TM 10-466

WAR DEPARTMENT TECHNICAL MANUAL

HANDLING PETROLEUM PRODUCTS

WAR DEPARTMENT • FEBRUARY 1946

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This manual supersedes TB QM 34, December 1944; and section V, War Department Circular 116, 1945.

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BY ORDER OF THE SECRETARY OF WAR:

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Refer to FM 21–6 for explanation of distribution formula.

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This manual supersedes TB QM 34, December 1944; and Section V, War Department Circular 116, 1945.

SECTION I
INTRODUCTION

1. Purpose and Scope.

a. PURPOSE. This manual is designed as a practical aid to officers and enlisted men of the Quartermaster Corps who have the job of moving gasoline, oil, and grease from the refineries in the zone of the interior up to the using units in theaters of operations.

b. SCOPE. (1) In this manual the individual handler is shown just what part he plays in the over-all picture of the flow of petroleum products.

(2) Since the petroleum handler should be familiar with the products he is handling, the nature of gasoline and oil is explained so that the man who moves these products from one place to another or transfers them from one container to another will understand the reasons for the strict precautions necessary in handling petroleum.

(3) Particular emphasis is laid upon safe and approved methods of handling and storing the commonly used petroleum products. Dangers from fire, rules to prevent fire, and most effective methods of extinguishing fires are discussed.

(4) Units authorized to handle petroleum are touched upon briefly and the equipment which they will have in their possession is described. For details of operation and for parts lists reference is made to appropriate manuals. Special attention is paid to the problems of transferring gasoline from tanks, tank cars, tank trucks, pipe lines, and collapsible containers to the standard 55-gallon drums and 5-gallon cans.

(5) The possibilities of contamination of petroleum products are recognized and a section is devoted to the importance of preventing contamination, of taking samples for tests, and of understanding the results of tests.

(6) Pictures, drawings, and descriptions of field expedients and special aids in the handling of petroleum products have been included in order to make the manual of the greatest possible practical help to the man who actually handles the products.

(7) A series of appendixes provides useful information on standard weights and measurements of petroleum products and their containers, lists of commonly used petroleum products, average consumption in various theaters, suggested methods of marking containers, approved layouts for bulk break-down points, volume correction tables for petroleum products according to temperature, and evaporation losses and instructions for cleaning and repairing gasoline containers.

SECTION II
PETROLEUM PRODUCTS

2. Responsibility for Procurement and Distribution.

The Quartermaster Corps is responsible for the purchase, inspection, storage, issue, and distribution of all petroleum products used by the Army Ground Forces, Army Air Forces, and Army Service Forces, excluding lubricants and greases for weapons, cutting oils, preservative oils, and petroleum products for use in Army Air Forces aircraft.

3. Varieties.

Petroleum means "rock oil." Petroleum products include gasoline, kerosene, Diesel fuel, lubricating oils, gear lubricants, and greases. These products are prepared or refined from crude "rock oil" taken from the earth and are used as fuels and lubricants. All of these petroleum products are made up primarily of two simple chemical elements —carbon and hydrogen. Appendix I lists and gives general uses of various petroleum products commonly used in theaters of operations. Appendix II shows amounts of petroleum products consumed by various army vehicles and the average petroleum consumption by the United States Army in various theaters of operations. Appendix III presents tables of weights and measurements useful in handling petroleum products.

4. Processing.

After the crude petroleum oil is taken from the earth, it is distilled to separate it into the various petroleum products desired. Crude oils are boiled or vaporized in a still, and the vapors are separated in a fractionating tower. (See fig. 1.) Unlike water, crude oil does not have a uniform boiling point. As the temperature is raised in the tower, the gasoline, which is the lightest fraction of the crude oil, is distilled off first at the top of the tower. The kerosene, which has a higher boiling point, is distilled off next, and is followed by fuel oil and Diesel fuel. Higher boiling fractions are processed for lubricating oils or residual heavy fuel oils.

5. GASOLINE.

a. Composition. Gasoline is a mixture of hydrocarbons (compounds of hydrogen and carbon) derived from petroleum by direct distillation and by cracking various charge stocks such as furnace or heating oil distillates and residual heavy oils after the removal of lighter distillates.

b. Use. Gasoline is a liquid fuel which will burn in the presence of oxygen and liberate heat energy. Burning gasoline in an internal com-

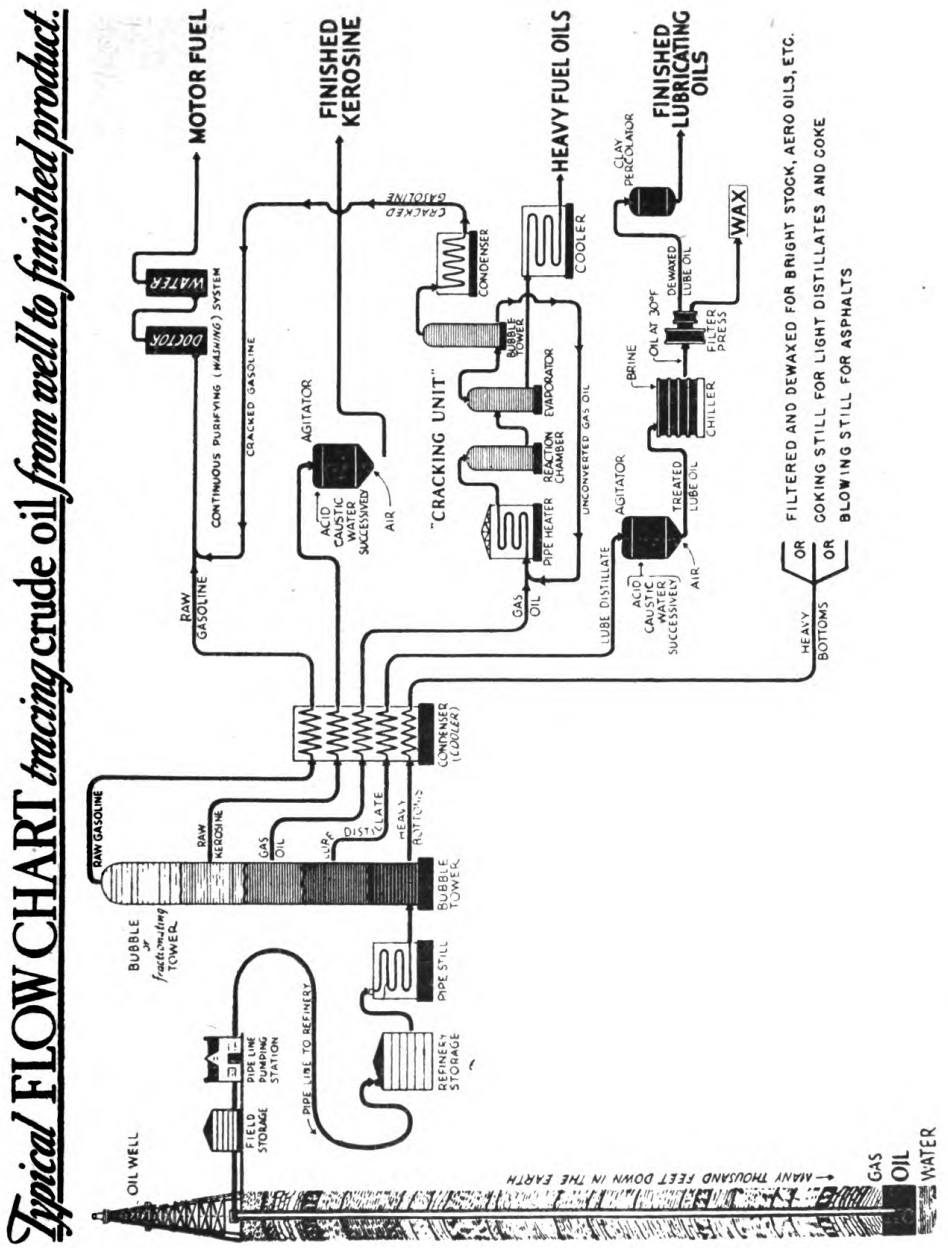

Figure 1. Fractionating tower, where various petroleum products are drawn off according to boiling point and separated.

bustion engine causes this heat energy to transform into mechanical energy to make the machine operate. White gasoline (unleaded and undyed) of 62-octane quality is used to power radar equipment, small generators, water-supply pumps, kitchen ranges, stoves, and lanterns, because the use of leaded gasoline in such equipment would form undesirable deposits.

c. OCTANE RATING. The octane rating of gasoline is its antiknock value. Knocking in a gasoline-engine cylinder occurs when the gasoline fuel burns too rapidly. Severe knocking may cause damage to valves, pistons, and bearings. Octane rating is determined by com-

paring in a standard, adjustable engine the relative knock of the fuel being tested and that of a mixture of reference fuels. Military aircraft is most efficiently operated on 100-octane gasoline. This is known as 100/130. The 100 indicates the octane number and the 130 the performance number. The all-purpose gasoline used overseas in combat is 80-octane. In the zone of the interior the fuel used is a civilian product of "premium" or "ethyl" grade.

d. VOLATILITY. Gasoline vaporizes at all temperatures encountered in the field, forming explosive mixtures which necessitate precautions in handling. Gasoline is a mixture of gases and condensible but highly volatile liquids boiling from atmospheric temperatures up to approximately 400° F. The vapor pressure of a gasoline is a function of its volatility and if too low will cause difficulty in starting at low temperatures. If the vapor pressure is too high, loss will result from the vaporization at normal temperatures; and if the gasoline is stored in containers, the pressure within the containers will be excessive.

e. EXPLOSIVE RANGE. Under certain conditions mixtures of gasoline and air can be formed which will burn with explosive violence. Under test conditions, mixtures which will act in this manner cover only a relatively narrow range. However, in practice, all mixtures of gasoline vapor and air must be considered dangerous and handled as explosive mixtures.

f. EXPANSION. All petroleum products expand with increase in temperature. In order to provide room for expansion when a container is exposed to increased temperatures, an allowance of 5 percent outage should be made when filling the container. This will provide safety for temperature increases of 50° to 60° F.

g. SPECIFIC GRAVITY. The specific gravity of gasoline is the ratio of the weight of a given volume of gasoline to the weight of the same volume of water at the specified temperature of 60° F. It is determined by hydrometer and expressed in degrees API (American Petroleum Institute). Since wholesale transfers are usually made on the basis of gallons at 60° F., the requisite number of gallons for delivery at any other temperature can be calculated with the aid of the temperature correction. (See app. VI.) The specific gravity of water is greater than that of gasoline; water therefore goes to the bottom of a tank of gasoline.

h. HANDLING HAZARDS. Fire is the chief hazard in handling gasoline, but if sensible precautions are taken, the hazards will be reduced materially. It must be remembered that it is the vapor that burns and not the liquid. Therefore, all possible precautions should be taken in the control of gasoline vapor and in training personnel in the knowledge of its dangers.

6. Kerosene.

a. COMPOSITION. Kerosene, like gasoline, is composed of hydrocarbon compounds.

b. CHARACTERISTICS. Kerosene is an illuminating oil used primarily in lanterns and stoves. It is a water-white hydrocarbon distillate with a boiling point between that of gasoline and of Diesel fuel. It has a minimum flash point of 110° F. but usually runs about 125°. This flash point indicates that it has less tendency to vaporize than gasoline, but its fumes are still dangerous in confined areas.

c. HANDLING HAZARDS. Care should be taken to prevent contamination with gasoline or heavier oils. The presence of gasoline would make the burning operation dangerous, and the presence of heavier oils would give a sooty flame. Kerosene may go off color in storage, but this change of color is not harmful to its performance. Contamination with dyed gasoline or Diesel fuel would also change the color, but this change would be harmful. Kerosene is usually handled in bulk or in 55-gallon drums.

7. Diesel Fuel.

a. COMPOSITION. Diesel fuel, also, is composed of hydrocarbon compounds.

b. CHARACTERISTICS. Diesel fuel is less volatile than gasoline and has a relatively low vapor pressure. The flash point is at least 110° F. for the winter grade and 150° F. for the regular grade. This means that a hazard exists in the form of combustible gases in inclosed spaces, but the vapors will not be as dangerous as those of gasoline.

c. HANDLING HAZARDS. The chief precaution in handling is to keep the fuel clean, because viscosity prevents dirt and sediment from settling rapidly and easily out of Diesel fuel. Diesel injectors are high-speed mechanisms operating at low clearances. Therefore freedom from abrasives or impediments to closing are important, and Diesel fuel must be free of contamination.

8. Lubricants and Greases.

Other petroleum products of various viscosities are derived from crude oil.

a. CLASSES. (1) *Lubricating oils.* Automotive lubricating oils are classified under the SAE (Society of Automotive Engineers) system according to their viscosity range. The classification figures do not evaluate the quality of an engine oil; they indicate the viscosity of the oil. The lower the viscosity, the lower is the identifying number. Only three of the grades, SAE 10, SAE 30, and SAE 50, are specified in Army lubrication orders and are designated by the symbols OE 10, OE 30, and OE 50. The current lubricating oil specification calls for heavy duty oils containing additives which impart oxidation resistance and detergency properties to the lubricant. These oils are superior lubricants for both Diesel and gasoline engines.

(2) *Gear lubricants.* These are based on mineral oil or various mineral-oil compounds. The viscosity of gear lubricants is shown by

gear oil SAE numbers, which do not have any relationship to engine oil SAE numbers. SAE 90 is used generally for temperatures above 0° F.; SAE 75 is used for temperatures below 0° F. Except where temperatures are consistently below zero, SAE 90 may be used throughout the year. The product symbols are GO–90 and GO–75. All standard gear lubricants, like the lubricating oils, have been submitted for qualification tests before approval. It is necessary to add from 5 to 12 percent of an additive to pass these tests. The additives give distinctive nonpetroleum odors to gear lubricants. They are quite soluble in the mineral oil, but agitation may be sometimes desirable to reincorporate the additives.

(3) *Lubricating greases.* Lubricating greases are composed of mineral oil and metallic soaps. They vary in consistency to suit the particular application for which they are designed. Grease is used for lubrication where an engine oil is too fluid or where it is feasible to lubricate the part only periodically. Greases are classified in grades No. 0 to No. 6, according to the "worked penetration," or consistency after they have been worked by the motion of the machine to which they are applied. Greases may show some separation (called "bleeding") of oil or may develop a "skin" on the top, but neither of these characteristics impairs the working qualities of the product. Some greases may also show a buttery appearance or a fibre structure. However, the structure, odor, or color should never be accepted as an indication of performance. Unless there is some other evidence of mislabeling, the greases should be used as specified.

b. PACKAGING. Lubricants and greases are handled in cans, pails, and drums of standard sizes.

(1) Lubricating oils are handled in 1-quart cans (12 to the case), 5-quart cans (6 to the case), 5-gallon cans, and 55-gallon drums.

(2) Gear lubricants are handled in 5-, and 55-gallon drums.

(3) Lubricating greases are handled in 1-pound cans (12, 24, or 48 to the case), 5-pound cans (6 or 12 to the case), 25-pound pails, 100-pound and 400-pound drums.

c. HANDLING HAZARDS. Since their flash point is 360° or above, lubricants and greases do not present serious fire hazards. The chief danger comes from dropping and from careless handling, because dirt, water, and other foreign substances may thus enter the packages and render the contents unfit for use.

9. Flow of Petroleum Supplies.

a. Petroleum products (including lubricants and greases) are transported from the zone of the interior to a theater of operations in bulk shipments by tanker or in filled 55-gallon drums, 5-gallon cans, and various packages loaded on cargo ships. The theater commander establishes procedures for handling petroleum within the theater. He works through an area petroleum officer in the office of the theater

G–4 or through the petroleum division of a base depot. Monthly estimates of the theater's petroleum needs sent to the Army-Navy Petroleum Board office in the zone of the interior by the theater commander indicate the varieties of petroleum desired and the amount to be shipped in bulk and in containers of various sizes.

b. Upon arrival at the port of debarkation, the petroleum products may be pumped into large storage tanks or moved to the base depot by pipe line, tank truck, cargo truck, railroad, or via inland waterway by barge. Normally the Transportation Section of the responsible headquarters is charged with the dock-to-depot delivery, except where such delivery is by pipe line. The Engineers Section is responsible for pipe line distribution. The Quartermaster Section takes over at the depot, where the petroleum is received by the quartermaster petroleum supply company.

c. If the bulk petroleum is broken down to 5-gallon cans or 55-gallon drums at the base depot, it may be moved forward to a class III railhead by freight cars or trucks. However, bulk products may be moved forward to bulk-reduction points by pipe lines, tank cars on the railroad, or tank trucks provided by the petroleum truck company.

d. At bulk-reduction points, petroleum is reduced to 5-gallon cans or 55-gallon drums by the quartermaster base petroleum supply company or the quartermaster gasoline supply company.

e. The cans and drums of petroleum are taken by quartermaster truck companies from the bulk-reduction point to advanced army supply points, where they are turned over to the using units in exchange for empty containers. These empty containers, serviceable and unserviceable, are returned to the bulk-reduction points. There the usable ones are cleaned, inspected, and refilled. The unserviceable ones are taken back to the base depot and turned over to a salvage repair company for reclamation.

f. The flow of petroleum supplies may differ in some details in the various theaters, but the general principles still apply. Bulk petroleum is pushed as far forward as possible in pipe lines or large tank cars and trucks, but the using units are issued their petroleum in the convenient, easily handled 5-gallon cans or in 55-gallon drums. An over-all sketch showing the flow of petroleum products (class III supplies) from the zone of the interior to the using units in the theater of operations is shown in figure 2.

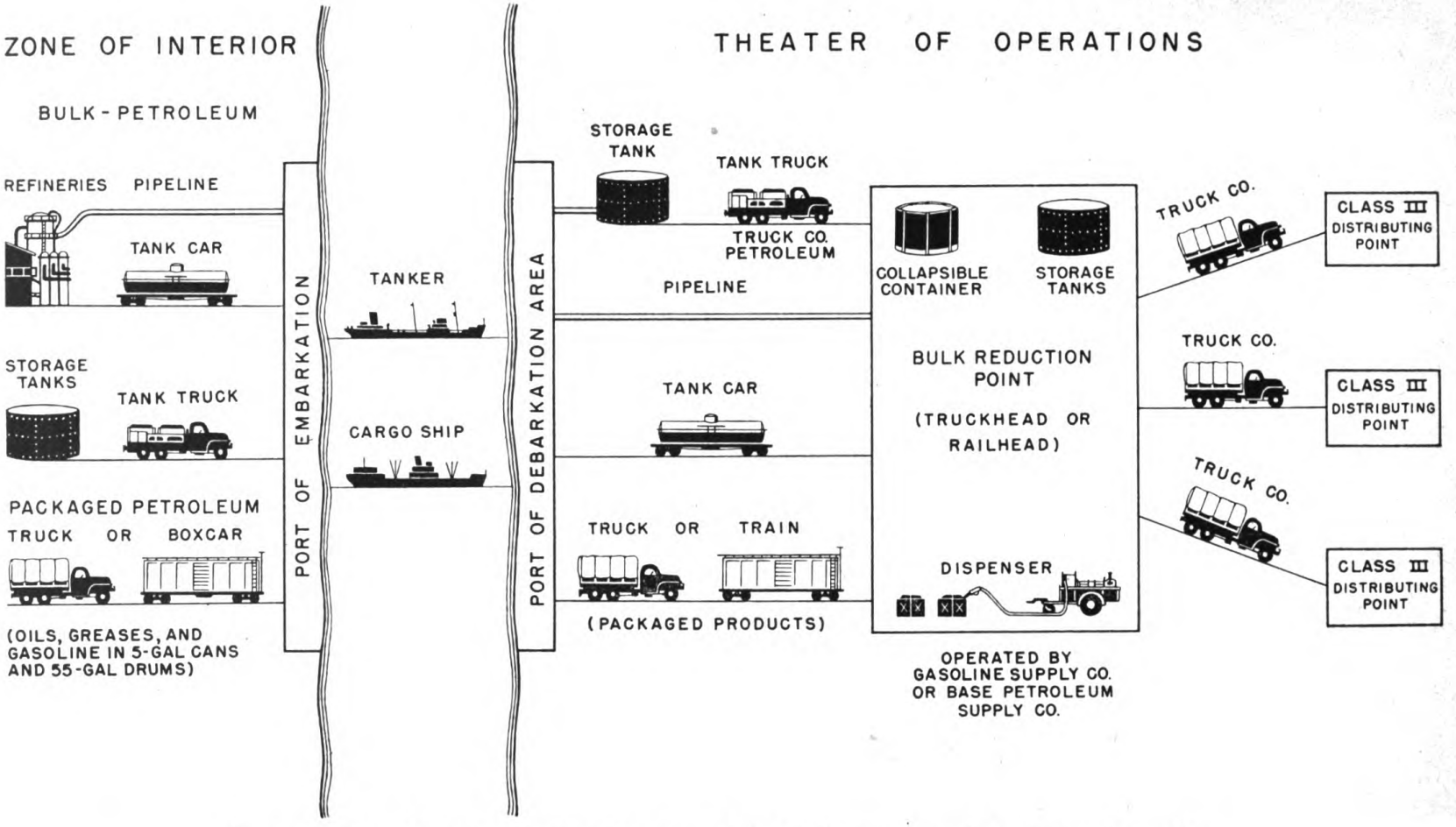

Figure 2. Flow of petroleum products from zone of the interior to using units in theater of operations.

SECTION III

PETROLEUM HANDLING PERSONNEL

10. Selection.

The key commissioned and noncommissioned officers of gasoline supply units should be selected from those who have had previous experience in handling petroleum products. Since most of the remaining personnel will probably be inexperienced, they must be carefully trained in the imporant phases of gasoline supply.

11. Training.

All men who are to handle petroleum products must be fully trained in safety measures, including accident prevention, fire precautions, and fire fighting. They should understand the characteristics of petroleum products and the dangers incurred in handling them and should learn to identify the various products in the daytime and at night. They should be taught the vital importance of maintaining the flow of gasoline and oil from the zone of the interior to the using units and should become familiar with the operating capacities of the equipment which they are likely to use. They should be trained in methods of camouflage, security, and demolition. Each man should be trained to fill at least two jobs in his unit to provide maximum flexibility of operations.

12. Quartermaster Gasoline Supply Company, T/O & E 10–77.

a. COMPOSITION. The company is made up of company headquarters and two platoons, each of which includes two sections.

b. FUNCTION. The function of this company is to deliver gasoline, oil, and lubricants to units in the field.

c. EQUIPMENT. (1) The company has Model 11–P–480 portable gasoline dispensers (100 gallons per minute) and Model 11–P–470 portable gasoline dispensers (30 gallons per minute) in sufficient number to pump the gasoline from bulk containers into 5-gallon cans.

(2) Sufficient 5-gallon cans are authorized the company to enable it to carry out its mission of providing gasoline to using troops.

(3) Collapsible containers of 3,000-gallon capacity are provided for temporary storage of petroleum products. Gasoline may be emptied from trucks into these containers and then placed in 5-gallon cans after the trucks have departed.

(4) Drum cleaners are provided to clean 5-gallon and 55-gallon containers in the field. The capacity of the unit is 300 5-gallon cans or 100 55-gallon drums per hour. With this capacity the unit can clean one-fourth of the cans filled. (See par. 21*c*.)

(5) The company has 2½-ton cargo trucks and 1-ton trailers to provide necessary transportation.

d. OPERATIONS. The company obtains gasoline from tank trucks, tank cars, pipe lines, or large drums at railheads, truckheads, or refilling points and breaks it down to 5-gallon or 55-gallon containers. One section of a platoon may operate the bulk-reduction point and the other transport the gasoline to an advanced distribution point, where it issues the full cans in return for empties. If the entire gasoline supply company is needed to operate the refilling point, the full cans may be transported to the distribution point by a truck company. The distribution point may be operated by a railhead company or another gasoline supply company.

13. Quartermaster Base Petroleum Supply Company, T/O & E 10–377.

a. COMPOSITION. The company is made up of company headquarters, a depot section, and three operating platoons. Each platoon has platoon headquarters, a canning section, and a cleaning section.

b. FUNCTION. The function of this company is to receive and store petroleum products at communications zone depots, tank farms, or petroleum pipe-line terminals, to supervise the distribution of bulk gasoline and lubricants to canning points, and to clean cans and fill them from bulk supply.

c. EQUIPMENT. (1) The company has 100-gallon-per-minute dispensers, 30-gallon-per-minute dispensers, and rotary-barrel pumps necessary to carry out its functions. It also has engine-driven drum cleaners to keep the gasoline containers in good condition.

(2) Sufficient 5-gallon gasoline cans and large collapsible containers for petroleum products are authorized the company to enable it to carry out its mission.

(3) The company has 2½-ton cargo trucks and 1-ton trailers to provide necessary transportation.

d. OPERATIONS. The company maintains a reserve of 100,000 gallons of gasoline in 5-gallon cans and approximately 15 tons of lubricants. It fills 20,000 5-gallon cans daily from bulk-gasoline supply, which has been transported to canning points by quartermaster truck company, heavy, or by rail or pipe line. In addition to the cleaning of cans, it performs such second echelon maintenance as replacing gaskets, chains, or caps of 5-gallon cans. If additional labor is required by the company, it will be furnished from the available labor pool. The company may operate as a unit, or the three platoons may operate separately if required. Operating separately, each platoon is considered capable of cleaning and filling approximately 6,700 5-gallon cans per day.

14. Quartermaster Truck Company (Petroleum), T/O & E 10–37.

a. COMPOSITION. The company is made up of company headquarters and three platoons, each of which includes a platoon headquarters and two sections.

b. FUNCTION. The function of this company is to provide bulk transportation for petroleum products from the base area to a bulk-reduction point, where they may be transferred to 5-gallon cans.

c. EQUIPMENT. (1) The company has 4-to-5-ton tractor trucks with 2,000-gallon semitrailer gasoline tankers. It also has a 4-ton wrecker, complete with equipment.

(2) Each semitrailer or 6-ton truck has self-contained emergency dispensing equipment or one 30-gallon-per-minute dispenser.

d. OPERATIONS. When pipe-line or railroad facilities are not available, the company moves gasoline from the base area to a bulk-reduction point in forward areas. The three platoons of the company may operate together, or they may operate separately to provide three chains of supply from rear to front. The capacity of the company is 96,000 gallons of the bulk-petroleum products.

e. ADDITIONAL TRANSPORATION. When the Quartermaster Truck Company, T/O & E 10–57, is given the mission of transporting gasoline, it may be equipped with 750-gallon tank trucks or with 2½-ton cargo trucks and enough 750-gallon skid tanks to provide two for each truck.

15. Quartermaster Service Organization, T/O & E 10–500.

The quartermaster service organization is designed to make available to the using services such quartermaster teams of various sizes as may be required to accomplish a given mission. One or more teams may also be used to augment fixed strength organization. Available petroleum handling teams include the following:

a. Petroleum products laborabory (base), which provides personnel and equipment for the inspection and testing of petroleum products, equipment, and supply activities in the field. It may function separately or as the parent unit for as many as three teams of mobile laboratories.

b. Petroleum products laboratory (mobile), which collects field specimens and information for a base laboratory and performs limited testing of petroleum products.

c. Drum-cleaning detachment (5-gallon), which provides personnel and equipment to clean gasoline cans prior to refilling or storage. It is designed to operate with a drum-filling team and can clean 6,500 5-gallon cans per day in a one-shift operation. A drum-cleaning detachment (5-gallon augmentation) provides personnel to operate equipment of the above detachment one extra shift and to clean an additional 6,500 cans per day.

d. Drum-filling detachment (5-gallon), which provides personnel and equipment for the packaging of bulk gasoline into 5-gallon cans. It can package 33,000 gallons of bulk gasoline in a one-shift operation. A drum-filling detachment (5-gallon augmentation) provides personnel to operate equipment of the above detachment one extra shift and package 33,000 additional gallons of bulk gasoline.

e. Drum-cleaning platoon (55-gallon drums), which provides personnel to operate a fixed drum-repair plant in the communications zone. It is capable of two-shift operation and can inspect, clean, and make necessary repairs to 2,000 55-gallon drums in one 16-hour day. It normally operates with a drum-filling platoon.

f. Drum-filling platoon (55-gallon), which provides personnel to operate a fixed drum-filling plant in the communications zone. It is capable of two-shift operation and can fill 3,500 55-gallon drums with petroleum products in one 16-hour day.

16. Petroleum Products Laboratory, T/O & E 10–500.

a. COMPOSITION. Under T/O & E 10–500, a petroleum products laboratory is set up to include a base laboratory unit, which normally functions at a base depot in connection with the petroleum division of the depot, and one or more mobile laboratory units, which may function at beachheads or other points in the field.

b. FUNCTIONS. (1) *Testing American products.* A general function of the laboratory is to perform quality inspections of petroleum products arriving in the theater by cargo ship or pipe line, of packaged materials in stockpile storage and intransit depots, and of products purchased in the theater. It makes tests to determine whether petroleum has been contaminated and recommends the disposal of any contaminated products. The laboratory inspects the exterior and interior of containers, the marking of containers, and methods of storage. It also recommends to the theater commander any desirable changes or better methods of handling petroleum products.

(2) *Testing captured products.* It is a function of the laboratory to determine whether a captured petroleum product is adaptable to the use of American forces and, for purposes of intelligence, to determine the geographical source of supply, the type of base stock, the processing methods employed, availability, and quality compared to the corresponding American product.

c. EQUIPMENT. The base laboratory unit is usually set up in a depot, where adequate housing can be provided for such special equipment as precision analytical balances, octane-rating engine, and heavy-duty electric generating plant. A bottled-gas system furnishes fuels for bunsen burners and blowpipes. A mechanical ice-making and refrigerating machine and a water-distillation apparatus are also provided. The mobile laboratory unit has a limited amount of equipment housed in a trailer pulled by a 2½-ton 6x6 cargo truck. Equip-

ment will be assigned to the mobile unit as it may be needed for particular jobs, on the assumption that the mobile laboratory will return to the base depot after completion of each major mission.

d. OPERATIONS. The nature of the two laboratory units determines to a large extent their methods of operation. The base laboratory unit makes tests on petroleum products received at the depot from the zone of the interior or secured locally. It also performs tests which require the use of heavy equipment or complicated laboratory work. On the other hand, the mobile laboratory does its work out in the field, makes petroleum tests on the spot, and inspects storage dumps, stock piles, or captured products.

17. Quartermaster Cooperation with Other Forces.

In whatever capacity personnel of the Quartermaster Corps may be engaged in handling and testing petroleum products, they will cooperate fully with representatives of the Transportation Corps, the Corps of Engineers, the Army Air Forces, the United States Navy, or other personnel working with the same objective—to provide petroleum for the armed forces whenever and wherever needed. The flow of petroleum products from the zone of the interior to the using units requires the labor of many different individuals and organizations. Only through their constant cooperation and a thorough understanding of the problems involved can the various handlers of petroleum carry out their mission successfully.

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SECTION IV
HANDLING FACILITIES

18. Means of Transporting.

a. TANKERS. A great part of the petroleum reaching the theater of operations arrives in tankers varying in capacity from 10,000 to 180,000 barrels. These tankers are subdivided into cargo oil compartments which may be used to carry different types of petroleum products. Pumps are provided for emptying the compartments at destination. Tankers are sometimes emptied by use of portable pipe lines extending from the tanker to storage tanks on shore. Special precautions are taken on tankers to prevent contamination of products and danger from fire or explosions.

b. PIPE LINES. Portable military pipe lines have proved to be a rapid and comparatively safe method of moving large quantities of petroleum over rough terrain. They relieve congested road traffic and can be quickly installed. The 4-inch pipe line has a capacity of 200 barrels an hour; the 6-inch, a capacity of 400 barrels an hour. The lines come in standard 20-foot sections. One of these sections, equipped with pressure reducers and nipples for attachment of hose, may be used as an outlet to form emergency filling stations for vehicles. Grooved-end-type flexible pipe couplings are used to join the section. Pumping or "booster" stations are set up along the pipe line to keep the petroleum flowing. Their frequency depends upon the topography of the country and the viscosity and temperature of the oil. Small pipe leaks are repaired by use of plug-type leak clamps. Large leaks may require the closing of block valves on both sides of the leak to make repairs. Operation of a pipe line should not be halted too abruptly, for the hydraulic shock might tear the line from the tank or jerk it apart. For details of construction and operation, see TM 5–350.

c. RAILROAD CARS. When rail facilities are available, tank cars are used to move petroleum. These cars are metal cylindrical tanks varying in capacity from 6,000 to 13,000 gallons. They have a manhole dome through which they are loaded and an outlet or discharge valve at the bottom through which they may be unloaded. Tank cars used for shipping one kind of petroleum product should be thoroughly cleaned before they are used for another kind. Railroad freight cars may also be used to move packaged petroleum products.

d. TANK TRUCKS. There are various types and sizes of tank trucks and trailers used to transport petroleum products over highways. Among those used most widely are the 750-gallon tank truck and the 2,000-gallon semitrailer. Skid tanks of 750-gallon capacity may be used to transport petroleum. Two of these can be mounted on a 12-foot-bed, cargo-body, 2½-ton, 6x6 truck to provide a 1,500-gallon

carrying capacity. The use of such tanks makes the truck available for other purposes. The gasoline may be dispensed from the unit by gravity or by a rotary hand pump.

e. BARGES. Flat-bottomed vessels called barges are used to transport petroleum short distances over water or to provide temporary or semipermanent storage. They may be towed or self-propelled. They range in capacity from 350 to 1,750 barrels.

f. COLLAPSIBLE CONTAINERS. Collapsible containers made of synthetic rubber-impregnated fabric may be used to transport petroleum. The 750-gallon rigid-cell container may be moved on a 2½-ton truck; three of the 2,700-gallon rigid-cell containers may be carried on a flatcar.

g. FIFTY-FIVE-GALLON DRUMS. Bulk petroleum may be placed in 55-gallon drums for convenience in handling. These drums are 16-gauge or heavier steel containers with bungs in the end for filling and emptying. When filled, they weigh approximately 400 pounds. A 2½-ton long-wheel-base truck can transport 18 drums; a barge can haul 1,500 to 2,500 drums; a cargo ship may accommodate approximately 33,000 drums.

h. FIVE-GALLON CANS. Petroleum is generally delivered to using units in 5-gallon cans. These are made of steel and when filled weigh approximately 42 pounds. A 2½-ton truck can transport 125 5-gallon cans, and a 1-ton trailer can transport 40. Filled cans and drums will float if placed in a stream or lowered overboard from a vessel.

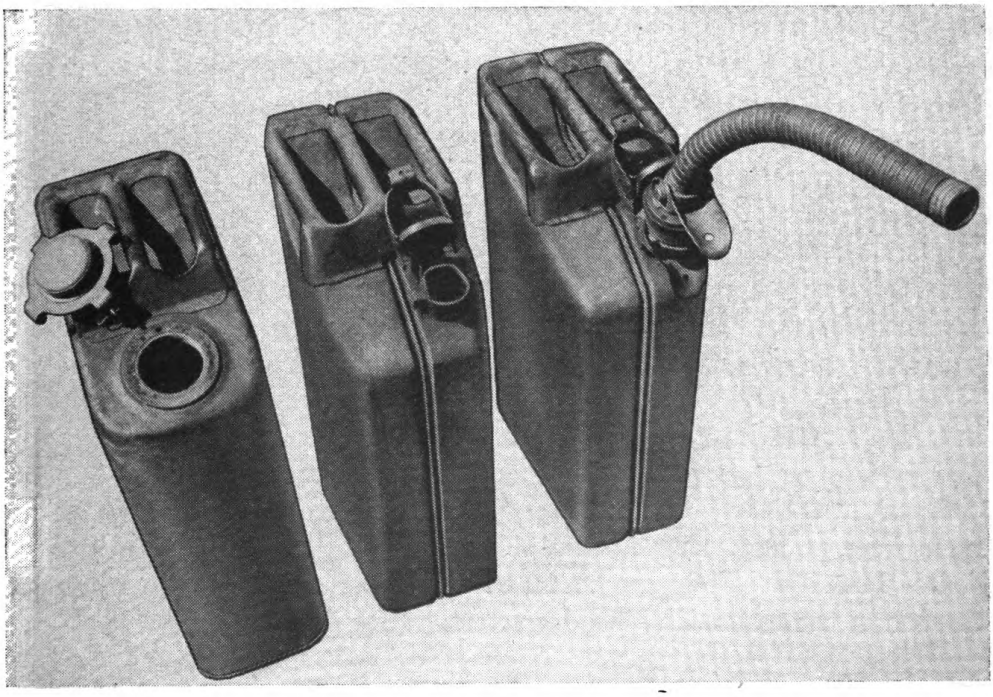

Figure 3. Five-gallon gasoline cans ("ameri-can," "jerrican," and "jerrican" with adapter and flexible nozzle).

(1) The standard Army container, Drum, Inflammable Liquid (Gasoline), Steel with Carrying Handle, 5-Gallon (commonly called "ameri-can" or "blitz can") is a three-piece construction, double-seamed or welded. It has a large 2-inch, screw-type closure, through which gasoline may be poured by the use of a flexible nozzle. It does not require an adapter.

(2) A large number of "jerricans" are also in use, either captured from the Germans or manufactured on a similar design. This is a two-piece construction, molded and welded together. It has a small cam-operated closure, and if a flexible nozzle is used to facilitate pouring, an adapter is necessary. (See fig. 3 for pictures of an "ameri-can" a "jerrican," and a "jerrican" with adapter and flexible nozzle.)

i. OTHER CONTAINERS. Lubricating oils, gear lubricants, and lubricating greases are handled in various cans, drums, and pails ranging from 1-quart cans to 400-pound drums. (See par. 8*b*.)

19. Marking of Containers.

All containers used in transporting petroleum should be clearly marked with the contents and date for the following purposes:

a. To identify products so that proper fuel may be issued for the required use.

b. To segregate stocks so that in any petroleum storage area the products can be readily located and rapidly issued.

c. To insure priority of issue so that stocks longest on hand can be issued first to avoid deterioration. (Complete information on marking may be found in Quartermaster Corps Tentative Specification No. 180, "Marking of Containers for Liquid Fuels, Lubricants, and Other Petroleum Products Purchased by Direction of The Quartermaster General.") (See app. IV.)

20. Equipment, Permanent Type.

Certain items of equipment employed in handling petroleum products are permanently installed in locations where they will be used during a period of time long enough to make installation practicable.

a. TANKS. Permanent storage tanks of various types and sizes are installed by the Engineers Section of the responsible headquarters and operated by the Quartermaster Section. (See par. 38*a*.)

b. PIPE LINES. Pipe lines, too, may be termed permanent equipment even though they can be dismantled and moved if a theater becomes inactive. They are installed and maintained by the Engineers Section of the responsible headquarters. (See par. 18*b*.)

21. Equipment, Quartermaster Mobile Type.

a. ROTARY PUMP. In transferring small quantities of petroleum, the rotary hand pump may be used as a substitute for or a supplement to the larger gasoline dispensers. The pump weighs approximately 25

pounds with a 6-foot hose and nozzle. Its rated delivery is 10 gallons per minute at 100 revolutions per minute of the crank handle, but 300 gallons an hour is the maximum that can be expected. One man can operate the pump.

b. PORTABLE GASOLINE DISPENSER. (1) The 30-gallon-per-minute dispenser (Federal Standard Stock No. 11–P–470) is a small portable unit mounted on a tubular frame and weighs approximately 300 pounds. It can be transported in either a cargo vehicle or a trailer or can be carried by two men. It is powered by a single-cylinder, air-cooled, four-cycle gasoline engine. It has one 30-foot length of 1½-inch suction hose

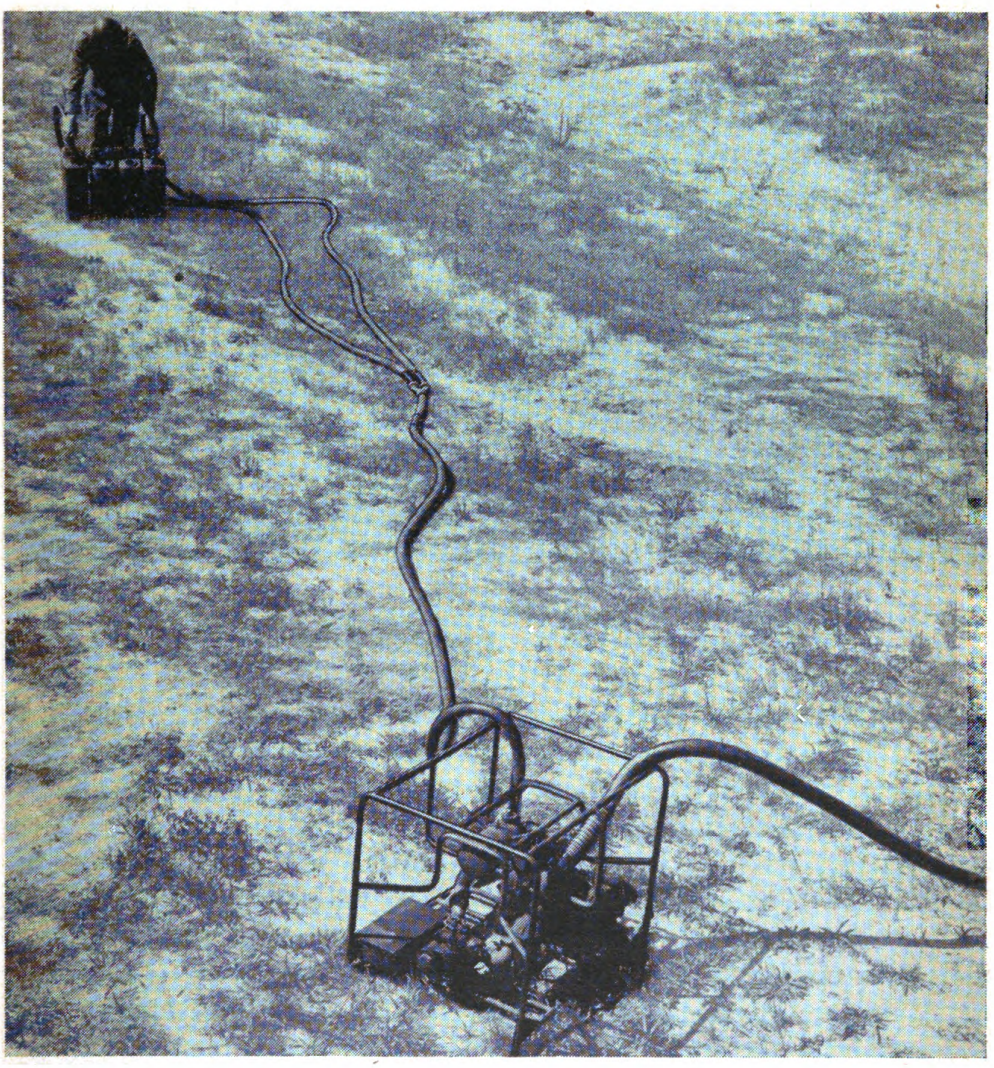

Figure 4. Small 30-gallon-per-minute dispenser in operation.

and one 20-foot length of 1¼-inch discharge hose equipped with a "Y" coupling providing two 1-inch 10-foot lengths each equipped with a nozzle. The pump is a variable volume-control type. Gasoline is with-

drawn into the pump and then discharged through the hose outlets. For parts list and details of operation see TM 10–1135. (See fig. 4 for 30-gallon-per-minute dispenser in operation.)

(2) The 100-gallon-per-minute dispenser (Federal Standard Stock No. 11–P–480) is skid-mounted, weighs about 2,000 pounds, and is usually carried on a 1-ton trailer. It is powered by a single-cylinder, air-cooled, four-cycle gasoline engine. It has four 25-foot lengths of 3-inch suction hose and four 75-foot lengths of 1¼-inch discharge hose each equipped with "Y" couplings providing two 1-inch by 10-foot lengths each equipped with a nozzle. The pump is a variable volume-control type. Parts list and details of operation are given in TM 10–1134, 10–1660, and 10–1693. (See fig. 5 for large 100-gallon-per-minute dispenser in operation.)

Figure 5. Filling 5-gallon cans with a 100-gallon-per-minute dispenser. Large hose at right extends to tank car or large collapsible container.

c. CAN-CLEANING DEVICE. (1) Various can cleaners have been devised in the field from chains, empty drums, and pieces of pipe. They are operated by compressed air to remove sand, mud, rust, and sediment from petroleum containers before refilling. A petroleum solvent or kerosene (*not* gasoline) may be used to rinse the cans and remove most of the sand or dirt. This solvent also dissolves any remaining petroleum product. Chains, alkali solution, sand blasting, or scraping may be used to remove interior rust. Any petroleum products or vapors remaining in the containers should be carefully removed before cleaning interior with chains or sand blasting in order to prevent danger of explosion.

(2) A portable, gasoline-engine-driven drum cleaner is now authorized (Federal Standard Stock No. 40–C–1007–50). It cleans ten 5-gallon cans per 72-second cycle and, with attachments, cleans 55-gallon drums. Approximately 3,500 5-gallon cans can be cleaned during an 8-hour shift. The cleaner looks like a small bottling machine, with 10 racks to hold the 5-gallon cans. These racks are evenly placed on a turntable, which re-

volves continuously around a central unit containing the engine and other working parts. Dirty cans are placed on the racks and a pipe nozzle is inserted into each can until it touches the bottom. Cleaning solution (kerosene) is sprayed into each can and then withdrawn by vacuum. Two 55-gallon drums may be cleaned at a time. They are placed on the ground near the machine. A nozzle is inserted in each bunghole, and both drums are flushed with the cleaning solvent, which is then removed by suction. The cleaner fits into a 1-ton trailer for transportation. (See fig 6 for a suggested production-line set-up for cleaning and salvaging 5-gallon cans.)

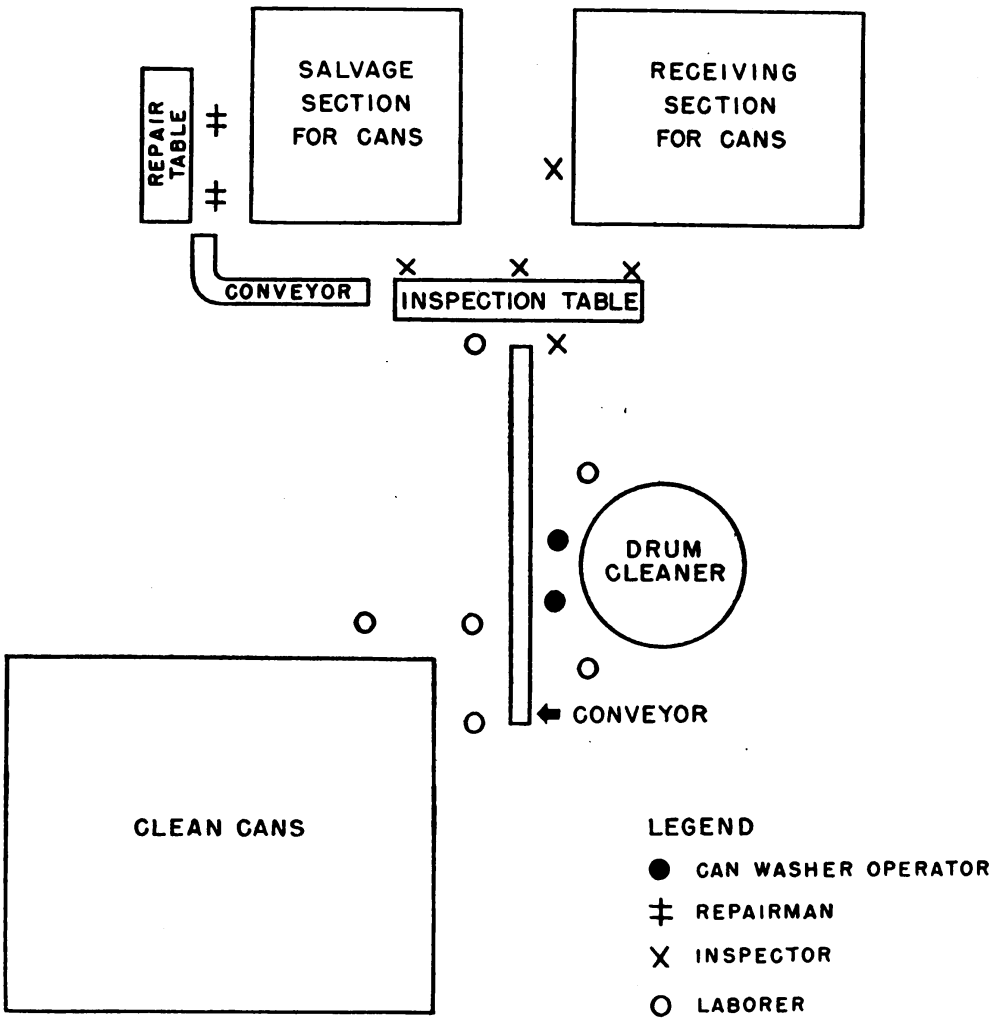

Figure 6. Production-line setup for cleaning and salvaging 5-gallon cans.

d. Labor-saving devices. Numerous aids in handling drums and cans have been improvised.

(1) Portable conveyor sections save time and labor in moving cans or drums from water front into storage or from storage areas to boxcars or trucks.

(2) Skids about 15 feet long are extremely useful in rolling 55-gallon drums from the ground into trucks or boxcars, or in unloading drums. (See fig. 7.)

Figure 7. Skids used by native laborers in loading 55-gallon drums into truck.

(3) Ropes are also used to help in raising drums from the ground along skids to a truck. Two men on a truck with a rope can help men pushing drums up the skids.

(4) Cranes or **A**-frames mounted on trucks may be used to hoist heavy drums from the ground. (See fig. 8.) In this manner 10 trucks may be loaded in the time it takes to load 1 truck by rolling the drums along skids.

22. Maintenance of Equipment.

In order to obtain best performance from all items of equipment, operating instructions provided by the manufacturer of each item should be carefully followed. If the equipment is kept clean and properly lubricated, repairs will have to be made less frequently. Only those men ex-

perienced in the operation of items of equipment should be allowed to operate, test, or adjust them. For detailed suggestions on maintenance, see Technical Manuals accompanying each piece of equipment. For instructions on lubrication, see the appropriate War Department Lubrication Orders.

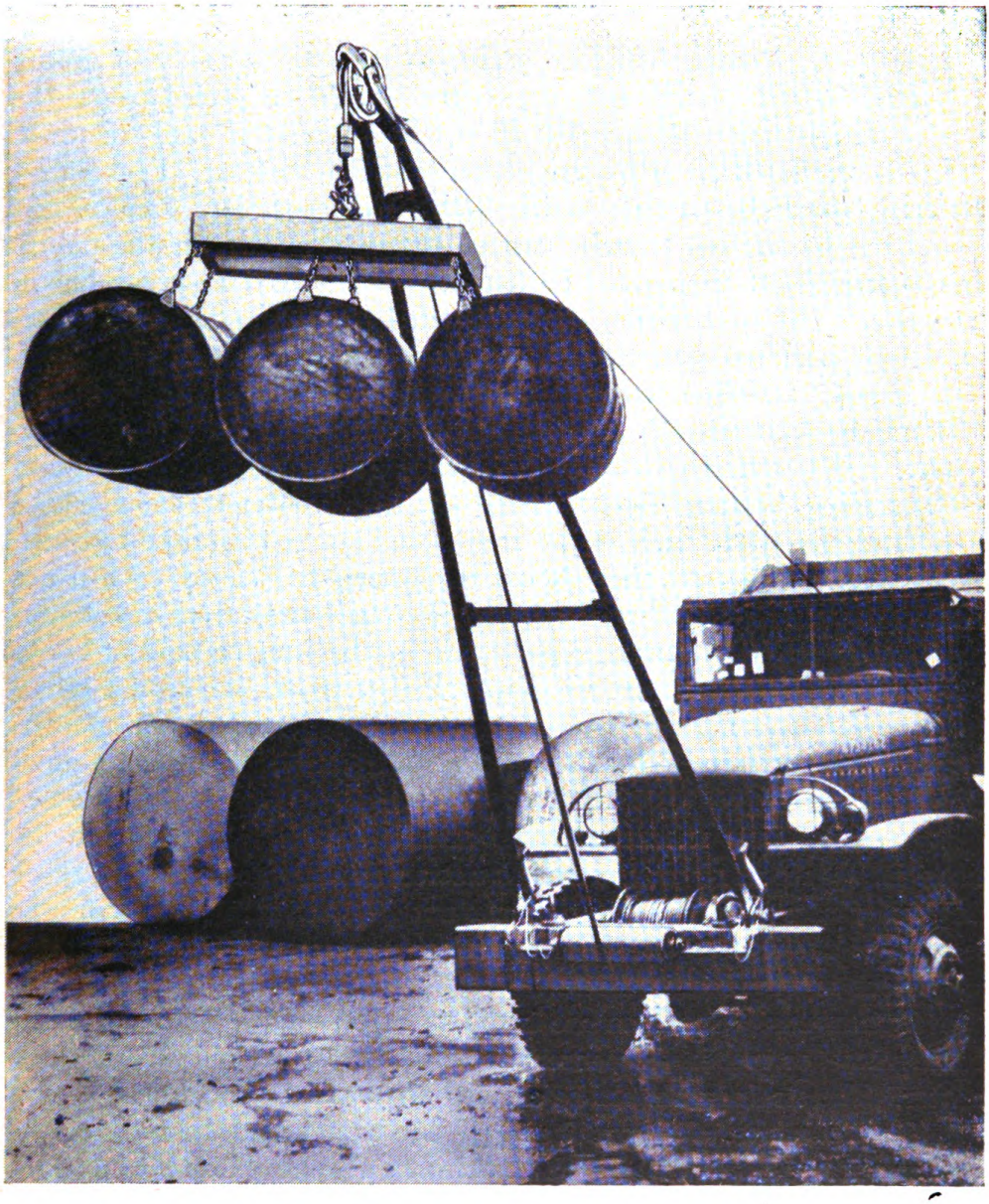

Figure 8. **A**-*frames mounted on trucks, used to hoist 55-gallon drums from the ground.*

a. ENGINES. Before attempting to start the engine to pump fuel, unit should be inspected to see that all parts are in good order. The engine should be checked to see that it has proper level of engine oil and that the gasoline tank has enough gasoline. All bearings should be lubricated through lubricating fittings with the prescribed lubricant at least once

a week. Old oil should be drained and fresh oil added after every 48 hours of operation. Once every 200 hours of operation, the oiler on the magneto should be filled. An air cleaner must be used on the carburetor intake if there is any dust where the engine is operated. Dust wears out cylinders, pistons, rings, and other parts of the engine. Never operate the engine with any part of the air shroud removed, for this would allow the engine to overheat.

b. PUMPS. Pumps should be located as close to the source of supply as conditions will permit and, if possible, should be placed below the level of the gasoline to be pumped. Pumps should have an easily removed and well-ventilated cover for protection from the weather. Packing on the pump should be carefully checked after each operation. Sand or grit should not be allowed to pass through the pipes and enter the pump. Pumps should not be operated for long periods unless there is gasoline in the system. All pumps should be inspected often for alignment, wear, valves and packing, seating of valves, corrosion, and proper lubrication.

c. HOSE. Gasoline hose is made of rubber and heavy woven fabric. It should be handled with care to prevent kinks, undue strain, or sharp bends. If it becomes kinked, the kink should be removed by hand and not by pulling the hose. Hooks, chains, and sharp tools may damage hose if carelessly handled. Ends of the hose should not be permitted to touch the ground. If they do, they should be thoroughly cleaned. When not in use, hose should be stowed in a cool, dry place away from direct sunlight and high temperatures. Hose should not be hung on nails or hooks which place a strain at any one point. Heavy trucks should not be allowed to run over hose, or heavy tools or rocks allowed to fall upon it. Inspect hose regularly at least every 3 months and replace when noticeably deteriorated.

d. VALVES AND MISCELLANEOUS PIPE FITTINGS. Care should be taken in opening and closing valves not to damage them. If cocks or plug valves are provided, they should not be shut with quick motions because of the danger of subjecting other valves or even the pumping equipment to a hydraulic shock.

e. STRAINERS. Strainers are installed in pipe lines, loading or unloading hose, or gasoline-dispenser hose to keep out dirt and other foreign matter. The strainers should be cleaned often and thoroughly.

f. SPARE PARTS. Various items of equipment and spare parts in frequent demand will probably be carried at all class III supply points.

g. COLD-WEATHER MAINTENANCE. If freezing is likely to occur, special precautions should be taken to see that pipe lines, pumps, valves, radiators, drains, traps, and other pieces of equipment are not damaged by having water freeze in them. Any fire-fighting equipment subject to freezing should be kept in buildings or otherwise protected from the weather.

23. Use of Captured Enemy Equipment.

Various items of petroleum handling equipment, such as tanks, dispensers, pipe lines, pumps, drums, and cans, may be captured from the enemy and made available for use by American forces.

a. ASSESSING VALUE BEFORE CHANGING. The value of captured enemy equipment should be carefully assessed before any changes are made to make it correspond to similar American items. It may be more useful without changes.

b. KEEPING CHANGES SIMPLE. If the captured equipment must be changed to be used, the necessary changes should be kept as simple as possible so that the equipment can later be reconverted to its original nature if desired.

SECTION V
RECEIVING AND DISPENSING FUELS

24. Transferring Gasoline, General.

Petroleum products may be transferred several times from one container to another during their movement forward to using troops. (See app. V for methods of setting up such transfer points.) In all such transfers, certain precautions must be taken.

a. All petroleum containers, whether empty or full, should have their plugs or other openings kept closed when not in use.

b. Static electricity is generated by the flow of gasoline from one container to another or through a hose. This is similar to the static charge built up as a man walks across a heavily carpeted floor and then touches a metallic object such as a door knob. A static spark leaps from hand to knob causing a sudden shock. In any transfer of gasoline care must be taken to ground this electricity to prevent a static spark from causing an explosion and fire in gasoline vapors.

c. During the transfer of gasoline, fire extinguishers should always be within reach. They should also be dispersed so that in case of fire in any area some of the extinguishers will be accessible. Operating personnel should know the exact location of such equipment.

d. The container into which gasoline is to be placed should be gauged before the transfer starts so that the available space will be known and no gasoline spilled on account of overflow.

e. Sufficient space should be allowed in the container for probable expansion.

f. Check should be made that the proper grade of gasoline is delivered and that it is being placed in the proper tank.

g. The nozzle or loading spout should be inserted well within the container opening so that no liquid or spray will fall outside and should be in contact with the metal container to eliminate danger of a static spark.

h. Personnel should watch the operation closely to prevent overflow or to stop the transfer in case of emergency.

i. Only nonsparking tools should be used.

j. The container into which the product is to be delivered should be inspected before transfer to determine whether any materials are present which would contaminate the product.

25. Transfer from Pipe Lines to Storage Tanks.

a. Pipe lines may carry gasoline to large storage-tank farms, where it may be maintained as a reserve or distributed as required.

b. Tanks should be set on hillsides, if convenient, so that the tank installations may be pitted and so that the tanks can feed by gravity to the pump or dispensing stations below.

c. Tanks should be located sufficiently far apart to prevent fire from spreading to another tank.

d. Before gasoline is transferred from pipe lines to tanks, the tanks should be inspected for cleanliness and gauged for capacity.

e. Flow of gasoline from pipe lines to tanks is regulated by inlet valves of the tanks. Changing from one tank to another is accomplished by opening the valve on the branch line of the tank to be filled before closing the valve to the tank just filled.

f. If the pumping capacity is higher than that normally used for tanks of a certain size, the vents may not be able to take care of the pressure, and it may be necessary to leave the hatch open to keep from blowing the top off. The same situation may arise when pumping gasoline out of tanks. If the valve plate rattles or flutters noticeably, it may mean that the pumping capacity has been reached. Vents should be checked to see that they are not rusted and are working properly.

g. After a tank has been filled, its contents should be allowed to settle as long as possible before being withdrawn. Any water will settle to the bottom of the tank and can be drawn off.

h. Pressure-reducing regulators may be installed in sections of the pipe line to reduce pressure on downhill lines or to reduce the pressure on an outlet where gasoline is being taken from the pipe line. If collapsible containers or other containers smaller than tanks are used, the stream of gasoline should be directed against the bottom of the container rather than the sides, which are subject to injury from pressure.

i. Special care must be taken in time of flood to prevent tanks from floating and thereby breaking loose from pipe lines, with consequent dangerous spillage of gasoline. To prevent damage in floods, tanks should be filled with gasoline or if necessary with water and gasoline.

26. Transfer from Storage Tanks to Trucks or Cars.

a. USE OF LOADING RACKS. When loading racks are used to transfer gasoline from storage tanks or pipe lines to trucks, or tank cars, they should be at least 100 feet from any building and clear of surrounding vegetation. To prevent the building up of static electricity, every loading rack should be equipped with a bonding line from the loading connection to the shell of the car, a bonding line from the track rails to the loading-rack supply line, and a permanent ground connection. Stationary or hinged platforms are built to provide a means of passing from the rack to the car. If a movable plank or footboard is used for this purpose, it should be in good condition and securely placed to prevent accidental falls.

b. LOADING TANK CARS. The receiving car should be inspected for cleanliness. It should be held down with the hand brakes once it is spotted at the rack, and stop signs should be erected to indicate that loading is going on. A rubber hose extension or pipe should either extend almost to the bottom of the car or rest on it. Loading gasoline

by allowing it to fall from the top to the bottom of the car should be avoided since it causes considerable vaporization with a resultant fire hazard and excessive loading loss. A hose that does not extend into the car interior may jerk out of the dome unless it is firmly fastened to the car. It is good practice to place a water-moistened burlap bag around the dome opening during the loading as a protection against fire or sparks. (See fig. 9.) Coal-burning locomotives working near the loading rack should have smokestack and firebox screens. Only vaporproof electric lanterns or flashlights and nonsparking tools should be used. The tank should not be overloaded. A two percent allowance for expansion should be made. In a few tank cars this requires some outage (level below shell). Overloaded tank cars, if subjected to a rise in temperature, may leak around the dome and through the safety valve. These vapors could become ignited. In case of an electrical storm, loading should be discontinued and the car capped. Fire-fighting apparatus should be available at all times.

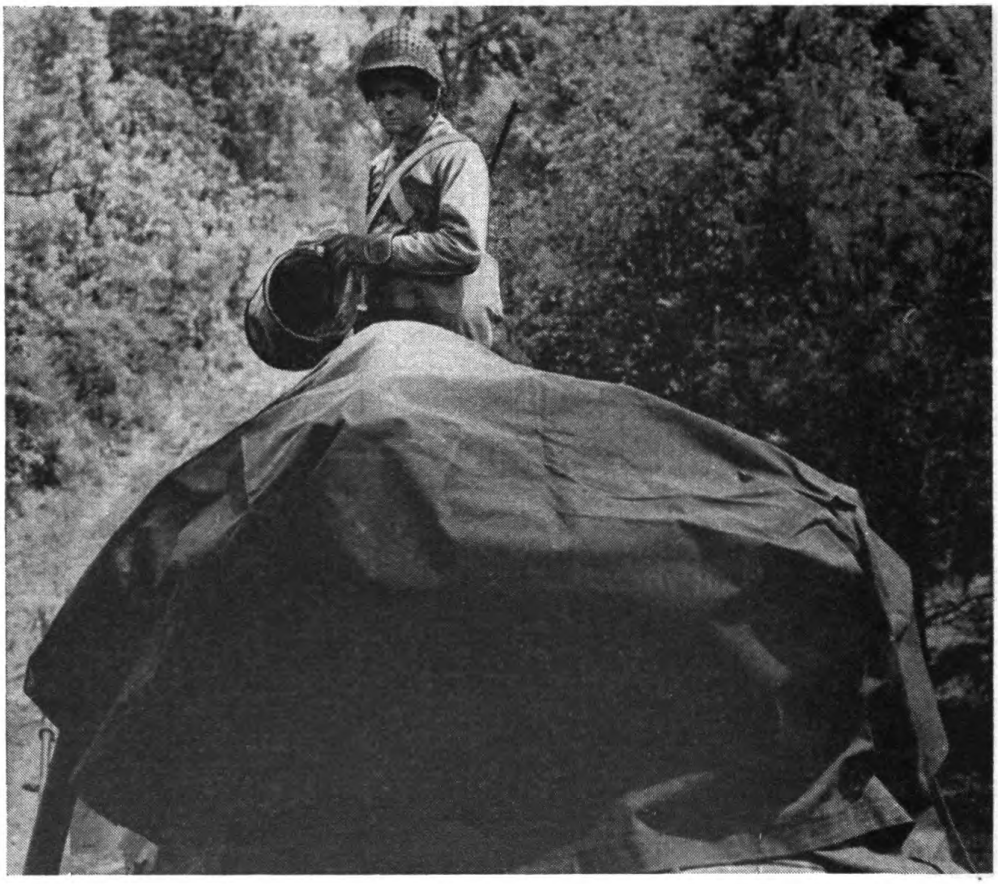

Figure 9. Wet burlap or tarpaulin around dome opening of tank car provides protection against fire or sparks and reduces evaporation.

c. LOADING TANK TRUCKS. Precautions similar to those in *b* above are taken in loading a tank truck with gasoline. The truck is spotted

at the loading rack. The engine is shut off and the brakes are set, before connections are made. To avoid static electricity, the truck is grounded. Before the truck is filled, its condition and capacity should be checked. Fire-fighting apparatus should be available. (See fig. 10 for the use of temporary loading racks and of pipe lines for rapid loading of trucks from storage tanks.)

Figure 10. Temporary loading racks may be devised from pipe lines for rapid filling of tank trucks from storage tanks.

27. Transfer from Trucks or Cars to Tanks and Drums.

a. UNLOADING TANK CARS. Tank cars may be unloaded through the bottom or through the dome. They will usually be unloaded through the bottom outlet except that under the following conditions they will be unloaded through the dome: when important buildings are located within 100 feet of the unloading point; when the outlet valve in the bottom of the tank cannot be properly seated or the outlet chamber is obstructed or damaged; or when the tank car is permanently fitted with a special dome cover provided with a safety vent and a tight connection for the discharge outlet.

(1) The following steps must be taken preparatory to making unloading connections, regardless of the method of unloading:

(*a*) Set the brakes of the car and block the wheels so that the car cannot move and break connections during unloading operations.

(*b*) Place signs bearing the words, "STOP—TANK CAR CONNECTED," midway between the rails at the open end or ends of the track on which the car is spotted. Place the signs in such a manner that they will be seen by switch crews operating on adjacent tracks. These

signs should be at least 12 by 15 inches and painted blue with white letters. The letters of the word, "STOP," should be 4 inches high and the letters of the words, "TANK CAR CONNECTED," should be 2 inches high.

(*c*) Gauge the storage tank into which the tank car is to be unloaded to make sure that it will hold the product intended for it. Check the storage-tank relief vent to insure that it will function properly.

(*d*) Insure that the proper grade of gasoline is being delivered and that it is put into the proper tank. Compare the car shipment numbers with those on the shipping papers.

(*e*) Ground the tank car by placing a cable in contact with the car anchorage or underframe, making contact with clean metal, and connect the other end to a grounding connection. If a permanent grounding connection is not available, extend the ground cable to about 4 feet from the car and attach it securely to an ordinary steel bar or rod driven a minimum of 2 feet into ground which has been moistened with water.

(2) Give undivided attention to the unloading until the car has been emptied, the line disconnected, and the manhole cover and outlet cap replaced. Never leave a connected tank car unattended. Allow no foreign objects to be dropped into the tank car, since they may interfere with the closing of the outlet valve or damage the unloading pump.

(3) If it becomes necessary to move a tank car before it is fully unloaded, take the following steps before moving the car:

(*a*) Insure that the bottom outlet valve is closed and that the bottom outlet cap is tightly in place.

(*b*) Close and tighten the dome cover.

(*c*) Remove all unloading and grounding connections, and be sure they will clear the car.

(*d*) Remove "STOP" signs from the track.

b. UNLOADING TANK CARS THROUGH THE BOTTOM (see fig. 11). (1) Open the safety vent to release gasoline-vapor pressure within the car. To do this, insert a sparkproof bar through the hole in the safety vent and pry it open, maintaining the opening until the sound of escaping gas ceases. If the tank is very hot, the time required to release the pressure may be shortened by cooling the outside of the tank with water. Be sure to release all pressure within a tank before loosening the dome cover.

(2) Loosen the cover on the dome of the tank car and remove it enough to allow access to the handle on the valve that controls the bottom outlet. This handle will be found immediately below the dome cover. Avoid breathing gasoline fumes while operating this valve. The valve handle should be operated a few times to assure that the outlet valve in the bottom of the tank is firmly seated. This must be determined *before* the outlet cap on the bottom of the car is loosened. If there is any doubt as to whether the internal valve is seated, unload the car through the dome.

(3) Adjust the manhole cover so as to prevent the entrance of sparks or other sources of ignition through the manhole, but with sufficient clear-

ance to allow air to enter the tank (otherwise the tank might collapse under suction). Adjust manhole covers as follows:

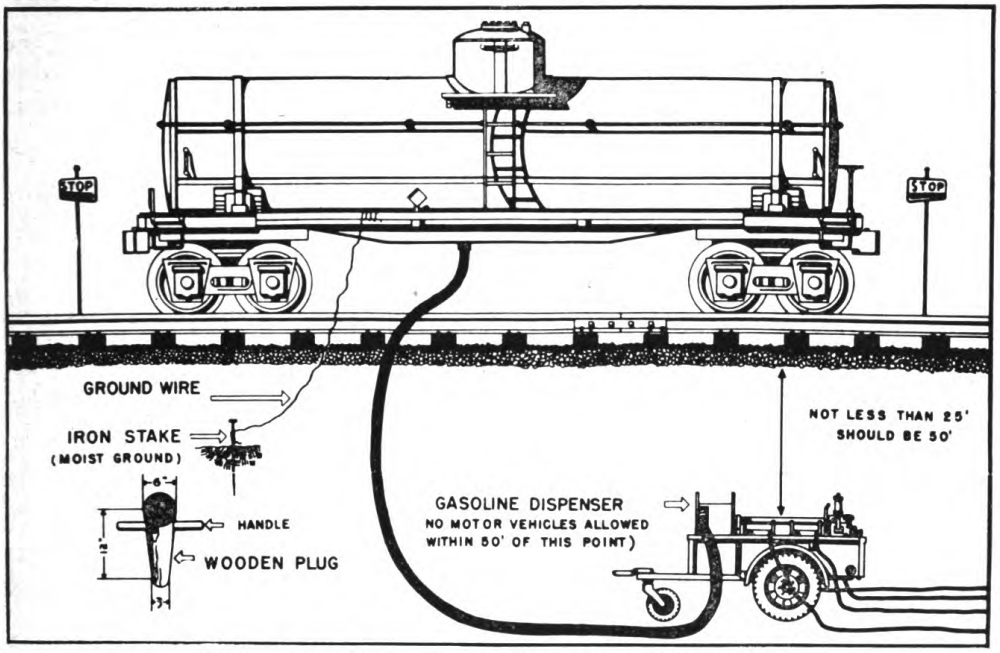

Figure 11. Unloading tank car through the bottom.

(*a*) *Screw type.* Put the cover in place but do not screw it down entirely, for air should enter the tank through vent holes in the threaded flange of the cover.

(*b*) *Hinged-and-bolted type.* Place a small wooden block under one edge of the cover to allow air to enter the tank.

(*c*) *Interior type.* Tighten the screw in the yoke so that the cover will be brought within ½-inch of the closed position.

(4) Loosen the outlet cap on the bottom of the car and unscrew it about two threads. If the outlet cap does not unscrew easily, tap it lightly with a wooden block or mallet in an upward direction. Use only sparkproof tools where flammable vapors may be present, and keep all tools clean of oil, grit, and dirt.

(5) Permit the fluid in the outlet leg to leak out around the threads until the accumulated liquid has been drained. This will require from 2 to 10 minutes. Use a drip pan to collect the leaking gasoline, and dispose of the contents of the pan immediately.

(6) If at the end of 10 minutes the outlet is still leaking an appreciable stream, indicating that the outlet valve in the car may be unseated, do not remove the bottom outlet cap but manipulate the valve lever located inside the dome of the car and try to seat the bottom valve.

(7) Observe the bottom cap again as on the preliminary trial. If the leakage rate has diminished to a mere dripping, the cap may be removed entirely and the discharge hose connected to the threaded fittings at the bottom of the outlet leg. Unloading connections must be securely at-

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tached to the bottom outlet before the valve is opened by operating the valve-rod handle or control in the dome.

(8) If during these operations it is found that the bottom valve cannot be properly seated, unload the car from the top dome with the power-type dispenser. To remove the bottom outlet cap when the bottom valve cannot be properly seated will cause loss of part or all the car contents, will add fire hazards, and will create serious delay or failure in delivering the necessary fuel to the using organization.

(9) Have a tapered wood plug with application handles in readiness at the time the bottom outlet cap is being removed from the tank car. The plug should be about 12 inches long and tapered from 6 inches in diameter at one end to 2 inches in diameter at the other. If there is a heavy stream discharge, indicating that the valve has become unseated before the hose connection can be made, insert the plug to stop the flow.

c. UNLOADING TANK CARS THROUGH THE DOME (see fig. 12). (1) Open the safety vent to release gasoline vapors that are within the car. To do this, insert a sparkproof bar through the hole in the safety vent and pry open the vent, maintaining the opening until the sound of escaping gas ceases. If the tank is very hot, the time required to release the pressure may be shortened by cooling the outside of the tank with water.

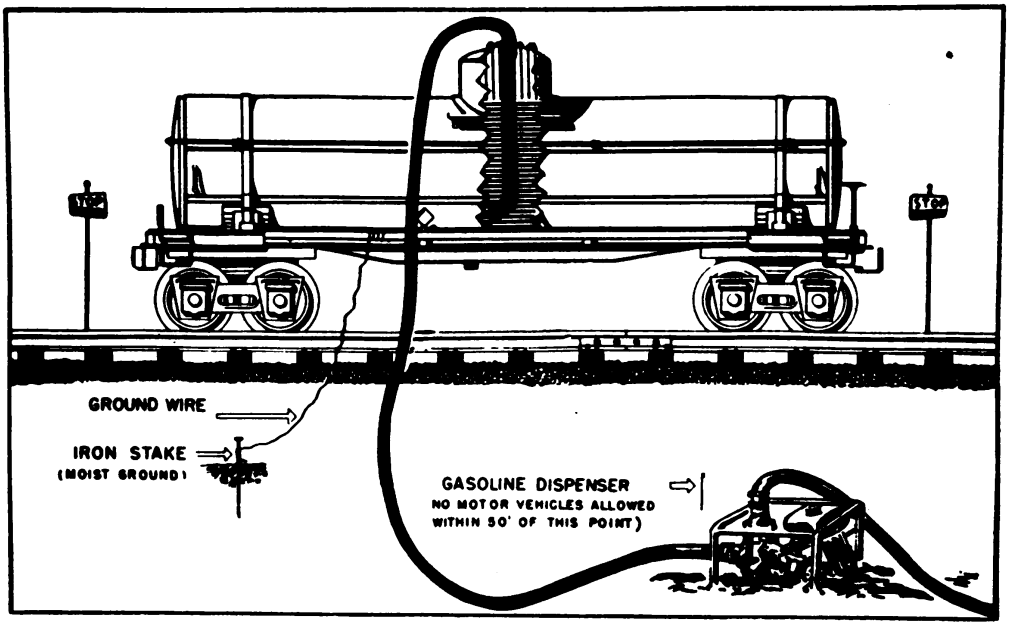


Figure 12. Unloading tank car through the dome.

(2) Open the dome cover only enough to allow the entrance of the suction hose. In order to avoid creating sparks, exercise care when moving metal parts across one another.

(3) In order to prevent the entrance of sparks, protect the opening in the dome by an asbestos or metal cover or wet burlap. If wet burlap is used, keep it moist by application of water throughout the loading operation.

d. UNLOADING TRUCKS. (1) Stop the truck engine and set the brakes.

(2) Gauge the storage tank into which the truck is to be unloaded to make sure that it will hold the product intended for it. Insure that the proper grade of gasoline is being delivered, and that it is put into the proper tank.

(3) Touch the nozzle of the delivery hose to the cap of the tank to equalize the electrical charge between the two *before* removing the cap from the tank. Hold the nozzle firmly against the fill pipe of the tank during the unloading operation in order to keep the truck and tank electrically bonded. Except for deliveries into drums and cans, use a bonding cable in addition.

(4) The truck operator must remain at the discharge valves during the entire period of discharge to shut off the liquid in case of emergency.

e. INSPECTION OF DRUMS. (1) Insure that drums which are to receive the gasoline are free of rust, water, and other foreign matter.

(2) After the drum is filled, install and tighten the plug by exerting 25 to 35 pounds of pressure on a 1-foot wrench. Any greater pressure may damage the gasket. Tri-sure type closures require only 5 to 15 pounds pressure for 2-inch plugs and 2 to 7 pounds pressure for ¾-inch plugs.

(3) Use only the type of plug and gasket required for the particular type of drum closure. Use of one type of plug and gasket in a different type flange will result in leakage.

28. Transfer from Drums to Cans.

a. GENERAL. (1) When cans are being filled place the hose nozzle in contact with the metal edge of the can opening to ground static electricity.

(2) Never fill cans while on a truck unless the truck and cans are properly grounded.

(3) Inspect cans that are to receive the gasoline for cleanliness of interior, condition of gasket surfaces, and the presence of proper plugs and gaskets.

(4) Avoid use of cans formerly used in water service, except in extreme emergencies.

(5) Handle drums and cans carefully to avoid damage and subsequent leaks. Do not drop drums from trucks but ease them down gently or drop them on some shock absorber like salvage tires.

b. POURING DIRECT FROM DRUMS. If no better means is available, gasoline can be poured from 55-gallon drums into 5-gallon cans through a short pipe nipple or a funnel. A siphon may also be used.

c. PUMPS AND DISPENSERS. (1) The hand-cranked rotary pump with attached delivery hose may be used to transfer small amounts of gasoline from drums to cans. (See par. 21*a*).

(2) The 30-gallon-per-minute and the 100-gallon-per-minute dispensers are used for more rapid transfer of gasoline from drums to cans. (See par. 21*b*).

(3) Arrange the cans in double rows in an area to allow ease in handling the hose of the dispenser. If a pump driven by a gasoline engine is used, make certain that the spark arrester on the engine is in place and functioning. Bury the gas lines leading to and from the dispensing device in a 6-inch to 1-foot trench to prevent firebacks. Fire trenches are dug around each group of cans to be filled. Fire extinguishers and pails of loose earth should be within reach.

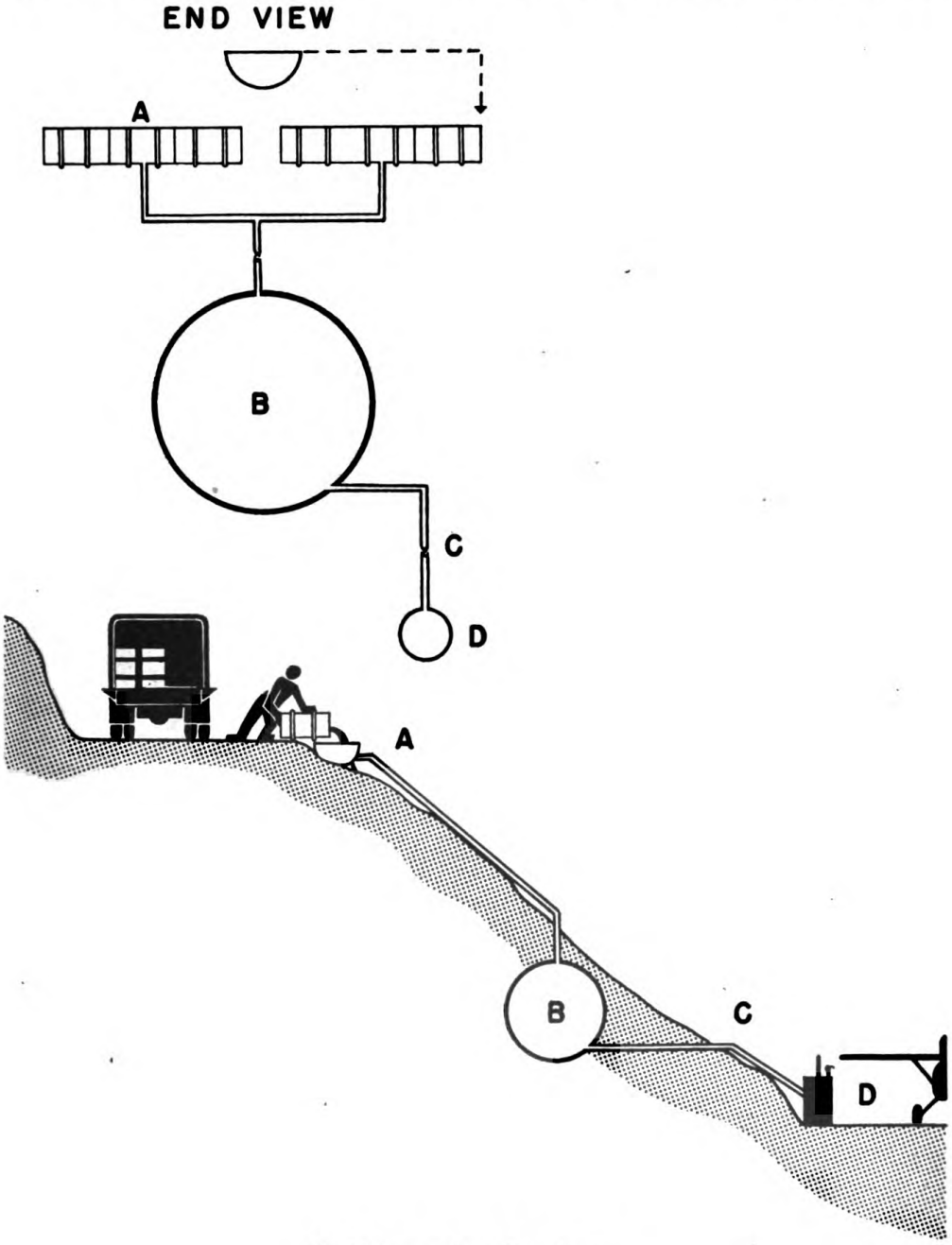
(4) Various methods of filling the cans have been worked out. In a three-man operation, one man goes down the line of cans removing the caps and inspecting the cans, another man operates the hose nozzle and fills the cans, and a third man replaces the caps. If only one man is available, he can operate two nozzles at the same time. He starts the first can on one side and when it is half full, he places the other nozzle in the can on the opposite side. As soon as one can is filled, he moves the nozzle forward to the next can in that line. (See fig. 13.)

Figure 13. Method of filling 5-gallon cans using 100-gallon-per-minute dispenser.

d. IMPROVISED DUMPING VATS. One of the most rapid and effective methods of pouring gasoline from 55-gallon drums to 5-gallon cans is the use of an improvised dumping vat, which may operate on the grav-

ity feed system or provide greater facility for the use of several gasoline dispensers.

(1) *Gravity feed system.* The vat may be improvised by cutting 55-gallon drums in half lengthwise. If available, large storage tanks or sections of Quonset huts may be used. The vat is installed on the side of a hill. Drums are hauled to the vat by truck and the gasoline



Ⓐ *Halves of 55-gallon drums.*
Ⓑ *Gasoline storage tanks.*
Ⓒ *Pipe to outlet.*
Ⓓ *Outlet.*

Figure 14. Use of improvised dumping vat to transfer gasoline from 55-gallon drums to 5-gallon cans.

is emptied into the vat. Tarpaulins or a shed protects the vat from bad weather. The gasoline flows by gravity from the vat to large storage tanks and then into pipe lines for distribution to 5-gallon cans or to the tanks of vehicles. (See fig. 14.)

(2) *Gasoline dispensers.* Large or small dispensers may be used to pump the gasoline from the dumping vat to 5-gallon cans. The greater surface of the vat enables the use of several dispensers at one time and makes possible much more rapid transfer of gasoline than when it is pumped directly from drum to can. It is then not necessary to change the dispenser from one drum to another as the drums are emptied.

29. Transfer from Cans to Users.

After the 5-gallon cans are filled, they are moved forward to the using units by truck.

a. LOADING. In loading the cans, a 2½-ton truck will afford space for 125 cans. They are loaded crosswise to the body of the truck, 12 to a row. The last row has 5 cans turned lengthwise. (See fig. 15.) A 1-ton trailer will hold 40 cans.

Figure 15. Loading 5-gallon cans into a 2½-ton truck.

b. HANDLING. Care should be taken in handling the cans so that they will not become damaged and begin to leak. Constant supervision by officers and noncommissioned officers is necessary to insure that cans and drums are not thrown from or onto trucks. Pads of rope or salvage rubber may be attached to the back end of the trucks that are being loaded to absorb the shock to the cans.

c. EXCHANGE OF CANS. Full cans of gasoline are distributed on the basis of turning in empty cans. Unless this is done, the distributing point will soon issue all its full cans and will have no empty containers to refill for issue.

d. CARE OF EMPTY CANS. (1) All empty containers should be inspected for mechanical damage and leakage and the interior inspected for contamination. They should be protected against denting from careless handling and from contamination by dirt or other foreign matter.

(2) Usable cans and drums are cleaned, inspected, and released to canning sections for refilling. (For process of can cleaning, see par. 21*c*.)

(3) Defective cans and drums are returned to a base depot for reclamation by a salvage repair company.

SECTION VI
STORAGE OP PETROLEUM PRODUCTS

30. Inside Storage.

In theaters of operations petroleum products will generally be stored in the open, but if circumstances require indoor storage, certain precautions must be taken.

a. HEIGHT OF STACKS. Stacks of filled containers of flammable or combustible liquids should be limited to 10 feet.

b. AISLES AND CURBS. Leave 3-foot aisles between stacks of petroleum products and any other supplies. Provide curbs to prevent flow of spilled liquids to other sections of the warehouse.

31. Selection of Outside Storage Area.

a. ACCESSIBILITY. An outdoor storage area should be accessible to a satisfactory network of roads and railroads, but not too near heavy rail traffic on account of danger from flying sparks. It should not be too near obvious military targets.

b. TERRAIN. The site should be well-drained to prevent water damage and reasonably level to permit building good stacks. Depressed areas should be avoided because dangerous gasoline vapors may remain in them. One advantage of storing gasoline on the sides of low hills is that in case of fire, contents of the drums would not flow from one stack to another but down into the gullies below. Care should be taken that the terrain does not allow such streams of burning gasoline to flow into a river where barges are assembled.

c. CAMOUFLAGE POSSIBILITIES. Importance of natural concealment and camouflage depends upon the expected danger from enemy aircraft. Advantages of exploiting such natural screens as trees, bushes, trenches, ruined buildings, and walls should be considered in choice of site.

d. DISPERSION. The site should be large enough to permit necessary dispersion of stacks for protection against enemy bombing.

e. DISTANCE FROM BUILDINGS. A clearance of 250 feet from all buildings is recommended.

f. WATER SUPPLY. Nearness to a natural water supply is a great advantage in fighting possible petroleum fires. If no natural supply is accessible, plans must be made for the installation of sufficient water tanks to control possible fires.

32. Plan of Storage Area.

The plan of a petroleum storage area depends upon the size of the dump, the nature of the terrain, and the character of activities to be carried on in the area. (See figs. 16 and 17 for petroleum storage in two different theaters of operations.)

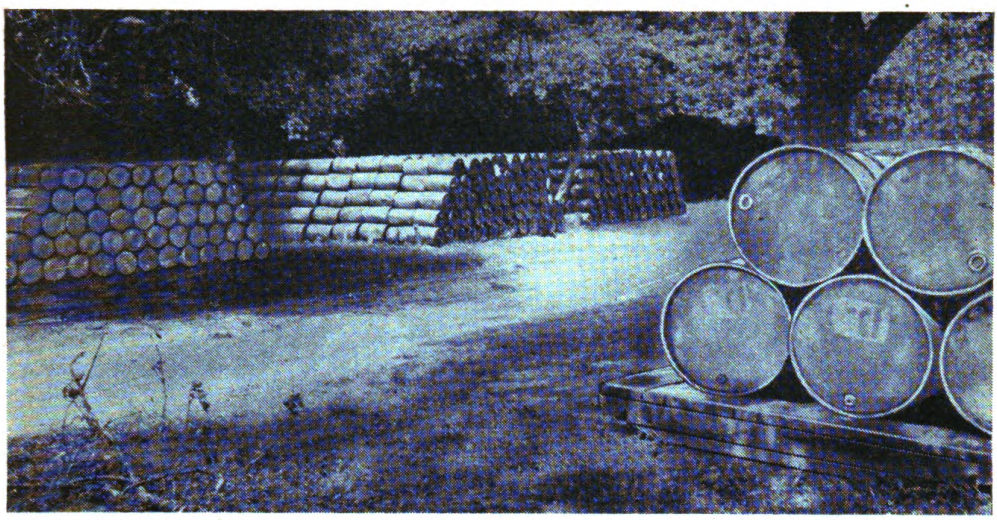


Figure 16. Petroleum storage area in France. In left background are 6-gallon oil drums, and in right foreground are 55-gallon Diesel oil drums. Note excellent use of natural concealment.

Figure 17. Petroleum storage area in the Southwest Pacific. Hillside site provides good natural drainage. No dispersion is practiced here.

a. SEGREGATION OF PRODUCTS. Different areas will normally be set aside for each size of different products, such as gasoline, Diesel oil, kerosene, white gas, lubricating oils, and greases.

b. CLEARING YARD. A special area may be set aside as a clearing yard for mixed loads of petroleum products.

c. DUMP OFFICE. At or near the entrance to the dump, a dump office will be set up to house the records and personnel maintaining the records.

d. TRAFFIC PLAN. A traffic-control system will be established for the dump in order to insure rapid and efficient movement of vehicles through the storage area. All personnel should be familiar with the

system, and signs should be posted to guide the drivers of incoming vehicles.

e. ROADS. In accordance with the set-up of the traffic-control system, roadways will be laid out and constructed to permit vehicles to pass through the storage area. Proper drainage will be provided so that roads will be passable in all weather.

f. SIGNS. Signs will be painted and placed along routes leading to the dump. Signs will be used to designate offices, storage areas, types of products, latrines, and "No Smoking" areas.

g. CONTINUOUS OPERATION. Each storage area will be so planned that it can function during any hour of the day or night and in any kind of weather.

h. WATER SUPPLY. A sufficient supply of water and fire-fighting equipment must be made accessible.

i. MAPS AND SKETCHES. Maps and sketches of the storage area should be available for use as working sheets. They should include information concerning dump areas and sections, fire stations and equipment, smoking areas, guard posts, latrines, traffic-control system, and location of various products.

33. Construction of Base.

a. CLEARING. Area for 30 feet around the storage blocks should be cleared of vegetation.

b. MATERIAL. Where possible, a bed of sand, rock, or gravel should be provided to help drainage. The base itself should be a concrete platform, brick paving, slabs, or similar material. Ashes and cinders should be avoided because of the corrosive damage to metal containers. Finished level of the foundation should be a few inches above the general ground level.

c. DIKES AND DITCHES. Adequate dikes or drainage ditches should be provided around the blocks to prevent the flow of burning liquids from reaching other blocks of petroleum products. They should be large enough to contain all the liquid stored within.

34. Method of Stacking.

a. FIVE-GALLON CANS (see fig. 18). (1) Store cans upright on their bases.

(2) Store cans not more than five high.

(3) Store cans in blocks or pyramids not more than 50 feet each way (2,500 square feet per block).

(4) When cans are stored in blocks, place shoring at ends of blocks to permit expansion of cans without toppling. When cans are stored in pyramids, indent each tier about 6 inches so that any can above the first tier will rest on at least two cans underneath. Pyramidal stacks, which require no bracing, lose only 6 percent of the volume of straight stacks having the same base dimensions.

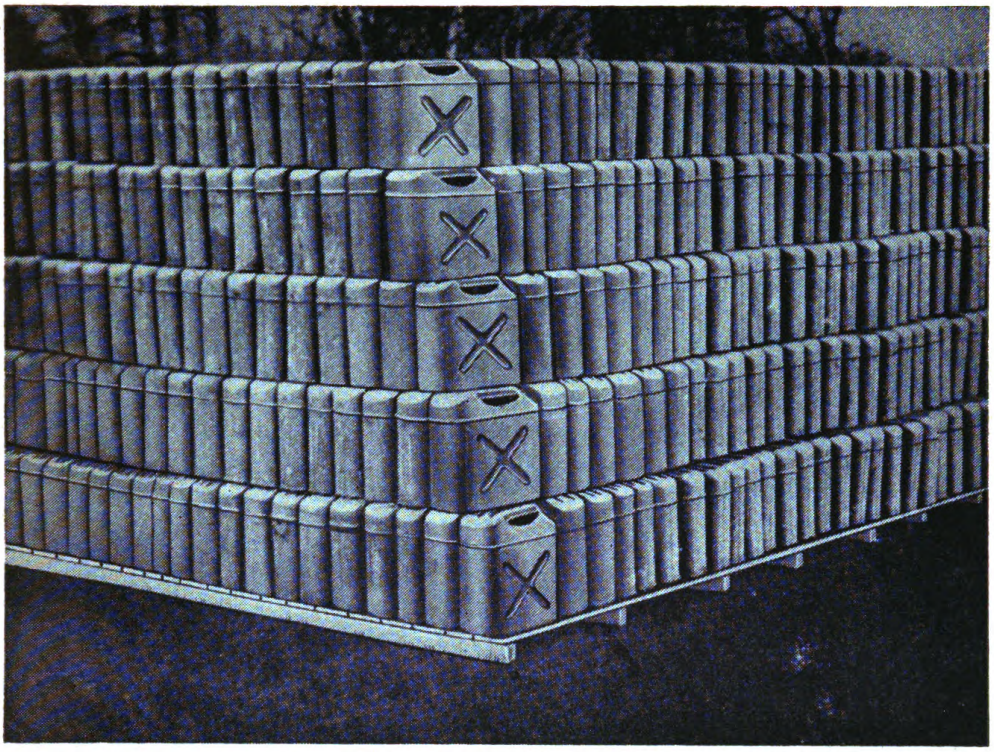


Figure 18. Proper stacking of 5-gallon cans of gasoline. In such pyramid stacks each tier is indented so that any can above the first tier rests on at least two cans underneath.

(5) Dunnage of 2- by 6-inch lumber is used beneath the first tier of cans. It should be tied in with wooden strips or boards to form at least partial flooring. No dunnage is required between upper tiers of cans, but pallets may be used if desired.

(6) Leave a 30-foot aisle on all sides of each 50-foot square section.

(7) Leave a 150-foot firebreak on all sides of each block made up of nine of these sections.

(8) Provide dikes or drainage ditches around each block.

(9) Tarpaulins should be used over stacks of empty 5-gallon cans.

b. FIFTY-FIVE GALLON DRUMS (see fig. 19). (1) Store drums on their sides, butt to butt, in rows of two, with bungs and vents turned outward and below the surface of the liquid. The bungs and vents are turned outward to assist in the detection of leaks; the bungs and vents are placed below the surface of the liquid to preserve the gaskets by keeping them wet. If stored on ends, the drums collect rain water, which rusts the top of the container and may seep through and contaminate contents.

(2) Store full drums not more than three high.

(3) Restrict length of rows to 51 drums on lowest tier, thus limiting the number of drums in a double row to 300 when they are stacked 3 high. This double row of 300 drums is called a unit. Twelve such units make up a section (3,600 drums); and nine sections compose a block (32,400 drums). (See figs. 20, 21, and 22.)

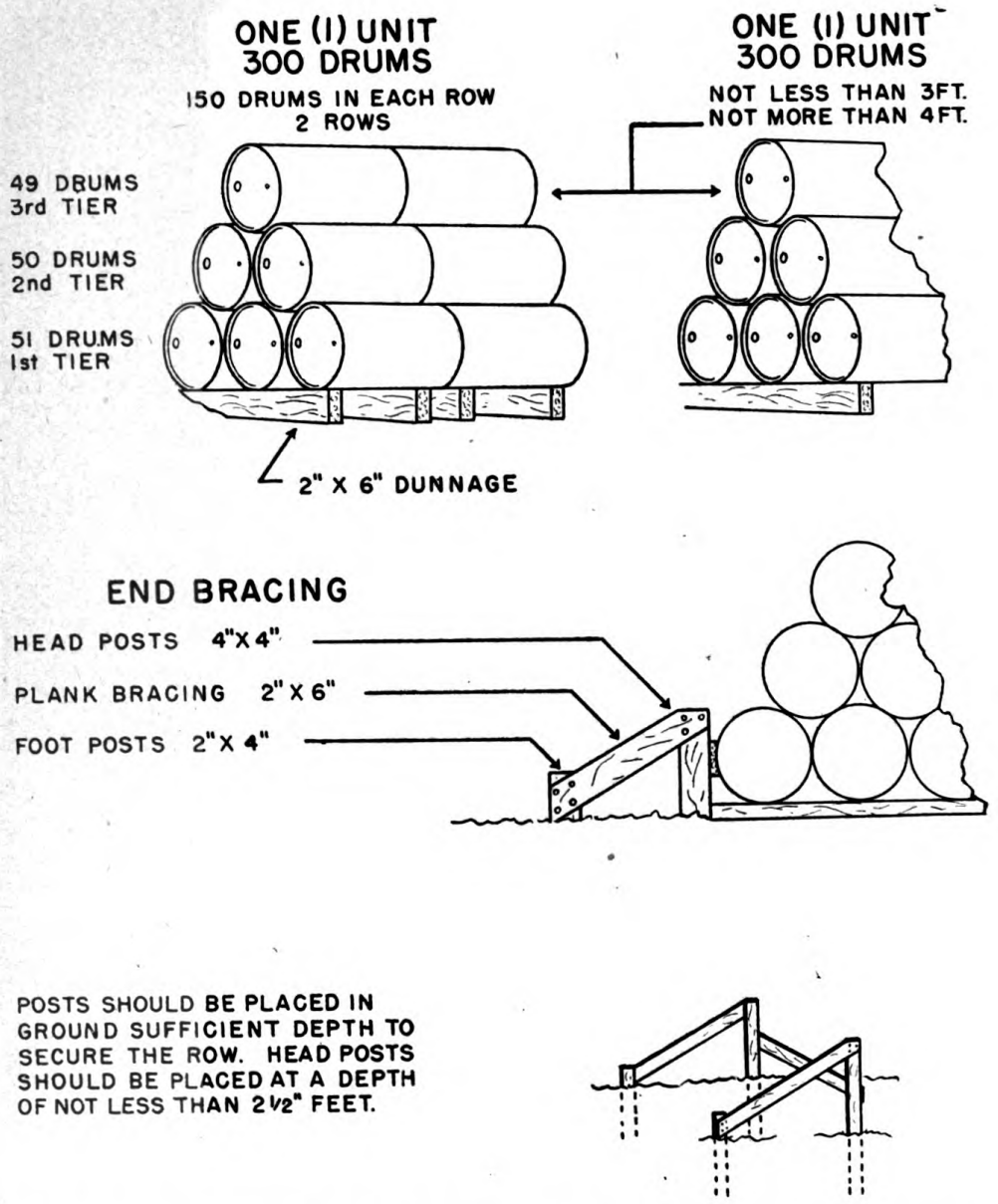


Figure 19. Proper storage of 55-gallon drums of gasoline. Stacks should be not more than three drums high.

(4) Brace ends of the bottom tier to insure drums against damage from rolling or toppling.

(5) Place dunnage between bottom tier of drums and the ground. Upper two tiers may be nested without damage.

(6) Leave an aisle of at least 3 feet and not more than 4 feet between double rows to permit inspection and the removal of leaky drums.

(7) Leave a 30-foot aisle on all sides of each section of 3,600 drums.

(8) Leave a 150-foot firebreak on all sides of each block of nine sections.

(9) Provide dikes or drainage ditches around each block.

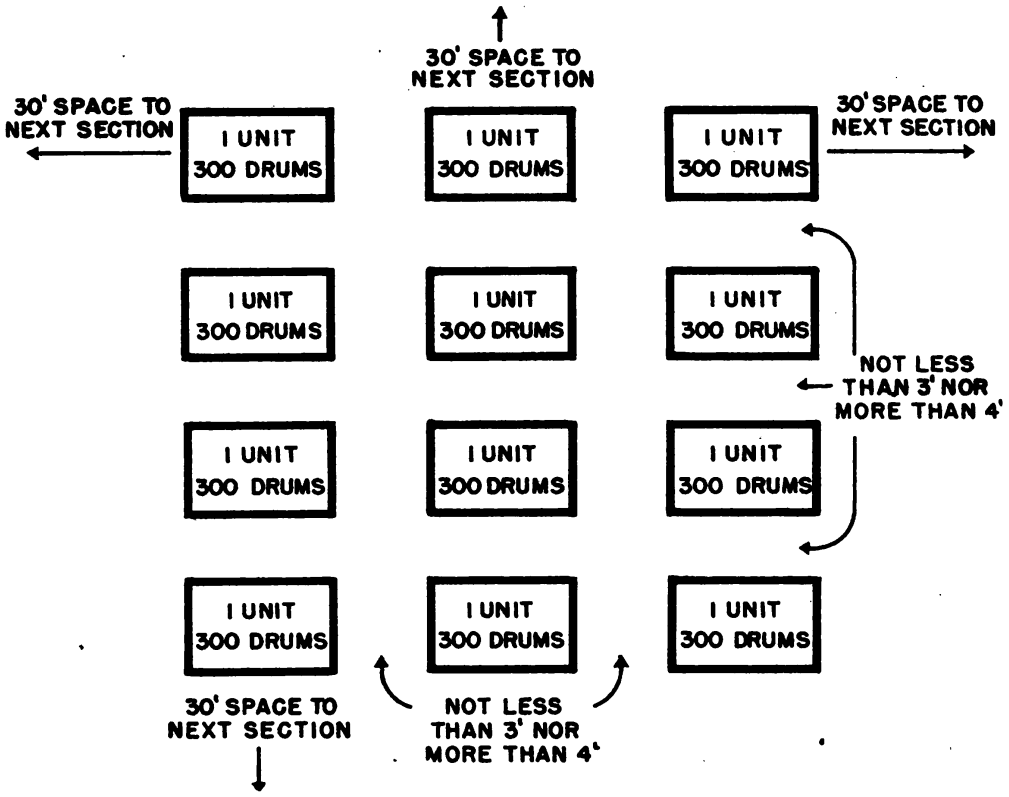


Figure 20. Outside storage of gasoline in drums. One section—3,600 drums.

(10) No tarpaulins need be used over stacks of drums, either full or empty.

c. PACKAGED LUBRICANTS. (1) Store all petroleum-product containers other than 5-gallon cans and 55-gallon drums upright on their bases in open storage.

(2) Cover these containers with tarpaulins to protect them from contamination or other damage.

(3) If the tarpaulins do not give sufficient protection, store the products in sheds.

35. Inspection of Containers.

All containers coming into a storage area will be carefully checked for leakage. If the drum or can is leaking, it will not be placed in the stacks but set aside for decanting into other containers or for immediate local use. Containers will also be inspected for proper markings and for dates so that the oldest petroleum can be issued first.

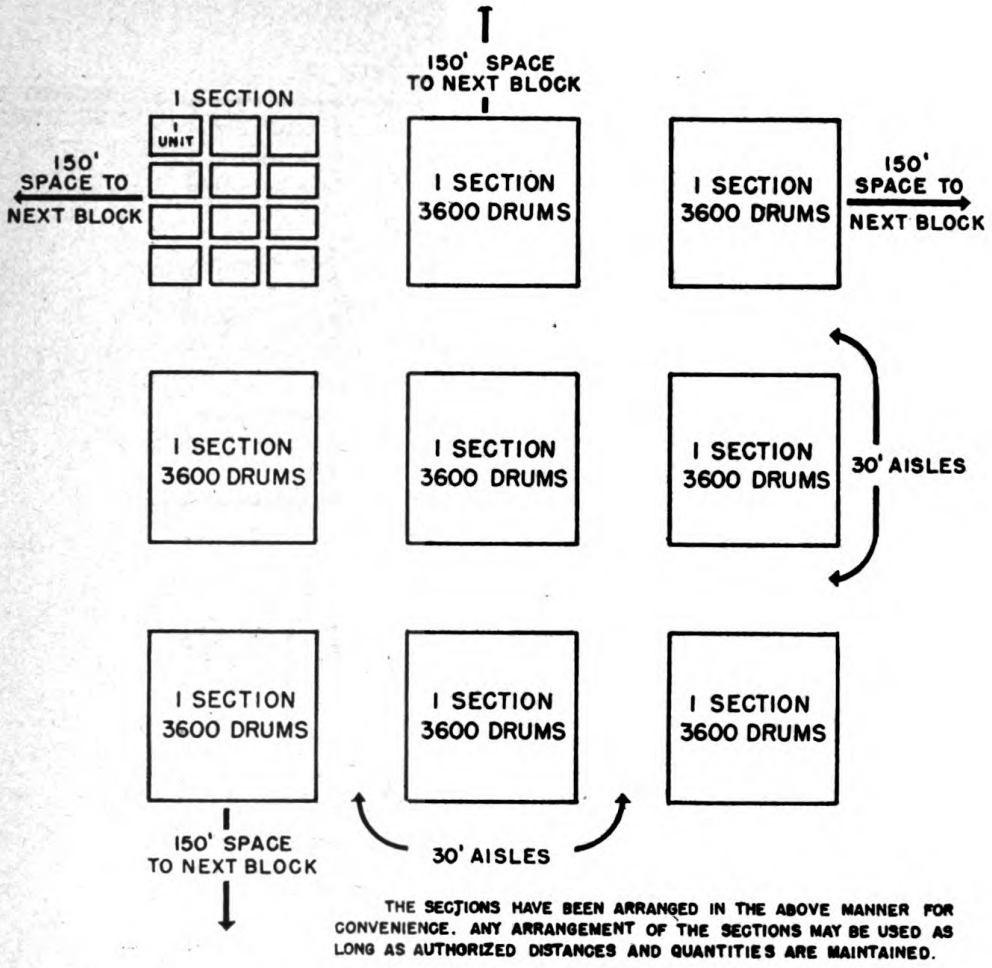


Figure 21. Outside storage of gasoline in drums. One block—32,400 drums.

36. Re-using Drums in the Field.

a. CLEANING. If empty drums are used again in the field, they should be thoroughly cleaned before a new supply of petroleum is placed inside.

b. MARKING. Old markings should be checked to see that they are correct for the new contents. If they are not correct, they should be obliterated and new markings properly placed on the containers.

37. Products in Damaged Containers.

a. USE AT BASE. Petroleum products in damaged containers should be transferred to good containers or they should be used at the base. Under no circumstances should they be forwarded to the front.

b. DISPOSITION OF CONTAINERS. If the damaged containers can be repaired for further use, repairs must be made as soon as possible. If they are unrepairable, they must be turned over to salvage for conservation of the material.

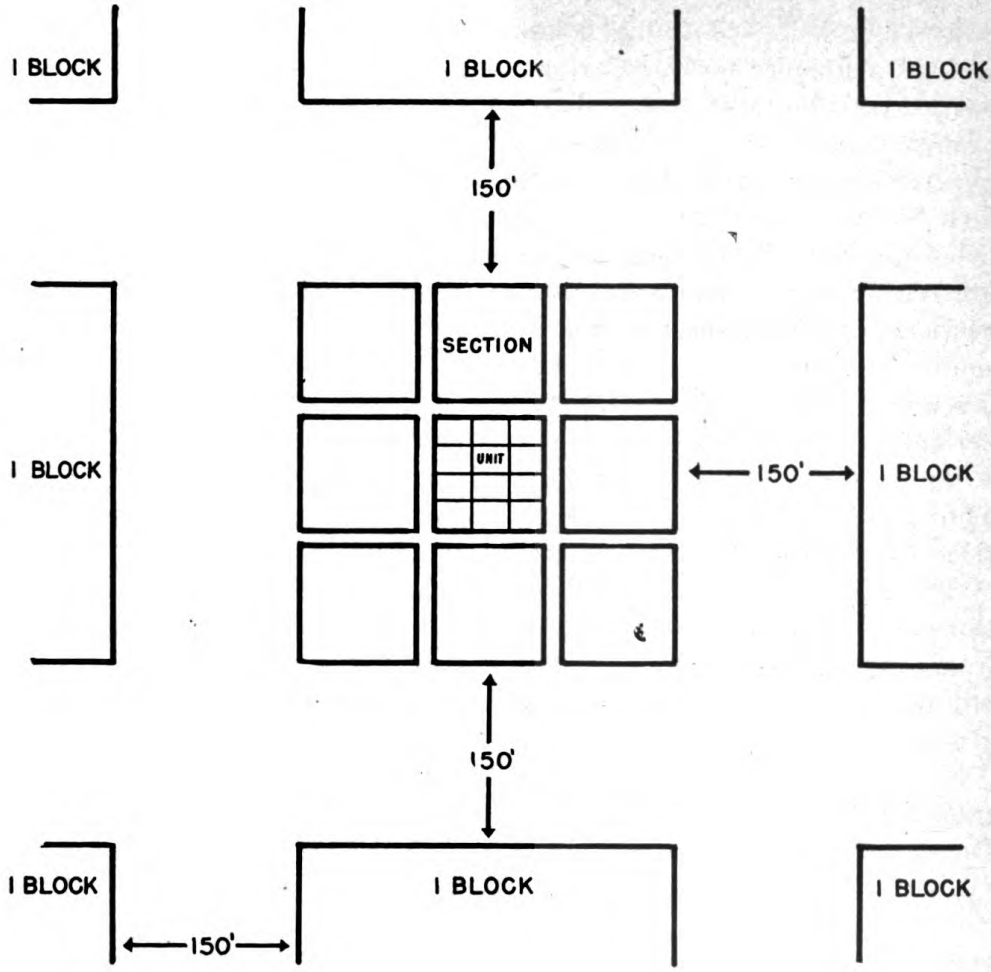


Figure 22. Outside storage of gasoline in drums. Layout of blocks.

38. Stationary Storage Tanks.

Bulk storage of petroleum products at ports, tank farms, and large gasoline dumps utilizes various types of stationary storage tanks. They may be cylindrical steel tanks placed underground or aboveground or collapsible containers of synthetic rubber-impregnated fabric placed aboveground. These large containers permit the storage of petroleum in large enough quantities to form the "cushion" necessary for uninterrupted operations. For details of construction see TM 5-350.

a. STEEL TANKS. These containers are usually bolted tanks ranging in capacity from 250 to 10,000 barrels. Some larger welded tanks have a capacity of 40,000 to 80,000 barrels. Tanks designed to contain products with high flash point such as fuel oil and lubricating oil have simple roof fittings, comprising a number of dip holes and vents and one

or two manholes. The dip holes are used for gauging and sampling, and the manholes for ventilating the tank before cleaning or repairing operations. Suitable fire arresters are installed to protect the tanks against flames. Roof fittings on tanks used for gasoline are more complicated because of the lower flash points and subsequent dangers from fires or explosions. To prevent the escape of oil vapors, the gauging holes are made gastight and the roofs are fitted with pressure and vacuum relief valves. Tanks are usually equipped with two pipe-line connections, one for filling the tank and one for draining. As a protection against the spreading of an oil fire, tanks are surrounded by a levee, or fire wall, made of soil, cement, or brick. It should be large enough to accommodate 125 percent of the tank contents.

(1) *Underground.* Tanks may be placed underground for concealment and for additional protection. They will be installed on a foundation of firm earth or other satisfactory material.

(2) *Aboveground.* Most of the storage tanks in theaters of operations are installed aboveground. They may be painted for camouflage from airplane observation. All possible fire precautions should be taken around the tanks, and suitable fire-fighting equipment should be kept accessible.

b. COLLAPSIBLE CONTAINERS. These are constructed of synthetic rubber-impregnated fabric and may be used for storage of gasoline and Diesel oil when short-time storage is expected and steel tanks are not available.

(1) Nonrigid cells of 1,000- and 3,000-gallon capacity are designed only for storage of liquid fuel. They are supported inside a canvas housing and rest on a canvas ground cloth. Since these containers are vulnerable to sharp, rough objects, a ground site should be level and free of stones, sticks, or other rough objects. Each cell should have a ditch around it large enough to hold 125 percent of the fuel in the container.

(2) Rigid cells of 750- and 2,700-gallon capacity are designed for both storage and transportation of liquid fuels. They are supported inside a plywood housing. When used for storage each cell should have a ditch around it and the distance between the collapsible containers should be not less than twice the diameter of the container. The 750-gallon cell and the 2,700-gallon cell when erected and filled, may be transported by truck. Three of the 2,700-gallon cells may be placed lengthwise on a flatcar for transportation. These cells should be grounded when used either to store or transport fuels.

39. Field Expedients.

a. BANKED EARTH. Stacks of drums or cans may be given additional protection from enemy fire by having dirt banked around them with a bulldozer. Earth should be piled around all four sides of stacks not used and on three sides of stacks not often used, the only stacks left completely open being those for the daily issue. This not only protects the

petroleum from direct hits but also prevents the spread of fire if one container is ignited. If a fire is started, this dirt prevents air from being sucked in from the bottom of the stack to feed flames on the top.

b. STORAGE PITS. When the nature of the terrain and the proximity of the enemy make it practicable, drums and cans may be stored in shallow pits dug into the soil and scattered strategically over the storage area. They provide both concealment and protection. Soil from the pits can be used as added protection around the cans. If an enemy hit is scored, the fire burns within the pit and may be extinguished by throwing soil from the sides and smothering it.

c. TREES. Trees or thick undergrowth may be used to conceal dumps of petroleum, with drums or cans stacked at the base of the trees and dispersed throughout the grove. If a hit is scored in any one pile, drums may be rolled away from the fire.

d. EXPLOITING TERRAIN. If available, such natural aids to concealment as ditches, trenches, caves, banks of earth, walls, or ruins of buildings may be utilized for storage purposes.

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SECTION VII
FIRE PROTECTION

40. Classes of Fires.

a. CLASS A FIRES. These are fires of ordinary combustible materials such as paper, wood, textiles, and rubbish and may be extinguished by water.

b. CLASS B FIRES. These fires of flammable liquids such as gasoline, oils, and greases and must be smothered in order to extinguish them.

c. CLASS C FIRES. These fires are in electrical equipment and require the use of some nonconducting extinguishing agent.

41. Causes of Petroleum Fires.

Class B fires in petroleum storage areas may be caused by the following:

a. Sparks, which can produce explosions and subsequent fires in flammable gasoline vapors.

b. Heat, which if excessive may become a dangerous fire hazard. Heat generated by burning drums may cause rupture of other drums, thereby spreading the fire.

c. Enemy action, which may cause explosions and huge fires at any time.

d. Static electricity, which may be generated by the passage of gasoline through a hose or by the movement of a truck over the highway. In the presence of readily ignitible gasoline vapors, such an electrical charge is a definite hazard.

e. Storms, which sometimes succeed in starting petroleum fires.

f. Leaks, which not only waste gasoline but also provide danger spots for fire hazards.

g. Smoking, which is a common hazard at all petroleum areas and should not be tolerated.

42. Fire Plan.

Every petroleum storage area should have a definite fire plan, with regulations on fire prevention and instructions on fire fighting.

a. All personnel handling petroleum should be made conscious of the constant danger from fires and of the precautions that must be taken every day.

b. Personnel should be thoroughly trained in fire fighting.

(1) Fire drills should be held often enough for all personnel to become familiar with the plans for fire fighting and with efficient operation of all equipment.

(2) Demonstrations of the best methods of combating petroleum fires should be given. All available types of extinguishers should be used to show their effectiveness.

c. Proper equipment for fighting fires must be provided.

(1) Fire signals are necessary, particularly in large storage areas. All personnel should be trained to recognize the sound of the signals.

(2) Suitable types of fire extinguishers must be easily accessible to all petroleum storage areas, such as smothering foam, loaded stream, carbon dioxide, carbon tetrachloride, or dry chemical. (See par. 45). Small hand extinguishers should be placed at every stack. Larger wheeled units should be available for combating fires which are too far out of control for the hand extinguishers.

(3) If available, a crash truck may be kept at a central location and rushed to the scene of the fire as soon as possible.

d. Fireguards may be assigned to strategic points in the area to report and to start fighting any fire immediately.

e. Fire walls and ditches may be used as protection against the spreading of fire from one stack to another.

f. If a civilian fire-fighting organization is within reach of the petroleum storage area, arrangements should be made to secure assistance in case of fire.

43. Fire Precautions.

a. GENERAL. (1) There will be no smoking within the storage area, and "No Smoking" signs should be prominently displayed. Personnel should not carry matches or lighters.

(2) Only vaporproof lights or flashlights should be permitted. Any electrical equipment in the area should be vaporproof.

(3) No filtering of gasoline under pressure should be allowed. If filtering through a chamois skin is necessary, the funnel holding the chamois will be adequately grounded to the container into which the gasoline is being poured and will not be supported by wood or other insulating materials. The practice of tying a chamois skin over the end of a nozzle to act as a strainer or filter should be prohibited.

(4) Trucks should not be parked in groups within a storage area. Vehicles should not be allowed within 50 feet of the actual discharging operation at a decanting point.

(5) Precautions should be taken against sparks from exhausts, nearby trains, shoes with metal nails, metal buttons, key chains or tools, and from striking the metal nozzle of a hose against a metal can.

b. STORAGE AREAS. (1) All petroleum storage areas should be kept clean and orderly. Particular attention should be taken to see that no piles of trash, waste paper, or oily rags are on hand as possible fire hazards.

(2) Banked earth or ditches may serve as protection against the spread of fire.

(3) All gasoline containers should be kept plugged when not being filled or emptied.

(4) All containers should be inspected frequently for leaks. Leaking containers should be removed from storage. Any gasoline which has

leaked upon the ground should be covered with sand. Sawdust should not be used for this purpose.

c. STORAGE TANKS. (1) When gasoline storage tanks are installed, they should be given every possible fire protection, such as dikes or fire walls.

(2) Proper vents and flame arresters should be installed in tanks to prevent any danger from fire flashing back to the tank.

(3) If tanks which have held gasoline are to be cleaned, they should first be freed from dangerous vapors. This requires thorough flushing with a strong chemical solution or thorough flushing followed by steaming for several hours to remove all vapors and sludge. Tank cleaning should not be attempted without experienced personnel and adequate equipment.

44. Principles of Extinguishing Fires.

Fire is a result of combining fuel, heat, and oxygen. (See fig. 23.) Petroleum fires are caused by combining petroleum vapor (fuel), ignition temperature (heat), and air (oxygen). Since all three of these must be present to make a fire burn, one of the three must be removed to extinguish a fire. (See fig. 24.)

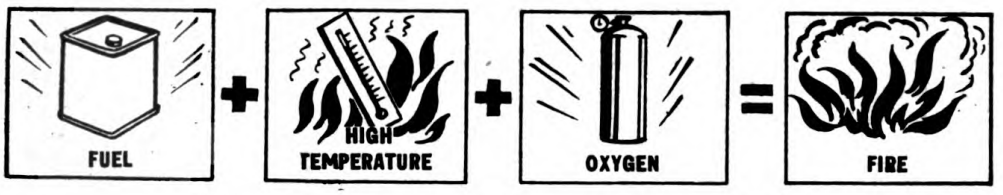


Figure 23. How fires are caused.

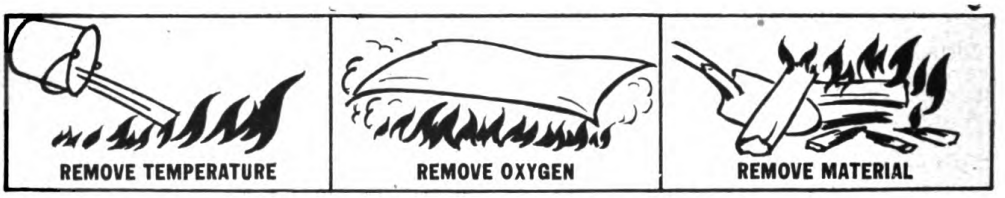


Figure 24. How to extinguish a fire.

a. COOLING. If you remove the heat from a fire, you extinguish it by cooling. This is usually done by the application of water.

b. STARVING. If you remove the fuel from a fire, you extinguish it by starving. This may sometimes be done in a petroleum fire by cutting off the flow of oil to the flames.

c. SMOTHERING. If you remove the oxygen from a fire, you extinguish it by smothering, just as you may snuff out a candle by placing an inverted glass over it or extinguish a cigarette lighter by closing the top. This smothering is the most effective means of fighting a petroleum fire and may be accomplished by the use of foam, carbon dioxide, carbon

tetrachloride, water, or steam. (Additional information on principles and methods of fire fighting may be found in TM 5–315, and TM 9–1799).

45. Methods of Extinguishing Fires.

a. FIRE EXTINGUISHERS. (1) *Foam.* Foam is a lather-like mass of carbon-dioxide-gas-filled bubbles. It is lighter than the lightest oil oil products and will therefore float on the surface of the liquid, forming a flexible, fluid blanket which cuts off oxygen from the burning oil and thereby extinguishes the flame. The cooling effect of water in the foam also helps to lower the temperature.

(*a*) *Nature of equipment.* In the chemical foam extinguishers an outer chamber contains bicarbonate of soda and a foam-stabilizing agent dissolved in water; and inner chamber contains a water solution of aluminum sulfate. When the extinguisher is inverted for use, the chemicals mix, creating carbon-dioxide gas which permeates the liquid and forms a tough, durable foam. Such devices as foam "playpipes" are sometimes used to apply foam solution and secure rapid coverage.

(*b*) *Use of equipment.* In order to build up an unbroken blanket of foam over the burning surface, it is well to play the stream against a vertical wall or side of a tank or the ground so as to permit the natural spread of the foam back over the burning surface. You may also lob the stream onto the surface so that the foam will fall gently. (See fig. 25.) If the burning oil is spattered by too strong and direct a stream of foam, the fire will be spread rather than smothered. Foam breaks down continuously. In order to build up a blanket over the entire surface, a foam stream must be applied faster than the fire will destroy it. Foam may be produced directly from a small extinguisher. (A 2½-gallon extinguisher will produce from 20 to 22 gallons of foam.) Foam may be applied from hose streams, with the foam solution introduced into the stream of water. (Nineteen gallons of water plus 1 gallon of foam solution will produce 350 gallons of foam.) Various foam-producing devices are available which will produce from 350 to 4,500 gallons of foam per minute. Fresh water

Figure 25. How to use a foam extinguisher.

or salt water may be used in making the foam. The use of foam as an extinguisher in stacks of cans has been declared not entirely effective because it has a tendency to remain on top of the cans instead of penetrating throughout the stack and extinguishing the fire between and below the cans. Water and mud have been used under such conditions.

(*c*) *Inspection of equipment.* Foam extinguishers should be carefully inspected monthly and recharged annually as well as immediately after use. They should not be stored in below-freezing temperatures.

(2) *Loaded stream.* (*a*) *Nature of equipment.* The loaded-stream unit has an extinguishing solution containing alkali metal salts, which is effective on small petroleum spill fires.

(*b*) *Use of equipment.* To use the extinguisher, turn it upside down and bump on floor or ground. This punctures the gas cartridge which expels the contents. The range is 30 to 40 feet, and the time of discharge is approximately 1 minute for a 2½-gallon unit.

(*c*) *Inspection of equipment.* Complete inspection of the extinguisher should be given monthly. It should be recharged immediately after use.

(3) *Carbon dioxide.* (*a*) *Nature of equipment.* The extinguisher holds liquid carbon dioxide under pressure. When the extinguisher valve is opened, the pressure is released. Extinguishers are made with both disk valve and seat valve. When the disk type valve is pierced, the entire contents of the cylinder are discharged, although a temporary shut-off is provided. The seat type valve permits any desired amount of gas to be discharged. When the valve is closed, the remainder of the gas can be saved for future use. The liquid carbon dioxide upon contact with the air turns into a gas which blankets the fire by shutting off the supply of oxygen. Approximately 9 cubic feet of gas is released for each pound of compressed gas. The range of the stream is about 6 feet.

(*b*) *Use of equipment* (*see fig. 26*). The stream should be aimed at the base of the fire. This type of extinguisher can be used effectively to put out "three-dimensional" fires, that is, oil fires which burn both vertically and horizontally, such as a waterfall of flame from a broken pipe, or burning oil pouring from a broken container over a bench to the floor. Another efficient use of the carbon-dioxide fire extinguisher is to flood a relatively large space with the gas to dilute the oxygen in the air and make combustion impossible.

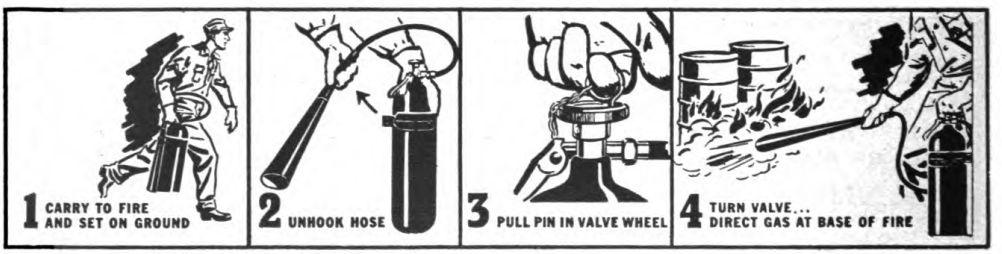
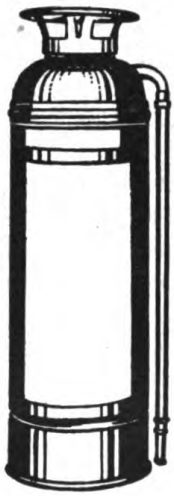


Figure 26. How to use a carbon-dioxide extinguisher.

(c) *Inspection of equipment.* Carbon dioxide extinguishers should be inspected monthly. It is not necessary to recharge them periodically, but their weight should be checked at least twice a year to detect leakage or accidental release. The correct charged weight is stamped on each extinguisher. If the extinguisher shows a loss of more than 10 percent in weight, it should be recharged.

a



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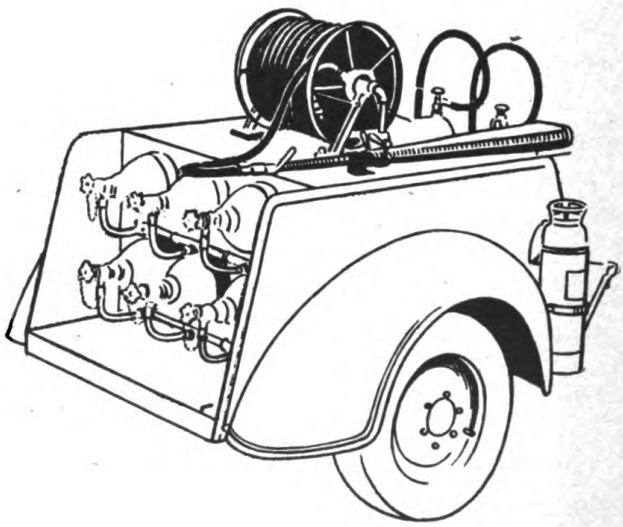


d

a. 1½-quart carbon tetrachloride.
b. 2½-gallon foam.
c. 15-pound carbon dioxide.
d. 300-pound carbon dioxide.

Figure 27. Various types and sizes of fire extinguishers.

(4) *Carbon tetrachloride (vaporizing liquid).* (*a*) *Nature of equipment.* The extinguisher holds carbon tetrachloride in liquid form which is vaporized into gas by the heat of the fire. Most extinguishers are of the pump type. The range is 20 to 30 feet. The discharge of a 1-quart unit lasts about 45 seconds and a 2-quart unit about 2½ minutes.

(*b*) *Use of equipment.* The liquid is pumped out and the stream directed at the base of the flames. When the liquid becomes gas, it cuts off the supply of oxygen and thus extinguishes the fire.

(*c*) *Inspection of equipment.* Extinguishers should be partially discharged and recharged semiannually and should always be refilled immediately after use. They should be inspected monthly. Do not use water in this extinguisher for any purpose.

(5) *Dry chemical.* (*a*) *Nature of equipment.* The extinguisher contains chemically processed bicarbonate of soda, which is released when a turn of the handwheel punctures an inner cartridge of carbon dioxide or nitrogen. A valve on the nozzle controls the discharge. The range is 10 to 14 feet. The discharge of the 7½-pound unit lasts about 15 seconds; of the 12-pound unit, 20 to 25 seconds; of the 20-pound unit, 40 to 45 seconds.

(*b*) *Use of equipment.* The stream should be aimed at the base of the blaze.

(*c*) *Inspection of equipment.* Extinguishers should be kept filled with the specified weight of chemical and should be refilled immediately after use even though only partly discharged. The carbon dioxide cartridge used to expel the compound should be removed and weighed annually. If it shows loss of one-half ounce or more, it should be replaced. Do not use water in this extinguisher for any purpose. (See fig. 27 for examples of various types and sizes of fire extinguishers.)

(6) *Characteristics and uses.* The various types of fire extinguishers, their characteristics, and uses in fire fighting are as follows:

Type of extinguisher	USE IN FIRE FIGHTING			Subject to freezing	Conductor of electricity
	Class A (ordinary fires)	Class B (flammable liquids)	Class C (electrical equipment)		
Water (*a*) Plain water	x			Yes	Yes
(*b*) Antifreeze	x			No	Yes
(*c*) Soda and acid				Yes	Yes
Foam	x	x		Yes	Yes
Loaded stream	x	x		No	Yes
Carbon dioxide (inert gas)		x	x	No	No
Carbon tetrachloride (vaporizing liquid)		x	x	No	No
Dry chemical		x	x	No	No

b. WATER. (1) *Disadvantages.* Water is not generally used in fighting petroleum fires because a jet of water striking into the surface of burning petroleum will disperse the petroleum and thus spread the fire. Because water has a greater density than oil, it is also likely to sink through the oil without its normal cooling effect.

(2) *Advantages.* However, if judiciously employed, water can be of considerable use. In the early stages of an oil fire there is usually a fairly shallow layer of hot oil at the top with a body of cool oil beneath. Directing a stream of water into such oils will tend to mix the hot layer with the cool oil beneath, causing the temperature of the mixture to go below the flash point and thus extinguish the fire. Oils which froth, such as lubricating, fuel, and crude oils, can be extinguished with water by producing a froth on the surface which insulates the oil and stops the formation of vapor essential to ignition. The water should be lightly and intermittently sprayed on the oil in small amounts to form a froth. Gasoline has little tendency to froth and, if burning, can be extinguished with water only by applying a very fine spray or fog over the entire burning surface. The vapor-air mixture must be diluted with fine water particles to such an extent that combustion cannot continue. Use of water applied through a fog nozzle has been found effective. It should be remembered that water is very valuable for protecting surrounding stacks of petroleum products which have not yet caught fire. Water sprayed on these stacks cools them and prevents their reaching the point at which they will ignite from nearby flames. In using water on burning tanks, care must be taken to keep excess water from floating the burning gasoline outside the fire walls.

c. SAND. In the absence of more effective extinguishers, sand may be employed to put out a small petroleum fire by blanketing it. The sand should be applied forcefully with hands or scoops and not just poured out of a bucket. In addition to the smothering effects of the sand, force beats out the flames. Buckets of sand may be kept accessible near stores of petroleum. Damaged drums may be used for sand containers. Sand is also used to cover areas where gasoline has leaked from the container or has been spilled. This prevents the formation of flammable vapors. Wet sand or mud may also be used to extinguish flames within stacks of cans where foam does not easily penetrate.

d. BLANKETS. If blankets are available, they may be used to smother small fires. Blankets are also effective for prompt extinguishing of burning clothing on personnel handling petroleum products. They exclude oxygen from the flames.

e. STEAM. Steam is useful for fighting fires in small, nearly inclosed places, where sufficient steam can be introduced to dilute the vapor-air mixture and prevent combustion. It is of little use outdoors.

f. EXTINGUISHING SPECIAL FIRES. (1) Brush or grass fires near stored petroleum may be extinguished by water. Trash fires may be

smothered by earth or sand, or by scattering the burning material if water is not available.

(2) A ground fire or a burning pool of gasoline may be extinguished by foam or water in the form of fog or very fine spray. Such fires should be approached from the windward side and the extinguishing fluid directed at the base of the flame.

(3) Fires at tank-car or truck unloading sites should be fought by first closing the outlet valves to cut off the supply of gasoline from the car or truck. The fire may then be smothered with foam or carbon dioxide. If the fire is in the dome of a tank car, it may be smothered by covering the dome opening with a wet blanket or burlap bag. If a fire is seriously exposing a truck, the extinguishing unit on the truck should be operated so that all vapor spaces are filled with the carbon dioxide.

(4) Fire at a vent or manhole of a storage tank may be extinguished by covering the opening with a wet blanket or by use of a carbon-dioxide extinguisher or high-pressure water spray or fog.

(5) Fire at a leak or break in a pipe line should be fought by stopping the flow of gasoline which feeds the fire. After the flow of gasoline has been cut off, any remaining pool of burning gasoline may be controlled by foam or water spray.

(6) Fires in storage tanks are most effectively extinguished by the application of foam allowed to flow onto the burning oil surface as gently as possible until it smothers the flame. Fine water sprays are also effective for smothering and cooling such fires. If several tanks are burning, fire in the windward tanks should be extinguished first.

(7) An electrical fire should be fought by first cutting off the source of power supply to the apparatus. Then carbon-dioxide or carbon-tetrachloride extinguishers should be used because they are nonconductors of electricity.

SECTION VIII
OTHER HANDLING HAZARDS

46. Inhaling Vapors.

a. DANGEROUS SYMPTOMS. Inhaling gasoline vapors may cause headaches, dizziness, nausea, or even unconsciousness.

b. FIRST AID. If any of these symptoms are noticed among men handling gasoline or working in an area where gasoline has been spilled, they should be taken as a warning of the presence of dangerous amounts of gasoline vapor in the air. All exposed persons should be sent out of the area at once. If men have been overcome, they should receive immediate medical attention. First aid consists of removing gasoline from the skin (if the skin or clothing has been contaminated), the prevention of chilling, and artificial respiration if breathing has ceased.

47. Injury to Skin and Eyes.

a. SKIN. Gasoline may cause severe burns if allowed to remain in contact with the skin, particularly under soaked clothing or gloves. Clothing or shoes through which gasoline has soaked should be removed at once. Gasoline should be washed from the skin with soap and water. Repeated contact with gasoline removes the protective oils from the skin and causes drying, roughening, chapping, and cracking and, in some cases, infections of the skin. Gloves should be worn as protection by persons handling petroleum.

b. EYES. If gasoline gets into a person's eyes, first aid should be given immediately. Olive oil, castor oil, or mineral oil may be applied, and medical attention should be secured.

48. Lead Poisoning.

Although lead poisoning is not likely to occur from skin contact with leaded gasoline or from swallowing it or inhaling its vapors from open containers, it may occur from repeated exposure to gasoline vapors in an inclosed or inadequately ventilated area where leaded gasoline has been spilled in considerable quantity. There is also danger of lead poisoning from tetraethyl-lead vapor in large tanks used for storage of gasoline and from fumes given off by stoves or other gasoline-burning equipment in which leaded fuel is used. Adequate ventilation should be insured. If operating personnel are exposed persistently to leaded gasoline, they should be rotated on the job in order to limit the period of individual exposure.

49. Accidents.

a. SLIPPING AND FALLING. Among the causes of accidents to personnel handling petroleum products are slipping and falling. This danger is particularly grave while men are climbing to and from loading racks, storage tanks, or stacks of drums and cans. Loose tools, pieces

of lumber, and other objects should not be left lying where they may cause accidents.

b. FALLING TOOLS OR TANK COVERS. Care should be taken not to leave tank covers off or loose tools lying on top of loading racks or tanks, where they might accidentally be dislodged and fall upon operating personnel.

c. STRAINS. Lifting of heavy drums may cause strained backs. Sufficient personnel and equipment should be provided to handle drums so that undue strains will not be incurred. Personnel habitually engaged in tasks involving lifting should be instructed in the most effective methods of lifting without injury.

d. SWALLOWING GASOLINE. If a person swallows gasoline by accident, first aid should be given immediately. Giving the victim a large quantity of warm, salty water to drink in order to induce vomiting is an effective aid. Medical attention should be secured promptly.

SECTION IX
CONTAMINATION OF PETROLEUM PRODUCTS

50. General.

Petroleum products may be contaminated by dirt, rust, water, gum, or by accidental combination with other varieties of petroleum. Avoiding such contamination is vital if the products are to serve the purpose for which they are intended.

51. Dirt.

a. CAUSES. Particles of dirt or dust may get into petroleum products through careless handling, through leaving containers uncovered, or through the use of improvised open vats. Rust may get into the product from rusted containers.

b. ELIMINATION. Dirt will settle to the bottom of gasoline tanks or drums. Then the clean gasoline at the top can be drawn off and used. The dust or rust in the bottom can be eliminated by filtering the gasoline through a suitable cloth or chamois skin. Particles of dirt and dust do not settle readily in heavier oils such as Diesel fuels and lubricating oils. Since the use of these products is greatly affected by small quantities of such contaminants, extreme care is necessary to prevent the entry of dirt or rust into containers. (See par. 43*a*(3).)

52. Water.

a. CAUSES. Water may get into petroleum products if containers are carelessly left open or if rain is allowed to fall into open vats or tanks. Water may also seep through faulty containers if they are exposed to rain or allowed to float too long in the sea. Water not only makes the product less effective as fuel but also may rust the container.

b. TESTING FOR WATER. Testing a tank or drum to determine its water content is called "thiefing," which was originally the term used for removing or "stealing" a sample from any part of the container. This test to determine the water content is usually made by inserting a gauge stick or tape which has the lower portion coated with some material such as plain chalk, a water-test paper, or a water-detector paste. Since water settles to the bottom of petroleum products and will remove or discolor the paste or chalk, this test will indicate the depth of water in the container.

c. ELIMINATING WATER. Gasoline should be protected as much as possible from contamination by water, but such contamination is not disastrous. The water will settle out of the gasoline if given adequate time. A small pump can be used to pump the water from the bottom of a tank or to pump the uncontaminated gasoline from the top. Frequently water traps or segregators may be installed in pipe lines or in various points in tank-car or truck unloading operations to remove any

water along with other possible contaminations. When segregators are used, water can be drawn off simply by opening the drain cock. Water may also be filtered out by use of a chamois skin but this is considered a very slow and unsatisfactory method.

d. WATER IN GREASE. If water has collected in a drum of grease, it should be poured off and the grease examined. All grease which appears to have been affected by the water should be removed with a clean scoop and burned or buried.

e. WATER IN LUBRICATING OILS. Water in engine oil or gear lubricant partially removes special additives which give the lubricants required operating properties. It also tends to emulsify in the oil and is therefore difficult to separate by settling. These oils will always be given preference in storage location to protect them against damage from water.

53. Gum.

a. CAUSES. Gasoline stored for long periods in contact with air tends to oxidize and form a resinous compound of a gummy nature. High temperatures and the presence of certain materials such as copper soldering flux, etc., hasten this gum formation.

b. DISADVANTAGES. Excessive amounts of gum in gasoline will cause sticking of valves and clogging of carburetor jets, fuel tanks, and fuel lines. It may also seriously interfere with the action of piston rings and intake manifolds.

c. PRECAUTIONS. Gasoline is treated at the refinery by the addition of suitable gum inhibitors and metal deactivators to deter gum formation. Gasoline treated according to present Army Specifications will not tend to form excessive gum for storage periods of 6 months or less. However, to lessen danger of gum, all gasoline should be issued as soon as possible after receipt, the oldest stock on hand being issued first.

54. Combination with other Petroleum Products.

a. The contamination of one petroleum product by the accidental addition of a different product should be guarded against because it may make the product unfit for its original use. If high-octane gasoline is contaminated by the addition of lower-octane gasoline it can then be employed only for purposes authorized for the lower octane. For instance, if aviation gasoline is contaminated with automotive gasoline, it can be used only in certain types of automotive equipment. In any case of suspected contamination, a report should be made to higher authority requesting a test of the gasoline and a decision as to its proper disposal.

b. A small percentage of gasoline added to kerosene, stove oil, or Diesel fuel oil will reduce their flash point and greatly increase the fire hazard. Kerosene, stove oil, Diesel fuel oil, or other petroleum products with high flash points should never be placed in containers which previ-

ously contained gasoline or other low-flash-point products unless the containers have first been thoroughly cleaned.

c. To avoid contamination, all petroleum containers should be clearly and accurately marked to indicate contents. (See app. IV.) Before adding any petroleum product to the contents of a partially filled container, investigation should be made to insure that both products are the same.

d. Care should be taken to prevent contamination of gasoline by small quantities of lubricating oil. The presence of lubricating oil in gasoline may be detected by putting a few drops of the suspected gasoline on a white blotter or white cloth. When the gasoline has evaporated, the oil will produce an oily stain.

e. Grease in which the soap and oil have become separated because of improper manufacture or improper storage should be condemned.

55. Samples.

If any petroleum products are suspected of contamination or cannot be properly identified, it may be necessary to take samples of the products and have the samples tested. Full directions for taking samples may be found in Federal Specification VV–L–791b.

a. TAKING SAMPLES. (1) Various kinds of sampling bottles may be used to take samples of petroleum products. (See fig. 28.)

(2) All sample containers should be thoroughly cleaned before using by washing in water, rinsing in fresh gasoline, and finally rinsing with a portion of the product to be sampled.

(3) An all-levels sample is taken by lowering a stoppered container to the bottom of a tank, pulling out the stopper by jerking the line, and withdrawing the container at a uniform rate so that it will not be quite full when it reaches the surface of the gasoline.

(4) Composite samples are taken by mixing samples drawn from the middle of the top third, middle of the middle third, and middle of the bottom third.

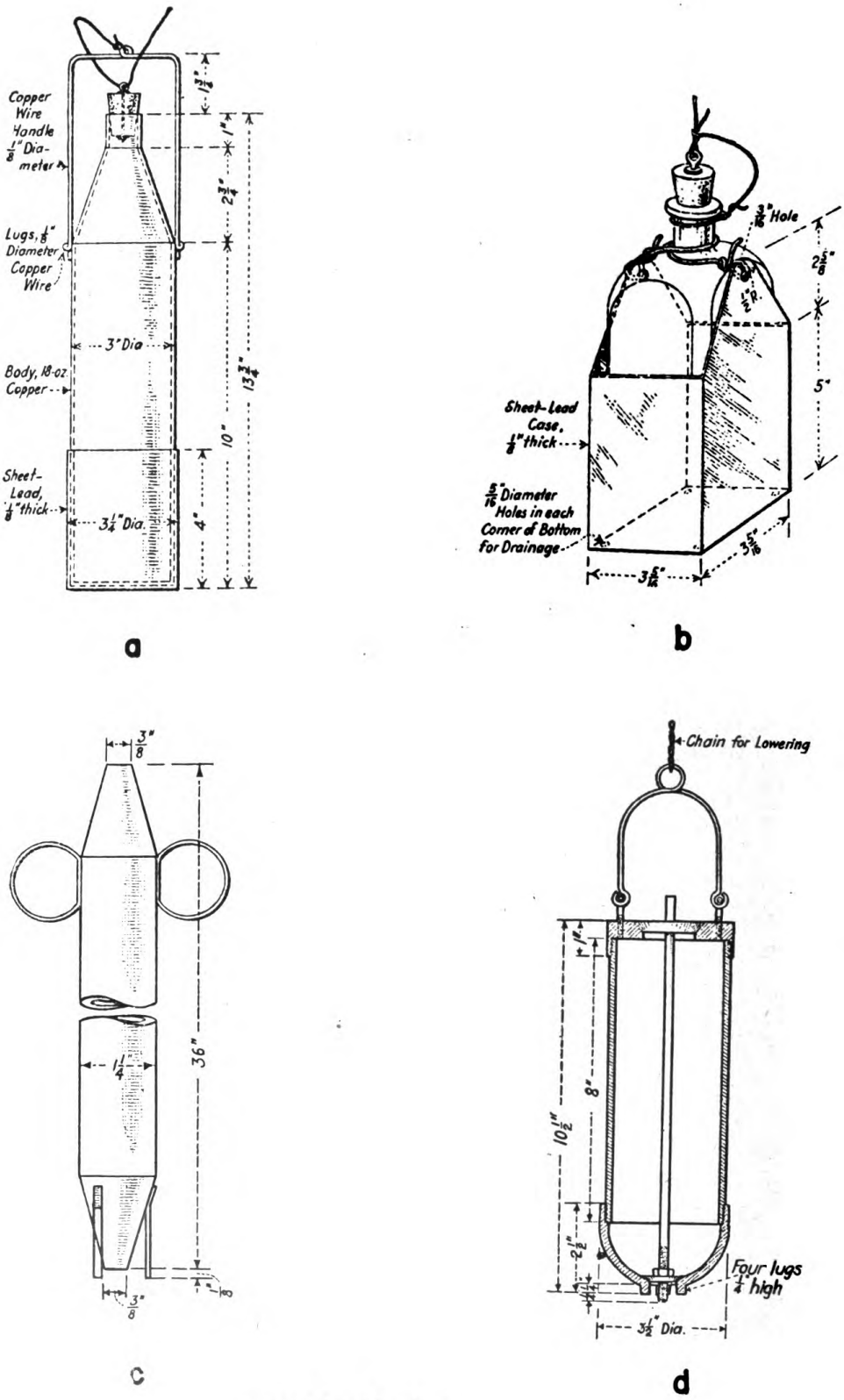
(5) Samples taken should be stored in vapor-tight containers or tightly corked bottles to prevent evaporation. As soon as the samples are inspected and properly marked, they should be stored in a cool, well-ventilated place away from light.

(6) Ordinarily, samples will be turned over to mobile petroleum laboratories for testing or will be carefully packed for shipment to a base petroleum laboratory.

b. TESTING SAMPLES. Among the tests which are commonly made on petroleum products are the following:

(1) *Gravity test.* To determine the weight or density of a petroleum product as compared to water.

(2) *Viscosity test.* To determine the resistance of the product to flow at a specified temperature.



a. Weighted beaker.
b. Weighted bottle.
c. Thief for sampling drums.
d. Thief for sampling tank cars.

Figure 28. Four devices for obtaining gasoline samples.

(3) *Flash-point and fire-point test.* To determine the temperature at which the product will give off enough vapor to ignite but not sustain a flame (flash point) and the temperature at which it will give off sufficient vapor to maintain a continuous flame (fire point).

(4) *Four-point test.* To determine the temperature at which the product will no longer pour under normal conditions but solidifies into a semisolid.

(5) *Distillation test.* To determine the volatility of the product, which means its ability to vaporize at various temperatures.

(6) *Reid vapor-pressure test.* To indicate the amount of pressure created by the product's expansion during its volatilization.

(7) *Gum test.* To determine the actual gum formed or the amount of gum-forming materials in the product.

(8) *Oxidation stability test.* To determine how long gasoline may be stored before gum may be expected to form.

(9) *Grease tests.* Tests made on greases include those for penetration, melting point, percent soap, analysis of soap, free acid and alkali, and filler determination.

c. INTERPRETING TESTS. Although personnel handling petroleum in the field will not generally conduct tests of the various products, they should understand the nature of the tests made by laboratories and the significance of the reports indicating results of these tests. Detailed information on methods for sampling and testing petroleum products may be found in Federal Specification VV–L–791b.

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SECTION X
VOLUME ADJUSTMENT

56. Gauging Gasoline Tanks.

Frequent gauging of gasoline tanks and other containers is necessary in order to determine the exact amount of gasoline on hand and to detect leaks or unauthorized withdrawals.

a. Gauges on storage tanks are innage gauges; that is, the measurement is made by the height of the liquid level above the tank bottom. On tank cars or trucks the gauges may be either innage or outage; that is, the measurement is made by the distance from the marker in the tank-gauge hatch or dome of the tank car down to the liquid level.

b. Measurements of horizontal tanks may be made with the standard gauge stick, which is graduated in one-eighth inches and equipped with a brass or other nonspark-striking metal protector strip on the bottom. Vertical tanks may be gauged with a steel tape of the height required. The tape is also graduated in one-eighth inches and has a standard plumb bob of brass or other nonspark-striking metal.

c. The gauging operation should be repeated until two consecutive readings are the same.

d. The tape or stick should be wiped dry after each operation.

e. The gauger who approaches the top of a tank to gauge it should first touch the steel handrail of the platform or the tank shell to ground any static electricity he may have accumulated. The steel gauging tape should be in contact with the hatch opening during lowering and raising in order to ground any static electricity generated.

57. Temperature.

The temperature of gasoline is especially important because it affects the volume. Quantities of gasoline are usually recorded on the basis of 60° F. If the temperature is higher or lower, corresponding adjustments must be made in the quantity recorded.

a. TAKING TEMPERATURE. (1) Temperature of gasoline in any tank is determined by lowering a standard tank thermometer into a tank by means of a cord to a depth of about one-half the distance from the surface of the liquid to the bottom of the tank and allowing it to remain for about 2 minutes.

(2) Temperature of gasoline in a tank car is taken by suspending a standard cap-case or oil-bath thermometer at a point approximately in the center of the contents and allowing it to remain for about 2 minutes.

b. ADJUSTING FOR TEMPERATURE. An abridged table has been prepared by the National Bureau of Standards as an aid to reducing the volumes of gasoline to the basis of 60° F. Extracts from this volume correction table of petroleum oils are given in appendix VI.

58. Evaporation.

Evaporation means not only loss of volume but also lowering of quality, because the vapor pressure, volatility, and octane number of the fuel are lessened.

a. Causes. Windage loss is caused by air currents entering a tank through a leaky roof or open vents and carrying off vapors. Breathing loss is caused by air being drawn into the tank at night and absorbing vapor and then being expelled as the temperature rises. Filling loss is is caused by the air-vapor mixture being forced out of a tank as additional gasoline is pumped in. (See app. VII for table of tank losses from evaporation.)

b. Precautions. Frequent inspections of tanks, valves, lines, venting and gauging equipment for any possible liquid or vapor leaks can reduce losses from evaporation. Windage losses can be prevented by installing pressure and vacuum valves and seeing that all roof seams and connections are gastight. Breathing losses are prevented by the use of tanks with variable space or expansion roofs to provide for maximum expansion of vapors caused by changes in temperature. Such losses may also be reduced by any means of limiting temperature variations such as the use of reflecting or light-colored paint on the roof or the use of water spray to cool the roof.

SECTION XI
CAMOUFLAGE AND DEMOLITION

59. Camouflage.

General principles of camouflage are followed in protection of petroleum storage areas from enemy action. Extent of the camouflage will vary according to the theater, to the danger of air or artillery attacks, and to the time available. For a general discussion of camouflage, see FM 5–20, 5–20B, and 5–20C.

a. PIPE LINES. In planning the course of a pipe line advantage should be taken of all possible natural growth. The pipe line should utilize natural depressions in the earth, such as roadside ditches. Dirt banked along both sides of the pipe will eliminate the pipe shadow. The entire line may be camouflaged by painting it a base color of olive drab and by applying desert colors in the form of disruptive patterns. Tanks and pumps used in connection with pipe lines may be set in recessed pits, installed under natural cover, or disguised by the use of nets garnished in appropriate colors. Tanks and other installations may also be painted in tone-down colors, with appropriate ground painting to disrupt the shadows cast.

b. STORAGE AREAS. Petroleum storage sites should be selected to take advantage of all natural concealment such as trees, orchards, ground contours, walls, and fences. In addition to this, such artificial camouflage as using garnished nets and painted tanks and installations may be necessary as further protection from enemy reconnaissance or attacks. Any large oil leaks or stains on the ground which might be observed from the air should be removed or covered with fresh earth. Pits or ditches dug in the area should be disguised and new buildings should be allowed to weather. The correct use and the incorrect use of camouflage positions and traffic circulation plan are shown in figure 29.

60. Demolition of Petroleum Products.

Since petroleum products would be of considerable value to the enemy if captured, it may sometimes be necessary to destroy them rather than let them fall into enemy hands.

a. CANS AND DRUMS. Gasoline cans and drums may be punctured with axes or bayonets or with machine-gun fire using incendiary bullets. At least two holes should be made in each can or drum, in opposite ends or sides.

b. TANKS. Gasoline may be pumped out of tanks or made to overflow by running water in with a hose. Machine-gun fire, rifle grenades, or rocket launches may be utilized to puncture tanks. If explosive is available, it may be used as a placed charge to blow up the tanks. The gasoline itself may be made unfit for use by contamination with dirt, sand, or sugar.

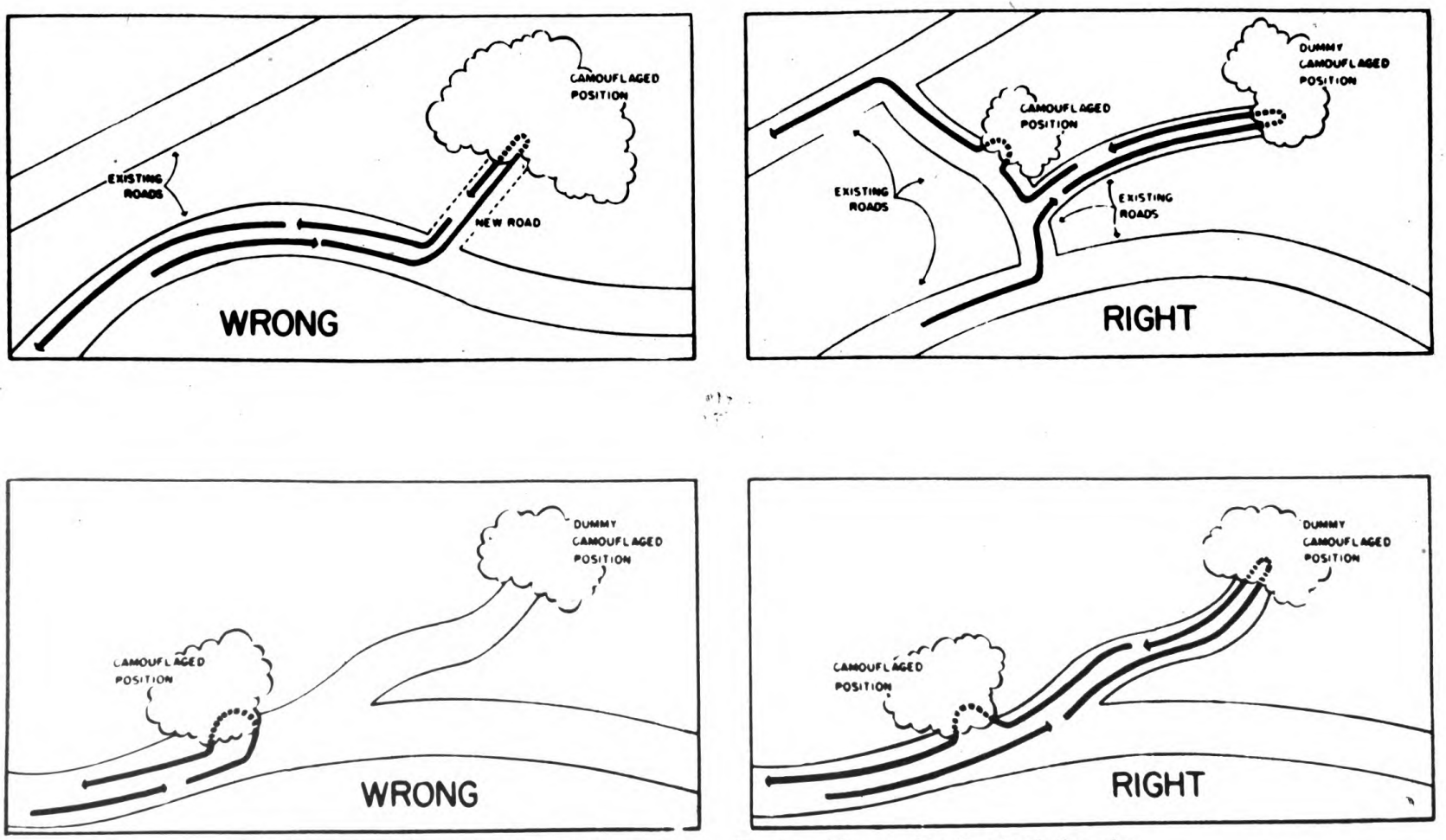

Figure 29. Correct and incorrect use of camouflaged positions and traffic circulation plan.

c. GREASE AND LUBRICANTS. Since grease, oil, or heavy lubricants do not burn easily, their destruction can be speeded if they are dumped into open gasoline storage or if they are saturated with gasoline. They may then be ignited with incendiary bullets or with a gasoline trail laid a safe distance away.

d. DISPENSING EQUIPMENT. Petroleum handling equipment should also be destroyed if it is in danger of capture. Engines and pumps should be smashed with sledge hammers, picks, or axes. Rifle grenades and rocket launchers may be used to complete the destruction. Hose should be slashed and made unusable.

e. DEMOLITION OF DUMP. If sufficient time is allowed for complete demolition, the entire gasoline dump may be wired for demolition and blown up by explosives.

APPENDIX I

PETROLEUM PRODUCTS COMMONLY USED IN THEATERS OF OPERATION

A tabulation of all standardized fuels and lubricants that have been approved for procurement and use in Army equipment other than aircraft operated by the Army Air Forces may be found in SB 10–139. The following extract from that bulletin provides information on the fuels and lubricants commonly used in the theater of operations.

Table I
Petroleum products used in theaters of operations

Product	General use	Product symbol	Container sizes
I. LIQUID FUELS A. Gasolines			
Motor fuel (all-purpose) 80-octane.	For all oversea motor vehicles.	80A	Bulk, 5-gallon can, and 55-gallon drum.
Gasoline (unleaded and undyed) 62-octane.	For oversea use in gasoline stoves, gasoline lanterns, etc.	62	Bulk, 5-gallon can, and 55-gallon drum.
B. Burning oils			
Kerosene	For lanterns and stoves designed to operate on this fuel.	K	Bulk, 5-gallon can, and 55-gallon drum.
C. Fuel oils			
Oil, fuel, Diesel 40-cetane	Fuels for high-speed Diesel engines.	D A	Bulk, 5-gallon can, and 55-gallon drum.
Oil, fuel, Diesel 50-cetane	Fuels for high-speed Diesel engines.	D A	Bulk, 5-gallon can, and 55-gallon drum.
II. LUBRICATING OILS A. Engine oils			
Oil, engine (SAE 10)	For the lubrication of internal combustion engines, etc.	OE 10	Bulk, 1-quart and 5-quart can, 5-gallon can and 55-gallon drum, 1-quart and 1-gallon screw-top can.
Oil, engine (SAE 30)	For the lubrication of internal combustion engines, etc.	OE 30	Bulk, 1-quart and 5-quart can, 5-gallon can, and 55-gallon drum, 1-quart and 1-gallon screw-top can.

Table I (Continued)

Product	General use	Product symbol	Container sizes
Oil, engine (SAE 50)	For the lubrication of internal combustion engines, etc.	OE 50	Bulk, 1-quart and 5-quart can, 5-gallon can and 55-gallon drum.
B. Gear lubricants			
Lubricant, gear, universal (SAE 75)	For lubrication of all automotive gear units as prescribed (below 0° F. temperature).	GO 75	5-gallon can and 55-gallon drum.
Lubricant, gear, universal (SAE 90)	For lubrication of all automotive gear units as prescribed (temperature above 0° F.).	GO 90	5-gallon can and 55-gallon drum.
III. GREASES			
Grease, general purpose, No. 0	Lubrication of vehicle chassis and other equipment where specified below 32° F.	CG 0	1-pound and 5-pound can, 25-pound pail, 100-pound and 400-pound drum.
Grease, general purpose, No. 1	Lubrication of vehicle chassis and other equipment where specified above 32° F.	CG 1	5-pound can, 25-pound pail, 100-pound and 400-pound drum.
Grease, general purpose, No. 2	Wheel bearings and other equipment as specified.	WB	1-pound and 5-pound can, 25-pound pail.
Grease, water pump	Water-pump bearings and other points as specified.	WP	1-pound and 5-pound can, 25-pound pail.

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APPENDIX II
CONSUMPTION OF PETROLEUM PRODUCTS

Table II. Army vehicle requirements of fuel and lubricants

The following excerpt from FM 101–10 gives useful reference data on the amount of gasoline, oil, and grease consumed by various Army vehicles

	1	2	3	4	5	6	7
1	Vehicle	Vehicle fuel tank capacity (gallons)	Miles per gallon of fuel	Gallons of fuel per 100 miles	Gallons of oil per 100 miles	Pounds gear lube per 100 miles	Pounds misc. grease per 100 miles
2	Car, armored, light M8	59	7.5	13.3	1.5	0.6	0.9
3	Car, armored, utility, M20	56	7.0	14.3	1.5	0.5	0.9
4	Car, 5 passenger	16	14.0	7.0	0.1	0.1	0.1
5	Carriage, motor, 75-mm How, M8	89	1.5	66.7	5.2	---	1.5
6	Carriage, motor, 3″ gun, M10A1	165	.14	71.4	11.0	---	2.4
7	Carriage, motor (76-mm gun), M18 [1]	160	1.0	100.0	11.0	---	2.4
8	Carriage, motor (105-mm How), M7	175	1.0	100.0	11.0	---	2.4
9	Carriage, motor, 155-mm gun, M12	200	0.8	125.0	11.0	---	2.4
10	Carrier, cargo, M30	200	0.9	111.1	11.0	---	2.4
11	Half-track vehicles [2]	60	3.3	30.3	1.1	0.7	1.2
12	Motorcycle, solo	3.5	42.0	2.4	0.2	---	---
13	Plane, liaison	14	17.9	5.6	0.2	---	---
14	Motor, scooter	2.0	50.0	2.0	0.2	---	---
15	Tank (L), A/B, T9E [1]	55	2.5	40.0	(5)	(5)	(5)
16	Tank, light [3]	115	1.4	71.4	5.2	---	1.5
17	Tank, medium [4]	175	0.8	125.0	11.0	---	2.4
18	Truck, ¼-ton	15	20.0	5.0	0.2	0.2	0.2
19	Truck, ¾-ton	30	8.0	12.5	0.3	0.6	0.2
20	Truck, 1½-ton, 4x4	30	9.0	11.1	0.5	0.7	0.2
21	Truck, 2½-ton, 6x6	40	7.5	13.3	0.6	0.9	0.3
22	Truck, crane, M2	100	1.5	66.7	0.7	0.7	0.5

Table II. Army vehicle requirements of fuel and lubricants (Continued)

	1	2	3	4	5	6	7
1	Vehicle	Vehicle fuel tank capacity (gallons)	Miles per gallon of fuel	Gallons of fuel per 100 miles	Gallons of oil per 100 miles	Pounds gear lube per 100 miles	Pounds misc. grease per 100 miles
23	Truck, 4-ton, 6x6	60	3.0	33.3	0.7	0.7	0.5
24	Truck, 6-ton, 6x6, prime mover	75	2.0	50.0	0.8	0.7	0.5
25	Truck, 7½-ton, 6x6, prime mover	160	2.5	40.0	0.5	0.8	0.5
26	Truck, heavy wrecker, 10-ton, M1A1	100	2.5	40.0	1.6	0.7	0.5
27	Truck, trailer, 40-ton, tank, transporter, M25	120	1.6	62.5	1.5	0.7	0.5
28	Tractor, medium, high speed, M5	110	2.0	50.0	1.0	1.1	0.5
29	Tractor, heavy, high speed, M6	300	0.5	200.0	2.0	1.8	0.5
30	Vehicle, landing, tracked	110	0.5	200.0	10.0	[5]	[5]
31	Carrier, cargo, M29	25	7.0	14.3	1.5	---	0.5

[1] Includes Vehicle, Armed Utility T41.
[2] Includes:
Carrier, personnel, half-track M2, M2A1, M3, M3A1, M3A2, M5, M5A1, M9A1.
Carriage multiple gun (AA) M13, M14, M15, M15A1, M16, M17.
Carriage 75-mm gun, M3, M3A1.
Carrier 81-mm mortar, M4, M4A1, M21.
[3] Includes:
Tank, light, M5, M5A1, M24.
[4] Includes:
Tank, medium, M4 (76-mm & 105-mm How), M4A1, M4A2, M4A3 (76-mm & 105-mm How), M4A4, TK recovery vehicle M32.
[5] Information not available.

Table III. Consumption factors for petroleum products of the U. S. Army for last three quarters of 1944

Petroleum product	Factor	European theater	Mediterranean theater	Southwest Pacific theater	China-Burma-India theater	Average all theaters
Motor gasoline	Gallons per man per day	0.97	1.00	0.86	1.14	0.90
White gasoline	do	.001	0	.15	.10	.05
Total gasoline	do	.97	1.00	1.01	1.24	0.95
Kerosene:						
Second quarter	do		.016	.031		.017
Third quarter	do	.007		.035	.028	.019
Fourth quarter	do	.007		.036	.032	.022
Diesel and light fuel:						
Second quarter	do			.31		.24
Third quarter	do	.05		.32	.12	.20
Fourth quarter	do	.07			.17	.026
Engine oil	do	.022		.037	.035	.028
	Percent of total gasoline	2.30		4.00	2.71	2.91
Gear lubricant	Gallons per man per day	.0062		.0112	.0108	.0073
	Percent of total gasoline	.64		1.20	.84	.77
General-purpose and water-pump grease.	Pounds per man per day	.018		.024	.020	.019
	Percent of total gasoline	1.88		2.54	1.45	2.05

APPENDIX III

TABLES OF PETROLEUM WEIGHTS AND MEASUREMENTS

Table IV. Weights and dimensions of standard petroleum containers

Description of item	Contents of package	Unit	Units in package	Type of package	Size of package (inches)			Weight of package empty (pounds)	Weight of package filled (pounds)	Cubic feet of package
					Lgth.	Wdth.	Ht.			
U. S. 55-gallon drum	Gasoline	ea.	1	Drum	0	23	36	72	412	10
U. S. 55-gallon drum	Diesel	ea.	1	Drum	0	23	36	94	443	10
Imp. 40-gallon drum (48 U. S. gals.)	Gasoline	ea.	1	Drum	0	23	32	60	348	12
Imp. 40-gallon drum (48 U. S. gals.)	Diesel	ea.	1	Drum	0	23	32	60	376	12
Imp. 5-gallon drum (6 U. S. gals.)	Oil	ea.	1	Drum	0	11	17	7	52	.93
U. S. 5-gallon can gas	Gasoline	ea.	1	Can	13¾	6¾	18½	10	40	1
Imp. 4.5-gallon can gas (5.4 U. S. gals.)	Gasoline	ea.	1	Can	13¾	6¾	18½	11.5	43.9	1
Imp. 4.5-gallon can gas (5.4 U. S. gals.)	Diesel	ea.	1	Can	13¾	6¾	18½	11.5	47.14	1
Imp. 4.5-gallon can gas (5.4 U. S. gals.)	Kerosene	ea.	1	Can	13¾	6¾	18½	11.5	47.14	1
U. S. 5-gallon can oil	Oil	ea.	2	Case	21	15	11	19	94	2
U. S. 5-quart can oil	Oil	ea.	6	Case	22	14	10	19.8	76	1.9
U. S. 1-quart can oil	Oil	ea.	12	Case	18	13	6	11.6	34	.87
25-pound pail grease, U. S.	Grease	ea.	1	Pail	0	10	11	4	29	.45
28-pound pail grease, Brit.	Grease	ea.	1	Pail	0	10	15½	6	34	.69
2-pound can grease, Brit.	Grease	ea.	24	Case	18½	14	10¾	14.25	62.25	1.61
7-pound can grease, Brit.	Grease	ea.	6	Case	20	13	9	8	50	1.35
1-pound can grease, Brit.	Grease	ea.	24	Case	15	11½	10¾	17	41	1.2
1-pound can grease, Brit.	Grease	ea.	48	Case	24	15	11	12	60	2

Table V. Measurements in gallons per ton (2,000 Pounds)

Product	Container	Measurement per ton (gallons)
Gasoline and kerosene	Can	250
Gasoline and kerosene	Drum	300
Diesel oil	Can	210
Diesel oil	Drum	250
Lubricating oils	Drum	250

Table VI. Containers per long ton (2,240 Pounds)

Product	Container	Number per long ton
Gasoline	5-gallon can	50
Gasoline	55-gallon drum	6
Oil	5-gallon can	50
Grease	25-pound pail	90

Table VII. Petroleum weights per gallon

In certain instances petroleum products may be measured in weight rather than in bulk. Approximate weights of the U. S. gallon in pounds and in kilograms on the basis of approximate averages are as follows:

Product	Weight of U. S. gallon	
	(in pounds)	(in kilograms)
Crude petroleum	7.3	3.311
Lubricating oils	7.5	3.402
Illuminating oils (kerosene)	6.6	2.994
Gasoline and related products (motor spirit, benzine, etc.).	6.1	2.767
Fuel and gas oils	7.7	3.493

Table VIII. Petroleum conversion factors

Rapid approximation of weights and measures in handling petroleum products may be found by use of the following conversion factors. To convert unit A to unit C, multiply unit A by factor B.

Unit	Factor	Unit
A	B	C
U. S. gallons	231	Cubic inches
Cubic inches	0.004329	U. S. gallons
U. S. gallons	0.1337	Cubic feet
Cubic feet	7.48	U. S. gallons
Imperial gallons	1.201	U. S. gallons
U. S. gallons	0.8327	Imperial gallons
Imperial gallons	0.1605	Cubic feet
Cubic feet	6.23	Imperial gallons
U. S. gallons	3.78533	Liters
Liters	0.264178	U. S. gallons
Barrels	42	U. S. gallons
Tons (long)	2,240	Pounds
Tons (metric)	2,204.6223	Pounds
Tons (short)	2,000	Pounds

APPENDIX IV
MARKING OF PETROLEUM PRODUCTS

The system of marking petroleum products for the Quartermaster Corps of the U. S. Army is fully covered in OQMG Specification No. 180, 1 December 1944 or latest revision or amendment.

All such markings on primary containers, that is, uncased, are solid characters of the size prescribed in the illustrations and are white in color. The composition of the marking is as follows:

a. Product Symbol (always in large characters for ready identification).

b. Grade, Type, or Class.

c. Approved product nomenclature.

d. Product Specification.

e. Supplier's Name.

f. Filling date or Batch or Lot Number.

g. Content of Container.

If through obliteration it becomes necessary to remark a product in the field *a*, *b*, *c*, and *d*, above will normally suffice, although *a*, and *b* above completely identify the product to those understanding the code markings. All markings are required originally to have clarity and to completely cover the base paint.

The markings of inner cartons and shipping cases are black in color and conform to requirements of the above listed composition of markings for primary containers.

Colored marking tags equipped with clips, while prescribed in OQMG Specification No. 180 and used to a limited extent during wartime on uncased primary containers of 5-gallon or larger capacity, are not used in peacetime.

APPENDIX V

LAYOUTS FOR GASOLINE-BULK BREAKDOWN POINTS

Section I. Lay-out for Filling Cans and Drums at a Class III Base Dump

The following system of breaking down gasoline from tank trucks to 5-gallon cans at a class III base dump has been satisfactorily employed in theaters of operations. (See fig. 30.) Notice that in order to prevent the spread of fire, wide dispersion is practiced. All pumping equipment, dumping vats, stacks of full and empty containers, or any other inflammable material are located so that there is a minimum distance of 100 feet from one inflammable item or group to any other inflammable item or group.

The system generally works in the following manner: The tank trucks, coming from the port bulk-storage plant or the end of the pipe line, pull up to the tanker unloading points (1) and unload their gasoline by gravity, or, with the aid of the pump installed in the system (3), into one of the dumping vats (2). If the delivery is in 55-gallon drums, the full drums are rolled up an inclined ramp to the edge of the dumping vat and their contents emptied into the vat. Gasoline is then pumped out of the vat through the 4-inch pipe line (6), and then through lengths of regular gasoline-dispensing hose (7) into the regularly dispersed containers. Gasoline tank trucks from using units are filled at the tanker-filling points (4).

The entire system is operated by one large 350-gallon-per-minute pump. The average daily pumping record of such a dump is over 250,000 gallons of gasoline, and the storage capacity is over 3,000,000 gallons of gasoline. A similar set-up may be used with the regular 100-gallon-per-minute gasoline dispenser, although in that case the pumping capacity will naturally be less.

Section II. Suggested System of Gasoline Handling by One or Three Platoons

The following is a recommended system of handling gasoline at bulk break-down points in the combat zone or in the zone of the interior. Figure 31 shows a recommended plan of operation for an individual platoon equipped with one 100-gallon-per-minute dispenser. Figure 32 shows the joint operation of three platoons.

The dispenser is located in the center of a large circle, approximately 60 feet in radius. This radius is controlled by hose lengths on the dispenser. On this circle, five points are set off at approximately equal distances from each other. Four of the points constitute centers of the zones of operation of the individual stations of one platoon. The fifth is

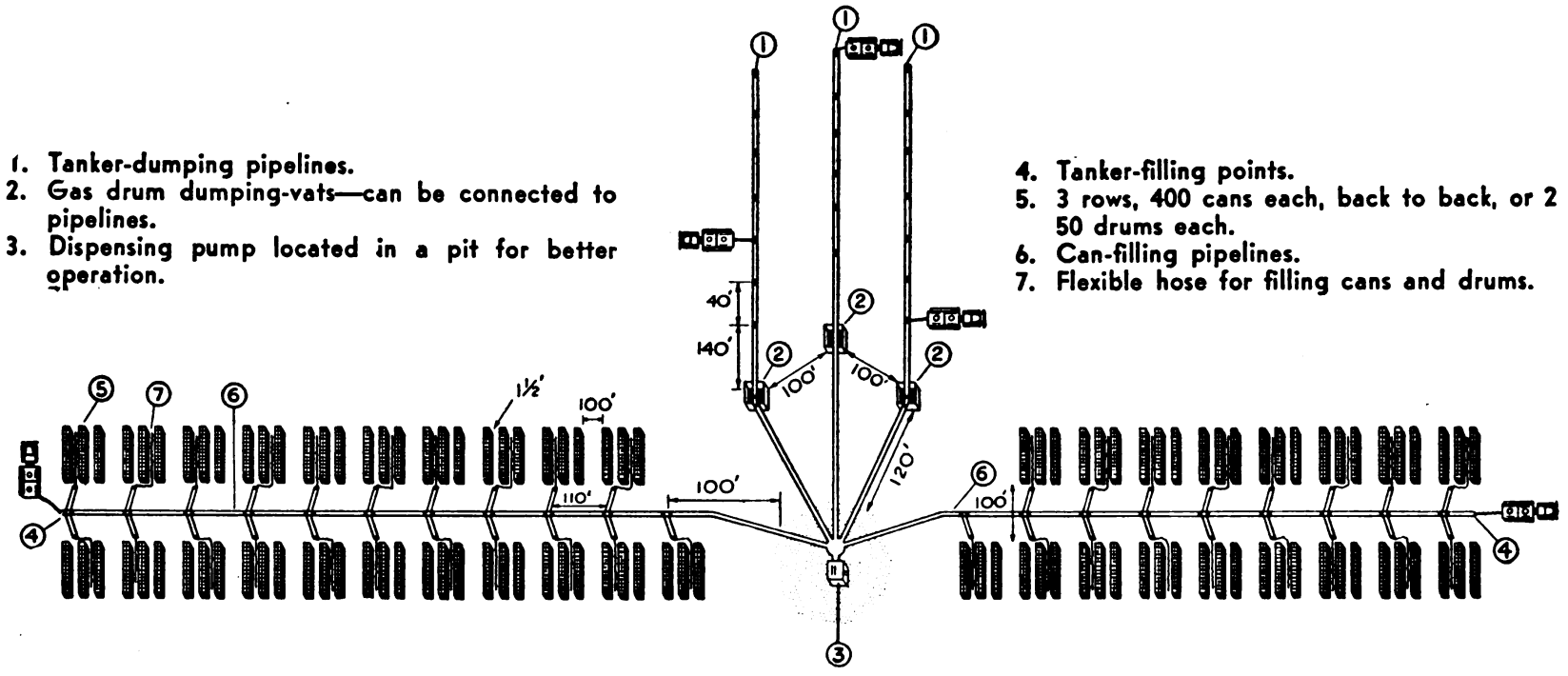
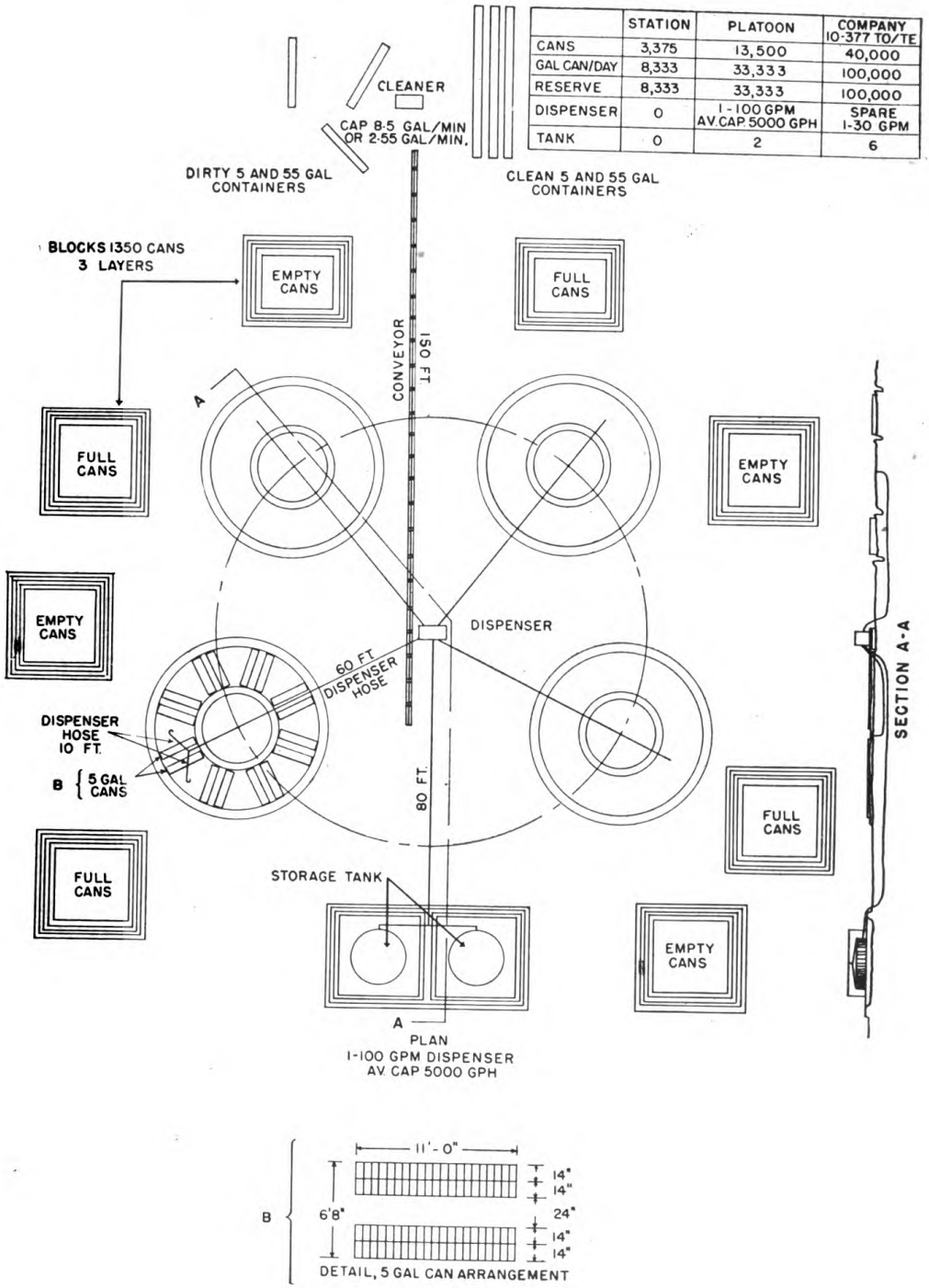


Figure 30. Lay-out for filling cans and drums at a class "III" base dump.



	STATION	PLATOON	COMPANY 10-377 TO/TE
CANS	3,375	13,500	40,000
GAL CAN/DAY	8,333	33,333	100,000
RESERVE	8,333	33,333	100,000
DISPENSER	0	1-100 GPM AV.CAP. 5000 GPH	SPARE 1-30 GPM
TANK	0	2	6

Figure 31. Suggested system of handling gasoline at a bulk breakdown point by one platoon of a base petroleum supply company.

the point at which the suction line going to tank car, tank truck, or collapsible tank passes through the large circle. At each of the four points at which can-filling operations will take place, a circle is made approximately 50 feet in diameter, with a fire wall or ditch at the outer edge. An inner circle is made 25 feet in diameter with a fire wall or ditch

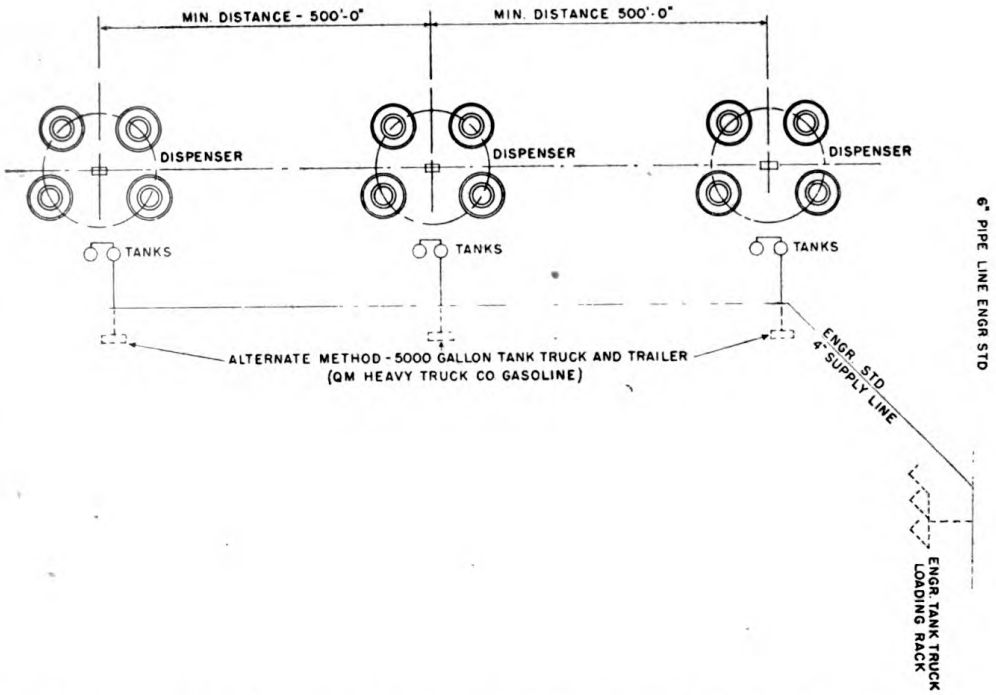


Figure 32. System for joint operation of bulk breakdown point by three platoons of a base petroleum supply company.

at the inside edge. This is illustrated in the section drawing "AA." (See fig. 31.)

In the space between the inner and the outer circle, cans are lined up back to back with a passage between each two rows in accordance with the "Detail 5-Gallon Can Arrangement" referred to as "B." (See fig 31.) Eight of these blocks are placed in this area. The discharge hose of the dispenser is buried in a few inches of earth shortly after it passes the trailer and is brought back above ground at the center of the circle of each one of these stations. The personnel engaged in filling may rotate in either direction to fill the necessary cans. Near each of these stations are two blocks of containers surrounded by fire walls or ditches. One of these blocks contains approximately 1,350 empty cans in three layers; the other block contains 1,350 filled cans in three layers. The remaining containers are located within the station circle, so that each station has 3,375 cans at all times. Half of the total quantity of cans in each station are held as reserve while the others are being filled. For the four stations in each platoon there are 13,500 cans on hand, 33,333 gallons of gasoline held in reserve, and 33,333 gallons filled into cans each day.

The can-inspecting, can-cleaning, and can-repairing operations must take place at a distance from the can-filling operation or at a point approximately 150 feet from the gasoline dispenser. Since the entire area directly adjacent to the dispenser has been cleared of hose (hose has been buried), either trucks or conveyors can be used to bring the cans which are cleaned to each individual station through the center ring. It is

anticipated that approximately one-third of the cans handled per day will require cleaning or repairing. If conveyors are available to convey the containers to the individual stations through the hub of the operation, there will be far less congestion than if trucks are employed. It should be noted that in this operation an attempt is made to keep cargo vehicles engaged in exchanging filled cans for empty cans a minimum distance of 150 to 175 feet from the gasoline dispenser itself. This decreases greatly the hazards of refueling operations.

When collapsible containers are used, they should be placed at sufficient distance from the normal refueling operations for bulk-haul tank trucks or pipe-line connections not to interfere with the personnel engaged in can filling. Although the use of the collapsible container adds another item in the fuel transfer problem, these tanks, when manifolded together, give approximately a 6,000-gallon reservoir. It is then possible for tank trucks in the least possible time to unload into these tanks either by gravity or by high-gallonage pumps. This insures a constant flow of gasoline and full utilization of the potential capacity of each platoon of the gasoline supply company. If these collapsible tanks are not used, extreme caution must be taken to see that the dispenser pump does not run dry or that it is shut down when the suction hose is removed from an empty compartment of the tank truck to another compartment. This pump will not run for more than a few minutes without scoring the rotor and damaging the bushings of the pump if fuel is not passing through the pump. This system also is inefficient because during the period of the transfer of the suction line from one tank to another personnel at all the stations are idle. With the daily requirements of the gasoline supply company, this delay will result in need for additional gasoline supply organizations which in many cases cannot be fully justified.

Section III. Lay-outs for Filling Drums or Cans from Tank Truck and Trailer

Figures 33 and 34 show additional layouts for bulk break-down points.

In figure 33 the tank truck and trailer are placed conveniently within the break-down area, and gasoline is pumped directly into the cans and drums. Trucks drive into the area, unload empty cans and drums, and then proceed to designated loading points and pick up loaded cans and drums.

In figure 34 the tank truck and trailer are driven near the 3,000-gallon collapsible containers. Gasoline is unloaded into the two containers and can then be dispensed from the containers into cans and drums without requiring the tank truck and trailer to remain at the break-down point.

Dashed lines in both figures indicate paths of travel for personnel who carry the cans by hand from unloading points to drum cleaners, to filling points, and finally to loading points.

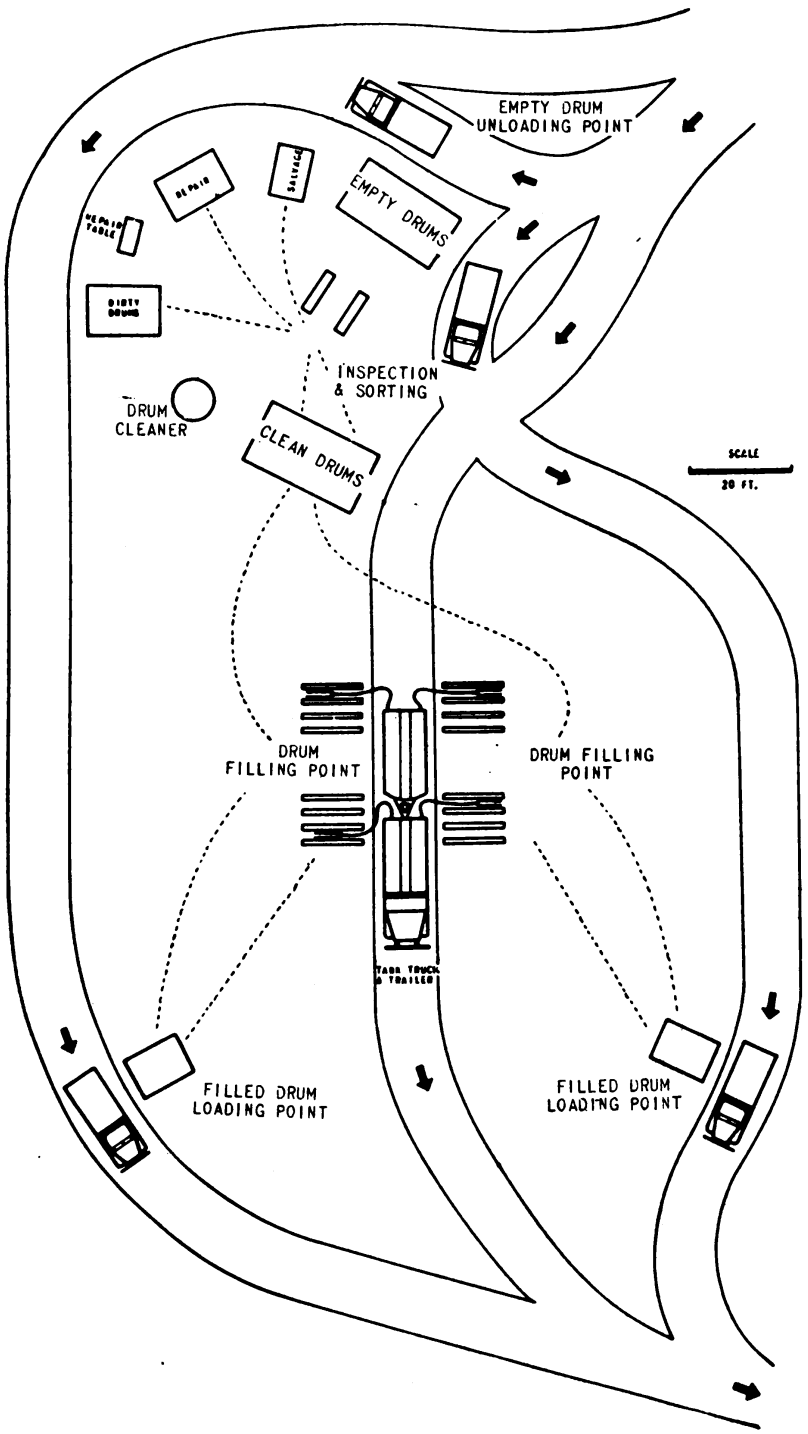


Figure 33. Layout for platoon operation filling drums or cans directly from a tank truck and trailer.

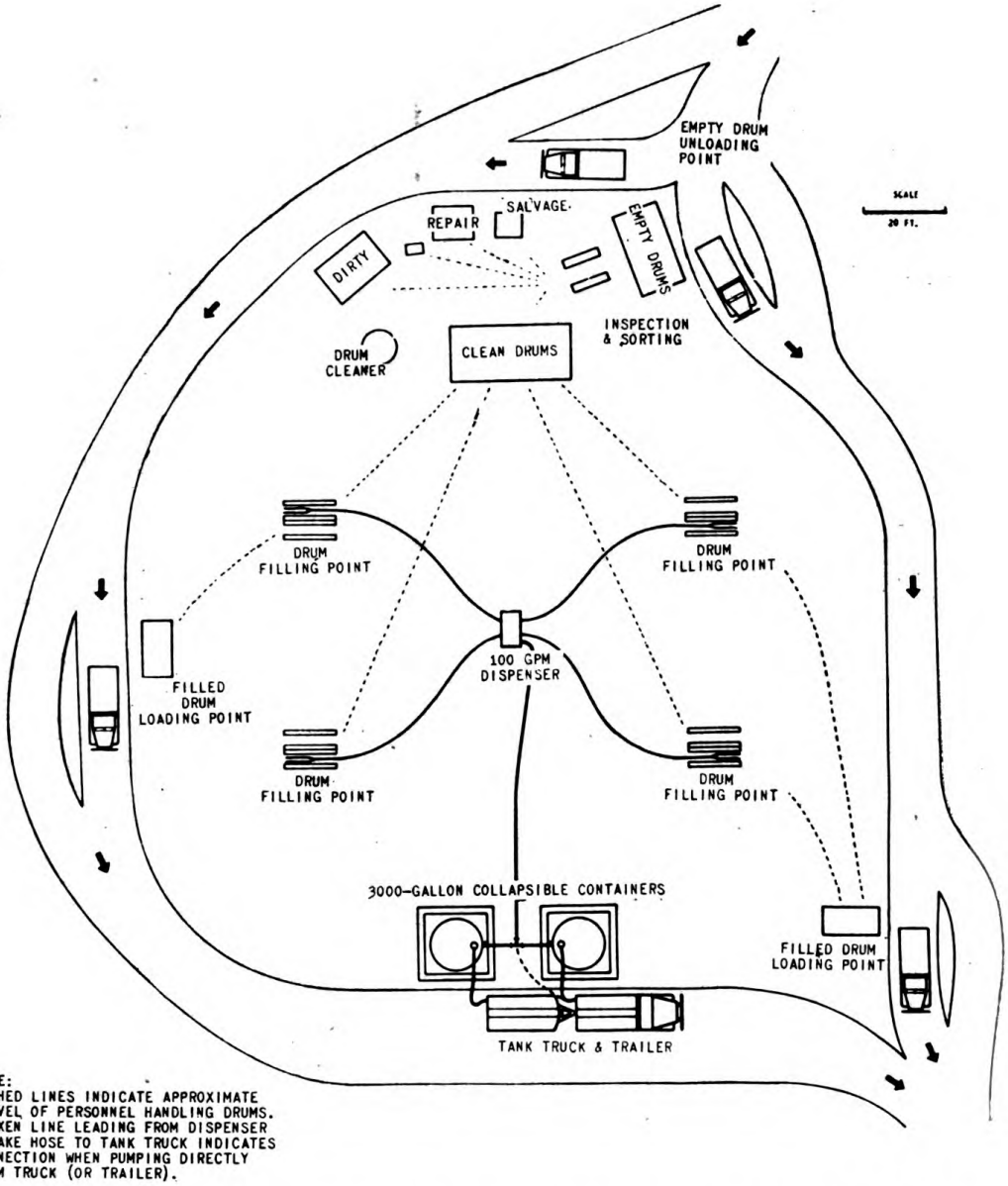


Figure 34. Layout for platoon operation filling drums or cans from a tank truck and trailer through use of 3,000-gallon collapsible containers.

APPENDIX VI

VOLUME CORRECTION TABLES FOR PETROLEUM OILS ACCORDING TO TEMPERATURE

The following tables were prepared by the National Bureau of Standards to provide a short and convenient aid for reducing oil volumes to the basis of 60° F., when extreme accuracy is not required. Columns with the heading T, show observed temperatures in degrees Fahrenheit. Multipliers, column M, are actually (volume at 60° F.).

(volume at T)

The volume of oil at the indicated temperature and degrees API for each group, multiplied by the corresponding factor in the table, equals the volume at 60° F. For example, if the degrees API of an oil at 60° F. equal 58 (group 3) and the volume at 88° F. equals 8,000 gallons, then the volume at 60° F. equals 8,000 x 0.9830 or 7,864 gallons.

Table IX. Group No. 3—Gravity range 51.0 to 63.9

T	M	T	M	T	M
0	1.0361	36	1.0145	72	0.9927
1	1.0355	37	1.0139	73	0.9921
2	1.0349	38	1.0133	74	0.9915
3	1.0343	39	1.0127	75	0.9909
4	1.0337	40	1.0121	76	0.9903
5	1.0331	41	1.0115	77	0.9897
6	1.0325	42	1.0109	78	0.9891
7	1.0319	43	1.0103	79	0.9885
8	1.0313	44	1.0097	80	0.9879
9	1.0307	45	1.0091	81	0.9873
10	1.0301	46	1.0085	82	0.9867
11	1.0295	47	1.0079	83	0.9860
12	1.0289	48	1.0072	84	0.9854
13	1.0283	49	1.0066	85	0.9848
14	1.0277	50	1.0060	86	0.9842
15	1.0271	51	1.0054	87	0.9836
16	1.0265	52	1.0048	88	0.9830
17	1.0259	53	1.0042	89	0.9824
18	1.0253	54	1.0036	90	0.9818
19	1.0247	55	1.0030	91	0.9812
20	1.0241	56	1.0024	92	0.9806
21	1.0235	57	1.0018	93	0.9800
22	1.0229	58	1.0012	94	0.9794
23	1.0223	59	1.0006	95	0.9788
24	1.0217	60	1.0000	96	0.9782
25	1.0211	61	0.9994	97	0.9776
26	1.0205	62	0.9988	98	0.9769
27	1.0199	63	0.9982	99	0.9763
28	1.0193	64	0.9976	100	0.9757
29	1.0187	65	0.9970	101	0.9751
30	1.0181	66	0.9964	102	0.9745
31	1.0175	67	0.9957	103	0.9738
32	1.0169	68	0.9951	104	0.9732
33	1.0163	69	0.9945	105	0.9726
34	1.0157	70	0.9939	106	0.9720
35	1.0151	71	0.9933	107	0.9714

Table IX. Group No.3—Gravity range 51.0 to 63.9 (Continued)

T	M	T	M	T	M
108	0.9708	114	0.9672	120	0.9635
109	0.9702	115	0.9666	121	0.9629
110	0.9696	116	0.9660	122	0.9623
111	0.9690	117	0.9654	123	0.9617
112	0.9684	118	0.9647	124	0.9611
113	0.9678	119	0.9641		

Table X. Group No. 4—Gravity range 64.0 to 78.9

T	M	T	M	T	M
0	1.0419	42	1.0127	83	0.9837
1	1.0412	43	1.0120	84	0.9830
2	1.0405	44	1.0113	85	0.9823
3	1.0398	45	1.0106	86	0.9816
4	1.0391	46	1.0099	87	0.9809
5	1.0384	47	1.0092	88	0.9802
6	1.0377	48	1.0084	89	0.9795
7	1.0370	49	1.0077	90	0.9788
8	1.0364	50	1.0070	91	0.9780
9	1.0357	51	1.0063	92	0.9773
10	1.0350	52	1.0056	93	0.9766
11	1.0343	53	1.0049	94	0.9759
12	1.0336	54	1.0042	95	0.9752
13	1.0329	55	1.0035	96	0.9745
14	1.0322	56	1.0028	97	0.9738
15	1.0315	57	1.0021	98	0.9731
16	1.0308	58	1.0014	99	0.9723
17	1.0301	59	1.0007	100	0.9716
18	1.0294	60	1.0000	101	0.9709
19	1.0287	61	0.9993	102	0.9702
20	1.0280	62	0.9986	103	0.9695
21	1.0273	63	0.9979	104	0.9688
22	1.0266	64	0.9972	105	0.9681
23	1.0260	65	0.9965	106	0.9673
24	1.0253	66	0.9958	107	0.9666
25	1.0246	67	0.9951	108	0.9659
26	1.0239	68	0.9943	109	0.9652
27	1.0232	69	0.9936	110	0.9645
28	1.0225	70	0.9929	111	0.9638
29	1.0218	71	0.9922	112	0.9631
30	1.0211	72	0.9915	113	0.9624
31	1.0204	73	0.9908	114	0.9617
32	1.0197	74	0.9901	115	0.9609
33	1.0190	75	0.9894	116	0.9602
34	1.0183	76	0.9887	117	0.9595
35	1.0176	77	0.9880	118	0.9588
36	1.0169	78	0.9872	119	0.9581
37	1.0162	79	0.9865	120	0.9574
38	1.0155	80	0.9858	121	0.9567
39	1.0148	81	0.9851	122	0.9560
40	1.0141	82	0.9844	123	0.9552
41	1.0134			124	0.9545

APPENDIX VII

EVAPORATION LOSSES BY MOTOR GASOLINE IN STORAGE TANKS

The following table is based upon results obtained through tests made by 14 oil companies on a wide range of tank capacities and petroleum products. The figures show losses per year from cone-roof, gastight storage tanks equipped with conventional pressure and vacuum valves.

Table XI. Losses by evaporation

Tank capacity (barrels)	Loss of capacity per year (percent)	Loss per year (gallons)
1,500	5½	3,465
2,500	5	5,250
5,000	4½	9,450
10,000	4	16,800
15,000	3½	22,050
25,000	3½	36,750
37,500	3¼	51,198
55,000	3	69,300
80,000	2⅗	87,400

APPENDIX VIII

CLEANING AND REPAIRING GASOLINE CONTAINERS

Section I. Inspection and Classification of Containers

1. General.

The maintenance and cleaning of gasoline containers falls into two categories: the first, consisting of field maintenance, which can be accomplished at the bulk break-down or fuel distribution point; the second, requiring repair equipment, which must be handled at a base reasonably removed from the combat area. There is also a salvage problem, but this does not enter into the maintenance of various-sized fuel containers.

2. Inspection.

a. CLASSIFICATION. A drum is considered to fall into one of four categories, with respect to condition, as follows:

(1) Will give satisfactory performance in its present condition.

(2) Can be put in usable condition in its immediate location (field maintenance).

(3) Requires major repairs, necessitating return to bases (base maintenance).

(4) Irreparable and fit only for scrap.

b. TYPE AND PLACE OF INSPECTION. Inspection may be said to be performed under two general sets of conditions.

(1) Any inspection conducted at the fill point or in a storage area where the primary consideration is to obtain drums in the first two categories.

(2) Any inspection conducted where large-scale reclamation can be undertaken. The greater part of drum inspection and segregation will be done at bases; but to avoid duplication of effort, when leaky drums show up at a fill point or in storage, those with leaks which cannot be eliminated by a new gasket or plug, which can be replaced forthwith, should be marked (with chalk or other means) as to leak location and classified in accordance with directions herewith.

c. INSPECTION EQUIPMENT. Inspection tools can be simple and few in number. All that are basically necessary are a flashlight, a brass probing rod, and a hand mirror (1 inch in diameter) mounted in a brass frame, attached to a brass rod 36 inches long. The flashlight should be vaportight. If such an item is not available, any standard flashlight can be used, if covered completely with friction tape or protected by a rubber reinforcement ring around the lens. This is necessary so that if by accident the flashlight is dropped, it will not break or create a spark. The switch should be on before the vicinity of gasoline vapors

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is entered. The probing rod consists of a brass rod about ¼ inch in diameter, tapered at one end for a distance of 1½ inches, with a slightly rounded point. It may be advantageous to have the other end shaped like a screw driver so that it may be used as a scraping tool. The 2 inch bung should be removed from the top of the drum, the rod with light and mirror attached should be lowered into the drum thus enabling the inspector to clearly see the interior portion of the drum. The probing rod should be inserted in a like manner and the interior of the drum should be checked for any rust or deterioration.

3. Classification of Containers.

a. FIELD MAINTENANCE. Containers which fall into field maintenance classification are those which—

(1) Have their original shape, with the exception of a few minor dents, and do not leak in the body or seams.

(2) Are in good condition except for slight outside rusting.

(3) Do not have appreciable rust on the interior.

(4) Have missing plugs, gaskets, or, in the case of 5-gallon blitz cans, chains or connector link and cotter pin.

(5) Contain excessive amounts of sand or debris.

(6) Have been contaminated by the use of other petroleum by-products.

(7) Have sufficient rust on flange to impair gasket seat, or, in case of blitz can, to materially reduce venting.

b. BASE MAINTENANCE. Containers which fall into the major base maintenance classification are those which have—

(1) Excessive rusting on the interior.

(2) Seized or corroded threads in the flange.

(3) Excessive exterior rusting.

(4) Broken handles. (Blitz can.)

(5) Minor leaks at the seam.

(6) Bullet holes (not exceeding 1 inch in diameter) through the body in places where there is no embossing or excessive curvature of metal. In connection with this, bullets which pass through the vapor space of the drum will frequently cause a flowering of metal to the extent that the drum will not be reparable. The actual selection of those which are to be repaired should include only those in which the metal is turned inward.

(7) Rusted flange seats.

(8) Pressed steel plugs requiring straightening (especially ears on blitz can).

c. SCRAP. Containers which fall into a scrap classification are those which—

(1) Have bent flanges, and large holes over embossing, or on the reinforcement chime.

(2) Have many leaks in the seams, which cannot be repaired by normal methods.

(3) Are distorted completely out of shape.

(4) Have a multiplicity of dents.

(5) Are rusted through.

(6) Have vent pipes torn out. (Blitz can only.)

Section II. Field Maintenance of Containers

4. Cleaning.

a. IMPORTANCE OF CLEANING. Cleaning under field conditions involves rinsing the interior of the container with a petroleum solvent or kerosene to remove foreign material. (*Do not use gasoline for cleaning.*) Periodic cleaning will often keep a container in circulation for a longer period by minimizing rusting, plugging of vents, and corrosion of threads.

b. METHODS OF CLEANING. There are numerous methods of accomplishing this type of cleaning. The easiest and simplest, if labor is available, is the sloshing of the solvent in the container, followed by complete drainage of the container. This will remove most of the sand and debris, and dissolve any petroleum product which may remain. It is not an efficient method, since not all the sand or debris will be removed. For this reason, portable drum cleaners have been developed for mass cleaning of drums and containers in field organizations. The use of a petroleum solvent, or kerosene, in this work is necessary to minimize contamination in the event some of the cleansing agent remains in the container. This is an extremely important point, because numerous chemical cleaners used with water may cause later contamination of contents, if a portion of the cleaner should remain after cleaning. Every effort should be made to remove any cleansing agent. In base repair operations, this problem is more difficult, because it is necessary to introduce water for gas-freeing purposes. However, in field maintenance cleaning, gas-freeing, or degassing is not necessary or practicable.

5. Replacement of Plugs and Gaskets.

After cleaning has been accomplished, plugs or gaskets, where necessary, must be replaced. Both plugs and flanges now found in service are of a wide variety. In consequence, a plug may fit better on one container than on another. Replacement plugs should fit loosely. They should not bind or seize while being inserted. The blitz can gasket must be placed on the plug with the bead facing away from the plug flange, so that it contacts the container flange when tightened. In an emergency a blitz can gasket can be used on a 55-gallon drum in lieu of a flat gasket by putting the gasket on the plug with the bead up or facing the plug flange. If plugs appear to have excessive white deposits or threads that are crossed, they should not be used, but either sent to the rear for major repairs or placed in a salvage scrap pile. Connector link, cotter

pin, and washer should be replaced, if lost from existing plugs (blitz cans only). Old-issue blitz cans with chained plug (no wire swivel) should have a replacement of complete plug assembly.

6. Painting.

It is not assumed that extensive painting can be done in forward areas, but wherever possible, large bare spots should be touched up. This may be accomplished by scraping the area around the bare spot with a wire brush to make sure the metal is clean, then applying either by brush or spray, olive-drab paint conforming to U. S. Army Specification 3–181, Type II. This paint was designed for one-coat applications, and a single coat, properly applied, will provide suitable rust protection.

7. Final Inspection.

If inspection discloses that all work indicated as necessary in the initial inspection has been accomplished, the drum is then ready for issue or storage. If a drum is to be used immediately after field maintenance has been accomplished, it will not be necessary to spray the interior with rust-inhibiting oil. The only precautions necessary are to make sure that the cap is placed on tightly, and that the drum is turned over for immediate filling. If the drum is to be stored empty, interior rusting may occur quickly, necessitating further maintenance. If there is doubt as to whether the drum is to be stored or issued, the interior should be sprayed (by means of a spray gun) with Oil, Lubricating, Preservative, Special U. S. Army Specification 2–120. It is extremely important that the oil enter the container in a fog or mist spray and that the entire interior of the drum be covered. The amount of oil required is directly proportional to the surface area of the container involved. Blitz cans should have a coating of not less than 4 nor more than 5 cubic centimeters (1 to 2 teaspoonsful) of liquid for each drum to be coated. Fifty-five-gallon drums require not less than 20 and not more than 25 cubic centimeters (5 to 6 teaspoonsful) to protect the surface adequately. The coating should be applied so thinly that no excess liquid is left on the bottom. All plugs, with gaskets in place, should be screwed up wrench tight (25 foot-pounds torque) immediately after the drums receive the prescribed oil spray.

Section III. Base Maintenance of Containers

8. Inspection.

a. Determination of necessary maintenance. Inspection is necessary to determine what methods of repair should be employed, or to what extent maintenance should be undertaken. Possibly the inspector may decide that some of the drums previously segregated into this category are not suitable for repair and he will turn these over to a scrap pile. The inspector will, in the same manner, determine whether

or not the plugs, gaskets, etc., are suitable for repair. Plugs require only a visual examination to determine whether or not satisfactory repairs can be made. The repairs on plugs usually consist of rethreading or cleaning out the threads of the individual plugs. In this work, however, the plating may be removed in the cleaning process. Thus, when these plugs are returned to other units for replacement or storage, they should be coated with a rust-preventive oil, U. S. Army Specification 2–120.

b. TEST FOR LOCATION OF LEAKAGE. Containers should be subjected to an air test. On 55-gallon drums, an air test of 15 pounds is usually sufficient to show the exact point of leakage. A 5-gallon blitz can usually requires no more than 10 pounds. Air can be introduced through an air valve (from an old tire tube) brazed into a standard plug. A small pressure gauge should be incorporated in the assembly to indicate the pressure in the container. Any of the existing compressors in the field, or a hand tire pump, is suitable for building up the necessary pressure. The drum, under pressure, should be placed in a tank of water so that the seam under test is well covered. Bubbles will rise to the surface and become readily visible to the tester. Another satisfactory method is to make an application of a soapy water solution, by brush or other means, to the seams of the drum under test. The location of the leaks should be chalked, to facilitate repair. In

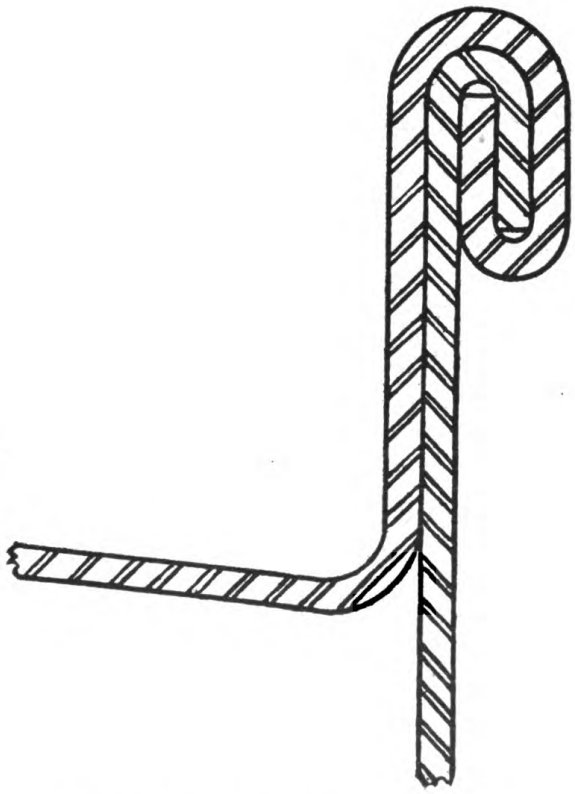

Figure 35. Detail of double-seamed chime.

the air testing of double seams, air bubbles are not conclusive evidence that the principal weakness of the seam is at the exact point where the bubbles appear. This is due to the possible formation of semiducts in the seams (if the metal in the chime is distorted). In some cases, the weakest spot in the joint may be at some distance from the place where air emerges. This matter will be further clarified by a study of a double-seam cross section. (See fig. 35.) Important leaks in double seams are usually repaired by completely welding or brazing the entire periphery of the chime. A sketch of a cross section of a welded or brazed drum is shown in figure 36.

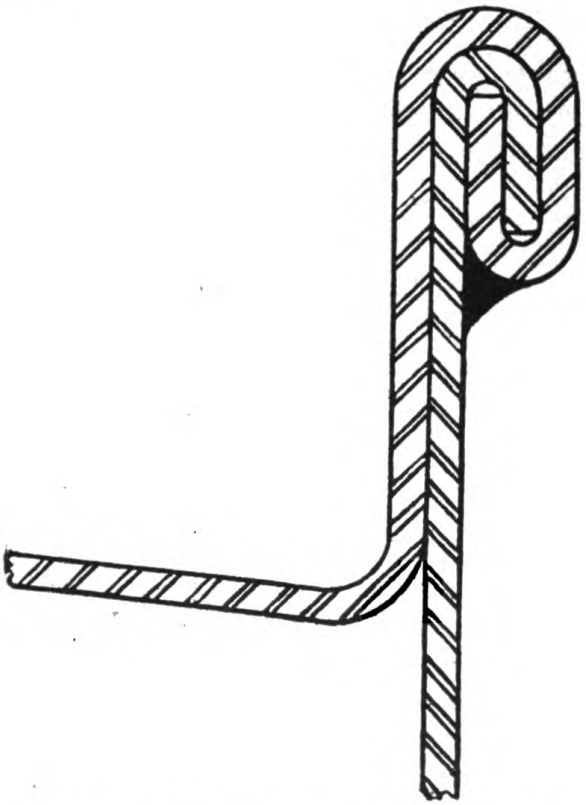

Figure 36. Repair of double-seamed chime by brazing or welding.

Drums equipped with chime reinforcement bands which leak in the chime cannot be repaired. If there are numerous leaks in the container, it may not be economical to undertake repairs. The decision as to whether maintenance should be undertaken is the responsibility of the officer in charge.

9. Major Maintenance Operations.

a. GENERAL. Major maintenance operations involve the reclamation of drums.

b. CLEANING. (1) *Degassing of container.* Prior to any work involving welding or hammering of any type, the container must be

thoroughly freed of gasoline residue, liquid or vapor. This can best be done as follows:

(*a*) Slosh about 1 gallon of water in each container, then invert the container and allow the water to run out. A small portion of the water will remain, which is advantageous.

(*b*) With the container still in an inverted position, introduce steam at 5 to 10 pounds pressure in sufficient quantity to bring the temperature of the container shell to 180° quickly. A hose ½ inch in diameter is sufficient. The interior of either a 5- or 55-gallon drum should be vapor-free within 10 minutes. The vent tube in the blitz can may easily trap water, steam, or gasoline and care must be taken to ascertain that this tube is thoroughly drained.

(*c*) A stream of air should be forced through the drum during the entire welding operation.

(*d*) There are other methods which have been used, such as rinsing with carbon tetrachloride, rinsing with plain cold water, rinsing with hot water, and rinsing with soapy water. None is, however, so effective as steam. ***Caution:*** Gasoline vapor in diluted quantities is always dangerous and should be so treated. As an added precaution, container openings should be held away from the operator during welding.

(2) *Method of cleaning rusted interiors.* Several methods for cleaning badly rusted interiors may be used. The selection of the process will depend largely on availability of necessary supplies and/or equipment. Several methods are listed below in order of preference: chaining, cleansing with alkali solution, sand blasting, and scraping.

(*a*) *Chaining.* Either chains or metal scraps may be used in this operation. The drum should be tumbled until the inside of the container is in serviceable condition. In cleaning the blitz can with this method, extreme care must be taken to prevent the chains from pulling out the vent pipe.

(*b*) *Alkali solution.* This method requires flushing the drum with a strong alkali solution until the drum appears reasonably free from rust. In this type of cleaning, care must be taken to insure removal of alkali from the interior.

(*c*) *Sand blasting.* The sand used in this method should be thoroughly screen and heated until completely dry. The blasting operation should be done through a wand with an adjustable tip to allow the sand to penetrate to the upper portions of the container, as well as to the sides and bottom. Here again it is extremely important to remove all the sand after the operation has been completed.

(*d*) *Scraping.* If no other method is feasible, a tool similar to a putty knife can be employed in scraping the sides of the container. This is not a very satisfactory method, and will remove only visible large deposits.

(3) *Cleaning of exteriors.* The outside of a container may be cleaned in the same manner as the interior. However, in most cases extensive cleaning will not be necessary, and a scraping of the rough spots for

removal of the old paint will suffice. After the interior and the exterior of the container have been cleaned in a satisfactory manner, the container should then be tested to determine whether it is free from leaks.

c. REPAIR OF LEAKING SEAMS. (1) *Factors governing repair of seams.* The factors entering into the decision to repair leaking seams are as follows:

(*a*) Whether the time and labor are justifiable.

(*b*) Whether the excessive use of welding rods can be justified.

(*c*) Whether the use of acetylene gas for the purpose can be justified.

(*d*) Whether there is an actual shortage of containers, which will necessitate the elaborage repairs to be undertaken.

(2) *Method of repairing seams.* (*a*) *Electric welding.* A system of repairing seams is by electric welding between the double seam and the body of the container. Care must be taken not to burn through the metal. This method requires a previous operation consisting of heating the seam to remove old seaming contact.

(*b*) *Gas welding.* Another method is by gas welding the entire circumference of the container, by filling the space between the top of the double seam and the container body. This method, as well as (*a*) above, requires a previous operation consisting of heating the seam to remove the old seaming compound.

(*c*) *Brazing.* The method for brazing is the same as for gas welding except for the use of brazing rods. The portion of the drum to be brazed is heated to a cherry red, then the brass or bronze filler material is melted as it is applied to the desired section by the use of gas torch. The section of the drum to be repaired may be heated by the use of a blow torch or if necessary some sort of oven may be improvised which will produce enough heat to bring the drum to the required temperature needed for the operation.

d. REPAIR OF HOLES. (1) Small bullet punctures on flat surfaces can be repaired by placing a piece of similar metal of slightly larger diameter over the hole and welding around the entire area. Care must be taken, however, to clean the entire surrounding area with a wire brush so thoroughly that no paint is left between the patch material and the hole in the drum.

(2) If holes occur on excessive curvatures of metal or in a place that has been embossed, it is usually not practicable to attempt welding, especially on sides of blitz cans, as a flexing of the metal would concentrate at that point and usually cause breakage or leakage soon thereafter.

When cans or drums are declared unrepairable they should be segregated and after all usable parts have been removed unserviceable material should then be disposed of as provided in paragraph 10.

e. REPAIR OF BLITZ CAN HANDLES. If repairing handles involves reattaching the handle to a container, it need only be held in place and

welded along the outer edge. If the handles are completely off, it is advisable that they be checked to determine whether they are the correct shape and whether rough edges are protruding. After this has been accomplished, they should be welded back onto the head of the container.

f. Repair of flanges. (1) Flanges which have been damaged by bending or by a bullet penetration will not be suitable for repair. Most repairs, however, will be a retapping of the threads, repiercing of the drain holes, and removal of the rust from the gasket-seating surface. After the tapping process, the threads should be covered with oil to prevent rust.

(2) Drain holes should be cleaned with a round file prior to the rethreading operation. The gasket-seating surface should be cleaned with crocus cloth or very fine sandpaper. Care must be taken to use a circular motion in cleaning the surface. In the case of the blitz can, after the surface has been thoroughly cleaned, if examination shows that the vent pipe is protruding above the gasket seat, it will be necessary to grind this down. In some instances, this process may loosen the vent and it will have to be soldered before the can is suitable for use.

g. Tests subsequent to repairs. The test consists of placing the container in water and introducing air pressure of 15 pounds per square inch into the 5-gallon blitz can. The air is introduced through the standard plug to which has been brazed a tire valve or other suitable device. The drum is manipulated so that each seam will be submerged and the absence of leaks determined. Care should be taken to prevent water from entering the interior of the drum before, during, or after the pressure test. After the pressure has been released and the plug used in testing has been removed, a properly fitting plug and gasket should be inserted, and the drum prepared for painting. The only remaining preparation is the drying of the drum on the exterior.

h. Painting. The container should then be coated (either brushed or sprayed) with one coat of olive-drab enamel, in accordance with U. S. Army Specification 3–181.

i. Final inspection. After the paint is thoroughly dry, the containers will be inspected to determine whether the work is satisfactory. After this is done, they are ready for storage and issue. In most cases, there will be a considerable period between the time the containers leave the maintenance base and arrive at the base of the using troops; therefore, the interior of all the containers should be sprayed with a coat of special lubricating preservative oil, U. S. Army Specification 2–120. This should be introduced by a paint spray in the form of a mist or fog. Care should be taken to make sure that all the surfaces of the container are well coated in this manner. The amount of coating applied, however, should not be less than 4 nor more than 5 cubic centimeters (1 to 2 teaspoonsful) for each 5-gallon drum, and not more than 25 nor less than 20 cubic centimeters (5 to 6 teaspoonsful) for 55-gallon drums. The material will be so applied that no excess liquid drains or collects on the

bottom. Plugs with gaskets in place will be screwed up, wrench tight (25 foot-pounds torque), immediately after the containers receive the oil spray.

Section IV. Scrap Containers

10. Disposition of Scrap Containers.

All containers which have been discarded as not suitable for repairs should be employed, wherever possible, as waste containers, bins, water troughs, or rain barrels, or in any way which may employ the usable portion of the scrap container. In some instances, when filled with sand, they may prove an effective aid in building bulwarks. Those containers which have been so badly crushed as to be of no use should be flattened and shipped to a scrap metal pile. Before this is done, however, the plugs of the containers should be removed and the containers placed upside down so that any remaining gas will flow out. This procedure should be followed because, if a baling machine is used, a capped gas tank under compression may cause an explosion.

Section V. Hazards and Safety Precautions in Handling Containers

11. Health.

The inhalation of gasoline vapors over long periods of time should be avoided. Avoid contact of the skin with gasoline. It is advisable when handling containers to use gloves. Clothing or shoes through which gasoline has soaked should be removed at once.

12. Vapor Dangers.

a. Explosions. Fuel containers should be considered as a hazard, and all necessary precautions observed in handling them. It must be remembered that the gasoline drums containing only a few drops are much more dangerous than full containers. For example, 1/10 ounce of gasoline in the bottom of a 5-gallon container, thoroughly shaken up to form saturated vapor, will mix with the volume of air present in the can and result in an explosive mixture. Extreme care must be taken, therefore, to prevent fires that may result from operating in the presence of an open flame, or that may be caused by sparks made by using steel tools for opening and closing of the plugs. This point should be emphasized to all personnel handling either full or empty gasoline containers. Hardwood, brass rods, or cadmium-plated bars should be used for removing plugs or straightening damaged portions, unless the container has been thoroughly gas-freed or degassed prior to the work.

b. Precautionary measures. (1) Many become careless after handling gasoline for a long period of time and cease to believe that it will readily ignite. Gasoline is very dangerous to handle. Military personnel should be cautioned to take necessary precautions when handling drums which contain fuel.

(2) Many fires have been started because operators were not careful about their dress. Handlers of containers should not have any exposed buttons made of sparking metals. Key chains, tools in pockets, etc., have frequently provided the necessary spark to create a severe explosion or fire.

(3) The maintenance of drums should be performed, so far as practicable, in outdoor areas. The use of closed buildings or tents is not advisable. Fires from obscure causes have later been found to have resulted from gasoline vapors which had collected in portions of a building and had been ignited by an unsuspecting person who had created a spark or lighted a cigarette. Smoking in the vicinity of can-cleaning or repairing operations must be prevented.

(4) Fires are frequently caused by exposed electric wires or open light sockets. This usually is not a problem in outdoor operation. If the work is to be handled in closed buildings, it is extremely important that a suitable explosionproof exhaust fan be used at the lowest point in the building, and that all light sockets, base plugs, drop cords, or electrical connections be of an explosionproof variety.

(5) Engines of motor trucks should not be operated in the vicinity of containers which have not been degassed.

(6) It must be impressed upon the minds of all officer and enlisted personnel that gasoline vapor is more dangerous than the liquid gasoline. Although in some cases safety precautions have been temporarily discarded with no disastrous results, under a different set of temperatures and climatic conditions an explosion or fire may occur.

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