present, the amount of residue increases. This form of contamination also causes the 50 percent to end-point results in the distillation test to be higher and product color to be darker.

- Distillate fuels that show carbon residues of 0.5 percent or less may be used in high-speed engines. Those that show residues of up to 12 percent may be used in slow-speed engines for limited periods. Carbon residue in engines can cause hot-spot ignition in combustion chambers and fuel-injector blockage. High-carbon residue fuels can be reclaimed by blending.
- Lubricating oils that show high carbon residues are poor lubricants. They are usually asphalt or mixed base products. These tend to form harmful deposits in engines. If a lubricating oil shows a high carbon residue, it should be disposed of as prescribed by regulation.
- Residual fuel oils that show high carbon residues may cause problems in heat-generating equipment. Carbon deposits formed during combustion can foul burner tips. Also, such fuel oils may smoke excessively when burned and cause severe air pollution.

CLEVELAND OPEN CUP FLASH POINT (ASTM D 92)

Scope. This test is performed on various lubricating oils, hydraulic oils, brake fluids, gear oils, and other heavy petroleum products flashing above 175°F. It is used to determine the lowest temperature at which ignition can occur.

Significance. The COC flash test is performed to ensure that low-flash point materials have not contaminated the product. In new oils, the test is used to ensure that proper refining methods have removed these low-flash materials.

The specification flash point is designed to ensure that the flash point of the product is above the expected operating temperature. In used oils, the COC flash test is used to detect the presence of low-flash point and low-boiling point contaminants. In engine lube oils, a faulty choke or poor engine timing can cause incomplete combustion of fuel in the cylinder. This unburnt fuel seeps down into the crankcase, diluting the oil and reducing its film strength causing oil burning and cylinder wall wear. The flash point usually is 50°-100°F above the specification. If test results show the oil to be slightly off specification or barely on specification, the oil probably has been diluted with a low-flash product. The dilution also reduces viscosity (ASTM D 445). New products that are off specification should be reported, and used oil found to be off specification should be disposed of according to local directives.

CLOUD POINT (ASTM D 2500)

Scope. This test is performed on diesel fuels, fuel oils, and other petroleum oils that are transparent and have a cloud point below 120°F.

Significance. The cloud point is an indication of the behavior of an oil in certain lubricating devices. The formation of minute, waxy crystals may plug the wick through which oil flows in some lubricating devices. However, extreme low-temperature operating conditions are rarely encountered with equipment lubricated in this manner. Fuel oils and diesel fuels with high cloud point could clog fuel filters if a preheater is not used. Contamination with a heavier product can raise the cloud point.

COLOR (ASTM D 156, D 1500, D 2392)

Scope. Color tests are made on many petroleum products to detect deterioration and contamination. In some cases color tests are performed to identify products.

- Jet fuels, kerosene, and solvents are usually color tested by the Saybolt chromometer method (D 156). Undyed motor and AVGASs can also be tested by this method. Equipment used in the test includes a Saybolt chromometer, color standards, and a daylight lamp.
- Diesel fuel, lubricating oils, and heating oils are color tested by the ASTM color scale method (D 1500). Equipment used in the test includes a light source, glass color standards, a sample container, and a viewing piece.
- Dyed AVGASs are color tested by ASTM method D 2392. Equipment used in the test includes a color comparator, fluid tubes, plungers, and aviation gasoline color standards.
- Dyed MOGAS is tested by FTMS No. 103.5. This method is similar to the method used to test dyed AVGAS. In both tests, the Hellige apparatus is used.

Significance. In refining, a color test is used to determine the uniformity of a product batch. Once the product is in the distribution system, a color test is used as a quick check for deterioration and contamination. If a color test reveals a color darker than expected, the test may indicate contamination by a heavier product or deterioration due to age. If a test reveals a color lighter than expected, the test may indicate contamination by a clear or straw-colored product.

CONE PENETRATION OF GREASE (ASTM D 217)

Scope. This test is performed on greases to measure their consistency (thickness) or resistance to breakdown under force. It is generally measured as unworked (new) or worked (simulated use) penetration. The higher the penetration number, the lower the consistency or thickness.

Significance. The penetration number is used by refiners to show a uniformly produced product. Its value is related to the oil used and the base soap used. Typically, a mineral oil is mixed with a calcium, sodium, lithium, aluminum, or barium soap base. Calcium base usually has a high penetration number and aluminum is generally in a medium range. Sodium, lithium, and barium have low

penetration numbers. An increase in the penetration number can indicate an oil/soap separation of the grease in storage. Greases are graded much like oils. Table 8-l, page 8-4 reflects the NLGI grading system for greases based on penetration range.

Table 8-1. Grades of grease

NLGI GRADE	WORKED PENETRATION RANGE MM/10
000	445-475
00	400-430
0	355-385
1	310-340
2	265-295
3	220-250
4	175-205
5	130-160
6	85-115

COPPER CORROSION (ASTM D 130)

Scope. This test is run on almost all petroleum products to check for any contaminant that could corrode copper components in equipment.

Significance. This test is a qualitative measure of the corrosiveness of a product. This corrosiveness comes from the presence of free sulfur or sulfur compounds. When properly refined, these products are non-corrosive, with ASTM D 130 ratings of 1A or 1B. Test results of greater than 1B indicate the presence of corrosive compounds. This is usually unacceptable; however, in the case of some products, short-term use of the product may be authorized. In bulk storage tanks, corrosion results from H_2S being formed in water bottoms and percolating up through the product. Off-specification corrosive fuel must be blended with a better, less corrosive fuel to bring it within acceptable limits. Sulfur tests should also be performed to determine the exact amounts of sulfur compounds present. In lube oils and hydraulic fluids, blending of off-specification corrosive product is generally not feasible, and these products should be reported according to directives for proper disposal.

DISTILLATION (ASTM D 86)

Scope. The distillation test is performed on light distillates such as aviation turbine fuels, MOGASs, AVGASs, distillate fuel oils, and kerosene.

Significance. The distillation test is used to evaluate vaporization characteristics of a fuel. To obtain a fuel that has specific characteristics, controls must be established over the amount of evaporation that will take place at different boiling temperatures. As distillation progresses, the composition of the sample changes. Some liquid residue may remain after the maximum temperature is reached. This portion of the fuel may not vaporize in service; it will remove the lubricant from the cylinder walls and contribute to crankcase oil dilution. Figure 8-1 shows a typical gasoline distillation

curve. The curve illustrates the significance of percentages evaporating at different stages in the boiling range and how these stages are evaluated.

- MOGAS is a complex mixture of relatively volatile hydrocarbons that have different boiling points. Easy starting, quick warmup, freedom from vapor lock, good manifold distribution, and minimum crankcase dilution are all performance features that are directly related to volatility of the gasoline. Fuel economy depends on volatility as well as other characteristics, such as combustion behavior. Seasonal and geographic grades of fuel differ principally in vaporization tendencies.

- AVGAS which vaporizes too readily may form bubbles particularly at higher altitudes, in the fuel lines or the carburetor. The bubbles cause partial or complete blockage of the fuel supply, and the engine may operate abnormally or stall. This is known as vapor lock. Conversely, gasolines which do not completely vaporize may cause poor engine performance of other sorts. Therefore, gasolines must conform to a very narrow volatility range to be suitable for use in aircraft engines.

- Diesel fuel contaminated by a lighter product will have a lower initial boiling point and a lower flash point. A dilution of one part of light product per hundred parts of diesel fuel may drop the initial boiling point by 50°F and the flash point by 12°F.

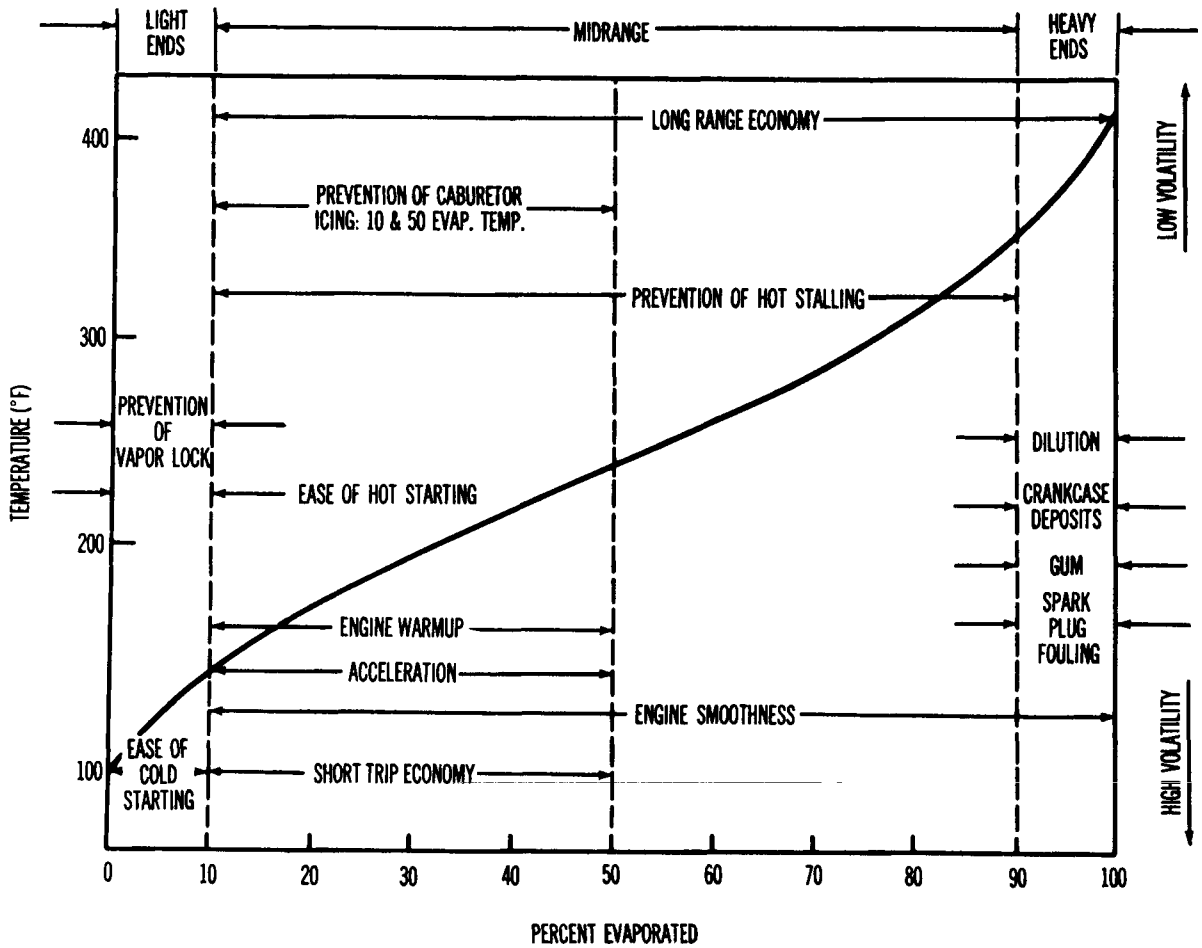


Figure 8-1. ASTM distillation curve.

(From Chemical Technology of Petroleum, by Gruse and Stevens; copyright 1960, McGraw-Hill Book Company, Inc. Used with the permission of McGraw-Hill Book Company)

DROPPING POINT OF GREASE (ASTM D 566)

Scope. This test is performed on many greases to determine the temperature at which the grease will change from a semi-solid to a liquid.

Significance. The dropping point test is useful in predicting the maximum temperature to which a grease may be subjected in use. In quality control work, it is useful in establishing a trend of results on which to base stock rotation. The dropping point is indicative of the type of thickener base. Calcium, aluminum, and lithium base greases have low to medium (175°-275°F) dropping points. Sodium and barium base greases have high dropping points (above 275°F). Greases that fail the test should be disposed of according to regulations.

EXISTENT GUM (ASTM D 381)

Scope. The existent gum by jet evaporation test is performed on MOGAS and aircraft fuels.

Significance. High gum content indicates that the fuel might cause deposits in the induction system and sticking of intake valves. The existent gum test can tell the user the amount of oxidation that has taken place before the test was performed. Storage tanks that are vented to the atmosphere, breathe when temperatures fluctuate.

This causes the fuel to oxidize and form gum. Contaminated fuel will show an oily gum; deteriorated fuel will show a dry gum. High-gum product can be blended down to a usable level by adding a low-gum product of the same grade.

FREEZING POINT (ASTM D 2386)

Scope. This test is run on aviation fuels to determine the lowest temperature at which a fuel will flow.

Significance. Wax and excess aromatic components in fuel raise the freezing point. These components can be present as a result of contamination or poor refining. Modern aircraft fly at high altitudes where temperatures can be as low as -67° F. At these low temperatures, wax and aromatics can freeze and clog fuel line strainers, shutting off the engine. At the procurement level, a fuel failing the freezing point test usually indicates poor refinery blending. Such fuel is rejected and reblended before shipment. In quality surveillance work, a fuel failing the freezing point test usually indicates contamination with diesel fuel or fuel oil. This can be confirmed by high distillation end points, oily gum results, and water reaction interface test failures. Fuels failing the freezing point test can be upgraded by blending with on specification product.

FUEL SYSTEM ICING INHIBITOR (FSII) (FTMS 5327.4 AND ASTM 5006 /B-2 TEST KIT)

Scope. This test is performed on jet turbine fuels that contain the inhibitor ethylene glycol monomethyl ether or diethylene glycol monomethyl ether. The B-2 test kit technique is not applicable to diesel fuel.

Significance. FSII is added to jet fuels to prevent dissolved water from freezing at high altitudes (above 8,500 feet). In 1962, the use of FSII was adopted worldwide in military jet fuels. FSII must be added at procurement at a 0.10 to 0.15 percent volume level. It must be retained in jet fuels until end usage from 0.08 to 0.20 percent volume (use limits). FSII will drop out of fuel easily when the fuel is in contact with water. Proper quality control of jet fuel requires that contact with water be strictly avoided. If test results show that the FSII content is between 0.15 and 0.20 percent, the cause is usually testing error or blending error in the storage tank. If the result is between 0.08 and 0.10 percent, the fuel is suitable for use but should be upgraded by blending or injecting additive. If the result is less than 0.08 percent, the fuel is not suitable for use until it is upgraded. Storage procedures should be evaluated to find the source of the water contamination.

IGNITION QUALITY OF DIESEL FUELS (ASTM D 613/ D 976)

Scope. This test is made on diesel fuels to determine ignition quality, which is expressed as a cetane number. The cetane number scale is similar to the octane number scale used in rating gasoline.

Significance. When a fine spray of fuel is injected into the combustion chamber of a diesel engine, ignition does not occur immediately. The heat produced by compression varies from about 825°F at 10:1 compression ratio to about 1,050°F at 15:1 compression ratio and is the sole source of ignition. The interval between the beginning of the fuel injection and ignition is called the ignition delay period. If the delay is long, the engine may be hard to start. When the accumulated fuel ignites, the excessive energy released causes the engine to knock. The shorter the delay, the easier the engine is to start and the smoother it operates.

- Cetane number scale. The cetane number scale is based on the ignition characteristics of two hydrocarbons (normal cetane and methylnaphthalene). Normal cetane has a short delay period and ignites readily. It has a cetane number of 100. Methylnaphthalene has a long delay period and does not ignite readily. It has a cetane number of 0. The cetane number of a diesel fuel is the percentage by volume of normal cetane in a blend with methylnaphthalene that matches the ignition

quality of a reference fuel with known cetane number.

- Cetane index. If a test engine is not available or the quantity of fuel is too small for an engine test, the cetane number can be estimated from API gravity and 50 percent distillation point or calculated by using a formula or nomograph (D 976). The index value so determined is called a calculated cetane index. This method of determining approximate cetane numbers is not valid for fuels containing additives for raising cetane number or for pure hydrocarbons, synthetic fuels. alkylates. or coal-tar products.
- Reclamation of off-specification fuels. Considering laboratory results and guidance, fuels that are off specification may be downgraded or blended with fuels that are on specification.

KINEMATIC VISCOSITY (ASTM D 445)

Scope. This test is performed on diesel fuels, fuel oils, hydraulic fluids, and lubricating oils to measure the internal resistance to flow. The result is reported in cSt. Tables exist for converting kinematic viscosity in cSt to Saybolt Universal Viscosity in seconds and Saybolt Furol Viscosity in Saybolt Furol seconds, see ASTM D 2161.

Significance. A viscosity range is established for fuel and is the prime test to separate various grades. The viscosity range is needed to maintain flow conditions in the heavier (4, 5, or 6) grades. In grades 1 and 2, the viscosity determines how well the fuel will be vaporized. Poor vaporization at the fuel nozzle can cause poor burning and carbon formation. Too low a viscosity can cause flashbacks in the burners. Viscosity test results may be high if the fuel is contaminated with a heavier fuel. The fuel should also show a darker color. When the result is lower than expected, contamination by a lighter product, such as gasoline or jet fuel, is indicated. A corresponding low initial boiling point in distillation and a low flash point will also occur. Either high- or low-viscosity problems can be corrected by blending.

SAE Weight/Grade. Viscosity in lubricating oils is used to determine the SAE weight/grade of the oil. Tables 8-2 and 8-3, page 8-8 show SAE numbers. Viscosities are expressed in cSt. Viscosity results are seldom higher than expected. Usually, low viscosity is caused by dilution or gasoline contamination. Off specification oils are changed and disposed of as permitted by regulation.

Viscosity Index. VI is a means of rating resistance to change in viscosity with change in temperature. The scale was originally set up with a paraffin base oil having a viscosity index of 100 and a cycloparaffin base oil having a viscosity index of 0. Now additives, such as polyisobutylene, are added to raise the VI to the 200 range. Multigrade oils, such as 10W-40, have a high VI. They have a paraffin base. Polyisobutylene acts as a pour-point depressant as well as a VI improver.

Table 8-2. Crankcase oil viscosities

SAE No	VISCOSITY AT 100° C (cST)	VISCOSITY AT 40° C (cST)
10	6.2	40.2
30	11.4	105.2
40	13.5	130.4
10W-30	10.0	61.0
15W-40	14.2	106.9

Table 8-3. Gear oil viscosities

SAE No	VISCOSITY AT 100° C (cST)
75w	4.1
80w	7.0
85w	11.0
90	13.5 to 24.0
140	24.0 to 41.0
250	41.0

LEAD IN FUELS (ASTM D 2547, D 2699, D 3341, AND MIL-HDBK-200)

Scope. These tests are performed on MOGAS and AVGAS to determine the quantity of lead present. Lead determination on unleaded gasoline and jet fuel suspected of lead contamination may be determined by ASTM D 3116, D 3229, D 3237, or MIL-HDBK-200.

Significance. Lead may be present in MOGAS and AVGAS as a result of intentional blending. It may be present as a result of contamination. This contamination may occur by an accidental mixing with a leaded fuel, or it may occur because of improper storage or transport. In jet fuel, lead is a contaminant; it is never intentionally added because it forms deposits on turbine fans. These deposits can affect the balance of the fans, which may result in fan failure. ASTM methods D 2599 and D 3341 are used to determine the amount of lead in MOGAS and AVGAS. It can be used to measure lead content in the range of 0.001 to 0.020 grams of lead per liter of fuel.

NEUTRALIZATION NUMBER (ASTM D 974)

Scope. This test is performed on new oils and distillate fuels to detect any excess acid or basic components left over from refining. It is also performed on used oils to detect acid or basic increases due to oxidation.

Significance. In new oils and distillates, the test results generally will be less than 0.1, showing that mineral acids or bases were removed during refining. Higher results than allowed in specifications indicate inadequate refining. In used oils, the test measures the increase in acids formed as a product of combustion. These organic acids, although weak, can have a corrosive effect on cylinder walls and rings. Basic additives are added to new oils to help neutralize these acids. Over long periods of use, these additives will be consumed and a rise in neutralization number will occur. This rise will indicate a need to change oil.

OXIDATION STABILITY AND POTENTIAL GUM (INDUCTION PERIOD METHOD AND POTENTIAL RESIDUE METHOD) (ASTM D 525 AND D 873)

Scope. These tests are used to predict the stability of AVGAS MOGAS in long-term storage.

Significance. When gasoline is subjected to long-term storage, they tend to oxidize. To retard this process, refiners add oxidation inhibitors and remove unstable hydrocarbons as much as possible. However, the products will retain some aromatics (which are unstable) to increase octane or performance number. To measure the tendency of gasoline to oxidize and form gum, two tests are used.

- MOGAS. ASTM D 525, Oxidation Stability of Gasoline (Induction Period Method) is

used to determine stability of MOGAS under accelerated oxidation conditions. In this test, a sample is oxidized in a bomb, and the pressure is read and recorded in chart form at stated intervals until the break point is reached. (The break point is the point in the pressure-time curve that is preceded by a pressure drop of exactly 2 psi within 15 minutes and succeeded by a drop of not less than 2 psi in 15 minutes.) If a break point is observed, the decrease in induction time over a period of months can be used to determine when stocks should be rotated. If no break point is reached, the Existent Gum Test (D 381) is run and stocks are rotated while they are still on specification.

- AVGAS. ASTM D 873, Oxidation Stability of Aviation Fuels (Potential Residue Method) is used to determine the tendency of AVGAS to form gum and deposits under accelerated aging conditions. In this test, a sample is oxidized in a bomb, and the amounts of soluble and insoluble gums and precipitate are weighed. An increase in precipitate signals possible 1088 of tetraethvllead. Results of the tests can be used as a basis for stock rotation action.

PARTICULATE CONTAMINANT IN AVIATION FUEL (ASTM D 2276, ASTM 5452, ASTM 3830)

Scope. These tests are run on aviation and ground fuels to test for the presence of excessive nonpetroleum contaminants such as dirt, sand, and metal.

Significance. From the time a fuel is refined until it is used, it comes in contact with iron, rust, sand, and other solid contaminants. Generally, fuel is allowed to settle and then filtered in order to remove these contaminants. The particulate contaminant test is performed at various distribution locations to determine the effectiveness of the cleaning process. If the test result is too high, an immediate resample should be taken as high results may be due to poor sampling technique. If a resample also fails, the entire system should be evaluated to detect the problem. The high result could be caused by inadequate settling times or unserviceable filter elements. Specification requirements for particular products may be found in their respective military specification. Deterioration limits may be found in MIL-HDBK-200.

PENSKY-MARTENS FLASH POINT (ASTM D 93)

Scope. This test is run on fuel oils and diesel fuels and is used to verify that the fuel oil or diesel fuel meets minimum safety levels for combustible vapor formation. It is especially significant for testing fuel to be used by ships.

Significance. The flash point generally is associated with the LCL for fuel. If the fuel oil flash point drops by more than 6°F, contamination with a lighter product (gasoline or jet fuel) should be suspected. This should also show up in a lower IBP in the distillation. If the flash point goes up more than 6°F, contamination with a heavier product (heavy fuel oil or lubricating oil) should be suspected. A higher distillation end point, higher viscosity, and possibly a color change will verify this. To a limited degree, off specification product can be upgraded by blending.

POUR POINT OF PETROLEUM OILS (ASTM D 97)

Scope. This test is performed on most petroleum products. It can also test the fluidity of a residual fuel oil at specified temperatures.

Significance. The tests are important in determining the use of products in cold climates. The pour point of a petroleum specimen is an index of the lowest temperature of its utility for certain applications. If a product will not pour below a certain temperature, it will have restricted use. Products that have a pour point that does not meet specifications usually are contaminated by a heavier product.

PRECIPITATION NUMBER (ASTM D 91)

Scope. This test is run on selected new oils to test for undesirable asphalt-base components. In used oil, it is used as a contamination indicator.

Significance. When lubricating oils are produced, they contain primarily paraffin base, heat-resistant components. Asphalt base products are unstable and are excluded from these lubricants. Precipitation number is used to quickly measure any asphalt base products in a lubricant. Test results generally show no more than traces in a sample. In used oils, the test measures oxidized components, such as dust and dirt, in the oil and can indicate how well the filter is cleaning the oil.

REID VAPOR PRESSURE (ASTM D 323)

Scope. The RVP test is run on JP-4 and gasoline to ensure the product will vaporize when required.

Significance. Vapor pressure must be at a level that will ensure the fuel vaporizes in the carburetor. If the pressure is too high, fuel will vaporize in the fuel line, causing vapor lock, and the engine will not run. Also, fuel in storage with too high an RVP will evaporate excessively. If the vapor pressure is too low, fuel will enter the carburetor as a liquid, causing oil dilution and incomplete combustion. RVP is directly related to temperature. For this reason, refiners adjust gasoline vapor pressures to fit the season. If the RVP of an AVGAS is too high, contamination with a higher RVP MOGAS is suspected. If the RVP of a gasoline is too low, contamination with a heavier product or deterioration due to weathering is indicated. The distillation test IBP and 10 percent points will be high when the RVP is lower, and deterioration is indicated. If caused by contamination, the distillation end point will be high. If the RVP of JP-4 is too high, gasoline contamination is indicated. Lead contamination should be suspected. If JP-4 RVP is too low, the same problem indicated by a low gasoline RVP exists. Generally, RVP problems can be solved by blending with on specification product.

SMOKE POINT (ASTM D 1322)

Scope. This test is run on aviation turbine fuel.

Significance. Smoke point of jet fuels is a property similar to the burning quality of kerosene, and tests are made in a lamp as in the case of kerosene. Excessive smoke can usually be observed when a jet aircraft takes off. Smoke consists of particles of free carbon suspended in the gases of combustion. This free carbon would not be seen if perfect mixing of fuel and air could be obtained, and there would be no deposits of carbon in combustors. Two types of carbon are deposited-soft and fluffy (amorphous) and hard and crystalline (graphitic). The hard variety can damage turbine engine fans and fuel injectors. Of several tests tried, the height of a flame at the point where smoking begins appears to give the best correlation with the tendency to deposit carbon.

SULFUR IN PETROLEUM PRODUCTS (ASTM D 129, D 1266, D 1552, AND D 2622)

Scope. Sulfur content tests are performed on all petroleum products. These tests are required usually because of pollution laws that restrict the amount of sulfur dioxide-producing elements in products.

Significance. Sulfur is an impurity in all petroleum products. Its presence can be either good or bad. In gear oils and cutting oils, it is desirable to have sulfur compounds present because they increase the lubricating film strength of the oil. In gasoline, diesel fuels, fuel oils, jet fuels, solvents, and lubricants, sulfur is undesirable. In the case of fuels, sulfur will oxidize to form sulfur dioxide in the combustion chamber. This test is especially critical on these products because of EPA regulations. This gas combines with water, also a combustion by-product, to form sulfurous or sulfuric acid. These acids are corrosive to metal engine parts. Sulfur dioxide also is an air pollutant that EPA closely monitors. In the case of leaded gasoline, sulfur reduces the effectiveness of the lead compounds. Sulfur is kept to a minimum by using a

low-sulfur crude oil (generally less than 2 percent). In refining, the distillates usually carry over only a minute amount of sulfur. The resulting residuals are then treated to reduce the sulfur content. In general, the sulfur content in gasoline ranges from 0.02 to 0.05 percent; in distillate fuels, 0.10 to 1.07 percent; and in residuals, up to 3.0 percent. Fuels with high sulfur content can be upgraded by blending with a low sulfur product of the same grade. If blending is not possible, permission can usually be obtained to burn the high sulfur fuel for a limited time.

TAG CLOSED CUP FLASH TEST (ASTM D 56)

Scope. This test is run on kerosene, solvents, JP-8, and commercial jet fuels. Liquids that flash below 100°F are considered flammable.

Significance. Flash point can be lower when the product is contaminated by a lighter product such as a gasoline or light jet fuel. This test is critical because many types of equipment run on fuels with a specific minimum flash point. Use of a lower flash point product can result in explosions or fires. A product with a low flash point should be upgraded by blending before it is used.

THERMAL STABILITY (ASTM D 1660 AND D 3241)

Scope. These tests are run on aircraft turbine fuels to check for resistance to thermal breakdown.

Significance. Thermal stability is the resistance of fuels to chemical and physical change upon exposure to high temperatures that tend to decompose them. Thermal stability of fuels under high temperatures has become increasingly important in the transition of jet aircraft from subsonic to supersonic speeds. Fuel is expected to perform a cooling function by providing a heat sink; that is, by absorbing the heat generated in high-speed flight. Fuel cannot do this unless it resists decomposition. A coke-like substance forms in thermally unstable fuels and plugs fuel jets and manifolds. Aircraft fuels are routinely exposed to test temperatures of -65° to 400°F. Presence of aromatics and olefin components are restricted in jet fuels because they are less heat resistant. Low thermal stability is usually caused by contamination with a MOGAS or AVGAS that contains these undesirable components. This problem can usually be corrected by blending with better product.

WATER AND SEDIMENT (ASTM D 95, D 1796, AND D 2709)

Scope. These tests are run to determine the amount of water in crude, fuel, and lubricating oils (D 95), the amount of water and sediment in crude and fuel oils (D 1796), and the amount of water and sediment in diesel and other distillate fuels (D 2709).

Significance. Water and sediment that accumulate in ship cargo tanks and in shore tanks affect quality and quantity. Excessive sediment can plug burner tips and prevent fuel from vaporizing properly. This is also true for injectors in diesel engines. Water in fuel may freeze and clog fuel lines. Water in lubricating oils can corrode metal surfaces and cause a loss of additives. Water and sediment can be removed by letting the product settle and filtering it. Drummed and canned stock contaminated by water or sediment or both must be disposed of as prescribed by regulations.

WATER REACTION (ASTM D 1094)

Scope. This test is performed on aviation fuels to determine the presence of excess alcohol or aromatic components and to evaluate the presence of surfactants on the fuel/water interface.

Significance. The water layer in the test is initially set at 20 milliliters. If the level increases in the test, this indicates the presence of alcohol. If the water layer decreases from 20 milliliters, the presence of aromatics is indicated. Aromatics absorb water, and excess amounts of them will cause excess water to be held in fuel. This water will freeze at high altitudes, clogging fuel lines. For these reasons, a water level change value is

set in aircraft fuel specifications. The interface ratings are set to measure the effect of surfactants in the fuel. These surfactants can cause excess sediment and water retention, which causes fuel filter clogging. There is a correlation between the WSIM rating or the MSEP surfactant rating and the interface rating. As the WSIM/MSEP rating goes down from 90, the interface rating goes up. Experience has shown the following relative correlation (see Table 8-4). Any result above 1b can indicate a problem, but the result should be double-checked with clean cylinders and new buffer solution.

Table 8-4. WSIM/MSEP- Interface rating correlation

WSIM/MSEP	INTERFACE RATING
90 and above	1
80 to 90	1b
70 to 80	2
60 to 70	3
Below 60	4

WATER SEPARATION CHARACTERISTICS: WSIM OR MSEP SURFACTANTS (ASTM D 2550, D 3948)

Scope. A water separation characteristics test is performed on aviation turbine fuels to determine the presence of surfactants and predict filter/separator problems resulting from these surfactants.

Significance. Occasionally in the refining of turbine fuels, sulfonates and naphthenates are retained in small quantities. These surfactants can cause fuels to retain water in emulsions that are difficult to separate using filter/separators. Thus, the water can get into aircraft fuel tanks. This water can freeze at high altitudes or reduce the FSII protection in the fuel. Jet fuels should never be batched in multiproduct pipelines immediately behind MOGAS or AVGAS. Additives in these fuels tend to coat the pipeline and are picked up by the next product in the line. These additives (corrosion inhibitors, lead scavengers) are very active surfactants in jet fuel and will cause the fuel to fail the water separation characteristics test (WSIM or MSEP) and the water reaction interface test. A SDA will also cause the fuel to fail the WSIM or MSEP test. Correlation exists between the WSIM/MSEP rating and the water reaction interface rating. WSIM/MSEP ratings should be tempered with the history of the fuel. If the ratings are on the base stock, the results are valid. However, if the fuel has moved through multiproduct lines or if an SDA has been added, the results will be invalid. Off specification fuel should be allowed to settle for at least one hour per foot in depth before being retested. If it is still off specification, the fuel should be passed through a filter/separator containing new filter/coalescer elements. The fuel could also be clay treated, but this would remove all of the additives, and new additives would have to be introduced.

NOTE: The microseparameter technique (ASTM D 3948) will eventually replace the WSIM (ASTM D 2550). It is necessary to list both techniques until the new apparatus is supplied to the laboratories.

CONDUCTIVITY (ASTM D 2624)

Scope. This test is performed on JP-4 and JP-8 turbine fuels containing a SDA.

Significance. The ability of a fuel to dissipate electrical charges that have been generated during pumping and filtering operations is controlled by its electrical conductivity, which depends upon its content of ion species. If the fuel conductivity is sufficiently high, charges dissipate fast enough to prevent their accumulation and dangerously high potentials at a fuel dispensing point. The use of SDA can increase fuel conductivity to safe levels. SDA is added to JP-4 or JP-8 turbine fuels in very small proportions so that its effectiveness can be diminished by blending with other fuels that do not contain SDA. Moreover, conductivity can be affected by filtering and transferring operations and by temperature changes. For this reason, the fuel sample for the conductivity test is taken close to where the fuel enters the aircraft.

SECTION II Identification of Unknown Products

GENERAL

In addition to routine analyses of petroleum products, tests are often needed to identify captured petroleum stocks, products that have been marked improperly, or products that have been stored so long that markings have become illegible. The unknown product must be identified as to type, and classified as to intended use by tests described in Section I of this chapter. This is done by comparing the unknown product specifications with the specifications established for its intended use. The use of the product is important. One that does not meet deterioration-use limits for a particular purpose must not be used for that purpose unless specifically authorized.

CLASSIFICATION BY GRAVITY

For convenience in identifying unknowns, an arbitrary division of products can be based on API gravity (see Figure 8-2, page 8-14). A test for API gravity is usually the first test made on an unknown product. Products which have a gravity of 35 ° API or higher and which are subjected to the distillation test are classified as light distillates. Products which have a gravity lower than 35° API and which are not subjected to the distillation test are classified as heavy distillates. This is an arbitrary division for convenience only. This division does not necessarily hold true for all petroleum products.

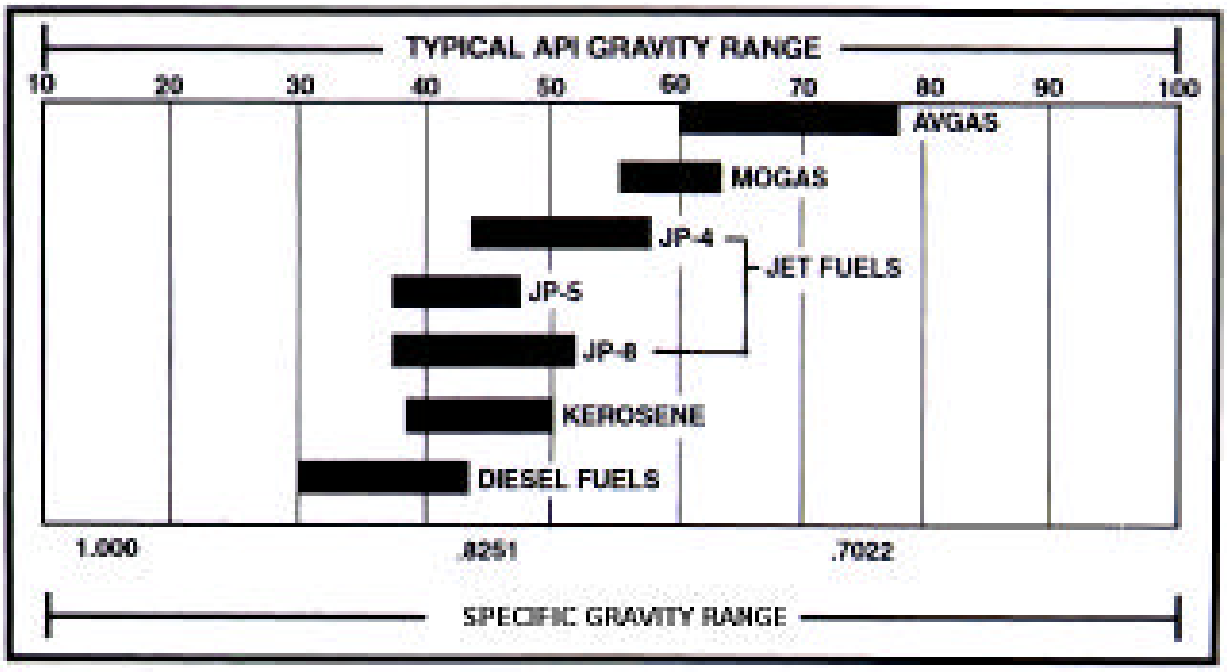


Figure 8-2. API gravity scale for petroleum products

LIGHT DISTILLATES

Gasoline. The first test for light distillates is a visual inspection. If the unknown has the characteristic odor and appearance of gasoline, the sample container should be recapped and refrigerated as soon as possible for the RVP test. If the product is red, green, or blue, it may be 80, 100/130, or 100/130LL AVGAS or a light product commingled with AVGAS. If the product is another color, it may be ordinary AVGAS specification, ASTM D 4814. RVP test and distillation separate these fuels into classes A, B, C, D, and E. Specifications ASTM D 4814 and MIL-G-3056 give the requirements that must be met if the unknown is to be used as gasoline. Colors may be confusing as some unleaded automotive gasoline are green and blue, and in some areas, diesel fuel is colored.

Water-White Products. Water-white products include some jet fuels, kerosenes, benzene, naphtha, solvents, and unleaded gasoline. Unleaded gasoline is not always white; colors that have been noted in the field include yellow, orange, blue, green, blue-green, and red. Any combination of tests for API gravity, RVP, and distillation will aid in separating products.

- Naphtha (D-95, type I, grades A and B) is separated by API gravity. API gravity is also extremely important in testing jet fuels because of maximum and minimum specification limitations.
- Distillation is the key test in separation of other products in this category. Each product has a distinctive distillation curve.
- API gravity and RVP tests will definitely separate JP-4 and kerosene.
- API gravity and RVP tests will separate JP-4 and JP-5.
- MIL-T-5624 (JP-4), ASTM D 3699 (kerosene), VV-B-231 and MIL-B-3137 (benzene), ASTM D 91 and TT-N-97 (naphtha), and P-D-680 (dry-cleaning solvent) give the requirements to be met if the unknown is to be used as any of the products named above.

Diesel and Burner Fuels. (Straw-Colored Products).

- If it is impossible to identify an unknown as either diesel or burner fuel, the identity of the unknown should be reported as burner fuel. Burner fuel is less critical in its use requirements than diesel fuel.
- Distillation, flash point, pour point, and viscosity tests usually simplify the identification and separate the identity of diesel fuels.
- Separation of grades 1 and 2 of burner fuels from diesel fuels is difficult. API gravity and viscosity tests are important.
- Specifications MIL-F-16884, ASTM D 396 and CID A-A-52557 provide the requirements for diesel and burner fuel.

HEAVY DISTILLATES

There are two categories of heavy distillates: burner fuels and lubricating and specialty oils. Burner fuels are readily separated from lubricating and specialty oils on the basis of relatively low flash point (below 220°F). Three key tests are used to identify and classify lubricating oils and specialty products. Viscosity tests provide information that can be used to recommend a product for a specific use. The saponification number and plain ash tests group the product according to general use. Results of saponification number and ash content tests permit heavy distillates to be divided into three groups:

- Group A distillates are those with a saponification number less than 2.0 and an ash content greater than 0.05 percent.
- Group B distillates are those with a saponification number greater than 2.0.
- Group C distillates are those with a saponification number less than 2.0 and an ash content less than 0.05 percent.

GROUP A DISTILLATES

Types of Products. Group A products include straight mineral oils containing organic additives or residual fuel oils. The group includes the following products:

- Residual burner fuels, heavy and Navy grades.
- MS 9000-series engine oils (diesel).
- OE-series engine oils (internal combustion).
- Preservative engine oils (PE).

Separation of Types. Fuel oils are easily separated from the remaining group A products by testing the flash points, which are considerably lower. Results of a viscosity test determine the grades of the products.

MS-9000, OE and PE Series. MS 9000-series oils, OE and PE, can be classified to a degree by viscosity. However, each series contains products with identical ratings. Therefore, the possibility exists that the product could meet the specification for one product in each series. If this happens, the product should be recommended as the applicable OE product (least critical).

The applicable specification gives the requirements for the unknown to be recommended for a particular use.

GROUP B DISTILLATES

Types of Oils. Test results yielding a saponification number greater than 2.0 show that certain oils should be considered as follows:

- MS 4065 oil, viscosity 65-80 SSU at 210°F, below rapeseed.
- MS 6135 oil, viscosity 120-150 SSU at 210°F, tallow.
- MS 7105 oil, viscosity 95-110 SSU at 210°F, tallow or lard.
- MS 8190 oil, viscosity 180-200 SSU at 130°F, lard.
- Sulfurized cutting oil.
- Soluble cutting oil.
- Hypoid gear oil.
- Other gear oils.

Separation of Types. Group B distillates are separated according to the following guidelines.

- The MS oils, except MS 4065 and MS 8190, can be separated easily by viscosity. A further separation of these two oils can be based on the percentage of fatty oils required.
- Sulfurized cutting oils can be separated from other products in this group by their extremely high saponification numbers and large sulfur content. The applicable specification gives the requirements if the product is to be recommended for a particular use.
- Soluble cutting oils can be distinguished by their solubility in water.
- Gear oils can be separated in several ways. Subzero gear oil can be separated by its low pour point, high ash content, and viscosity at -65°F.

GROUP C DISTILLATES

Types of Oils. Group C products are straight mineral oils containing additives that do not form ash. Additives of this kind include pour point depressants, viscosity index improves, and oxidation inhibitors. The group includes types of oils as follows:

- MS 1000-series aircraft engine oils.
- MS 2000-series general-purpose oils.
- MS 3000-series general-purpose oils.
- MS 5000-series steam cylinder oils.
- Specialty oils.

Separation of Types. The viscosity test separates most of the oils in this group. Oils whose viscosity ranges overlap are discussed below.

- MS 3000 and MS 5000 oils can be separated by a combination of results from the VI, pour point, and carbon residue tests. MS 5000-series oils usually have much higher flash points than others in the group.
- There are several instances where a 2000-series product will have overlapping specifications with a 3000-series product. If positive identification is not possible, the unknown should be recommended for use as a 2000-series product.
- The applicable specification gives requirements to be met if the product is to be recommended for a particular use.

REPORTS AND RECOMMENDATIONS

When the tests for identifying or classifying an unknown product have been completed, the laboratory performing the tests prepares a letter of identification for the requesting agency. The letter contains identifying information and recommendations for the use, reclamation, or other disposition of the product. A copy of DA Form 2077, Petroleum Products Laboratory Analysis Report accompanies the letter, indicating all test results. Any necessary charts or graphs should also be included. If a product cannot be identified or reclaimed and is unfit for any military use, the laboratory should recommend that it be disposed of, unless otherwise instructed by higher authority. The disposition of any product that has been condemned for military use is a responsibility of the owning department. Further correspondence relative to this product should be between the activity having possession of the product and the department owning it.

Section III Product Reclamation and Disposition

GENERAL

Reclamation is a procedure that will restore or change the quality of a contaminated or off-specification product so that it will meet the specification of the original product or a lower grade

product. The process of reclamation, when properly applied, will result in downgrading, blending, purification, or dehydration. Reclamation may be recommended by the laboratory when products are identified or classified or when contaminated or deteriorated products are analyzed.

FACTORS AFFECTING RECLAMATION

Reclamation may not be undertaken without specific approval from the technical activity of the owning department. The following factors must be carefully considered before reclamation is recommended:

- What contaminating agents are present, source of contaminants, and degree of contamination?
- Probable end use of the product in its present condition. Consideration must be given to laboratory analysis, purchase specification, established deterioration use limits, and safety factors.
- Feasibility of removing or canceling undesirable effects of contaminants to make the product usable.
- Location, type of storage, and quantity of off-specification product.
- Probable need for the reclaimed petroleum product.
- Availability of time, materials, equipment, funds, and labor necessary to reclaim the product.
- Benefits derived by the government through the reclamation of products that otherwise might be classified as hazardous waste.

RECLAMATION TECHNIQUES

Downgrading. Downgrading is the procedure by which an off-specification or slightly contaminated product is approved for use as a lower grade of a similar petroleum product.

Blending. Blending for reclamation is the procedure by which an off-specification product is mixed with on-specification stocks to produce a product of intermediate grade or quality that is wholly within use limits. However, it is unlikely that an old product deficient in many of its critical properties could be brought within use limits. Everything depends on whether the quality of fresh stocks is much better or only slightly better than that of the old stock. Unless all critical properties can be brought up to use limits, downgrading or other types of disposition must be considered (MIL-HDBK-200).

Dehydration. Dehydration is the removal of water by a filtering or settling process. Free water settles out of most light products if allowed to stand undisturbed for about 24 hours. Excess water can then be drawn off, and the water that remains, except dissolved water, can be removed by adequate filter/separators. Warming residual products may help to break emulsions, permitting the water content to be removed as free water.

Filtration or Purification. Filtration or purification is the removal of contaminating agents by settling, filtration, or a filter/ separator. Coarse particles of dirt, mill scale, and rust settle out of light products if allowed to stand undisturbed after receipt. A minimum tank settling period of 2 hours is required for all aviation fuels, automotive gasoline, and diesel fuels after fresh stocks have been added. At least 24 hours is advisable for heavy products such as burner fuels. In addition, the product should be subjected to visual or quality tests prior to issue. Fine particles can be removed by adequate filter/separators.

IMPROVING CRITICAL PROPERTIES

Some critical properties of a few petroleum products that may be improved by use of reclamation techniques are shown below. The requirements for these products can be obtained from the appropriate military specification. The use limits can be obtained from the latest revision of MIL-HDBK-200.

Aviation Gasoline. AVGAS properties include the following.

- Performance number
- Existent gum, mg/100 ml

- Residue, percent (maximum)
- Vapor pressure, psi
- TEL, ml/US gallons

Jet Fuels. Jet fuel properties include the following.

- Existent gum, mg/100 ml:
- Steam jet (JP-4, JP-5)
- Vapor pressure, psi: (JP-4)
- Fuel system icing inhibitor
- Static dissipating additive (JP-4. JP-8)

Combat Automotive Gasoline. Combat automotive gasoline properties include the following.

- Unwashed gum, mg/100 ml
- Vapor pressure, psi:
- Type I
- Type II
- Octane number
- Lead/US galons

Kerosene. The critical property for kerosene is the flash point.

Diesel Fuels/Fuel Oils. Diesel fuel oil properties include the following.

- API gravity
- Flash point
- Bottom sediment and water (FO)
- Particulate contamination (DF)

APPROXIMATING A BLENDING RATIO

Figure 8-3 illustrates a specimen graph that can be used instead of a formula to approximate a blending ratio. Other properties with appropriate scales can be substituted. The results provide only pilot blends, and each pilot blend must be tested and adjusted as needed. It is a good practice to allow a safety factor in any reclamation blending.

Problem. Prepare a pilot blend of fresh, on-specification MOGAS containing 4 mg gum/100 ml and off-specification MOGAS containing 26 mg gum/100 ml to produce a mixture containing 7 mg gum/100 ml.

Solution. Prepare a graph showing percentage of on-specification stock across the top from 100 to 0 and percentage of off-specification stock across the bottom 0 to 100. Show gum content (or other property on a suitable scale) at both ends of graph from 30 to 0. Draw a line across the graph

at the point that represents required gum content 7 mg/100 ml. Draw a line from the point that represents gum content of 4 mg/100 ml on the left-hand scale to the point that represents gum content of 26 mg/100 ml on the righthand scale. Project the point of intersection between the sloping line and the 7 mg/100 ml line to the top and bottom scales, and read approximate percentage of fresh and old stocks for the pilot blend.

DOWNGRADING AND REGRADING

MIL-HDBK-200 contains thorough descriptions of the critical properties, use limits, downgrading, and regrading requirements for petroleum products. A few of the important points are as follows:

Jet Fuels. Jet fuels are not readily downgraded or regraded, even with blending. Because of the many limitations imposed on jet fuels, it is recommended that downgrading of these fuels not be attempted, except for ground use when possible.

Combat Automotive Gasoline. Combat automotive gasoline may be downgraded to ASTM D-4814, commercial grade fuel.

Kerosene. Kerosene containing more than 1 percent of distillate fuel, or more than 0.1 percent of residual fuel, and not passing the lamp test, should be downgraded. Blend grade K-1 (low sulfur) Kerosene with DL2 for winter use in diesel consuming equipment, or as a burner fuel. Blend grade K-2 (regular) Kerosene with burner oils and use as heating fuel. Care must be taken to main-

tain flash point and sulfur requirements within use limits.

Marine Diesel Fuel. Marine diesel fuel that fails to meet carbon residue and distillation requirements should be downgraded for use in low-speed diesel engines ashore, or for USE as boiler fuel ashore.

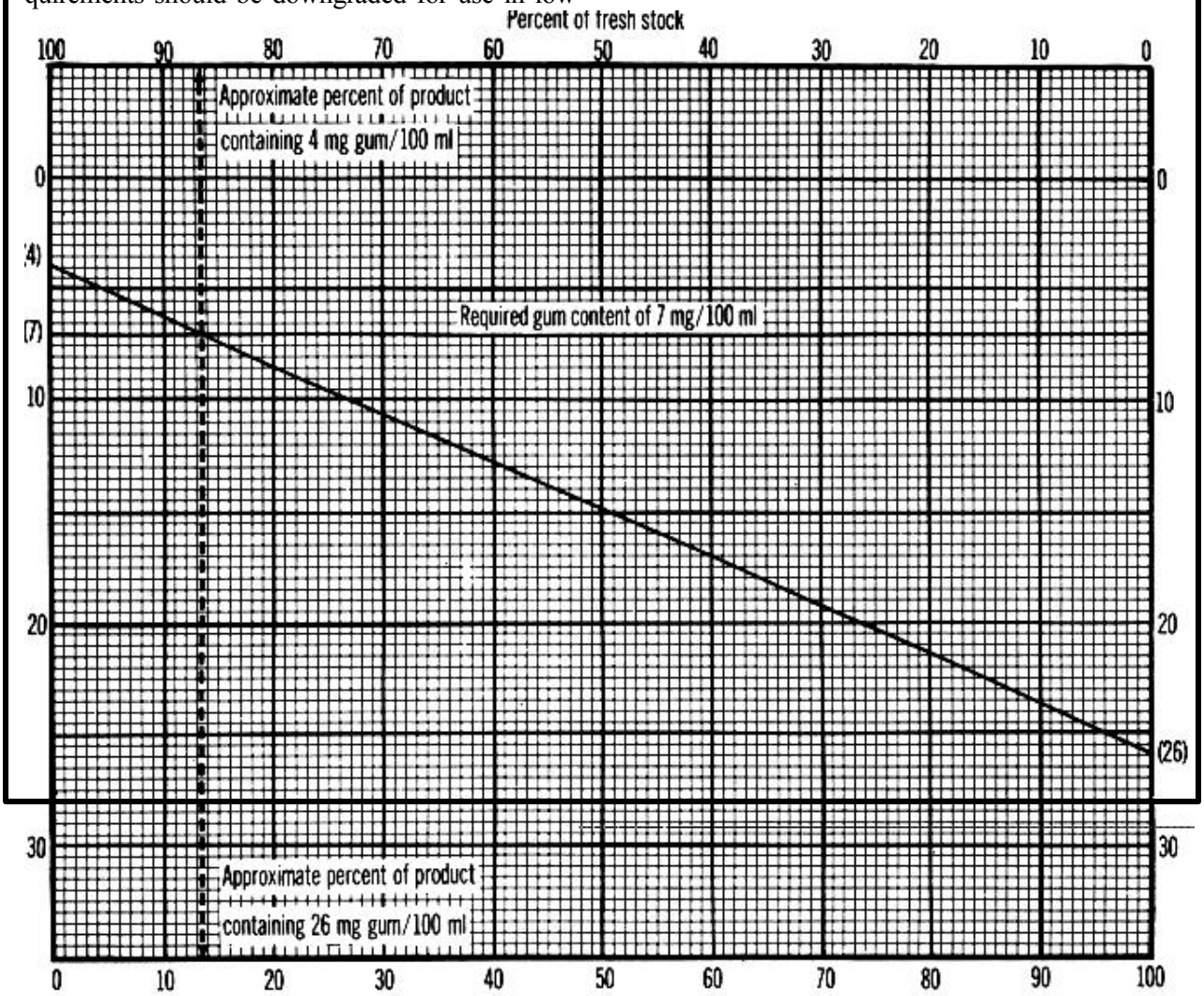


Figure 8-3. Specimen graph to approximate a blending ratio.

DISPOSITION PROCEDURES

When a DLA-owned product does not meet specification limits at intermediate storage points, the activity having physical possession of the product will contact the Defense Fuel Supply Center, for a decision about its use or disposition. When an Army-owned product does not meet use limits at the location of use, the US Army Petroleum Center, New Cumberland, PA 17070, should be contacted for a decision concerning its use or disposition. The request for disposition instructions should include the following information:

- Specification and grade.

- Quantity.
- Location.
- Date of receipt.
- Name of manufacturer, contract number, batch number, qualification number, and date of manufacture.
- Type of container or storage.
- Accountable military department.
- Need for replacement product.
- Detail laboratory test results.
- Recommended alternate use, disposition, or recovery measures.

CHAPTER 9

SAMPLERS AND SAMPLING PROCEDURES

GENERAL

A sample is a small portion of a substance used to inspect or to determine the quality of the substance. Samples of petroleum products are to be taken as described in ASTM Method D 4057.

TYPES OF SAMPLES

Various types of samples are explained below.

- Top Sample. A top sample is one taken 6 inches below the top surface of a tank's contents.
- Upper Sample. An upper sample is taken with a weighted bottle or beaker sampler from the middle of the top third of a tank's contents.
- Middle Sample. A middle sample is taken from the middle of the tank's contents. (A point halfway between the upper and lower sampling point.)
- Lower Sample. A lower sample is taken from the middle of the bottom third of a tank's contents.
- Bottom Sample. A bottom sample is taken on the bottom of a tank.
- All-Level Sample. An all-level sample is taken by submerging a closed bottle or beaker sampler to a point as near as possible to the tank draw off point. Then the sampler is opened and raised to a constant rate so that it is between 75 and 85 percent full when it emerges from the liquid.
- Average Sample. A sample that consists of proportionate parts from all levels of the product. For example, an average sample from a horizontal, cylindrical, or a spherical tank should contain more material from the middle of the tank where the diameter is greatest.
- Composition Sample. A sample combining individual samples that represent the bulk from which they were taken. A single-tank composite sample is a blend of the upper, middle, and lower samples from a tank's contents. A multiple-tank composite sample is a blend of individual, all-level samples taken from the compartments of a tanker or barge containing the same product. The sample consists of parts proportionate to the volume of product in each compartment sampled.
- Outlet Sample. An outlet sample is taken with a bottle or beaker sampler at the level of a tank outlet, whether fixed or swingline.
- Drain Sample. A drain sample is taken from the drawoff or discharge valve.
- Continuous Sample. A continuous sample is taken from a flowing pipeline by allowing a slow trickle of the product to collect in a sampler during the entire flow time. This sample is representative of the stream of product during the period of sampling.
- On-Line Sample. An on-line sample is taken from a flowing pipeline by opening the valve and collecting the sample during the flow of the product. These samples are used mostly for the water separometer index and particulate contaminant tests.

SAMPLERS

The four most frequently used samplers are the weighted beaker, weighted bottle, Bacon bomb thief, and drum thief (see Figure 9-1, page 9-2). A fifth type is the vacuum pump sampler (see Figure 9-2, page 9-3). Its use is generally restricted to drawing samples in a petroleum laboratory.

Weighted Beaker (Copper Cylinder). The weighted copper beaker sampler (NSN 6640-00-946-3600) consists of a copper bottle permanently attached to a lead base. A drop cord is attached to the handle through a ring in the stopper so that a

short, quick pull on the cord opens the beaker at any desired point beneath the surface of the liquid. This sampler is used to take upper, middle, lower, or all-level samples of liquid products of 16 psi or less RVP. It is used in tanker or barge compartments, shore tanks, tank cars, and tank trucks.

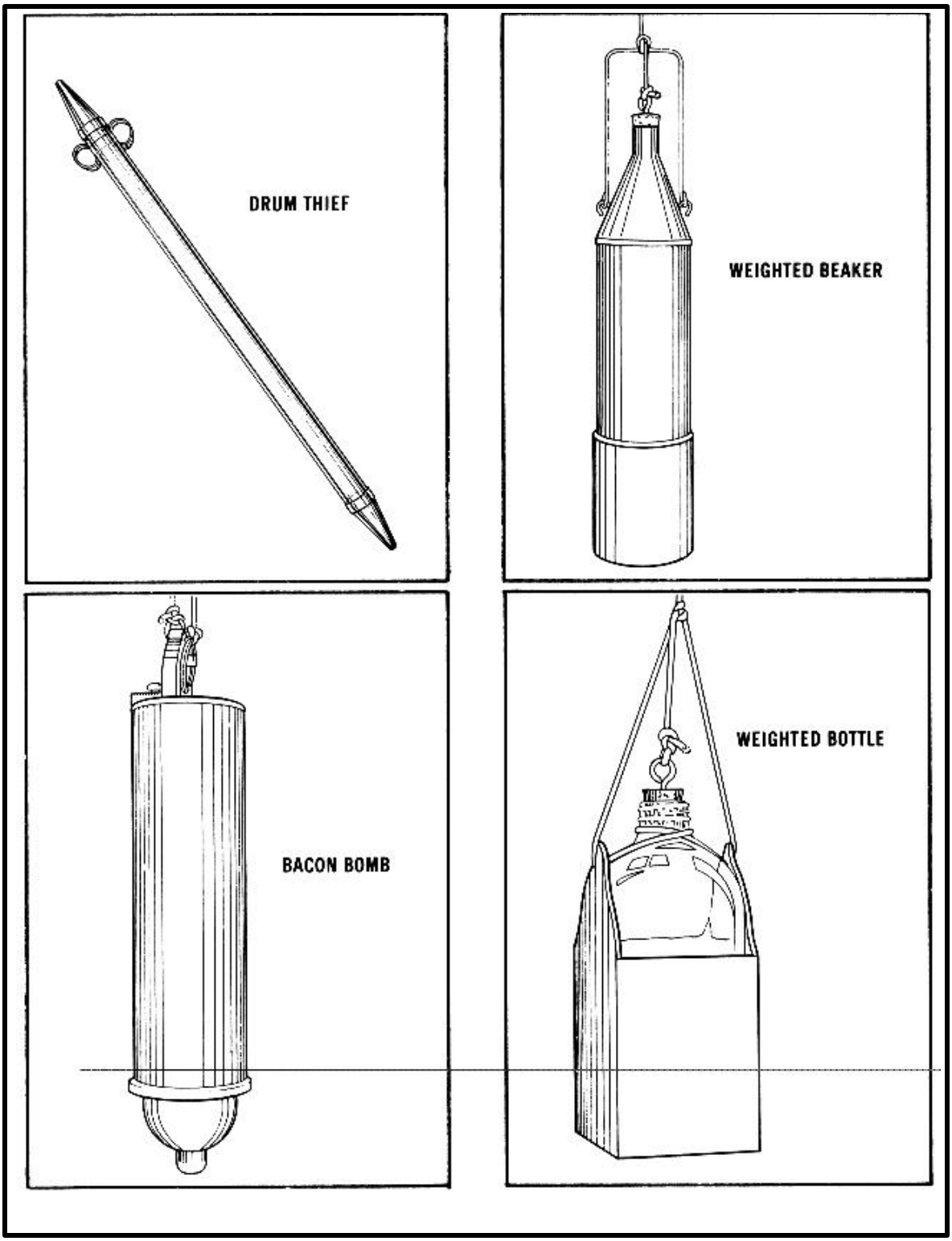


Figure 9-1. Samplers

Figure 9-2. Vacuum-pump sampler

Weighted Bottle (Glass Cylinder). The glass-cylinder sampler (NSN 6640-00-946-3601) consists of a glass bottle within a square, weighted metal holder. A drop cord is attached through a ring in the stopper so that a short, quick pull on the cord opens the bottle at any desired point under the surface of the liquid. This sampler has the same application as the weighted beaker sampler, but because of its wider mouth, can be used for sampling heavier products.

Drum Thief (Plastic Cylinder). The plastic-cylinder (tube type) sampler (NSN 6695-00-496-9624) consists of a two-piece, plastic tube, 39 1/2 inches long and 1 1/2 inches at maximum diameter. The tube is fitted with two finger rings at the upper end and three supporting legs at the bottom. Both ends are tapered and have openings. The top opening of the sampler is closed with the thumb until the sampler is submerged in the liquid. Then the thumb is removed from the opening, allowing the liquid to fill the sampler. This sampler is used to take samples of liquid products of 12 psi or less RVP and samples of semi-liquid products. It is used in drums, barrels, or cans.

Bacon Bomb Thief (Tank Car Thief). The Bacon bomb thief sampler (NSN 6695-00-946-3602) consists of a nickel-plated brass cylinder tapered at both ends and fitted with an internal, plunger-type valve. The valve opens automatically when the sampler strikes the bottom of a container and closes when lifted. A drop cord is attached to a ring at the top of the sampler: A trip cord can also be attached for the purpose of opening the sampler at any level. This sampler is used to take bottom samples of liquid products of 2 psi or less RVP and samples of semi-liquid products. The Bacon bomb thief can be modified to provide handling and finger rings and pouring spout for use with the standard sample can with 1 3/8-inch opening (see Figure 9-3, page 9-4). Minor differences in the sampler may require deviations from the instructions.

Vacuum-Pump Sampler. The vacuum pump sampler (No NSN, manufactured by the Daigger Company of Chicago) is made of brass or aluminum except for its neoprene valve and neoprene O-rings. It consists of a tube, plunger handle, and tubing. It has an outside diameter of 1 1/4 inches and is 7 inches long. A brass sampler weighs 1 pound and an aluminum sampler 6 ounces. The sampler can lift about 25 feet of water at sea level. With 1/4-inch inside diameter tubing, the sampler will fill a pint bottle with water in less than 10 seconds. Fittings include a 1/8-inch female pipe tap in the pump base, permitting use of standard fittings. The sampler can be attached to a container and the tubing dropped into the liquid to be pumped. Air is extracted from the empty container on the upward stroke of the plunger. The sample

liquid is drawn or siphoned from the source into the container through the tubing and base of the sampler.

1. HANDLING RING: 1/8"-BRASS WIRE 2" WIDE, 4" LONG.
2. FINGER, RING: 1/8"-BRASS WIRE 2" DIAMETER.
3. TOP EXTENSION DRILLED FOR FINGER RING.
4. TOP EXTENSION: 5/16" BRONZE ROD 2 3/4" LONG OVERALL, THREADED LOWER END TO SUIT TAPPED HOLE IN VALVE ROD. (SEE 7)
5. BAIL DRILLED FOR HANDLING RING.
6. TRIP CORD GUIDE DRILLED LARGER TO RECEIVE TOP EXTENSION.
7. TOP OF VALVE ROD GROUND OFF, DRILLED AND TAPPED TO RECEIVE TOP EXTENSION. (SEE 4)
8. CYLINDER WALL.
9. VALVE ROD OR PLUNGER.
10. BOTTOM OPENING (15/16") BORED TO 1 3/16" AND TAPPED TO RECEIVE POURING SPOUT. (SEE 13)
11. SHOULDER: 1/8" THICK, 1 3/8" O.D.
12. BOTTOM OF PLUNGER DRILLED AND TAPPED TO RECEIVE BOTTOM EXTENSION.
13. BRONZE POURING SPOUT 13/16" I.D., 1" O.D., 2 3/8" LONG OVERALL.
14. BOTTOM EXTENSION: 7/16" BRONZE ROD, 3" LONG OVERALL, THREADED TO SUIT TAPPED HOLE IN BOTTOM OF PLUNGER.

NOTES:

1. Pouring spout is intended for standard sample can with 1 3/8" opening.
2. Minor differences in sampler may require deviations from the instructions to suit.

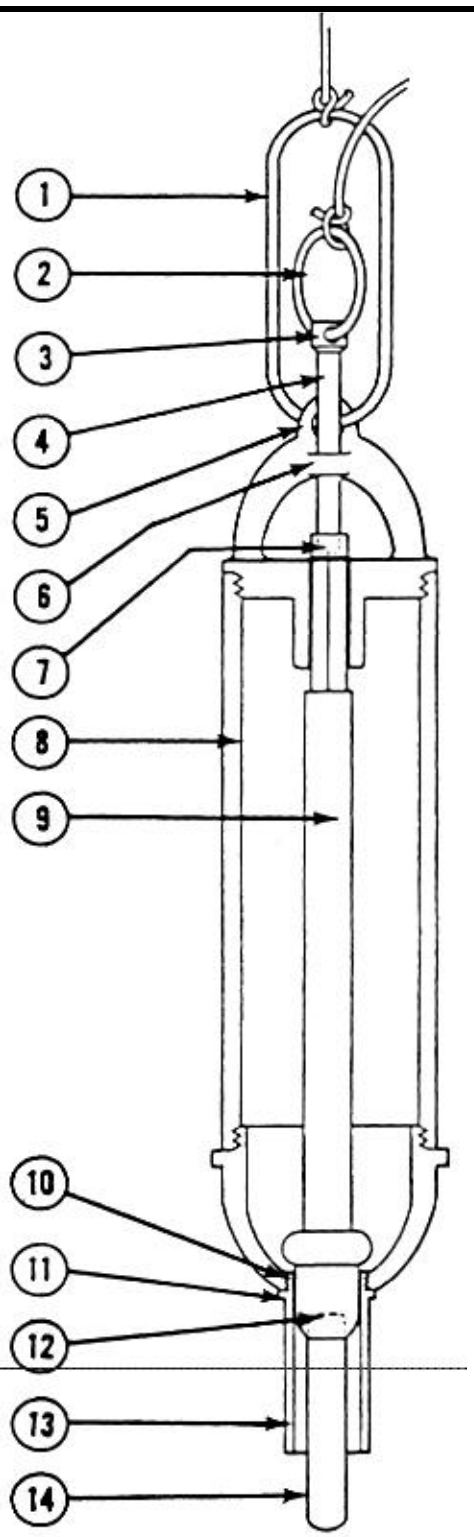


Figure 9-3. Directions for modifying Bacon bomb sampler locally

SAMPLE CONTAINERS

Containers may be clear or brown glass bottles, or they may be cans. Clear glass bottles permit visual examination of the sample. Brown glass bottles protect light sensitive samples. Only those cans that have been soldered on the outside with a rosin flux may be used. Minute traces of flux may contaminate samples and interfere with tests for dielectric strength, resistance to oxidation, and sludge formation. The sample container should be of the type best suited to the product and to the purpose of the test. It must also be clean, dry, and lint-free. When necessary, sample container should be rinsed with a solvent. Discard the solvent as prescribed by local environmental laws and regulations, or local SOP.

Approved Sample Containers. A list of approved sample containers with stock numbers is given below:

- Can, sample, 1/2-sBal (metal), 8115-01-090-0660
- Can, sample, 1-gal (metal), 8110-00-879-7182
- Can, sample, 1-gal (metal, rectangle), 8115-00-2247935
- Can, sample, 1-gal (metal), 8110-00-128-6819
- Can, sample, 1-gal (metal, round), 8115-01-192-0935
- Can, sample, 1-qt (metal), 8110-00- 178-8281
- Screwcaps, polypropylene, 1-gal, 6640-00-410-4461
- Bottle, screw, clear-glass, 16-oz, 6640-00-4040660
- Bottle, screw, clear-glass, 32-oz, 6640-00-4040661
- Bottle, screw, amber-glass, 16-oz, 6640-00-4040658
- Bottle, screw, amber-glass, 32-oz, 6640-00-4040659

Cleaning. The sample container should be cleaned by the following procedures.

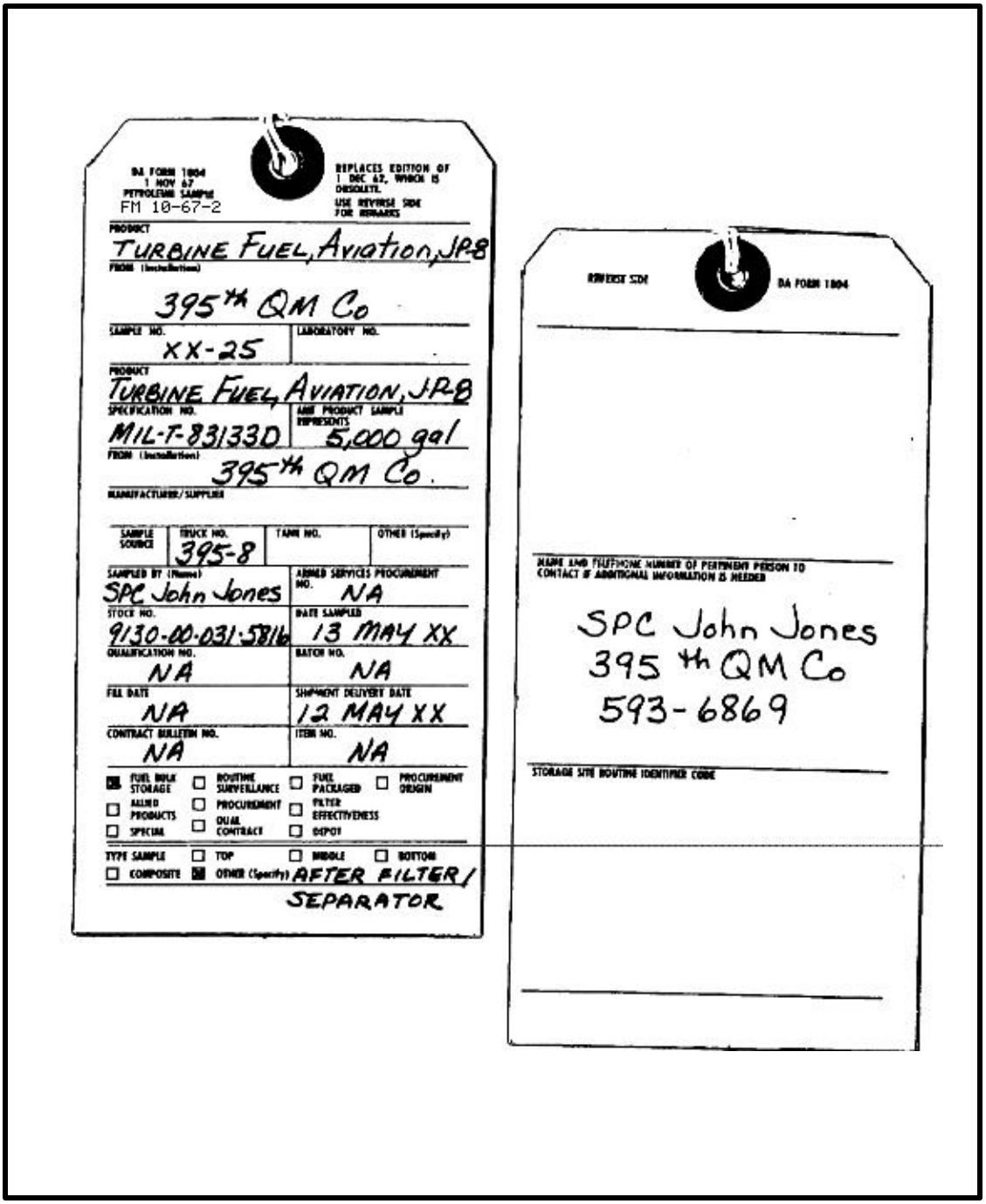
- Step 1. Rinse with a solvent. Discard the solvent as prescribed by local environmental laws and regulations or local SOP.
- Step 2. Wash with a strong soap solution.
- Step 3. Rinse with tap water and then distilled water.
- Step 4. Dry in a dust-free cabinet at 104°F or warmer.
- Step 5. Close container immediately after it is dry.

Filling. Before a sample is taken, the container should be rinsed with a small quantity of the product being sampled, except for sediment (millipore) samples. Discard the rinsing material. The sample container should not be filled to more than 80 percent of its capacity to allow for thermal expansion. Samples submitted in 1-quart containers for vapor pressure testing will be filled to the 70 to 80 percent level. Use only those tops that are supplied with the container to seal it. Close the container tightly immediately after filling.

Tagging. Each sample container should be tagged immediately after sampling. Complete identifying information should be included on the sample tag. DA Form 1804 (see Figure 9-4, page 9-6). It should be filled out to the maximum extent possible as directed by the instructions (see Table 9-1, page 9-7). Assign a sample number to the tag, and record data in a sample log.

SAMPLING PROCEDURES

A simple set of sampling procedures cannot be given because products are different, the media of transportation and storage differ, and sampling requirements for some tests are different. General guidelines for sampling are provided in this section.



DA FORM 1804
1 NOV 67
PETROLEUM SAMPLE
FM 10-67-2

REPLACES EDITION OF 1 DEC 62, WHICH IS OBSOLETE.
USE REVERSE SIDE FOR REMARKS

PRODUCT: TURBINE FUEL, Aviation, JP-8
FROM (Installation): 395th QM Co
SAMPLE NO.: XX-25
LABORATORY NO.:
PRODUCT: TURBINE FUEL, AVIATION, JP-8
SPECIFICATION NO.: MIL-T-83133D
ONE PRODUCT SAMPLE REPRESENTS: 5,000 gal
FROM (Installation): 395th QM Co.
MANUFACTURER/SUPPLIER:
SAMPLE SOURCE: TRUCK NO. 395-8 | TANK NO. | OTHER (Specify)
SAMPLED BY (Name): SPC John Jones
ARMED SERVICES PROCUREMENT NO.: NA
STOCK NO.: 9130-00-031-5816
DATE SAMPLED: 13 MAY XX
QUALIFICATION NO.: NA
BATCH NO.: NA
FILL DATE: NA
SHIPMENT DELIVERY DATE: 12 MAY XX
CONTRACT BULLETIN NO.: NA
ITEM NO.: NA
☒ FUEL BULK STORAGE ☐ ROUTINE SURVEILLANCE ☐ FUEL PACKAGED ☐ PROCUREMENT ORIGIN
☐ ALLIED PRODUCTS ☐ PROCUREMENT ☐ FILTER EFFECTIVENESS
☐ SPECIAL ☐ DUAL CONTRACT ☐ DEPOT
TYPE SAMPLE ☐ TOP ☐ MIDDLE ☐ BOTTOM
☐ COMPOSITE ☒ OTHER (Specify) AFTER FILTER/SEPARATOR

REVERSE SIDE — DA FORM 1804

NAME AND TELEPHONE NUMBER OF PERTINENT PERSON TO CONTACT IF ADDITIONAL INFORMATION IS NEEDED
SPC John Jones
395th QM Co
593-6869

STORAGE SITE ROUTINE IDENTIFIER CODE

Figure 9-4. DA Form 1804

Table 9-1. Instructions for preparing DA Form 1804

ITEM	ENTRY
Petroleum sample tag section	Applicable entry on petroleum sample tag
Product	Specification nomenclature of the product represented by the sample.
From (Installation)	Installation submitting sample.
Sample No.	Applicable sample identification number of installation submitting sample.
Laboratory No	Reserved for use by the petroleum laboratory.
Specification	Applicable specification of product sampled.
Amt Produced Sample Represents	Gallons of product within the container (such as storage tank, tank car and tank truck) represented by the sample.
Manufacturer/Supplier	Company that supplied the product.
Source of Sample	Source of sample, truck number, tank number, or other (such as tank car number, cans, drums, and pails.
Sampled By	Signature of person that obtained sample.
Armed Services Procurement No	Applicable contract number.
Stock No	Applicable national stock number.
Date Sampled	Date sample was taken.
Qualification No	Applicable qualification number (for certain type lubricants only).
Batch No	Applicable batch number.
Fill Date	Date container was filled with product (applies only to cases, cans, pails, and drums).
Shipment Delivery Date	Date delivery of shipment was made.
Contract Bulletin No	Applicable Defense Fuel Supply Center contract bulletin number (if any).
Item No	Applicable Defense Fuel Supply Center contract bulletin item number (if any).
Program	X in the applicable box.
Type Sample	X in the applicable box. When an X is entered in the box titled “Other”, specify the type of sample taken, for example average, all-levels, and random).
Reverse Side	Weather conditions and any remarks necessary to accomplish and expedite the analysis of the sample. Also, telephone number, address, and name of person to contact for sample information.

Representative Sample. A sample must represent the entire quantity of product sampled. Otherwise, the resulting analysis can only reflect the quality of a part of the whole substance, and the quality reflected may be better or worse than the true quality.

Size of Sample. The normal size of a sample is 1 gallon for liquids and 5 pounds for semisolids. Special samples and gasoline samples submitted for testing performance numbers by the supercharge method should be 5 gallons. Samples of jet fuel to be tested for thermal stability should be 5 gallons.

Standard Sampler. The sampler should be one of the standard types and the one best suited to the product and to the container. If a standard sampler is not suitable because of small openings through which the sample must be taken, an improvised sampler may be used. In any case, the sampler must be clean and be made of a material that will not contaminate the sample.

Drum Thief. A tube sampler or drum thief should be used to take samples from a drum or similar container. The container should never be tipped, and the product should never be poured through a funnel. The area around the closure should be cleaned before removing the cap or plug.

Cleaning Sampler. Rinse sampler with the product being sampled.

Protecting Samples. All sample containers should be protected for shipment. Samples of gasoline, jet fuel, and kerosene should be protected from direct sunlight by using brown bottles or cans or by covering clear bottles with paper or foil. Samples of gasoline and JP-4 should be kept cool (30° to 40°F if possible) to prevent loss of light ends. Samples of products containing lead additives must be protected from sunlight.

Serial Numbers. A serial number should be assigned to each sample. This number is made up of the last two digits of the calendar year and the sample number for that year. For example, the first sample from an activity for 1996 is numbered 96-1. A station log should be kept with a record of the samples submitted and the designated testing laboratory.

Laboratory Log. A permanent record should be kept of the samples received by a laboratory. For each sample, this log should contain the following.

- Record of the date of receipt and laboratory sample number.
- Product, unit's sample number.
- Source of sample.
- Quantity sample represents.
- Sampler's name.
- Date sampled.
- Date of completion of tests.

Sample Storeroom. A sample storeroom should be prepared apart from the laboratory to protect samples from extreme heat or cold. Samples that have been tested and reported should be stored for an appropriate length of time, tightly stoppered or capped, and segregated from samples that are awaiting tests.

SPECIAL PROCEDURES FOR MILLIPORE TESTING

All containers and their caps, sampling lines, and other equipment used in obtaining the sampler for analysis must be thoroughly cleaned as described in ASTM D 2276, Preparation of Apparatus and Sample Containers.

Sampling Loading Line. The sample will be extracted from the loading rack fill line during filling of aviation refueler trucks. Before the sample is taken, at least 300 gallons of fuel must be circulated or dispensed into a refueling truck. The container is then filled to within 1 inch of the top. The container is immediately capped and sealed to prevent evaporation and leakage.

Sampling Aviation Refueling Trucks. Fuel will be circulated through the piping, filter/separator, hose, and nozzle for a minimum of one half the rated volume of the truck at normal operating pressure. The sample will be taken directly from the nozzle. Immediately after the container is filled, the cap and seal are secured to prevent evaporation and leakage.

Sample Tag. DA Form 1804 should be filled out as indicated in Table 9-1. However, when laboratory analysis for filter effectiveness is required, the appropriate block must be marked on the sample tag.

CHAPTER 10

PETROLEUM LABORATORY OPERATIONS

Section I. Safety During Laboratory Operations

GENERAL PRECAUTIONS

All petroleum products present fire hazards for personnel who handle them. However, petroleum laboratory personnel, who work with chemicals in close quarters, are exposed to additional dangers. The chemicals handled may be toxic, corrosive, explosive, flammable, irritant, or carcinogenic. Safe and efficient laboratory operations depend on the observance of well-established safety practices and a thorough knowledge of testing procedures. The testing procedures usually involve using equipment and materials that are potentially dangerous. Injury to personnel and damage to equipment by fire, chemicals, dangerous pressures and vacuums, or misuse of equipment can be avoided by alert and responsible laboratory technicians. Each laboratory should have operating procedures that include all safety considerations. Strict observance of established safety, care, and handling procedures will allow laboratory personnel to perform their duties in a safe and hazard-free environment. All laboratory personnel should be familiar with safety awareness and communication issues concerning substances used or tested at the facility. Also, Material Safety Data Sheets for those substances should be on hand. Some of the more common safety precautions that should be observed during laboratory operations are as follows:

- Do not consume any food or beverages in the laboratory or storage rooms.
- Check for leaks in the oxygen, gas or vacuum systems by listening for hissing sounds, checking unexplained drops in pressure and applying soapy water to the joints and fittings.
- Always have someone else with you in the laboratory when performing test procedures.
- Pay attention to the test in progress. If it is necessary to leave the laboratory or to leave a test in progress, request assistance from another technician or notify the supervisor. Make sure no safety hazard will result from your absence.
- Maintain a professional manner in the laboratory. Any unnecessary diversions can result in increased hazards and unsatisfactory test results.
- Do not attempt to perform tests simultaneously unless each test can be given the required attention.
- Whenever in doubt concerning any operation, consult qualified authority for advice.
- Do not attempt unauthorized shortcuts to save time, as they generally are not in accordance with safe laboratory procedures or valid test results.
- Be prepared for any emergencies that may arise. Be familiar with the proper action to take in event of emergencies.
- Protective gear (gloves, goggles, and approved lab coat) should be worn when working with chemicals or fuels in the laboratory.
- Wear hearing protection when working around loud machinery (air compressor, generator, and so on).
- When ending daily operations, make a thorough and orderly check of laboratory, equipment, and facilities to ensure that no hazards may develop during the time the laboratory is unattended. Inspections should be performed when the laboratory is unoccupied for an extended length of time.

PREVENTING FIRES

Fire probably represents the greatest single hazard in the laboratory. Laboratory personnel must be aware of the potential sources of fire and work conscientiously when handling combustible materials or supplies and samples that may form flammable vapors. Chapter 2 of FM 10-67-1, discuses the properties of petroleum and their inherent fire hazards, safety procedures, and fire fighting practices. This should be required reading for anyone associated with petroleum products. Specific to the petroleum laboratory, the following fire prevention rules, at a minimum, should be observed to prevent personal injury and equipment damage.

DO:

- Inspect the laboratory for adequate ventilation.
- Ventilate the laboratory and storeroom to prevent the accumulation of fumes and vapors.
- Check seals, tags, pressure gages, and hoses of fire fighting equipment periodically to make sure they are properly serviced and ready for use.
- Inspect any apparatus you will be working with to ensure that it is fixed firmly in place.
- Check burner tubing frequently to ensure that it is not faulty.
- Check electrical wiring frequently. Look for loose or defective connections or frayed insulation.
- Keep volatile liquids and flammable products away from direct (engine exhausts, open flames, and direct sunlight) and indirect (circuit breakers, switches, and electric motors) sources of heat.
- Make certain there is no open flame or exposed heating element nearby when pouring highly volatile liquids.
- Use glass beads or porcelain fragments, to prevent boiling over or splattering of liquids when heating.
- Use flammable liquids near a source of ignition ONLY if the test procedures require it.
- Move flammable debris away from hazardous areas as soon as possible.
- Set hot liquids aside to cool in covered containers before discarding
- Break burned matches, or dispose of them in an ash receiver before discarding them in a refuse container.
- Discard organic products in authorized containers.
- Keep oily rags in a metal, airtight, closed container.
- Immediately clean the area of a spill with absorbent material. Dispose of this absorbent material according to the installation waste disposal plan.
- Perform ohm tests every two years on all static grounds in the laboratory. (Maximum resistance is 25 ohms.)
- Inspect to see that the funnel and funnel base of the filtration apparatus have electrical continuity and are grounded.
- Store chemicals that are hazardous, when near one another, in separate areas. (Oxidizers must be kept separate from flammable and corrosives.)

DO NOT:

- Smoke in the laboratory or associated areas where chemicals are handled or stored.
- Leave open flames or heating elements unattended.
- Discard organic products (hot or cooled) in sinks or drains.
- Store oily rags in cabinets or drawers.

MODULAR,MOBILE AND AIR MOBILE LABORATORIES

The following procedures should be observed when operating in the modular, mobile or airmobile laboratories.

- Purge the laboratory prior to entering. If the purge system is inoperative, open all the doors and vents, and wait at least 30 minutes before entering the laboratory.
- Ground the laboratory and generator.

- Remove all waste drums and sample cans from the area when setting up or taking down the nets from the laboratory and equipment. (The nets generate static electricity.)
- Do not store empty or full sample cans in the laboratory. Store empty or full sample cans in a protective area, at least 50 feet away from laboratory and generators.
- Test and calibrate the gas alarm system, as required.

FIRE EXTINGUISHERS

Trained personnel may use solid water streams, water sprays, and water fogs to control or extinguish fires in specific situations. One of the most immediate means of extinguishing a fire is with the use of a fire extinguisher. The Army uses both portable hand extinguishers and wheeled units. Portable hand fire extinguishers are effective only in a fire's earliest stages. Portable hand fire extinguishers, except pump-tank units, are available in different sizes and types. The pump-tank unit uses water or an antifreeze solution (usually calcium chloride with corrosion inhibitors). Wheeled fire extinguishers offer more flexibility because they have longer hoses and greater capacities. Procedures for extinguishing fires should be posted in the laboratory. Personnel should be thoroughly drilled in the areas of fire prevention and proper, quick response to the sighting of a fire. They should also be familiar with the nature of petroleum fires and with the fire extinguishing equipment in the laboratory. Fire extinguishers and other fire fighting equipment should be within easy reach but safe from fire. In order for the extinguisher to be an effective tool, the following general rules must be followed.

- Know the location of and types of fire extinguishers on hand in the laboratory, and the classes of fires they are intended for.
- Inspect the laboratory facility monthly to ensure that all extinguishers are in their designated places, are readily accessible, are not damaged, and the nozzles are not clogged
- When using the extinguisher, follow the manufacturer's instructions exactly
- Recharge extinguishers immediately after use.
- All fire extinguishers must be tested.
- Examine all fire extinguishers, at least once a year or more often, depending on local regulations.
- Ensure that pressure-type extinguishers are tested hydrostatically.
- Testing should be performed on all fire extinguishers IAW current directives.

TYPES OF FIRE EXTINGUISHERS

The following paragraphs describe the more common types of fire extinguishers and their properties.

Soda-Acid Extinguisher. The soda-acid extinguisher is the most common type of water-solution extinguisher that uses gas pressure as the expellent. The chemicals in the extinguisher are sodium bicarbonate (baking soda) and sulfuric acid. The sodium bicarbonate is in water-solution form in the extinguisher, and the acid is contained in a loosely stoppered glass bottle. When someone inverts the extinguisher, a chemical reaction produces carbon dioxide that builds up pressure and expels the water. Use this extinguisher type for Class A fires only.

Antifreeze Extinguisher. The antifreeze extinguisher contains a calcium chloride solution charge. The expellant is gas from carbon dioxide cartridges or from a chemical reaction. The operator charges the extinguisher by inverting it and bumping it on the floor or by squeezing a valve lever. Use this type of extinguisher for Class A fires.

Loaded-Stream Extinguisher. The loaded-stream extinguisher is charged with an alkali-metal salt solution and other salts. Potassium salts are part of the charge. The way the agent works on a fire differs with the class of the fire. It puts out class A fires immediately and helps keep them from starting again. The way it works on small class B fires is unclear. The agent produces no

smothering vapor, but there seems to be a chemical reaction that tends to hold down combustion.

Carbon Dioxide Extinguisher. The carbon dioxide extinguisher comes in many sizes. The charge of liquid carbon dioxide under 800 to 900-psi pressure is released by a hand valve at the top of the unit. A tube runs from the top to the bottom of the unit. This tube allows the release of only liquid carbon dioxide until the extinguisher uses about 80 percent of its charge. Gaseous carbon dioxide then flows until the charge exhausts. The charge flows in a high-velocity stream, and a horn or flaring nozzle keeps it from being diluted. When the operator releases the charge and it enters the horn, the chilling effect turns about 30 percent of the charge into dry ice or snow. Cooling of the gas as it expands causes this. Carbon dioxide dilutes air in class B fires. It works well on class C fires because it is not a conductor.

Dry Chemical Extinguisher. The dry-chemical fire extinguisher is available in a wide range of sizes. The chief agent is sodium bicarbonate powder with additives that produce water repellency and free flow. The expellant is carbon dioxide, nitrogen, or compressed air. The extinguisher puts out the fire by smothering it. It works well on class B and C fires.

Purple K Extinguisher. The purple K extinguisher is a dry chemical extinguisher using the extinguishing agent potassium bicarbonate (KHCO3), commonly called purple K. Carbon dioxide gas discharges the purple K in a wide stream from a low-velocity nozzle. This fire extinguisher works by smothering and is designed for use on class B and C fires. Purple K is highly corrosive. Purple K extinguishers usually have a 20-pound capacity.

METHODS OF EXTINGUISHING PETROLEUM FIRES

The following methods may be used to extinguish petroleum fires, depending on the class of the fire. Table 10-1 illustrates the National Fire Protection Association's four classes of fire, their source and extinguishing agent(s).

- Water and Water Fog. Water should be used as an absolute last resort for extinguishing petroleum fires. Keep in mind that water is heavier than petroleum, and could cause the fuel to float thus spreading the fire. It is more effective as a cooling agent.

Table 10-1. Classes of Fire

Class of Fire	Source of Fire	Extinguishing Agent
A	Combustibles, such as: wood, paper, grass, brush, rubbish.	Water
B	Liquid, such as: gasoline, and other fuels, solvents, lubricants, paints, oils, and similar substances that do not leave embers.	Air-diluting agent, such as carbon dioxide; or a smothering agent, such as foam or a fire blanket.
C	Electrical equipment, such as motors, switches, and transformers.	Air-diluting agent, such as carbon dioxide or a smothering agent, such as foam or a fire blanket. DO NOT use an agent that is a conductor of electricity.
D	Combustible materials and other chemicals,	Use a smothering agent, such as foam

	such as: sodium, potassium, titanium, and phosphorous. DO NOT allow water to come in contact with these substances, if ignited.	or a fire blanket.

- Blankets. Blankets are mainly used to put out a fire on a person's clothing. Wet blankets can sometimes be used effectively to help smother a fire at a vapor leak or a vent.
- Carbon Dioxide. As opposed to water, carbon dioxide can be used on most petroleum fires.
- Sand. Sand can be used to cover or absorb liquids for fire prevention. Sand is most useful in coping with fires caused by small quantities of flammable liquids and greases on the floor.

WARNING: Do not use water for extinguishing oil fires because it will spread the fire. Water is also a conductor of electricity and should not be used on electrical fires

HANDLING CHEMICALS

Many of the chemicals in the laboratory are dangerous. Any action associated with these chemicals should be done safely. Broken or damaged containers must be handled with caution to prevent exposure of personnel to the hazards that may be involved with a particular chemical. The following safety precautions need to be observed by all personnel handling chemicals.

Personal Safety. To prevent personal injury in the laboratory, the following safety measures should be employed.

- Wear rubber gloves when you handle acids or bases.
- Wear goggles when it is necessary to break up chemicals, or when you handle quantities of corrosive liquids.
- Exercise caution when handling a 30 percent or stronger solution of hydrogen peroxide, to prevent contamination. Wash the area thoroughly with water if skin becomes contaminated.
- Do not handle mercury with your bare hands.
- Do not taste laboratory chemicals.
- Smell a chemical only when it is necessary and then, only by wafting a small amount of vapor with the hand, toward the nose.
- If any acid contaminates your skin, rinse the contaminated area thoroughly with water. The affects of strong acidic solution may be lessened by applying sodium bicarbonate (baking soda) after rinsing the area with water. Consult a physician immediately.

Storing Chemicals. To prevent personal injury when storing chemicals in the laboratory, the following measures should be employed.

- Make sure that every container and bottle is properly labeled.
- Store heavy and large containers of chemicals on or as near to the floor as possible.
- Do not fill a container with material other than that indicated on the label.
- Store a standard solution of an acid or a base to avoid contamination by atmospheric CO_2 (see Figure 10-1, page 10-6).
- Do not store oxidizing agents with reducing agents.
- Do not store acids and bases together; they will react with each other.
- Do not place bottles containing acids or alkalis on high shelves or on top of equipment. Store them on low shelves so they can be easily reached.
- Store caustic soda solution and sulfuric acid in strong glass containers, never in galvanized iron drums.
- Keep all sample containers capped or plugged at all times, except when pouring out test portions. Always replace the same cap or stopper in the container from which it was removed.
- Hold the stopper of a reagent bottle between two fingers of the pouring hand when pouring from a bottle. Never lay the stopper on a surface that might be touched by personnel or their garments.

- Keep reagent bottles stoppered tightly, and dry reagent bottles before replacing them on the shelf.
- Wipe up any acid that spills or splashes on benches, tables, or floors.
- Dispose of all unlabeled and contaminated chemicals IAW local environmental regulations or SOPs.

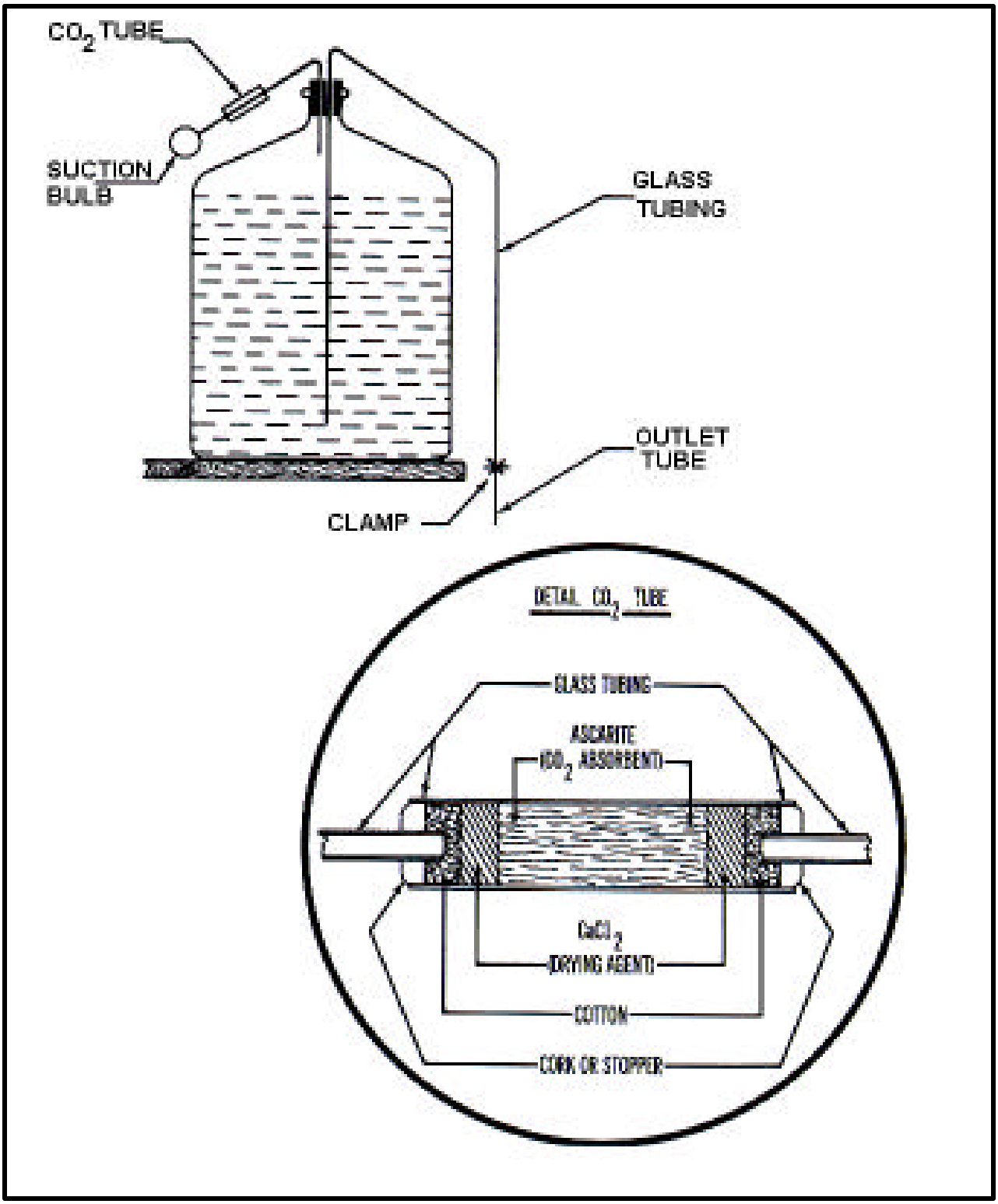


Figure 10-1. Preparation of a carboy for storage of acidic and basic solutions

Handling Chemicals. To prevent personal injury and damage to surrounding areas while handling chemicals, the following measures should be employed.

- Always pour acid into water, especially sulfuric acid. Never pour water into acid.
- Use Pyrex glassware when diluting acids. Ordinary glassware may be broken by the heat generated from the mixture of acid and water.
- Never heat mercury in an open container and never shake more than 20 millimeters of mercury in a glass container. If a spill occurs, ensure adequate ventilation.
- Hold the container cap in your free hand when pouring a sample from a container or bottle. Never place the cap or stopper on a counter, as it may contaminate the sample. Clean up the mercury and sulfur together and put them in a suitable container for disposal IAW local environmental regulations.
- If any chemical is spilled or splashed on the body, immediately wash the contaminated area thoroughly with water.
- If a strong solution of tetraethyl lead is spilled, cover the spill with dry chloride of lime, $CaOCl_2$. Sand or other noncombustible absorbent material may also be used. Wait 5 minutes for reaction to be completed. Flush off with water and wash area with soap and water. If the solution is spilled on clothing, remove clothing and discard contaminated articles. Do not attempt to wash contaminated clothing for reuse. Collect all contaminated absorbent materials and place them into a suitable container for disposal IAW local environmental regulations or SOPs. Contact the local environmental office for further guidance on spill reporting, cleanup, and disposal procedures.
- Make certain that a supply of dilute (18%) acetic acid is available when a doctor test or alkali wash is being performed. Use the dilute acid freely on any part of the body, except the eyes, that may be contaminated with doctor or caustic solution. If doctor or caustic solution should contaminate the eyes, immediately wash out with water and report to hospital.

WARNING: Mercury is a poisonous material that may enter the body by ingestion, inhalation, or skin absorption. Mercury has such density, high surface tension, and low viscosity that pouring without splashing and spilling is almost impossible. When mercury is poured, always use a funnel and make the transfer over spill trays. If a mercury spill occurs, make sure there is adequate ventilation. Do not vacuum or sweep the area as this will disperse mercury throughout the laboratory. Cover the spill with sulfur. Clean up the mercury and sulfur together and discard them in a suitable container. All spills must be reported to the local environmental office.

SUBSTITUTE SOLVENTS

Field conditions may require the substitution of certain solvents. In this case, the commonsense rule of "like dissolves like" should be used. When in doubt as to the correct solvent to substitute, consult the ASTM test method. For example, toluene could possibly be substituted for benzene in a solvent capacity, but n-hexane would not serve the purpose.

HANDLING EXCESS CHEMICALS

Contaminated chemicals are useless. Do not place spatulas and other objects in chemical containers, as the spatula may contain foreign matter that will cause contamination. Similarly, if excess chemicals or samples are removed from a container, do not put it back into the container. All

used chemicals should have well-established rules for disposal.

HANDLING SOLUTIONS

Prepare a chromic acid cleaning solution by slowly adding 800 milliliters of concentrated sulfuric acid to 500 milliliters of a saturated solution of potassium di chromate and water. Prepare the solution in a sink, using a Pyrex container or equivalent glassware. Although chromic acid is more effective as a cleaning agent when it is heated, precaution should be taken to avoid boiling the solution. If the solution develops a greenish color, it is useless and should be discarded.

WARNING: Handle the solution with extreme care to avoid personal injury. A face shield and rubber gloves should be used. Chromic acid is a powerful oxidizing agent.

To increase the rate of solution, use a hotplate, not an open flame. Heat the solution in a Pyrex container or equivalent glassware under a fume hood. If a water-free solution is not necessary, dissolve the solute in a small quantity of water before adding it to the warm alcohol. (Alcoholic solutions have toxic and flammable properties.)

WARNING: Never use high-temperature ovens to heat volatile fluids. An explosion may occur and injure personnel.

CONTROLLING PRESSURE AND VACUUM

The following safety precautions should be observed by all personnel while operating the air/vacuum systems.

- Handle cylinders of compressed gas with particular care. Never allow cylinders to drop or bounce or to come in contact with fire, sparks, or electrical circuits, as explosions may result. (Because compressed-gas cylinders are made of steel, such explosions have the same destructive effect as a bomb burst.)
- Make sure that all store cylinders are capped, are supported to prevent rolling or falling, and are stored away from heat.
- Always store and transport cylinders in an upright position.
- Never put oil or grease on the valves of cylinders or pressure regulators (pressurized oxygen and oil can create an explosion).
- Do not exceed the pressure or temperature that has been designated as the safe upper limit for the apparatus or equipment being used, Do not use a cylinder without a regulator.
- Do not use faulty copper, plastic, or rubber tubing when performing operations requiring pressure or vacuum.
- Make sure that glass vacuum apparatus is properly shielded when it is in use.
- Release pressure cautiously when using gasoline bombs for tests. The bomb plug may stick momentarily and then blow out suddenly.
- Always wear goggles when opening air valves that are close to the face.
- Store propane cylinders in the propane storage locker, away from heat or ignition sources.

The following safety precautions should be observed by all personnel handling chemical containers.

- Make sure that chemical containers having vent caps are inspected, and containers that do not have vent caps are vented periodically.
- Keep containers of volatile liquids as cool as possible. Exercise caution in releasing any pressure that may have formed in the container. Always release the pressure gradually.
- Remove caps or stoppers periodically to vent the vapor. (The practice of venting containers of volatile liquids does not apply to those samples collected for vapor pressure tests.)
- Vent separator funnels frequently when shaking volatile liquids. Always wrap the funnel

with a rag when shaking an extremely volatile liquid.

Other laboratory equipment that requires safe handling procedures are discussed below.

- Glassware. Wash the apparatus with solvent, soapy water, tap water, or distilled water, and then allow to dry. If necessary use a cleaning solution. When glassware is prepared for storage, the stopcocks should be free of grease. Store Teflon stopcocks, or their equivalent, loosely in the barrel and keep them free of grease. Wrap glass stopcocks with a strip of paper for long-term storage to avoid fusing of surfaces such as glass stoppers in flasks.

- Crucibles. Mark crucibles permanently with ink manufactured for this purpose. India ink or pencil markings cannot withstand the high temperature crucibles may be exposed to and cannot be used for this purpose.
- Pipets. Before using, inspect pipets for damage to the tip. Use a suction bulb, not the mouth, to draw the liquid up to a point above the etched line. Remove the bulb and rub thumb across the orifice, letting the meniscus drop to a position where its lowest point coincides with the etched line. Touch the tip to a smooth surface to remove any remaining drop. Allow liquid to drain into an appropriate container. Touch the tip to the side of the glass to ensure complete drainage. Pipets marked TD should not have the remaining drops blown out upon drainage.
- Spatulas. Use steel spatulas only when necessary. A small, clean sheet of paper will often serve the same purpose and can be disposed of after use.
- Centrifuge and Centrifuge Tubes. Do not open the centrifuge enclosure while the centrifuge is in operation. Centrifuge tubes positioned opposite each other must not differ in weight by more than 1 gram.
- Separatory funnels. Hold separatory funnels with the palm of the left hand, securing the stopper firmly in place. Use the right hand to operate the stopcock. When the stopcock is opened for venting, the outlet should be directed away from the operator for safety reasons. Remove the stopper for rapid drainage.
- Corks. Bore corks on a soft wood surface after softening the cork with a roller. When inserting glass tubing or thermometers into corks, wrap the glass in a cloth and hold it as near to the cork as possible. Use water or glycerin as a lubricant. Fire-polish edges of glass tubing to avoid injury to laboratory personnel. Use corks in preference to rubber stoppers because corks are easier to bore and are less reactive.
- Thermometers. The mercury in thermometers may contain bubbles. To remove the bubbles, carefully heat the bulb so that the mercury line slowly extends the length of the instrument; then slowly cool the thermometer.
- Ventilation and Fume Hoods. Make sure that the laboratory is ventilated adequately and that fume hoods are operating properly. Use fume hood when working with toxic vapors. Leave the area immediately if a material that gives off toxic vapors is spilled. Return to the area only after it has been ventilated, or if fresh-air respirators have been obtained.

CONTROLLING FUMES

The following safety precautions are presented to aid in controlling toxic fumes.

- Make sure the laboratory is properly ventilated and the fume hoods are operating properly. The supply room, where chemicals are stored, must also be adequately ventilated.
- Always work in a fume hood when using benzene, aniline, bromine water, or other materials producing toxic vapors.
- Perform all gas alarm system tests and calibrations as specified to ensure proper operation of system.
- If any material is spilled which gives off toxic fumes, all personnel should leave the area immediately and return only after the area has been adequately purged, or after suitable breathing equipment has been obtained.

ELECTRICAL SAFETY

The following electrical safety precautions apply to all operators and maintenance personnel for the petroleum laboratories.

- Equipment producing a tingle sensation should be reported promptly for repair.
- Keep the use of extension cords to a minimum and the cords as short as possible.
- Be sure insulation and wire size are adequate for the voltage and current to be carried.
- Work on electrical devices should be done after the power has been disconnected or shut off, and suitable precautions taken to keep the power off during the work.
- If it is necessary to work on "live" electrical equipment, the person doing so must be fully knowledgeable and have a second person present who is trained in first aid. Never work on "live" equipment alone.
- Wear safety glasses or a face shield where sparks or arcing may occur.
- Never use metallic pencils or rulers, or wear rings or watches when working on electrical equipment.
- Avoid using or storing flammable liquids near electrical equipment.

Section II. Laboratory Analysis Reporting

GENERAL

Laboratory administrative procedures discussed in this section are not mandatory. They are included only as suggested methods of accounting for samples received for the following purposes:

- Testing.
- Initiating the analysis reports.
- Assigning routine and special tests to laboratory technicians.
- Recording test results.
- Reporting test results to requesting agencies with recommendations for use, reclamation, downgrading, or other disposition.

PETROLEUM SAMPLE TAG FILE

The petroleum sample tag should be detached (at the perforation) from the sample container at the time of receipt. The laboratory number is assigned serially from the laboratory logbook, and preliminary information about the sample is recorded in the logbook. This information includes the sample number, date sampled, unit submitting sample, laboratory number, grade of product, specification, source of sample, quantity represented, date received, date test started, date test completed, and remarks.

PETROLEUM LABORATORY ANALYSIS REPORT

Recording Analyses. The senior laboratory technician transfers information on the sample tag to the heading of a DA Form 2077 (see Figure 10-2). The sample tag is then returned to the card file.

The technician refers to the product specification to determine the tests to be performed and records limits on the DA Form 2077 work copy. He then sends this information by informal memorandums to the technicians. The memorandums are identified by the laboratory number of the analysis report. Work copies of all analysis reports in process are arranged by laboratory report number and attached to a clip board kept in a central location. Notebooks may be kept by laboratory technicians to record test data. When a test or a series of identical tests are completed, the technicians turn in results to the senior technician. The senior technician reviews each complete work copy for completion of required tests and test accuracy. The results are recorded on the work copy. He then makes a recommendation for disposition and gives it to the laboratory NCOIC for review/approval. The NCOIC reviews the test results, compares them with use limits for the product, and decides

whether the product represented by the sample can be safely used for its intended purpose. If all use limits have been met, the product is approved for use. The approval is indicated on the bottom of the report with or without a time limitation, as appropriate.

Processing. A typed report is prepared from the approved work copy. The senior technician sends the report, including enough copies to satisfy interested agencies, to the requesting agency. The technician also provides a copy for the laboratory. The original is forwarded to the requesting agency. A carbon copy of the typed report, the work copy, and the sample tag are fastened together and placed in a permanent file for future reference.

PETROLEUM PRODUCTS LABORATORY ANALYSIS REPORT
For use of this form, see FM 10-67-2; the proponent agency is TRADOC.

SAMPLE NO: XX-09 | LAB REPORT NO: XX-401

PRODUCT NOMENCLATURE AND TYPE: TURBINE FUEL, AVIATION GRADE JP-8 | SPEC NO: MIL-T-83133D

SAMPLE SUBMITTED BY (Installation): 49th QM GROUP, FORT LEE, VA 23801 | AMT PROD SAMPLE REPRESENTS: 5,000 GALLONS

MANUFACTURER OR SUPPLIER OF PRODUCT: Sun Oil Company | SOURCE OF SAMPLE (Truck, Tank, Aircraft, etc.): TRK 31P

SAMPLE TAKEN BY (Name): SPC Willie Roc | CONTRACT NO: | ITEM NO: | NSN: 9130-01-031-5816 | DATE SAMPLE TAKEN: 15 AUG XX

QUAL NO: | BATCH NO: | FILL DATE: | DLVR DATE: | DATE SAMPLE REC: 15 AUG XX

NAME AND LOCATION OF LABORATORY: SEAMAN PETRL LAB, FORT LEE, VA 23801

- ☐ FUEL BULK STORAGE
- ☐ FUEL PACKAGED
- ☐ ALLIED PRODUCTS
- ☐ FILTER EFFECTIVENESS
- ☐ QUALIFICATION CONTRACT
- ☐ ROUTINE SURVEILLANCE
- ☐ PROCUREMENT ORIGIN
- ☐ PROCUREMENT
- ☐ SPECIAL
- ☐ DEPOT

DATE TESTS STARTED: 15 AUG XX
DATE TESTS COMPL: 16 AUG XX

TEST	SPEC/QUAL	RESULT	TEST	SPEC/QUAL	RESULT
1. GRAVITY °API/~~SQ.GR~~ 60°/60°F ~~TOP~~ AVG	37-51	43.0	27. WATER AND SEDIMENT % VOL MAX		
a. MID			28. FSII % VOL TOP		
b. BOT			a. MID		
c. SPGR 60°F AVG	.775-.840	.800	b. BOT		
2. ~~APPEARANCE~~ WORKMANSHIP	C&B	C&B	c. AVG	.10-.15	.130
3. COLOR VISUAL	RPT	W/W	29. PARTICULATE CONTAMINANT MGS/GAL		
a. HELLIGE (Colorimeter)			30. THERMAL STABILITY INCHES HG		
b. ~~ASTM/SAYB~~/SAYB ~~MIN~~	RPT	-10	a. PREHEATER RATING		
c. SAYB AFTER HEAT MIN			31. SULFIDES (Tank Water BTMS)		
4. ODOR			32. WATER SEPAROMETER INDEX MIN	70	85
5. DISTILLATION I BP C	RPT	139.0	33. % ASH PLAIN/SULF MAX		
a. 10 % REC - ~~EVAP AT~~ MAX C	205	172.0	34. % LEAD		
b. 20 % REC - ~~EVAP AT~~ C	RPT	183.0	35. % PHOSPHORUS		
c. 50 % REC - ~~EVAP AT~~ C	RPT	211.0	36. % CHLORINE		
d. 90 % REC - ~~EVAP AT~~ C	RPT	249.0	37. BURNING TEST (16 hrs)		
e. FBP ~~DEW PT~~ MAX C	300	262.0	38. KIN CS/~~CSU~~ AT -20 C MAX	8.0	7.0
f. % RECOVERED	RPT	98.0	a. KIN CS/SSU AT °F		
g. % LOSS	1.5	1.4	b. KIN CS/SSU AT °F		
h. % RESIDUE	1.5	.6	c. KIN CS/SSU AT °F		
i. 10% + 50% EVAP °F MIN			d. SSF AT °F		
6. ENGINE RATING O.N. MOTOR METHOD			e. VISCOSITY INDEX MIN		
a. ON RESEARCH METHOD			39. EVAP LOSS % MAX		
b. LMR AVIATION METHOD			40. PRECIPITATION NO MAX		
c. RMR SUPER CH METHOD			41. SEPARATION % MAX		
d. CETANE ~~NUMBER~~/INDEX MIN	RPT	46.0	42. ACID NO/BASE NO MAX		
7. RVP (PSI)			43. CHANNEL PT °F MAX		
8. GUM EXISTENT MG/100 ML MAX	7.0	5.0	44. SAPONIFICATION NO MAX		
GUM (Wash) MG/100 ML MAX			45. DIELECTRIC STRENGTH KV MIN		
GUM POTENTIAL MG/100 ML MAX			46. FOAM SEQ 1. MLS MAX (TND/STAB)		
PRECIPITATE MG/100 ML MAX			a. SEQ 2. MLS MAX (TND/STAB)		
9. TEL/TML (MUGM/GAL) MAX			b. SEQ 3. MLS MAX (TND/STAB)		
10. OXIDATION STABILITY MINUTES			47. PENETRATION UNWORKED 77°F		
11. DR TEST/MERC S% MAX			a. PENETRATION WORKED 77°F		
12. SULFUR BY LAMP BOMB % MAX			48. DROP PT/MELT PT °F MIN		
13. FREEZING PT C MAX	-47	-53	49. CORR AND OXIDATION STAB		
14. CORROSION COPPER STRIP 2 HR @ 100°	1 MAX	1b	50. SWELLING SYN RUBBER %		
15. AROMATICS % VOL MAX			51. LOW TEMP STABILITY		
16. OLEFINS % VOL MAX			52. SALT SPRAY TEST		
17. SMOKE POINT MM MIN			53. WORK STABILITY		
18. SMOKE VOLAT INDEX MIN			54. WATER STABILITY		
19. ANILINE PT °F/ANILINE GRAV PROD MIN			55. THICKENER TYPE		
20. FLASH ~~FIRE~~ POINT C MIN	38.0	39.0	56. THICKENER CONTENT %		
21. CLOUD POINT °F MAX			57. CORROSION PROTECTION		
22. POUR POINT °F MAX			58. REMOVAL		
23. WATER REACT INTERFACE RATING MAX	1b	1b	59. APPARENT VISC AT °F		
a. SEPARATION VOLUME CHANGE ~~MAX~~	rpt/rpt	1/0	a. SHEAR RATE POISES		
24. CARBON RESIDUE % WT MAX			60. SED CONTAM. MILLIPORE, MG/L MAX	1.0	3.0
25. WATER % VOL MAX			61. EFFECTIVENESS OF FILTRATION MAX	15 min	30
26. SEDIMENT % VOL MAX			62. OTHER (Specify)		

REMARKS: NSFU. Product is not suitable for use for items #60 & 61. Possible contamination with heavier product. Recommend recirculation and resample ASAP.

DATE FORWARDED: 17 AUG XX | SIGNATURE: MICHAEL HERITAGE, SFC Michael Heritage | TITLE: LAB NCOIC

Figure 10-2. DA Form 2077

Recommendations for Disposition. If the product should not be used for its intended purpose, an alternative use must be considered and suitable recommendations made. The report should include the following information:

- Probable cause of product not meeting use limits.
- Nature and probable cause or source of contamination.
- Suggestions for preventing future contamination or deterioration.
- Recommendations for reclamation or other disposition of the product.
- On grade—Sample meets all specification requirements and can be retained for long storage.
- Suitable for use—Product is either deteriorated or contaminated to the point where one or more tests do not meet specification requirements but meet use limits (MILHDBK-200). Product should be used as soon as possible.
- Not suitable for use—Product fails to meet one or more use limits or specification requirement that has no use limit. Product must be downgraded or blended as recommended and retested before use.

TESTING

Correlation Testing. Correlation testing may be done by sending identical samples to two or more laboratories. These laboratories use the same apparatus in performing the tests. Correlation testing may also be done by having two or more technicians within a given laboratory perform tests on identical samples using the same apparatus under controlled conditions. Another way of testing is to have a single technician perform duplicate tests on identical material using the same apparatus under controlled conditions. Results should not differ by more than those specified in the test method. The first two procedures are checks on reproducibility, the third is a check on repeatability.

Equipment Calibration. Results of all tests are dependent on calibrated equipment. Most Army equipment requiring calibration is listed in TB 43-180. Also, the calibration frequency and standard for test equipment is specified in the applicable test methods. Internally, the laboratory should verify calibration more frequently than TB 43-180 requires.

- C-level calibration procedures. C-level calibration will be performed by qualified laboratory personnel assigned to the laboratory.
- Analytical balance. The electric balance is a single-arm balance and has a weighing capacity of 100 grams. When the balance is provided with the manual taring accessories, the weighing capacity is increased to 150 grams. The precision (standard deviation) of the balance is plus or minus 0.05 milligrams; digital readability is 0.1 milligrams; and accuracy in the optical range is plus or minus 0.05 milligrams. ASTM E 319 procedures are recommended for evaluating performance and verifying the accuracy of the balance. These procedures determine the precision that a balance can compare known weight loads; that is, the built-in weights of the balance and a known weight load. Section 5, ASTM E 319, outlines procedures for preparing the balance for evaluation and section 8 outlines procedures for evaluating balance accuracy. A precision weight set (class S) is used to evaluate balance performance. The verification and evaluation of the balance are performed by operating personnel. The double beam balance may be evaluated using the above procedures. The standard deviation of the double balance is plus or minus 0.1 grams.
- Manometer. The manometer is used to verify the accuracy of the RVP gauges. Mercury is used as the indicating fluid. The manometer is equipped with a double scale graduated in inches of mercury and psi. The scale has provisions for zero adjustment. The scale must be adjusted to the zero position prior to verifying gage accuracy. The accuracy of the manometer is verified by using a certified master gage with a range of zero to 15 psi graduated in increments of 0.1 psi and an accuracy of plus or minus 0.05 percent. Recommended A-level calibration frequency is 180 days.
- RVP gages. The RVP gages must be verified for accuracy after each test when deter-

mining vapor pressure of MOGAS. When determining the vapor pressure of aviation fuels (AVGAS and turbine engine fuel), operating personnel verify the gage for accuracy before and after each test. The accuracy of RVP gages is verified by using the manometer. When the gage reading and the manometer reading differ by 1 percent or less; that is, the gage correction factor is not greater than 0.05 psi for 5-pound gages or 0.15 psi for 15-pound gages, the gage is considered accurate. However, if the readings differ by more than 1 percent, the gauge is considered inaccurate and must be repaired or replaced.

- Thermometers. The routine laboratory thermometers, ASTM 9 F, 12 F, and 58 F, have scales including 32°F and are verified for accuracy by determining the ice point. ASTM 18 F is verified at 100°F. ASTM 7 F, low distillation thermometer, is verified for accuracy at 200°F. ASTM 10 F, high range thermometer, is verified for accuracy at 212°F. ASTM 7 F, 10 F, and 18 F are verified for accuracy by direct comparison with a certified precision thermometer. The two certified precision thermometers (ASTM 64 F and 68 F) are certified by the A-level calibration facility. The precision thermometers must be certified at 360-day intervals. The error of the certified thermometers must not be more than the maximum scale error of the specification (ASTM E-1).

Section III. Standard Publications and Forms

GENERAL

Publications that describe the acceptable military procedures for testing and evaluating the quality of a petroleum product are essential for use in a petroleum laboratory. The latest editions, with all change notices and current petroleum product specifications, must be on hand at all times to be used by laboratory personnel.

MILITARY STANDARDIZATION HANDBOOK FOR FUELS, LUBRICANTS, AND RELATED PRODUCTS (MIL-HDBK-200)

This handbook provides general instructions and minimum procedures to be used worldwide by the military services in QS of US government-owned fuels, lubricants, and related products. The procedures described in MIL-HDBK-200 include QS testing and use limits, minimum sampling and testing requirements, types of tests required on various petroleum products, and storage and transportation requirements.

FEDERAL TEST METHOD STANDARD NO. 791

FTMS No. 791 covers methods adopted for use by federal agencies in testing lubricants, liquid fuels, and related products. Only the federal test methods without adopted ASTM test standards are included in the publication. The federal standard has both alphabetic and numeric indexes of test methods. These list both the federal test designation and the corresponding ASTM test designation. New and revised federal test material and cancellation are issued as change notices by the General Services Administration. These are numbered consecutively and dated. Laboratories should retain all change notices until superseded by a reissue of the entire federal standard.

ASTM STANDARDS 23, 24, 25, AND 47

The ASTM standards 23, 24, 25, and 47 are published annually and contain test methods for petroleum products.

DFSCH 4120.1, REFERENCE LIST OF SPECIFICATIONS AND STANDARDS

This list shows all current petroleum specifications and is published periodically by the Defense Fuel Supply Center.

DOD MANUAL 4140.25-M, PROCEDURES FOR THE MANAGEMENT OF PETROLEUM PRODUCTS

This manual covers procedures for management of DOD-owned petroleum stock.

AR 715-27 (DLAM 4155.1), PETROLEUM PROCUREMENT QUALITY ASSURANCE MANUAL

This manual covers all areas of petroleum QA.

FORMS

The following forms may be used in a petroleum laboratory.

- DA Form 285 (US Army Accident Investigation Report.
- DA Form 1804 (Petroleum Sample). See Figure 9-4.
- DA Form 2077 (Petroleum Products Laboratory Analysis Report). See Figure 10-2.
- DA Form 2404 (Equipment Inspection and Maintenance Worksheet).
- DA Form 2407 (Maintenance Request).
- DD Form 250 (Material Inspection and Receiving Report). See Figure 10-3.
- DD Form 250-1 (Material Inspection and Receiving Report - Continuation Sheet). See Figure 10-4.
- DD Form 314 (Preventive Maintenance Schedule and Record).
- DD Form 1425 (Specifications and Standards Requisition).
- SF 361 (Discrepancy in Shipment Report).

MATERIAL INSPECTION AND RECEIVING REPORT

Form Approved
OMB No. 0704-0248

Public reporting burden for this collection of information is estimated to average 30 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0248), Washington, DC 20503.

PLEASE DO NOT RETURN YOUR COMPLETED FORM TO EITHER OF THESE ADDRESSES.
SEND THIS FORM IN ACCORDANCE WITH THE INSTRUCTIONS CONTAINED IN THE DFARS, APPENDIX F-401.

1. PROC. INSTRUMENT IDEN. (CONTRACT)	(ORDER) NO.	6. INVOICE NO./DATE	7. PAGE	OF	8. ACCEPTANCE POINT
DSA-owned stock			1	1	S

2. SHIPMENT NO.	3. DATE SHIPPED	4. B/L	5. DISCOUNT TERMS
00012	30 Aug XX	TCN AZ40ZZ81930044XXX	

9. PRIME CONTRACTOR	CODE	10. ADMINISTERED BY	CODE

11. SHIPPED FROM (If other than 9)	CODE	FOB:	12. PAYMENT WILL BE MADE BY	CODE
BULK STORAGE FACILITY APO AE 09345				

13. SHIPPED TO	CODE	14. MARKED FOR	CODE
TANK FARM 209TH SUPPLY CO APO AE 09227			

15. ITEM NO.	16. STOCK/PART NO. DESCRIPTION (Indicate number of shipping containers - type of container - container number.)	17. QUANTITY SHIP/REC'D*	18. UNIT	19. UNIT PRICE	20. AMOUNT
1	9130-00-031-5816 Turbine Fuel, Aviation, Grade JP-8, Kerosene type, MIL-T-83133	5,000	bbl		0

21. CONTRACT QUALITY ASSURANCE

A. ORIGIN

☐ CQA ☐ ACCEPTANCE of listed items has been made by me or under my supervision and they conform to contract, except as noted herein or on supporting documents.

DATE | SIGNATURE OF AUTH GOVT REP

TYPED NAME AND OFFICE

B. DESTINATION

☐ CQA ☐ ACCEPTANCE of listed items has been made by me or under my supervision and they conform to contract, except as noted herein or on supporting documents.

DATE | SIGNATURE OF AUTH GOVT REP

TYPED NAME AND TIITLE

22. RECEIVER'S USE

Quantities shown in column 17 were received in apparent good condition except as noted.

DATE RECEIVED | SIGNATURE OF AUTH GOVT REP

TYPED NAME AND OFFICE

* If quantity received by the Government is the same as quantity shipped, indicate by (✓) mark, if different, enter actual quantity received below quantity shipped and encircle.

23. CONTRACTOR USE ONLY

DD Form 250, NOV 92 Previous edition may be used. USAPPC V2.00

Figure 10-3. DD Form 250

TANKER/BARGE MATERIAL INSPECTION AND RECEIVING REPORT

Form Approved
OMB No. 0704-0248

PLEASE DO NOT RETURN YOUR COMPLETED FORM TO EITHER OF THESE ADDRESSES.
SEND THIS FORM IN ACCORDANCE WITH THE INSTRUCTIONS CONTAINED IN THE DFARS, APPENDIX F-401.

1. Shipment number: ☒ LOADING REPORT ☐ DISCHARGE REPORT	2. Inspection office: UNIT 15300, DONCI, APO AP 96221	3. Vessel number: TRE-0019
4. Contract number and name of prime contractor, city, state and mailing address: DEFENSE FUEL REGION, PUGLPIG, GARF SMITH, HI	5. Contract number:	6. Prime contract or P.O. number: SPO 8BD-XX-G-8652
7. Name of prime contractor, city, state and mailing address: SEEKYUNG LIMITED, CPO 9999, SEOUL, KOREA		8. Storage company:
9. Terminal or delivery carrier name, city, state and mailing address: TERING LIMITED, ULSAN COMPLEX, KOREA (FOB ORIGIN)		10. Bill of lading or carrier no.: JO17-01 (X00118)
11. Ship to (Receiving Activity City, State and Mailing Address): BFSF PETROLEUM DISTRIBUTION SYS OKINAWA, JAPAN MOGGGF		12. P.O. number:
		13. Bill of lading no.: 14. Date received:
15. Vessel: M/C CHIKAT WARRIOR	16. Draft forward: 199.02' 06" AFT 03' 05"	17. Draft aft: 199.12' 00" AFT 12' 06"
18. Vessel tank number: PAR 205 STBD NEW	19. Flow meter number:	
20. Temperature at time of flow meter: FULL BEFORE AND AFTER LOADING	21. Temperature reading: 3000/988.5CRO.3699999	22. Contract line no.: 0001
23. Product: GASOLINE AUTOMOTIVE, MID-GRADE NSN 9130-01-272-9651	24. Specification: ASTM D4814 w/Vendor	

25. Tankers or quantity	Gross	Deductions	Tankers	Net Gal
Shipped at loading	34,521.88			
Delivered ashore	1,451.170			
Ullage	4,070.33			

26. Statement of quality

Test	Specification Limits	Results PT-T105	Results SKIP CONT
COLOR, DYED	YELLOW	YELLOW	YELLOW
VISUAL EVAL CODE	CAB	C&B	C&B
TOTAL SULFUR, WT%	MAX 0.10	0.002	
IBP, C°	RPT	36.0	36.0
10% EVAP, C°	MAX 70	54.0	54.5
50% EVAP, C°	77-121	86.0	87.5
90% EVAP, C°	MAX 190	150.0	150.5
FBP, C°	MAX 225	185.0	182.0
RESIDUE, VOL%	MAX 2.0	1.0	1.0
LOSS, VOL%	RPT	1.0	1.0
GRAVITY, API	RPT	56.1	56.1
DENSITY, KG/L	RPT	0.7544	
V/L RATIO	MAX 20	17	
VAPOR PRESSURE, PSI	MAX 9.0	8.3	8.5
LEAD CONTENT, G/L	MAX 0.013	LT 0.001	
COPPER CORROSION, CODE	MAX 1	1a	1a
EXISTENT GUM, MG/L	MAX 5	1.0	0.5
OXIDATION STAB. MIN	MIN 240	2404	
OCTANE NO. RESEARCH	MIN 94	94.6	

27. Time statement	Date	Time
Arrival of tankers in load anchorage	320916	0830
Vessel moored in port	320916	1145
Hoses hooked	320916	0515
Tanker ready for discharge	------	-----
Tanker ready for loading	------	-----
Tankers and ready for load discharge	320916	0856
Large hose connected	320916	0938
Commenced loading discharge	320916	0903
Stopped loading discharge	------	-----
Resumed loading discharge	------	-----
Finished loading discharge	320917	0113
Large hose removed	320917	0120
Hose released by inspector	320917	0440
Commenced departure	------	-----
Departure completed	------	-----
Hose off berth (Load/Discharge)	320917	0700

28. Remarks (Show in detail cause of delay that is reported, shortfall, time operation stopped, etc.)

29. I certify that the cargo was inspected, accepted and loaded or discharged as indicated herein.
SSGT(T) Robinson, Thomas W. USA
Date / Signature of Inspector or Contract Representative

30. Company representative:
Kim, Chang Ho, Quality Assurance Rep
Signature

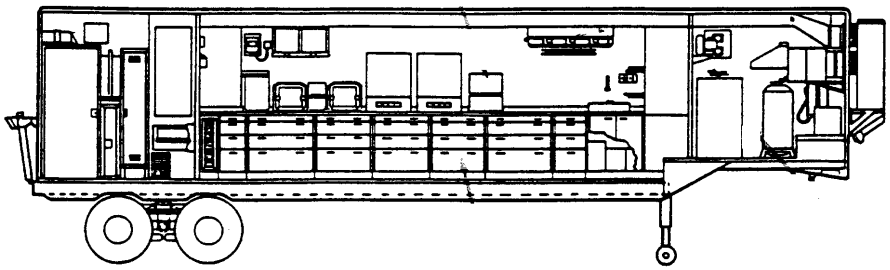
31. I hereby certify that the time statement is correct.
Rand, Joseph J.
Master or Agent

DD Form 250-1, NOV 93 — Previous edition may be used

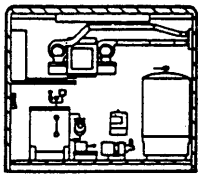
Figure 10-4. DD Form 250-1

APPENDIX A

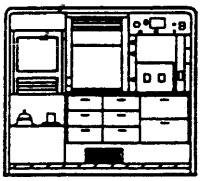
Petroleum Laboratories



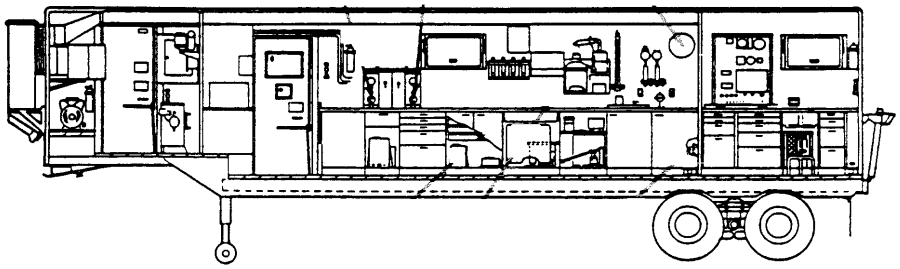
EQUIPMENT LOCATION
ROADSIDE



EQUIPMENT LOCATION
MACH RM REAR WALL



EQUIPMENT LOCATION
FRONT LAB WALL



EQUIPMENT LOCATION
CURBSIDE

Figure A-1. Mobile petroleum laboratory

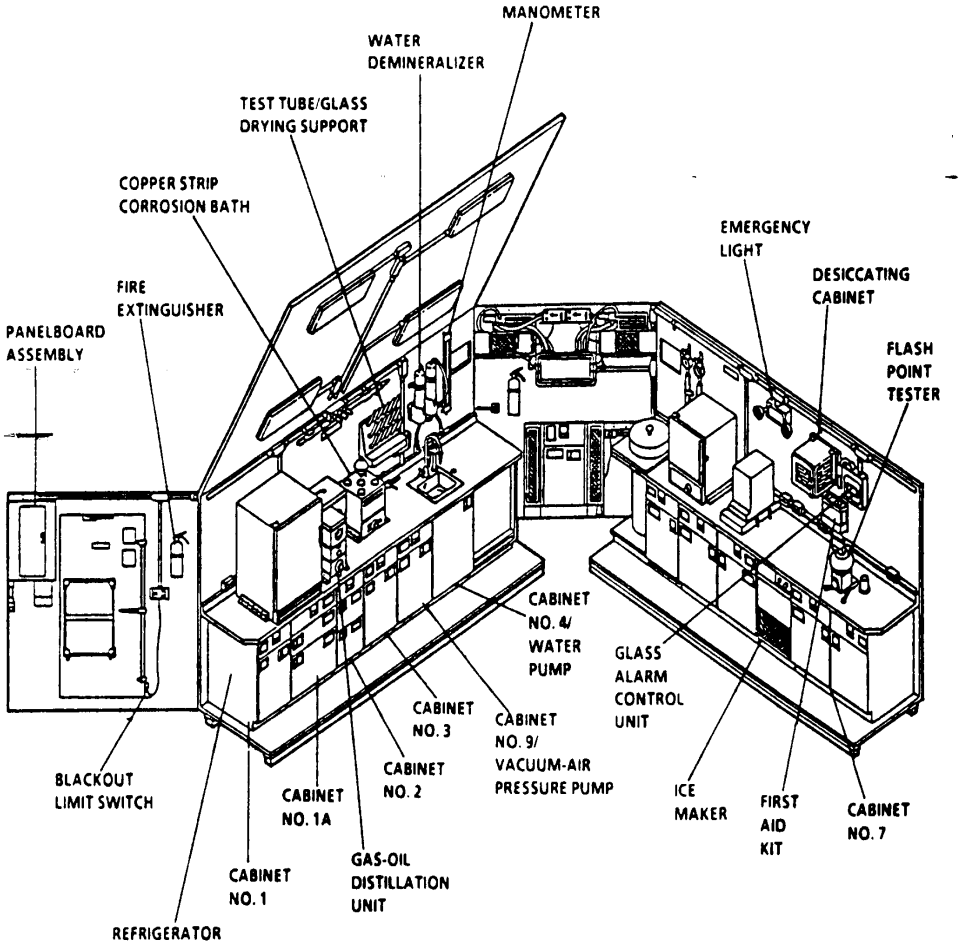


Figure A-2. Airmobile petroleum laboratory

APPENDIX B

Test Man-Hours for Type of Fuel

Man hours for each type of test are based on the applicable test method. The hours cited for a particular test are for one individual to set up the laboratory test equipment, perform the test, report and file the results, and clean and put away the equipment, under normal operating conditions.

Table B-1. Test man hours for type of fuel

Characteristics	Approximate Man-Hours	Test Type B1	Test Type B2	Test Type B3	Test Type C
TYPES OF TEST REQUIRED ON AIRCRAFT TURBINE FUELS					
Water and Solids	10 minutes	X	X	X	X
Color (visual)	10 minutes	X	X	X	X
Specific or API Gravity	20 minutes	X	X	X	X
Solids (Millipore) Particulate	2 hrs., 50 min	X	X	X	
Contamination					
Distillation	1 hr., 30 min	X	X	X	
Copper Strip Corrosion	3 hrs., 50 min	X	X	X	
Freezing Point	1 hour	X	X	X	
Existent Gum	8 hours	X	X	X	
Reid Vapor Pressure	2 hours	X	X	X	
Flash Point	45 minutes	X	X	X	
Water Reaction	30 minutes	X	X	X	
Lead Content (if contaminati with leaded fuels is suspectec	1 hr., 30 min	X	X	X	
Fuel System Icing Inhibitor (FSII)	1 hour	X	X	X	
Filtration Time (JP-4, JP-8)	2 hrs., 50 min	X	X	X	
Water Separation Index (mini)	30 minutes	X	X	X	
Conductivity (JP-4, JP-8)	10 minutes	X	X	X	
Thermal Stability (D 3241)	8 hours		X		
Total Acid in Aviation Fuel	1 hour		X		
Color (Saybolt)	15 minutes		X		
Peroxide Number (JP-5)	30 minutes		X		

Table B-1. Test man hours by type of fuel (continued)

Characteristics	Approximate Man-Hours	Test Type B1	Test Type B2	Test Type B3	Test Type C
TYPES OF TESTS REQUIRED ON AUTOMOTIVE GASOLINE					
Appearance	10 minutes	X	X	X	X
Water and Solids (visual)	10 minutes	X	X	X	X
Color (visual)	10 minutes	X	X	X	X
Specific or API Gravity	20 minutes	X	X	X	X
Distillation	1 hr., 30 min	X	X	X	
Reid Vapor Pressure	2 hours	X	X		
Copper Strip Corrosion	3 hrs, 50 ,min		X	X	
Unwashed Gum	8 hours		X	X	
Oxidation Stability	8 hours		X		
Lead Content	6 hours			X	
TYPES OF TESTS REQUIRED ON DIESEL FUELS					
Appearance	10 minutes	X	X	X	X
Color (visual)	10 minutes	X	X	X	X
Specific or API Gravity	20 minutes	X	X	X	X
Distillation	1 hr, 30 min	X	X		
Flash Point	45 minutes	X	X	X	X
Carbon Residue	2 hours	X	X		
Cloud Point	1 hour		X		
Pour Point	1 hour		X		
Corrosion	2 hrs, 50 min		X		
Cetane Index	10 minutes		X		
Viscosity	2 hours		X		
Water and Sediment by Centrifuge	30 minutes		X		
Solids, Millipore, Particulate Contamination	2 hrs, 50 min	X	X		

APPENDIX C

Conversion Charts

AREA

To Convert	To	Multiply By
Acres	Square Feet	43,560
	Square Yards	4,840
	Square Miles	0.0015625
	Square Meter	4,046.873
	Hectares	0.4046873
Hectares	Square Yards	11,959.85
	Acres	2.47104
	Square Miles	0.003861
	Square Meters	10,000
	Square Kilometers	0.01
	Square Feet	107,600
Square Centimeters	Square Feet	0.001076
	Square Inches	0.1550
	Square Meters	0.0001
	Square Miles	3.861×10^{-11}
	Square Millimeters	100
	Square Yards	0.000196

Square Feet

Acres.....0.0000296
Square Centimeters.....929.0
Square Meters.....0.09290
Square Inches.....144.0
Square Yards.....0.11111
Square Miles.....3.587 x 10^{-8}
Square Millimeters.....9.29 x 10^{4}

Square Inches

Square Centimeters.....6.452
Square Feet.....0.6944
Square Millimeters.....645.2
Square Yards.....0.000716

Square Kilometers

Acres.....247.1
Square Centimeters.....10^{10}
Square Feet.....10.76 x 10^{6}
Square Inches.....1.550 x 10^{9}
Square Meters.....10^{6}
Square Miles.....0.3861
Square Yards.....1.196 x 10^{6}

To Convert	To	Multiply By

Square Meters

Acres.....0.0002471
Square Centimeters.....10,000
Square Feet.....10.76

Square Inches.....1,550
Square Miles.....3.861 x 10^{-7}
Square Millimeters.....1.10^{6}
Square Yards.....1.196

Square Miles
Acres.....640.00
Square Feet.....27.88 x 10^{6}
Square Kilometers.....2.590
Square Meters.....2.590 x 10^{6}
Square Yards.....3.098 x 10^{6}

Square Yards
Acres.....0.0002066
Square Centimeters.....8,361
Square Feet.....9.0
Square Inches.....1,296
Square Meters.....0.8361
Square Miles.....3.228 x 10^{-7}
Square Millimeters.....8.361 x 10^{5}

FLOW

Barrels per Day
Gallons per hour.....1.75
Gallons per minute.....0.0292

Barrels per Hour
Cubic Feet per Minute.....0.0936
Gallons per Minute.....0.7

Gallons per Hour
Cubic Feet per Hour.....0.1337
Cubic Feet per Minute.....0.002228
Gallons per Minute.....0.016667

Gallons per Minute
Barrels per Day.....34.286
Barrels per Hour.....1.4286
Barrels per Minute.....0.0381
Cubic Feet per Day.....192.50
Cubic Feet per Minute.....0.1337
Gallons per Day.....1,440
Liters per Second.....0.0631
Cubic Feet per Second.....0.002228

To Convert	To	Multiply By
Cubic Feet per Minute	Gallons per Second	0.1247
	Liters per Second	0.4720

Cubic Centimeters per Second.....472.0

Cubic Feet per Second Million Gallons per Day.....0.646317 Gallons per Minute.....448.831

Cubic Yards per Minute Cubic Feet per Second.....0.46 Gallons per Second.....3.167 Liters per Second.....12.74

Liters per Minute Cubic Feet per Second.....0.0005886 Gallons per Second.....0.004403

LENGTH

Centimeters

- Feet.....0.03281
- Inches.....0.3937
- Kilometers.....1 x 10^{-5}
- Meters.....0.01
- Miles.....6.214 x 10^{-6}
- Millimeters.....10.0
- Mils.....393.7
- Yards.....0.01094
- Microns.....10,000

Feet

- Centimeters.....30.48
- Kilometers.....0.0003048
- Meters.....0.3048
- Miles (Nautical).....0.0001645
- Miles (Statute).....0.0001894
- Millimeters.....304.8
- Mils.....12,000
- Microns.....30,480

To Convert	To	Multiply By
Kilometers		
	Centimeters	1×10^5
	Feet	3,281
	Inches	39,370

Meters.....1,000
Miles.....0.6214
Millimeters.....10^6
Yards.....1,094

League
Miles.....3

Meters
Centimeters.....100
Feet.....3.281
Inches.....39.37
Kilometers.....Miles.....0.001
(Nautical).....Miles.....0.0005396
(Statute).....0.0006214
Millimeters.....1,000
Yards.....Microns.....1.094.....1 x 10^6

Miles (Nautical)
Feet.....6,080.27
Kilometers.....1.853
Meters.....Miles.....1,853.0
(Statute).....1.1516
Yards.....2,027

Miles (Statute)
Centimeters.....1.609 x 10^5
Feet.....5,280
Inches.....63,360
Kilometers.....1.609
Meters.....Miles.....1,609.0
(Nautical).....0.8684
Yards.....1,760

Millimeters
Centimeters.....0.1
Feet.....0.003281
Inches.....0.03937
Kilometers.....10^{-6}
Meters.....Miles.....0.001.....6.214 x 10^{-7}
Mils.....39.37
Yards.....0.001094
Microns.....1,000

To Convert	To	Multiply By
Microns	Centimeters	1 x 10^{-4}
	Inches	3.937 x 10^{-5}
	Meters	1 x 10^{-6}

Yards (US)
Centimeters.....Fathoms.....91.4402.....
0.03
Feet.....3
Inches.....36
Meters.....Miles.....0.9144.....5.68182 x
10^{-4}

VOLUME

Barrels (US) US
Gallons.....Cubic.....42
Inches.....Cubic9,702
Feet.....Imperial
Gallons.....5.6146
34.9726
Liters.....Cubic.....158.984
Meters.....0.15899

Cubic Centimeters Cubic Feet.....3.531 x
10^{-5} Cubic
Inches.....Cubic0.06102
Meters.....Cubic Yards.....1,308 x
10^{-6} Gallons (US
Liquid).....0.0002642
Liters.....Pints.....0.001 (US
Liquid).....0.00211 (US
Liquid).....0.001057

Cubic Feet Cubic
Centimeters.....Cubic28,320.00
Inches.....Cubic1,728.00
Meters.....Cubic0.02832
Yards.....Gallons.....1.03704 (US
Liquid).....7.48052
Liters.....Pints.....28.32 (US
Liquid).....Quarts.....59.84 (US
Liquid).....29.92

To Convert	To	Multiply By
Cubic Inches	Cubic Feet	5.787 x 10^{-4}
Centimeters	Cubic Meters	0.02832
Cubic		

Cubic Yards.....2.143 x 10^{-5} Cubic Gallons.....0.004329
Liters.....Mil. Feet.....0.01639.....1.061 x 10^{5} Pints (US Liquid).....0.03463 (US Liquid).....0.01732

Cubic Meters Bushels (dry).....28.38
Cubic Centimeters.....1 x 10^{6} Cubic Feet.....35.31
Cubic Inches.....61.023
Cubic Yards.....1.308
Gallons (US Liquid).....264.2
Liters.....Pints.....1,000
Quarts (US Liquid).....2,113.0
1,057.0

Cubic Yards Cubic Centimeters.....7.646 x 10^{5} Cubic Feet.....27.0
Cubic Inches.....46,656
Cubic Meters.....0.7646
Gallons.....202.0
Liters.....Pints.....764.6
(US Liquid).....1,615.9

Gallons (Imperial) Quarts (US Liquid).....807.9
Cubic Inches.....277.42
Cubic Feet.....0.160544
US Gallons.....1.20094
Barrels.....0.028594
Liters.....Cubic Meters.....4.54596
0.004546

Gallons (US) Cubic Centimeters.....3,785.0
Cubic Feet.....0.1337
Cubic Inches.....231.0
Cubic Meters.....0.003785
Yards.....0.004951
Liters.....3.785
Pints.....8.0
Quarts.....4.0

To Convert	To	Multiply By
Gills		
Liters	Pints	0.1183
(Liquid)		0.25

Liters Bushels (US Dry).....0.02838
Cubic Centimeters.....1,000.0
Cubic Feet.....0.03531
Cubic Inches.....61.02
Cubic Meters.....0.001
Cubic Yards.....1.3081
Gallons (US Liquid).....0.2642
Pints (US Liquid).....2.113
Quarts (US Liquid).....1.057

FORCE

Pounds per Square Inch Kilograms per Square Inch.....703.06687
Inches of Mercury.....2.036009
Feet of Water.....2.306009
Atmospheres.....1.....0.068045
Kilograms per Square Centimeter...0.7036

KGs per Square Meter Pounds per Square Inch.....0.00142234
Pounds per Square Foot.....0.2048169
Inches of Mercury.....0.0028959
Feet of Water.....0.003280833

WEIGHT

Pounds
Grams.....453.59
Kilograms.....Ounces.....45359
Ounces (Avoirdupois).....16
Long Tons (Troy).....14.5833
Short Tons.....4.4643 x 10^{-4}
Short Tons.....5 x 10^{-4}

Short Tons
Kilograms.....Long.....907.185
Metric Tons.....0.892857
Metric Tons.....0.907185
Pounds.....2,000

To Convert	To	Multiply By
Kilograms		
Pounds	Short	2.20462
Tons	Metric	0.001
Tons		0.001

Long Tons.....9.842 x 10^{-4}

Long Tons

Kilogram.....Metric.....1,016.05 Tons.....1.01605

Pounds.....Short.....2,240 Tons.....1.12

Metric Tons

Kilogram.....Long.....1,000 Tons.....0.98421

Pounds.....Short.....2,204.6 Tons.....1.10231

APPENDIX D

POSSIBLE CAUSES OF CONTAMINATION/DETERIORATION

TEST RESULTS	POSSIBLE CONTAMINANT	POSSIBLE DETERIORATION FACTOR
API Gravity is high	Commingling with a lighter product	
API Gravity is low	Commingling with a heavier product	Loss of light ends (weathering)
Visual color changes	Commingling with another product	Loss of color additives
Distillations, IBP + 10% is low	Commingling with a lighter product	
Distillation, 90%, FBP and residue is high	Commingling with a heavier product	
Distillation, IBP + 10% is high		Loss of light ends
Oxidation Stability is low		Weathering/oxidation
Reid Vapor Pressure is high	Commingling with a lighter product	
Reid Vapor Pressure is low		Loss of light ends (weathering)
Existent Gum is high and oily	Commingling with a heavier product	
Existent Gum is high and dry (does not specify “OILY”)		The formation of excess gum through oxidation
Freezing Point fails	Commingling with a heavier product	
Flash Point is low	Commingling with a lighter product	
Fuel System Icing Inhibitor (FSII) is low		Contaminant with water (loss of additive)
Visiscosity is low	Commingling with a lighter product	
Viscosity is high	Commingling with a heavier product	
Octane Number is low		Loss of additive (TELS)
Filtration time is high	Commingling with a heavier product, wate or sediment	

Table D-1. Possible causes of contamination/deterioration

GLOSSARY

Section I. Acronyms and Abbreviations

AA	air assault
ABN	airborne
AC	alternating current
AFC	aviation fuel contamination
AL	Alabama
AMC	United States Army Materiel Command
APAP	Air Pollution Abatement Program
API	American Petrdeum Institute
AR	Army regulation
ARM	armored
ARNG	Army Reserve National Guard
ASTM	American Society for Testing and Materials
ATTN	attention
AVGAS	aviation gasoline
AVN	aviation
BN	battalion
BOE	Bureau of Explosives
C6H5COOH	benzoic acid
C	carbon; celsius
CA	California
CFR	Code of Federal Regulation
CHEMWARN	chemical warning
CO	company
COC	Cleveland Open Cup
CONUS	continental United States
COMMZ	communications zone
cST	centistokes
CU	conductivity unit
DA	Department of he Army
DC	District of Columbia
DCMC	Defense Contract Management Command
DCMCI	Defense Contract Management Command International
DD	Department of Defense
DFA	Diesel Fuel Arctic
DFM	Diesel Fuel Marine
DFP	decimal fractional purity
DFR	defense fuel region
DFSC	Defense Fuel Supply Center
DIEGME	diethylene glycol monemethyl ether
DIV	division
DLA	Defense Logistics Agency
DOD	Department of Defense

DODISS	Department of Defense Index of Specifications and Standards
EGME	ethylene glycol monomethyl ether
EMP	electromagnetic pulse
EPA	Environmental Protection Agency
EVAP	evaporation
F	Fahrenheit
FM	field manual
FOB	free on board
FSB	Forward Support Battalion
FSC	federal supply classification
FSII	fuel system icing inhibitor
FTMS	Federal Test Method Standard
g	gram(s)
GA	Georgia
gal	gallon(s)
GEN	General
GP	group
H2C2O4	oxalic acid
H2C2O4.2H2O	oxalic acid dihydrate
H2S	hydrogen sulfide
HDBK	handbook
H&F	hard and flinty
HQ	headquarters
hr	hour
hrs	hours
HVY	heavy
IAW	in accordance with
I.D.	inside diameter
INF	infantry
IPB	initial boiling point
IQUE	In-Plant Quality Evaluation
JFTOT	jet fuel thermal oxidation tester
JP	jet propulsion
JPO	Joint Petroleum Office
KHP	potassium biphthalate, potassium acid phthalate; potassium hydrogen phthalate
KHCO3	potassium bicarbonate
KW	kilowatt
KY	Kentucky
LAB	laboratory
L&F	loose and flaky
LCL	lower combustible limit
LIN	line item number
M	molarity
MACOM	major Army command
MBPL	modular base petroleum laboratory
MECH	mechanized
MEW	milliequivalent weight

mg	milligram
MgC12	magnesium chloride
MIL	military
MIL-HDBK	military handbook
MIL-STD	military standard
min	minute(s)
ml	milliliter
MOGAS	motor gasoline
MOPP	mission-oriented protective posture
MOS	military occupational specialty
MSB	Main Support Battalion
MSDS	Material Safety Data Sheet
MSEP	microseparameter
N	notification; normality
Na2B4O7.10H2O	borax
Na2CO3	sodium carbonate
Na2C2O4	sodium oxalate
NA	not applicable
NATO	North Atlantic Treaty Organization
NCO	noncommissioned officer
NCOIC	noncommissioned officer in charge
NBC	nuclear, biological, chemical
NC	North Carolina
NH2SO3H	sulfamic acid
NLGI	National Lubricating Grease Institute
No	number
NSN	national stock number
NUCWARN	nuclear warning
OCONUS	outside continental United States
O.D.	outside diameter
OHSA	Occupational Health and Safety Act
1M	one molar; one molar
1N	one normal
OP	operations
oz	ounce(s)
PA	Pennsylvania
PETRL	petroleum
PGF	petroleum ground fuels
pH	potential of hydrogen
PL	pipeline
PLL	prescribed load list
POC	point of contact
POL	petroleum, oils, and lubricants
PQAR	petroleum quality assurance representative
PQAS	Petroleum Quality Analysis System
psi	pounds per square inch
pS/m	picosienebs per meter
QA	quality assurance

QAR	quality assurance representative
QC	quality control
QM	quartermaster
QPL	quality products list
QS	quality surveillance
RVP	Reid Vapor Pressure
S4	Supply Officer (US Army)
SAE	Society of Automotive Engineers
SAPO	subarea petroleum office
SC	supply catalog
SDA	static dissipating additive
SF	standard form
SFS	Saybolt Furol Viscosity in Saybolt Furol seconds
SG	sampling and gauging
SOP	standing operating procedure
STANAG	Standardization Agreement
STD	standard
SUP	supply; support
SUS	Saybolt Universal Viscosity in seconds
T12CO3	thallous carbonate
TB	technical bulletin
TD	to deliver
TDA	tables of distribution and allowances
TEL	tetraetyl lead
TEMP	temperature
TERM	terminal
TM	technical manual
TMDE	Test, Measurement, and Diagnostic Equipment
TOE	tables of organization and equipment
TPT	tactical petroleum terminal
TROSCOM	United States Army Troop Support Command
TX	Texas
US	United States (of America)
USACASCOM	United States Army Combined Arms Command
USAF	United States Air Force
USAPC	United States Army Petroleum Center
USAR	United States Army Reserve
UST	underground storage tank
VA	Virginia
VA	Virginia
VI	viscosity index
WSIM	water separation index, modified

Section II. Terms

accelerated gum test A test to determine the amount of gum and lead precipitate formed in aviation fuels as a result of accelerated oxidation or aging. Potential gum is the amount of residue obtained by evaporating the fuel at the end of the specified aging period.

acid A chemical compound usually having a sour taste and capable of neutralizing alkalis and turning blue litmus paper red.

acidity The amount of free acid in a substance.

additive An agent used for improving existing characteristics or for imparting new characteristics to certain petroleum products.

alkylate The product obtained in the alkylation process. Chemically, it is a complex molecule of the paraffin series, formed by the introduction of an alkyl radical into an organic compound.

all-levels sample A sample taken by lowering a closed sampler to the drawoff level of a tank, opening the sampler, and raising it at a uniform rate so that it is between 75 and 85 percent full when it emerges from the liquid.

American Petroleum Institute (API) The institute represents and is supported by the petroleum industry. It standardizes the tools and equipment used by the industry and promotes the advancement of research in the petroleum field.

American Society for Testing and Materials (ASTM) A national scientific technical organization formed for the development of standards or characteristics performance of materials, products, systems, and services and the promotion of related knowledge.

aneroid barometer A barometer in which the action of the atmospheric pressure bending a metal surface is made to move a pointer.

antifoam agent An additive used in some lubricating oils to control foam.

antiknock Resistance to detonation or pinging in spark-ignition engines.

antiknock agent A chemical compound such as tetraethyllead which, when added in small amounts to the fuel charge of an internal-combustion engine, tends to lessen knocking.

antioxidant A chemical added to gasoline, lubricating oil, and certain other petroleum products to inhibit oxidation.

API Gravity An arbitrary scale expressing the gravity or density of liquid petroleum products. The measuring scale is calibrated in terms of degrees API. The gravity of any petroleum product is corrected to 60°F (16°C). (See Specific Gravity.)

appearance Refers to the visual examination of fuels. The terms used to describe appearance are clear and bright, hazy and cloudy.

aromatic (noun) One of a broad class of unsaturated hydrocarbons that is characterized by the ring structure of its molecules.

aromatic (adjective) Derived from, or characterized by, the benzene ring.

ash content The percent by weight of residue left after combustion of a sample of fuel oil or other petroleum oil.

atmospheric pressure The pressure of air, more specifically, the pressure of that sea level. As a standard, the pressure at which the mercury barometer stands at 760 millimeters or 29.92 inches (equivalent to approximately 14.7 pounds per square inch).

atom The smallest complete particle of an element which can be obtained that retains all physical and chemical properties of the element. According to present theory, the atom consists of a nucleus of protons and neutrons positively charged, surrounded by negatively charged particles called electrons.

automotive gasoline (MOGAS) A hydrocarbon fuel for use in internal-combustion engines and procured by the military under two specifications. The specification for leaded and unleaded gasoline is VV-G-001690. Specification MIL-G-3056 specifies combat grade type I and II.

average sample A sample that consists of proportionate parts from all levels of the product. For example, an average sample from a horizontal, cylindrical tank or from spherical tank should contain more material from the middle of the tank where the diameter is the greatest.

aviation fuels (AVFUELS) Those refined petroleum products specifically formulated and blended for use in aircraft engines, both jet engines and piston (reciprocating) engines. AVGAS (below) is an aviation fuel.

aviation gasoline (AVGAS) A hydrocarbon fuel for use in reciprocating piston-type aircraft engines. AVGAS is characterized by high vapor pressure and distillation range and high tetraethllead content. It is procured by the military under specification MIL-G-5572.

bacon bomb A thief-type sampler, also called a tank-car thief, consisting of a special metal cylinder tapered at both ends and fitted internally with a plunger valve that opens automatically when the sampler strikes the bottom of the tank car. A trip cord may be attached to make it possible to open the cylinder at any desired depth. The sampler is used in storage tanks and tank cars to take bottom samples of liquid products of 2 psi, or less; Reid vapor pressure; and samples of semiliquid products.

ballast Water, usually salt water, carried in tanker cargo tanks when the tanks are empty of petroleum products to reduce buoyancy and improve stability and sea-keeping qualities. Ballast may be clean or black, depending on whether it is contaminated with petroleum products.

barge A flat-bottomed boat used to carry cargo on inland waters or in lighterage service. Barges are usually towed. A petroleum barge has internal tanks to transport liquid cargo.

barium-base grease A water-resistant grease with high heat stability made by thickening a petroleum oil with a barium soap.

barometer See Aneroid Barometer.

barrel (bbl) A common unit of measurement of liquids in the petroleum industry. It equals 42 US standard gallons.

batch A specific quantity and type of product pumped into a pipeline.

batching Determining the sequence in which two or more products are to be pumped and introducing those products into the pipeline in a sequence that results in the least formation of interfacial material.

beaker A cylindrical glass vessel with straight sides, a flaring rim, and pouring lip used in the laboratory.

benzene Colorless liquid hydrocarbon, with one ring of carbon atoms. Made from coal tar and by catalytic reforming of naphthenes, it is used in the manufacture of various products, as a solvent, and as a component of high-octane gasoline.

benzol The general term which refers to commercial or technical benzene.

bitumen A mixture of hydrocarbons of natural or pyrogenous origin, or both, which are frequently accompanied by their nonmetallic derivatives and which are completely soluble in carbon disulfide.

black cargoes A general term used to refer to liquid cargoes of crude oil.

black oil A general term applied to crude oil and the heavier and darker colored petroleum products such as residual fuel oils.

bleeding Separation of liquid lubricant from a lubricating grease.

blending Mixing refinery products to suit market conditions. Mixing on specification fuel with off-specification fuel to bring the latter to specification or use limits (a method of reclamation). Mixing an interface with either or both adjacent products, or with a third product, without degrading any of them beyond use limits.

boiling point The temperature at which a substance boils or is converted into vapor by bubbles forming within the liquid. The temperature varies with atmospheric pressure.

boiling range The range of temperature, usually determined at atmospheric pressure in standard laboratory apparatus, over which the boiling or distillation of an oil commences, proceeds, and finishes.

bonding Electrically connecting units or containers before operations begin in order equalize any static potential that might exist and to provide a continuous path for any static potential that might be generated after operations begin.(See Grounding.)

bottoms In a distilling operation, the portion of the charge remaining in the still or flask at the end of a run, in pipe stilling or distillation, the portion which does not vaporize.

bottom loading Refers to the loading of a railway tank car or tank vehicle through the bottom outlet. Bottom loading reduces loss through vapor formation.

bottom sample A sample taken with a Bacon bomb or thief sampler from material at the bottom of a tank.(See Bacon Bomb.)

bottom sediment and water Amount of sediment and water measured in bottom of a tank.

bright stocks Pressure distillate bottoms which have had petrolatum wax removed and which have been filtered so that the stock has a low cold test and a good color (dark red by transmitted light and green by reflected light). Bright stock constitute the body of lubricants manufactured for internal-combustion engines.

bulk petroleum products Those petroleum products (fuels, lubricants) which are normally transported by pipeline, rail tank car, tank truck, barge, or tanker and stored in tanks or containers having a capacity of more than 55 gallons, except fuels in 500-gallon collapsible containers, which are considered to be packaged.

burner fuel oil A fuel oil used under boilers and in furnaces to generate power or heat. Under Federal Specification (FS) VV-F-815, it is produced in six grades: FS No. 1, FS No. 2, FS No. 4, FS No. 5 (Light) FS No. 5 (Heavy), and FS No. 6. Under specification MIL-F-859, one grade, Navy special, is produced.

butane Either of two isomeric, flammable, gaseous hydrocarbons, of the paraffin series, n-butane or isobutane. Bottled, butane is referred to as LPG and is used for domestic and laboratory purposes and for general brazing.

calcium-base grease A grease composed of a mineral oil thickened with calcium (lime) soaps and suitable for slow-moving machine parts. It does not retain consistency at high temperatures.

calibration The graduation of a measuring instrument. The determination of accuracy of graduation in a measuring instrument.

calorific value The heat liberated by the combustion of a unit quantity of fuel.

calorimeter An apparatus for measuring quantities of heat, such as the bomb calorimeter, which is used to determine the heat of combustion or the thermal value of a fuel in calories or British thermal units.

carbon dioxide A heavy, colorless gas, which will not support combustion (therefore, useful as a fire-extinguishing agent).

carbon monoxide A colorless, odorless, and poisonous gas, CO, resulting from the incomplete combustion of carbon.

carbon terachloride A colorless, nonflammable liquid, used as a solve detergent, and drying agent for electrical parts. It is no longer used as an extinguishing agent because of its toxic qualities.

catalyst. A substance that promotes chemical action without the substance undergoing chemical change.

cathodic protection An electrolytic method of protecting a buried pipeline or other metal structure against corrosion by surrounding it with an electrical field strong enough to overpower the currents seeking to leave the metal to go into the soil. The method involves putting electrical current into the soil so that it flows to and into the line or structure. The protective current may be obtained by the galvanic action between magnesium anodes and the steel of the pipeline or structure or by a rectifier to convert alternating current to direct current. The current is put into the soil through a scrap metal graphite ground-bed.

centigrade scale A thermometer scale on which the interval between the freezing point and boiling point of water is divided into 100 parts or degrees centigrade, 0°C corresponding to 32°F, and 100°C to 212°F. Also called Celsius after Anders Celsius who first described it.

centistoke A unit of kinematic viscosity; 0.01 stoke.

centrifugal pump An apparatus that builds up pressure head using centrifugal force as the principal means and angular velocity as the secondary means.

cetane number The percentage by volume of normal cetane (100 cetane number), in a blend with heptamethylnonane (O cetane number), which matches the ignition quality of the diesel fuel under test when compared by the procedure specified in ASTM Method D 613. The determination of the cetane number of diesel fuel is similar to the determination of the octane number of gasoline.

change of product Change of service; refers to transporting or storing a product in vessel, tank car or vehicle, storage tank, or other container after having transported or stored a different product in it. The difference between the two products governs the nature and extent of preparations (draining, flushing, cleaning) needed before the change can be made.

Class III (POL) Petroleum fuels: lubricants, hydraulic and insulating oils, preservatives, liquid and compressed gases, chemical products, coolants, deicing and antifreeze compounds, together with components and additives of such products and coal.

Class III A (Air) Petroleum and chemical products used in support of aircraft.

Class III W (Ground)Petroleum and chemical products and solid fuels used in support of ground and marine equipment.

class of fires Class A, fires of ordinary combustibles, such as paper, wood, textiles, or rubbish and extinguished by water. Class B, fires of flammable liquids like gasoline, oil, or grease and extinguished by smothering. Class C, fires involving electrical equipment and extinguished by non-conducting agents. Class D, fires involving burning metal.

clean cargoes Cargoes such as aviation and motor gasoline, diesel oils, jet fuel, kerosene's, and lubricating oils.

clean product Products such as aviation and motor gasoline's, jet fuel, diesel fuel, kerosene, and lubricating oil; contrasted with black oil.

clear and bright Clear is the absence of visible solids, a cloud, a haze, an emulsion, or free water in the product. Bright is the sparkle of clean, dry product in transmitted light.

closed circuit refueling A system of refueling in which the nozzle mates with a lock into the fuel tank, eliminating spillage.

closing gage A volume measurement of product taken after a delivery or receipt of product and after at least a 30-minute settling time (and at close of business at terminals and supply points).

combustion Burning or rapid oxidation caused by the union of oxygen and any material capable of being ignited.

commingling The intentional or unintentional mixing of two or more products.

compatibility Refers to the ability of additives or of lubricating oils of different composition or from different sources to mix together without separation or reaction.

composite sample A mixture of individual samples representing the bulk from which they were taken. A composite sample is not the same as a mixed sample.

compound A substance formed by combining two or more ingredients in definite proportions by weight. A compound possesses physical and chemical properties entirely different from those of the combining ingredients if used separately.

compounding The addition of fatty oils and similar materials to lubricants to impart special properties. Lubricating oils to which such materials have been added are know as compounded oils.

compression ignition Ignition in a diesel engine, in which the heat of compression ignites the fuel, in contrast to the spark ignition in a gasoline engine.

consistency The degree to which a material, such as a lubricating grease, resists deformation under the application of force. It is, therefore, a characteristic of plasticity, as viscosity is a characteristic of fluidity. Consistency is indicated by apparent viscosity; or as in the case of grease, is measured by the penetration of a special cone into the grease under prescribed conditions of temperature, load, and time, as described in ASTM Method D 217.

contaminated fuel module A 100,000 gallon storage set used to store off-specification fuel until it is blended or loaded into tanker trucks for disposal.

contaminant A foreign substance in a product.

contaminated product A product in which one or more grades or types of products have been inadvertently mixed, or a product containing foreign matter, such as dust, dirt, rust water, or emulsions.

contamination The addition to a petroleum product of some material not normally present. Common contaminants are water, dirt, sand, rust, mill scale, and other petroleumproducts.

continuous sample A sample taken from a flowing pipeline in such a manner that the sample is a representative average of the stream during the period of sampling.

copper strip corrosion A qualitative method of determining the corrosiveness of a product by its effects on a small strip of polished copper suspended or placed in the product (ASTM Method D 130).

corrosion Rusting; a gradual eating away or oxidation such as the action of moist air on steel, and the more rapid chemical action of acid on metal or steel.

critical velocity That zone of velocities between laminar flow and turbulent flow, where the exact nature of flow is unpredictable. Flow is considered laminar when the Reynolds number is less than 2,000, turbulent when the Reynolds number is greater than 4,000, and critical or indeterminate in between those values.

crude In a natural state; not altered, refined, or prepared for use by any process, as crude oil or crude petroleum.

crude oil (petroleum) See Petroleum.

cup-case thermometer An instrument, consisting of a thermometer attached to a hardwood or plastic back, with the base of the thermometer enclosed by a metal cup, used to measure the temperature of products in storage tanks. The thermometer is lowered to the desired level, allowed to remain for a prescribed time, withdrawn immediately, and read. The liquid-filled cup prevents a change in the height of the mercury before it can be read.

cut A fraction obtained by a separation process. Product withdrawn from a pipeline and routed into tankage. Product withdrawn from the middle of a batch is referred to as a heart cut. In gaging bulk fuel, the mark made by a petroleum product in contact with the gaging instrument. The cut shows the level of the product.

datum plate A level metal plate attached to the tank bottom directly under the reference point to provide a smooth surface for the innage bob to rest on.

Defense Fuel Supply Center (DFSC) An activity under the Defense Logistics Agency (DLA) with responsibility as the integrated materiel manager (IMM) for wholesale bulk petroleum products until their delivery to the point of sale. This responsibility includes contract administration in oversea areas.

Defense Fuel Supply Point (DFSP) Any military or commercial bulk fuel terminal storing product owned by DLA.

Defense General Supply Center (DGSC) An activity, under DLA, responsible for management of packaged petroleum products, exclusive of packaged fuels.

Defense Logistics Agency (DLA) The agency, at the DOD level, charged with providing the most effective and economical support of common supplies and services to the military departments and other designated DOD components. It is the agency under which the DFSC operates.

density Specific weight or mass of a substance per unit volume (pounds per cubic foot or gallon or grams per cubic centimeter). Specific gravity is the ratio of the mass of any volume of a substance to the mass of an equal volume of some standard substance (water in the case of liquids and hydrogen or air in the case of gases) at 40°C (104°F).

detergent oil A lubricating oil possessing special sludge-dispersing properties for use in internal-combustion engines. These properties are usually the result of the incorporation in the oil of special additives. Detergent oils hold sludge particles in suspension and thus promote engine cleanliness.

deterioration Any undesirable chemical or physical change that takes place in a product during storage or use. Some of the more common forms of deterioration are weathering, gum formation, weakening of additives, and change in color.

diesel engine An internal-combustion engine in which air drawn in by the suction stroke is so highly compressed that the heat generated ignites the fuel, which is automatically sprayed into the cylinder under high pressure.

diesel fuel A hydrocarbon fuel used in diesel engines. Diesel fuels used by the Armed Forces are manufactured under two specifications: VV-F-800 and MIL-F-16884.

diesel fuel additive Material added to diesel fuel to improve the ignition quality. Examples are amyl nitrate and ethyl nitrate.

differential pressure The difference between suction pressure and discharge pressure of a pump; increment of pressure added by each pump operating in series in a pump station; pressure drop or loss between the inlet and outlet of a filter, meter, or other accessory offering resistance to flow.

dissolved water See Water (Water, Dissolved).

distillate That portion of a liquid which is removed as a vapor and condensed during a distillation process.

distillate fuel oils Fuel oils which are distillates derived directly or indirectly from crude petroleum (chiefly from the gas oil fraction).

distillation Vaporization of a liquid and its subsequent condensation in a different chamber. In refining, it refers to the separation of one group of petroleum constituents from another by means of volatilization in some form of closed apparatus, such as a still, by the aid of heat. ASTM distillation: Any distillation made according to an ASTM distillation procedure, especially a distillation test made on such products as gasoline, jet or turbine fuels, and kerosene to determine the initial and final boiling points and the boiling range.

downgrading Assigning a lower grade to an off-specification product, provided it meets the requirements of the lower grade.

drum thief A metal or plastic tube, 1 1/2 inches in diameter and 30 inches long, used to withdraw samples from drums.

effluent Outflowing or outflow; a term applied to a stream that has passed through a process or apparatus and has been altered in some way; product flowing out of a filter/separator, for example, or past a device that adds an inhibitor.

electrolysis Chemical decomposition by the action of an electric current. This process is both the cause of external corrosion of buried pipelines and the basis for providing protection against such corrosion.

end point (EP) The point indicating the end of some operation or at which a certain definite change is observed. In titration, this change is frequently a change in the color of an indicator which has been added to the solution or the disappearance or excess of one of the reactants which is colored. In the distillation of liquids, such as gasoline, the end point is the maximum temperature which occurs during the test.

evaporation The conversion of a liquid into vapor, usually by means of heat.

evaporation loss Evaporation loss is the loss of a liquid volume or weight due to the free evaporation of the liquid usually in a storage tank at atmospheric pressure. It varies with the temperature, the amount of liquid surface exposed, the temperature of vaporization of the lightest components of the liquid, the velocity of air currents over the surface exposed, and the degree of vapor tightness of the tank roof. Since petroleum products are not homogeneous liquids, the rate of evaporation is not constant. The rate of evaporation is greatest at the beginning when the largest percentage of light-volatile hydrocarbons are present and slowest when evaporation has proceeded so far that only heavy residues are left.

Fahrenheit scale A thermometer scale on which the freezing point of water is 32° and the boiling point is 212° (at sea level atmospheric pressure).

filter (noun) A porous material on which solid particles are caught and retained when a mixture is passed through it.

filter (verb) To remove mechanically the solids or free water from a petroleum product.

filter/separator A device used to separate both solid contaminants and water from a petroleum fuel.

flammable A term describing any combustible material which can be ignited easily and which will burn rapidly. Petroleum products which have flash points of 100°F (37.8°C) or lower are classed as flammable.

flash point The lowest temperature at which a liquid petroleum product gives off vapor in sufficient concentration to ignite (that is, flash) on application of a flame under specified conditions.

flow rate The amount of fuel passing through a point along a pipeline or hoseline over time. Flow rate is usually stated in gallons per minute or gallons per hour.

foaming The formation of froth or foam on lubricating oils or other oils as a result of aeration or release of gas dissolved in the oil. Foaming characteristics of lubricating oils are determined by ASTM Method D 892.

fuel oil Any liquid petroleum product burned for the generation of heat in a furnace or firebox or for the generation of power in an engine, exclusive of oils with a flash point below 100°F (38°C) (Tag closed-cup tester) and oils burned in cotton- or wool-wick burners.

Fuel System Icing Inhibitor (FSII)An agent to be used only as an anti-icing additive for jet turbine engine fuels.

gage (noun) An object used as a standard of measurement or comparison; that is, an instrument for measuring, indicating, or regulating the capacity, quantity, amount, or other properties.

gage (verb) To measure the contents or capacity, as of a tank.

gaging for water Obtaining the depth of water bottom by taking a water cut. This is usually accomplished by coating a plumb bob, tape, or gaging stick with water finding paste.

gallon (gal) A unit of measure of volume. A US gallon contains 231 cubic inches or 3.785 liters; it is 0.83268 times the imperial gallon. One US gallon of water weighs 8.3374 pounds at 60°F(16°C).

gas detector An instrument for determining the explosibility of a gas and air mixture (explosimeter).

gas oil A term originally used to refer to an oil suitable for cracking to make illuminating gas. The term is now used to designate an overhead product in between refined oils and low-viscosity lubricating oils, used primarily as thermal or catalytic cracking feed stock, diesel fuel, furnace oil, and the like.

gas turbine An engine in which vapor (other than steam) is directed, under pressure, against a series of turbine blades. The energy contained in the rapidly expanding vapors is converted into rotary motion.

gravitometer Permanently installed hydrometer that gives a continuous reading of the API or specific gravity of the product passing through the pipeline.

Gravity See API Gravity and Specific Gravity.

grease A mixture of petroleum oil, soap (or other thickeners), and sometimes an additive, used for lubricating under conditions where an oil cannot meet all requirements.

grounding Connecting single or bonded units to a ground rod so that any static potential will be discharged into the earth. If two or more units are bonded and one is grounded, the whole system is effectively grounded. (See Bonding.)

ground products Refined petroleum products normally intended for use in administrative, combat, and tactical vehicles, materials-handling equipment, special-purpose vehicles, and stationary power and heating equipment.

gum Varnish-like, tacky, noncombustible insoluble deposits formed during the deterioration of petroleum and its products, particularly gasoline. The amount of gummy material in gasoline is known as its gum content, which is determined by ASTM Methods D 381 and D 873. (See Gum Test.)

gum test An analytical method for determining the amount of existing gum in gasoline by evaporating a sample from a glass dish on an elevated-temperature bath with the aid of circulating air.

heavy product A liquid in stored drums, which gives off flammable vapors above the temperature of 80°F (27°C).

hydrocarbon A compound containing only hydrogen and carbon. The simplest hydrocarbons are gases at ordinary temperatures; with increasing molecular weight, they change to the liquid form and, finally to the solid state. Hydrocarbons are the principal constituents of petroleum.

hydroforming A special cataltic reforming process used to upgrade straight-run gasoline.

hydrometer A graduated instrument for determining the gravity of liquids. It is usually made of hollow glass and weighted at one end so as to float upright. The depth to which the instrument sinks when immersed in a liquid is determined by the density of that liquid. The lighter the liquid, the lower the instrument sinks. Some hydrometers are marked so that the percentage of each constituent of the product in them can be read. Hydrometers used to measure petroleum are usually marked with degrees API or specific gravity.

icing The solidification of particles of moisture in the fuel system, especially the carburetor, of an aircraft or ground vehicle. The moisture may either be contained in the fuel or it may enter the system through the air intake. Icing may cause either partial or complete loss of power.

identification tests Selected tests applied to a sample to identify quickly the type or grade of material represented or to determine that the quality has not been altered by time or handling.

ignition quality The ability of a fuel to ignite upon injection into the engine cylinder.

inhibitor A substance added in small amounts to a petroleum product to prevent or retard undesirable chemical changes from taking place in the product or in the condition of the equipment in which the product is used. The essential function of inhibitors is to prevent or retard oxidation or corrosion.

innage The height or volume of liquid in a storage tank, as measured or gaged from the bottom of the tank to the top of the liquid.

innage tape and bob A steel measuring tape connected by a harness snap to the eye of cone-tipped bob. Used to measure the distance from the bottom of the tank to the liquid level of product in a tank or gage pipe.

insulating oil An oil used in circuit breakers, switches, transformers, and certain other electrical devices for insulating, cooling, or both. In general, such oils are well-refined petroleum distillates of low volatility and high resistance to oxidation and sludging.

interface A mixture, or commingling, between adjacent products in a multiproduct pipeline; interfacial mixture.

internal-combustion engine An engine which operates by means of combustion of a fuel within its cylinders.

into-plane The requirement and procurement of fuel and lubricating oils for delivery into government-owned aircraft normally at nonmilitary air facilities. Charges for this include the cost of fuel, lubricating oils, and related services.

jet engine An engine which converts air and fuel into a fast-moving stream of hot gases that propel the item on which it is mounted.

jet fuel Fuel meeting the required properties for use in jet engines and aircraft turbine engines. Jet fuels are procured for the Armed Forces in several grades. The most important grades are JP-4 (low vapor pressure) and JP-5 (high flash point), and JP-8.

Joint Petroleum Office (JPO) An office established by the Joint Chiefs of Staff with petroleum logistics responsibilities in a unified command in oversea areas.

kerosene A refined petroleum distillate used in space heating units, in wick-fed lamps, bomb-type flares, for cleaning certain machinery and tools, and as a base for liquid insecticide sprays. A single multiple-use type is procured under Federal Specification VV-K-211. A deodorized type, which is

used as a base for insecticide sprays, is procured under Specification VV-K-220.

kinematic viscosity The ratio of the absolute viscosity to the density at the temperature of the viscosity measurement. The metric units of kinematic viscosity are the stoke and centistoke, which correspond to the poise and centipoise of absolute viscosity.

knock Noise, also called ping, associated with internal-combustion engines. After the spark ignites the charge, the charge burns smoothly until part of it is burned; then if either the fuel or engine operating conditions are unsuitable, the remaining portion burns suddenly, which makes a knock or ping.

lead A general term used to denote tetraethyllead or other organometallic lead antiknock compounds used as gasoline additives.

lead poisoning Poisoning caused by tetraethyllead or another of the organometallic lead antiknock compounds used as additives in gasoline. It may result from ingestion, absorption through the skin, or inhalation of fumes.

light ends The most volatile portions of a carbon and hydrogen mixture, the low boiling components that boil off first in distillation. Opposite of heavy ends.

light product A light product is any liquid which gives off flammable vapors at or below 80°F (27°C).

liter (l) A metric unit of capacity equal to 0.9081 dry quart (US) or 1.0567 liquid quarts (US).

load line The line defining the maximum mean draft to which a tanker may be lawfully submerged. It is the lower limit of the freeboard for various conditions and seasons. The six load line used on tankers are the Summer load line; Winter load line; Winter, North line; Tropical load line; Freshwater load line; and Tropical freshwater load line.

lower sample A sample with a bottle or beaker sampler from the middle of the bottom third of a tank's contents.

lubricant A substance, especially oil, grease, and graphite, which may be interposed between moving surfaces to reduce friction and wear.

maximum working pressure The highest pressure that equipment is designed to operate safely.

maximum fill level The highest level to which a container may be filled.

meniscus The curved surface of the top of a column of liquid in a narrow tube; the curve is concave when the containing walls are wet with the liquid and convex when they are not wet.

methane A light, odorless, flammable gas, CH_4. The first member of the paraffin series. It is the principal constituent of natural gas.

micron One micron is a thousandth part of one millimeter (approximately 25,400 microns equal 1 inch). The average human hair is about 100 microns in diameter.

middle sample A sample taken from the middle of a tank's contents.

military sealift command The US Navy command responsible for providing ocean transportation for the military services and for other governmental agencies and departments, as directed.

mixed sample A sample taken by mixing or stirring the original sample and then drawing off the desired quantity for testing.

molecule Unit of matter; the smallest particle of an element or compound that retains chemical identity with the substance in mass.

multigrade oil A multiviscosity number oil which acts as a high-viscosity oil in high temperatures but as a low-viscosity oil in low temperatures.

naphtha A general term applied to refined, partly refined, and unrefined petroleum products and liquid products deriving from natural gas which distill between 347°F (175°C) and 460°F (238°C).

natural gas Naturally occurring mixtures of hydrocarbon gases and vapors, the more important of which are methane, ethane, propane, butane, pentane, and hexane.

nonrecoverable tank bottom That quantity of liquid that is below the suction manifold or drawoff line of a storage tank and is not available in normal day-to-day operations.

octane number Term used to indicate numerically the relative antiknock value of automotive gasolines and of aviation gasolines having a rating below 100. It is based on a comparison with the reference fuels, isooctane(100 octane number) and normal heptane (O octane number). The octane number of an unknown fuel is the volume percent of isooctane in a blend with normal heptane which matches the unknown fuel in knocking tendencies under a specified set of conditions. Above 100, the octane number of a fuel is based on the engine rating, defined in terms of milliliters of tetraethyllead in isooctane, which matches that of the unknown fuel.

off-specification product A product which fails to meet one or more of the physical, chemical, or performance requirements of the specification.

olefin One of a major series of hydrocarbons that appear chiefly in refinery operations. They have the general formula of naphthenes and the chain structures of paraffins, but they are unsaturated. Molecular structure and nomenclature correspond to paraffins having the same amount of carbon. Ethylene, or ethene, is the lowest, member of the olefins, and the series is sometimes called the ethylene series.

outage The volume of unoccupied space in a storage tank or other container, measured or gaged from a reference point above the product to the surface of the product. The difference between rated capacity and actual contents. (Some space will always be left unoccupied for expansion of product.) (See Ullage.)

outage tape and bob A steel measuring tape connected by a harness snap to the eye of the rectangular bob. The outages tape and bob is used to measure the distance from a reference point above the product to the surface of the product in the tank.

oxidation The process of combining with oxygen, a process which all hydrocarbons are capable of doing.

packaged petroleum products Those petroleum products other than fuels (generally lubricants, greases, and specialty items) that are stored, transported, and issued in containers with a capacity of 55 gallons orless.

paraffin Any of the white, tasteless, odorless, and chemically inert waxy substances composed of saturated hydrocarbons obtained from petroleum.

penetrating oil A thin, nonviscous oil used to loosen rusted or frozen metal parts such as nuts, screws, bolts, or pins. Penetrating oil is not intended for use as a lubricant. It is produced to specification VV-P-216.

petrochemical Derived from the words petroleum and chemical and originally coined to designate chemicals of petroleum origin. At present, petrochemical covers a wide variety of products.

petroleum Crude oil. Petroleum is a mixture of gaseous, liquid, and semisolid hydrocarbons varying widely in gravity and complexity. Petroleum can be removed as a liquid from underground reservoirs, and it can be separated into various fractions by distillation and recovery. Petroleum is a general term that includes all petroleum fuels, lubricants. and specialties.

petroleum measurement tables ASTM-IP tables provided for the calculation of quantities of petroleum and its products under the required conditions in any of three systems of measurements. Tables are provided for the reduction of gravity and volume to standard states over normal operating ranges, for calculation of weight-volume relationship, and for interconversion of a wide variety of commercially useful unit's (ASTM Method D 1250).

petroleum, oils, and lubricants See POL.

petroleum testing kit A kit provided for limited quality surveillance testing under field conditions.

POL Petroleum, Oils, and Lubricants. Included are petroleum fuels, lubricants, hydraulic and insulating oils, temporary protectives, liquid and compressed gases, chemical products, liquid coolants, deicing and antifreeze compounds, together with components and additives of such products.

polymerization Changing a substance of a given molecular weight to another substance with chemical ingredients in the same proportions as in the first but with a new molecular weight that is a multiple of the first, depending upon how many molecules of the first have been combined. It is a method of changing hydrocarbon gases into high-octane gasoline.

pour point The lowest temperature at which an oil can be poured (ASTM Method D 97).

preservative A petroleum product designed to prevent corrosion of ferrous and nonferrous metals. General-purpose lubricating oils produced to specifications VV-L-800, MIL-L-7870, and MIL-L-3150 have preservative qualities.

pressure A force or impulse. Pressure differential is incremental pressure, or the difference between suction and discharge of a pump. Pressure gage is an instrument used to measure and indicate pressure in a fluid.

procurement quality assurance That program by which the government determines if contractors have fulfilled their contract obligations for quality and quantity of products and related services.

purple k Potassium Bicarbonate. A dry chemical used in the trailer mounted fire extinguisher that puts out fires by smothering them.

qualified products list A list prepared by the procuring service of civilian-type or off-the-shelf items that comply with specifications and have been found to be acceptable to the government.

quality surveillance The measures taken to ensure that petroleum products which have been accepted by the government as being of the required quality are still of the required quality when delivered to the user. QS includes watching over and caring for products during all storage and handling operations, adhering to handling methods and procedures designed to protect quality, and examining and testing of products in storage and on change of custody.

receiving tests Tests prescribed by MIL-HDBK-200 to supply information quickly on the quality of products received so their disposition can be planned.

reclamation Restoring or changing a contaminated or off-specification petroleum product so that it will either meet specifications or will be within use limits. (See Blending.)

Reid Vapor Pressure (RVP) The measure of pressure exerted by a product on the interior of a special container due to its tendency to vaporize.

reapeatability The allowable difference between two results on the same sample by the same operator using the same equipment.

reproducibility The allowable difference between two results on the same sample by different operators in different locations.

residual fuel oils Fuel oils which are either topped crude petroleum or viscous cracked residuum.

rust preventive A preservative oil used to provide a waterproof film over iron or steel surfaces exposed to oxidation.

Society of Automotive Engineers (SAE) Numbers of Lubricants A classification of lubricating oils for crankcases and transmissions in terms of viscosity, standardized by SAE.

sample A quantity of product taken as prescribed in ASTM Method D 270 for examination and testing. See specific kind of sample.

sampler A device used to obtain samples of various petroleum products. Another term for sampler is thief.

saturated hydrocarbon A hydrocarbon of such composition that the valence, or combining power, of all carbon atoms present is fully satisfied. Such a hydrocarbon is a stable substance and does not oxidize readily. The degree of saturation is a measure of instability.

scale A formation of oxide in a flaky film or in thin layers.

sediment Foreign matter other than water that settles to the bottom of a container.

sediment and water Solids and aqueous solutions which may be present in an oil and which may be left to settle or which may be separated more rapidly by a centrifuge.

settling time The elapsed time that a product remains undisturbed or unagitated between receipt of product into and discharge from storage.

slop Any liquid petroleum product known to be off specification. Storage tanks may be reserved for such products until the products can be analyzed, reclaimed, or disposed of. Interfaces not disposed of in the adjacent products or not fit for such disposition should be taken off in slop tanks until they can be disposed of.

slop tanks Tanks regularly containing products which are not up to quality, or products which are to be treated or downgraded and transferred to selected tanks.

sludge A heavy sedimentation or deposit on the bottom of storage tanks consisting of water, dirt, and other settings; gunk. Crude oils and residuals form the heaviest sludges, and light products form lightest sludges. Engine sludge is a particular kind of sludge

containing products of combustion deposited in internal-combustion engines.

soluble cutting oil An industrial term used to describe a mineral oil containing an emulsifier, making it capable of mixing with water to form a coolant for metal-cutting tools.

solution A uniform mixture of a solute in a solvent from which the solute can be separated by crystallization or other physical means. Called a physical solution when no chemical changes take place; otherwise called a chemical solution.

specific gravity The ratio of the weight of any quantity of matter, a petroleum product for example, to the weight of an equal quantity of water; usually determined by use of a hydrometer.(See API Gravity.)

specification Prescribed limits of control tests used to maintain uniformity of a specific product.

spectrometric oil analysis The detection, by spectrometer, of wear metals in regularly taken samples of used oils from oil-wetted mechanical systems. By examining the wear metals, the rate of friction wear of the various metal parts of the mechanical system can be determined.

split loading Carrying more than one product in a compartmented tanker.

spontaneous combustion Self-ignition of combustible materials caused by accumulation of heat through slow oxidation; cannot take place if the heat is dissipated as fast as it is generated.

static electricity Electricity generated by friction between unlike substances and in the atmosphere; contrasted with voltaic or current electricity.

static pressure Hydrostatic pressure produced with a column of liquid because of weight alone; measured by feet of head.

stratification The condition that may occur in a tank in which batches of product of different gravities are stored. The heavier product settles to a layer on the bottom instead of mixing with the lighter product.

subarea petroleum office (SAPO) A suboffice of a JPO established by the JPO to fulfill petroleum logistics responsibilities in a section of the geographical area for which the JPO is responsible.

surfactant A surface active agent which enhances fuel and water emulsification and can interfere with removal of entrained water from fuels.

suspension Dispersion in a liquid or in a gas of small particles of a solid substance or of small droplets of a liquid.

sweet crude Crude oil that contains so little sulfur that chemical treatment to remove sulfur or sulfur compounds is not needed.

synthetic detergent The term synthetic is used to distinguish the newer chemical cleansers from the older ones, such as soaps.

synthetic fuels The term commonly used to refer to fuels manufactured from sources other than crude petroleum, such as shale or coal.

thermal jet engine A power unit in which air is taken in from the atmosphere, heated by combustion of a hydrocarbon, and then exhausted at a velocity greater than that at which it was taken in.

thermal stability Resistance of a petroleum product to breakdown of its properties as a result of heat.

thermometer A device for measuring temperature or degrees of heat or cold; may depend upon the expansion of mercury or liquids or change in electrical conductivity. (See ASTM standard El and E77 for specifications.)

thief See Bacon Bomb and Sampler.

top sample A sample taken about 6 inches below the surface of the tank contents.

topped crude Crude oil from which some of the lighter parts have been removed by distillation.

trace An amount large enough to be detected but not to be measured.

turbine oil Lubricating oil for steam turbines, military symbol 219OTEP, made to specification MIL-L-17331.

ullage The amount a tank, or container, lacks of being full.

unsaturated hydrocarbon An unsaturate; a hydrocarbon with a molecular structure containing one or more double or triple links between adjacent carbon members. Olefins and aromatics are the principal groups of such substances. In addition to being unsaturated, these substances are also unstable and are more capable of undergoing change than the saturates (paraffins and naphthenes). Oxidation is an example of undesirable change in a product.

upgrade A grade that slopes upward in the direction of pipeline flow. To change service from a dark or heavy product to a light or volatile product; refers to the nature of a product stored in a tank or transported in a tanker, tank car, or tank truck. To blend a higher grade gasoline interface into tankage containing a lower grade gasoline.

upper sample A sample taken from the middle of the upper third of the tank contents.

use limits Tolerances established by MIL-HDBK-200 to permit use, under certain conditions, of products that do not fully meet specifications.

vapor The gas-like form of a substance that is normally a solid or a liquid; any gaseous substance that can be condensed by cooling or compression.

variable vapor space Refers to the vapor space in tanks specially constructed for storage of volatile products. (These tanks usually have a balloon roof, a breather roof, or a lifter roof (gasometer).) The vapor space is described as variable because the tank roof moves up or down with the expansion or contraction of the confined vapors.

velocity of flow Rate of flow usually measured in feet per second equal to volume of flow in cubic feet per second divided by the cross-sectional area of the pipe in square feet. Velocity head is the head in feet equivalent to the velocity in feet per second; equal to the square of the velocity divided by twice the acceleration of gravity in feet per second (64.3).

viscosity Internal resistance to flow; usually measured as time in seconds for a given quantity of sample to flow through a standard capillary tube. Viscosity index is a means of rating resistance to change in viscosity with change in temperature. Oils of high viscosity index are more resistant to change; oils of low viscosity index thicken quickly when chilled and thin too much when hot.

viscous Heavy, thick-bodied, gluey, or slow in motion.

volatile Tending to evaporate or vaporize readily; volatility is the extent to which a liquid vaporizes or the ease with which it turns to vapor.

volume correction The correction of measured quantity of product, determined by gaging at observed temperature and gravity and reference to a gage table, to net quantity of product at 60°F (16°C) after deducting bottom water and sediment.

water An odorless, colorless, transparent liquid compound.

water bottom Water put in a tank bottom to keep product from leaking.

water contamination Water present in a fuel in any form; includes dissolved water similar to moisture in the air, entrained water suspended in the form of minute droplets, and free water.

water separator Segregator; a filtering device that separates or segregates water from a flowing stream by coalescence.

water test A method of testing a newly completed pipeline. The line should be blocked off in sections and clean, fresh water pumped until 1 1/2 times the working pressure is reached. Pressure is observed for a period of 24 hours when possible.

weathering Loss of the most volatile components of crude oils and light products during storage and handling and the formation of products of oxidation.

weighted beaker Consists of a copper bottle permanently attached to a lead base. A drop cord is attached to the handle through a ring in the stopper so that a short, quick pull on the cord opens the beaker at any desired point beneath the surface of the liquid. This sampler is used to take upper, middle, lower, or all-level samples of liquid products of 16 psi or less, Reid vapor pressure. It is used in tanker or barge compartments, shore tanks, tank cars, and tank trucks.

white oils A term applied to substantially colorless, tasteless, and odorless oils with various viscosities.

worked penetration A test method of determining penetration (consistency) of lubricating grease after mechanical working.

REFERENCES

SOURCES USED

These are the sources quoted or paraphrased in this publication.

AR 55-355. Defense Traffic Management Regulation. 31 July 1986
AR 200-1. Environmental Protection and Enhancement. 23 April 1990.
AR 700-36. Overseas Laboratories for Support of Quality Surveillance on Petroleum Products. 25 October 1977.
AR 710-2. Supply Policy Below the Wholesale Level. 31 January 1988
AR 715-27 and DLAM 4155. Petroleum Contract Quality Assurance Manual. February 1988.
AR 750-25. Army Test, Measurement and Diagnostic Equipment (TMDE) Calibration and Repair Support Program. 1 September 1983.
Bureau of Explosives (BOE) Tariff Number 6000-B.
Available from:
Bureau of Explosives
1920 lst Street, NW
Washington, DC 20036
Code of Federal Regulations (CFR) 49.
Available from:
Superintendent of Documents
US Government Printing Office
Washington, DC 20042
DA Pam 710-2-1. Using Unit Supply System. 1 January 1982.
DLAM 8200.2. Assurance Support Manual for Defense Contract Administration Services. April 1982.
DOD 4140.25-M. DOD Management of Bulk Petroleum Products, Natural Gas and Coal Volumes I - IV. June 1994.
FM 3-3. Chemical and Biological Contamination Avoidance. 16 November 1992.
FM 3-4. NBC Protection. 29 May 1992.
FM 3-5. NBC Decontamination. 17 November 1993.
FM 3-100. NBC Defense, Chemical Warfare, Smoke, and Flame Operations. 23 May 1991.
FM 10-67. Petroleum Supply in Theaters of Operations. 16 February 1983.
FM 10-602. Headquarters and Headquarters Units, Petroleum and Water Distribution Organization. 12 September 1996.
FM 21-2. Soldier's Manual of Common Tasks (Skill Level 1). 3 October 1983.
FM 21-11. First Aid for Soldiers. 27 October 1988.
FM 25-50. Corps and Division Nuclear Training. 30 September 1991.
MIL-HDBK-200. Military Standardization Handbook, Quality Surveillance Handbook for Fuels, Lubricants, and Related Products. 1 July 1987.
Available from:
Commanding Officer
Naval Publications and Forms Center
ATTN: NPFC 105
5801 Tabor Avenue
Philadelphia, PA 19120-5099

SC 6640-97-CL-E01. Laboratory, Air Mobile, Aviation Fuel (NSN 6640-00-902-9711) (LIN L33184). 30 November 1973.
TB 43-180. Calibration and Repair Requirements for the Maintenance of Army Materiel. 19 December 1994.
TM 5-6630-218-10. Operator's Manual for Aviation Fuel Contaminant Test Kit (NSN 6630-01-008-5524). 23 May 1990.
TM 10-4320-314-13&P. Operator's, Unit and Direct Support Maintenance Manual Including Repair Parts and Special Tools List for Centrifugal Pump Unit 11/2" Suction and Discharge, 24 Volt DC Electric Motor Driven. 15 June 1990.
TM 10-6640-230-13&P. Operator's, Unit and Direct Support Maintenance Manual Including Repair Parts and Special Tools List for Precision Universal Centrifuge. 28 September 1990.
TM 10-6640-214-14. Operator's, Organizational, Unit, Direct, and General Support Maintenance Manual Including Repair Parts and Special Tools List for Petroleum Base Laboratory Assembly (NSN 6640-00-303-4940). 21 December 1981.
TM 10-6640-215-13&P. Operator's, Unit and Direct Support Maintenance Manual Including Repair Parts and Special Tools List for Petroleum Laboratory, Semi-Trailer Mounted (NSN 6640-00-538-2736). 30 June 1993.
TM 10-6640-215-23&P. Unit and Direct Support Maintenance Manual Including Repair Parts and Special Tools List for Airmobile Aviation Fuel Laboratory (NSN 6640-00-902-9711). 24 October 1990.
TM 10-6640-216-13&P. Operator's, Unit and Direct Support Maintenance Manual Including Repair Parts and Special Tools List for Airmobile Aviation Fuel Laboratory (NSN 6640-00-902-9711). 24 October 1990.
TM 10-6630-247-13&P. Operator's, Unit and Direct Support Maintenance Manual Including Repair Parts and Special Tools List for Ground Fuels Petroleum Test Kit, Model PTK-200. 18 January 1994.
TM 38-250. Preparing Hazardous Materials for Military Air Shipments. 25 November 1994.
TM 750-244-3. Procedures for Destruction of Equipment to Prevent Enemy Use (Mobility Equipment Command). 23 September 1969.

INDEX

Air Pollution Abatement Program, 3-7
Aqua-Glo test kit, 4-9, 5-4
atomic mass, 7-3
aviation fuels, 3-11
balances, 7-8
    analytical balance, 7-8
    harvard trip balance, 7-9, 7-10
    triple beam, 7-10
burner fuels, 2-3
classes of fire, 10-4
compound, 7-1
concentrations, 7-5
cutting oils, 2-6
diesel fuel, 2-3
element, 7-1
Engineering Technical Review Program, 3-7
environmental protection stewardship, 1-1, 5-2
    hazardous materials, 1-4
    hazardous materials management, 1-4
equivalent weight, 7-3
filters/separators, 3-11
fire extinguishers
    soda-acid extinguisher, 10-3
    antifreeze extinguisher, 10-3
    loaded-stream extinguisher, 10-3
    carbon dioxide extinguisher, 10-4
    dry chemical extinguisher, 10-4
    purple K extinguisher, 1-4
free water, 3-12
indicators, 7-7
insulating oils, 2-6
kerosene, 2-4
laboratory analysis
    reporting, 9-8, 10-10 through 10-12
    correlation testing, 10-12
laboratory equipment
    maintenance, 4-11
    calibration, 4-11, 10-12, 10-13
lubricant, 2-4
lubricating oils, 2-4, 2-5
matter
    composition, 7-1
    state, 7-1
methyl orange, 7-7
methyl purple, 7-7
MEW, 7-3
mixture, 7-1
molality, 7-5
molar volume, 7-3
molarity, 7-5
mole, 7-3
molecular or formular weight, 7-3
NBC operations, 5-4, 5-5, 5-8, 5-9
    biological attack, 5-6, 5-7
    chemical attack, 5-7
    contamination avoidance, 5-7
    decontamination, 5-7
    nuclear attack, 5-6
    protection, 5-7
neutralization, 7-5
Operational Surveillance Program, 3-6, 3-7
P-Naphtholbenzein, 7-8
paranitrophenol, 7-7
paraffin waxes, 2-6
percent by volume, 7-5
percent by weight, 7-5
petroleum laboratories, 4-2, 5-3, 5-5, 5-8, 6-2
    base laboratory, 4-3, 5-3, 6-1
    mobile/airmobile laboratory, 4-3, 5-3, 5-4, 6-1
    modular base laboratory, 4-3, 5-3, 6-1
    petroleum quality analysis system, 4-7
petroleum laboratory certification, 3-6, 3-7
petroleum laboratory officer, 4-1
petroleum laboratory specialist
    skill level 1, 4-1
    skill level 2, 4-1
    skill level 3, 4-2
    skill level 4, 4-2
petroleum products, 2-1 through 2-6
    AVGAS, 2-1
    burner fuels, 2-3, 2-4
    diesel fuel, 2-3
    fuel oils, 2-3, 2-4
    JET A, 2-3
    JETA-1, 2-3
    JP-4, 2-2
    JP-5, 2-2
    JP-7, 2-3
    JP-8, 2-3

kerosene, 2-4
lubricating oils and greases, 2-4 through 2-6
miscellaneous products, 2-6
MOGAS, 2-1, 2-2
petroleum base liquid propellants, and fuels, 2-1, 2-2
petroleum Technical Assistance Program, 3-6, 3-7
petroleum test kits, 4-7, 4-8
aviation fuel contamination test kit, 4-7, 5-4, 6-1, 6-2
captured fuels test kit, 4-9, 5-4, 6-1, 6-2
ground fuels contamination test kit, 4-9, 4-10, 5-4, 6-1, 6-2
sampling and gaging kit, 4-9, 5-4, 6-1, 6-2
phenolphthalien, 7-8
pH scale, 7-7, 7-8
PLL, 4-12
primary standards, 7-5, 7-6
publications, 4-12, 4-13
QA, 3-1 through 3-5
QAR, 3-1
QC, 3-1
QS, 3-1, 3-6 through 3-10
developed theater, 6-1 through 6-5
undeveloped theater, 6-5 through 6-7
Quality Surveillance Program, 3-6, 3-7
reagents, 7-4
safety during laboratory operations
air/vacuum systems, 10-8
electrical systems, 10-9,10-10
fumes, 10-9
handling chemicals, 10-7
laboratory supplies, 10-8, 10-9
personal safety, 10-5
storing chemicals, 10-5, 10-7
samples
average sample, 9-1
bottom sample, 9-1
composition sample, 9-1
continuous sample, 9-1
drain sample, 9-1
all-level sample, 9-1
lower sample, 9-1
middle sample, 9-1
on-line sample, 9-1
outlet sample, 9-1
top sample, 9-1
upper sample, 9-1
Samplers, 9-2
bacon bomb thief, 9-3, 9-4
drum thief, 9-3
vacuum-pump, 9-3
weighted beaker , 9-1
weighted bottle, 9-3
solid contamination, 3-12
sampling procedures, 9-5 through 9-9
solubility, 7-4
solute, 7-4
solutions, 7-4, 7-5
solvent, 2-6, 7-4
standard items, 4-12
standardization, 4-12
titration, 7-6, 7-7
Underground Storage Tank Program, 3-6, 3-7
water contamination, 3-12