

DEPARTMENT OF THE ARMY  
U.S. Army Corps of Engineers  
Washington, DC 20314-1000

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Technical Letter  
No. 1110-3-466

26 August 1994

Engineering and Design  
SELECTION AND DESIGN OF OIL/WATER SEPARATORS  
AT ARMY FACILITIES

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1. Purpose. This letter provides basic criteria and information pertaining to the selection and design of oil/water separators at Army facilities.
2. Applicability. This letter applies to all HQUSACE elements, major subordinate commands (MSC), districts, laboratories and field operating activities (FOA) having Army military construction and design responsibility.
3. Objective. The military is one of the largest purchasers of oil/water separators in the United States. The total number of separators currently owned and operated by the U.S. Army is in the thousands. A typical installation such as Ft. Carson has in excess of 150. In recent years, it has become obvious that many of the separators the Army has installed are not performing as anticipated. Deficiencies have occurred primarily as the result of inadequate design, misapplication of commercially available, pre-manufactured separators, failure to adequately understand the character of wastewaters being treated, and lack of maintenance frequently caused by inconvenient access to the separator and its working components. The Army has historically purchased and installed separators under the assumption that only oil and water has to be separated, and only under gravity conditions. However, the most common military applications seldom involve simple oil and water mixtures. Waste streams encountered frequently contain significant quantities of dirt, cleaning aids (detergents, solvents, etc.), fuels, floatable debris (vegetation, light sticks, etc.), as well as various other materials such as ammunition and ammunition casings, bolts, beverage cans and other items common to military equipment and activities. In order to correct the above deficiencies, this ETL has been prepared to provide guidance for design and construction of oil/water separators at Army installations.
4. Action. The information attached at Appendix A to this technical letter will be used for planning, design and construction of oil/water separators and appurtenances at Army facilities.

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6. Implementation. This technical letter will have immediate application, as defined in paragraph 6c, ER 1110-345-100.

FOR THE DIRECTOR OF MILITARY PROGRAMS:

1 Appendix  
APP A - Selection and  
Design of Oil/Water  
Separators at Army  
Facilities

  
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Chief, Engineering Division  
Directorate of Military Programs

## **APPENDIX A**

# **SELECTION AND DESIGN OF OIL/WATER SEPARATORS AT ARMY FACILITIES**

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AT ARMY FACILITIES**

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## 1. INTRODUCTION AND BACKGROUND

The military is one of the largest purchasers of oil/water separators in the United States. The number of separators currently owned and operated by the U. S. Army is in the thousands. A typical installation such as Ft. Carson has in excess of 150. In recent years, it has become obvious that many of the separators the military has installed are not performing as anticipated. Inadequacies have often resulted from poor design, improper selection of pre-manufactured, off-the-shelf units, failure to adequately understand the character of wastewaters being treated or pretreated, and lack of maintenance, frequently caused by not providing convenient access to the separator and its components. The same problems are very common with field-constructed separators.

The Army has historically purchased and installed separators under the assumption that they have only an oil/water separation problem to solve. However, the most common military applications seldom involve simple oil and water mixtures. Waste streams encountered frequently contain significant quantities of dirt, cleaning aids (detergents, solvents, etc.), fuels, floatable debris (vegetation, light sticks, etc.), as well as various other materials such as ammunition and ammunition casings, bolts, beverage cans and other items common to military equipment and activities.

The widespread failure of oil/water separators in the military is frequently the result of improper or inadequate maintenance. Often these systems are not designed or installed to provide for convenient access or maintenance. Many separator designs have only manhole access ports, and some have been found installed completely below paved surfaces with small access ports. These factors assure that timely and effective maintenance is not possible.

It is common for separators to discharge to one of three locations: an industrial sewer, a sanitary sewer, or to the environment via some portion of the stormwater drainage system. It should be noted that many pre-manufactured separators, and some field-constructed units designed by engineers, have provisions for bypass to stormwater drainage. Different discharge locations can place very different effluent requirements on the separator, with the industrial sewer being the most lenient, and the environment the most strict. The designer should know exactly where the separator effluent will be going, and design for the standards and regulations governing that particular system. Discharging the most common oil/water



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wastes found on Army installations to the environment will generally require that the treatment unit be designed for more than simple gravity separation.

These considerations, along with new environmental regulations and the widespread failure in performance of oil/water separators at Army installations, are the impetus for this ETL.

## 1.1 Sources of Waste

The most common sources of wastewater requiring pretreatment or treatment for oil or grease separation are associated with vehicle maintenance activities. Within a typical motor pool or aircraft hangar, there are numerous areas which produce wastewaters that will require treatment. Wastewaters from these sources will commonly be intermittent in flow pattern, contain grease, oil and other floating or floatable liquids, floating debris, settleable solids including soil, mechanical components of vehicles, and other materials having a specific gravity greater than that of the wastewater. Cleaning aids such as detergents, solvents, and fuels, will commonly be present. Figure 1-1 shows a breakdown of the various areas in which wastes are produced, as well as particular wastes produced in each area. The "source" is described further by a partial listing of the contaminants which are frequently present in the wastewater or "runoff." This ETL in no way covers every possible waste or waste stream that may enter an oil/water separator. Those listed are only the most common. The designer should always consider where the separator is to be placed and what type of waste stream will be involved. Also, source control should be emphasized to the greatest extent possible. A discussion of some of these areas follows. It is critical that the designer understand the process generating the wastewater. This requires knowledge of the activities, equipment, and procedures being utilized in the process.

### 1.1.1 Hardstand Drainage

Drainage from interior and exterior hardstand areas will occur during "wash down" of the area, from vehicle wet cleaning activities, spillage or leakage of oil or cleaning agents, and during a storm event. These activities generally produce a wastewater stream consisting of large volumes of water, dirt which has accumulated on the hardstand area, and possibly small quantities of oil from leaking vehicles or overflowing drip cans.

### 1.1.2 Drip Cans

Cans placed under vehicles to capture oil leaks are often left exposed to rainfall. The oil and water mixture that results is frequently emptied into an oil/water separator. If unchecked for an extended period, drip cans may overflow and mix with drainage from the rest of the hardstand area.

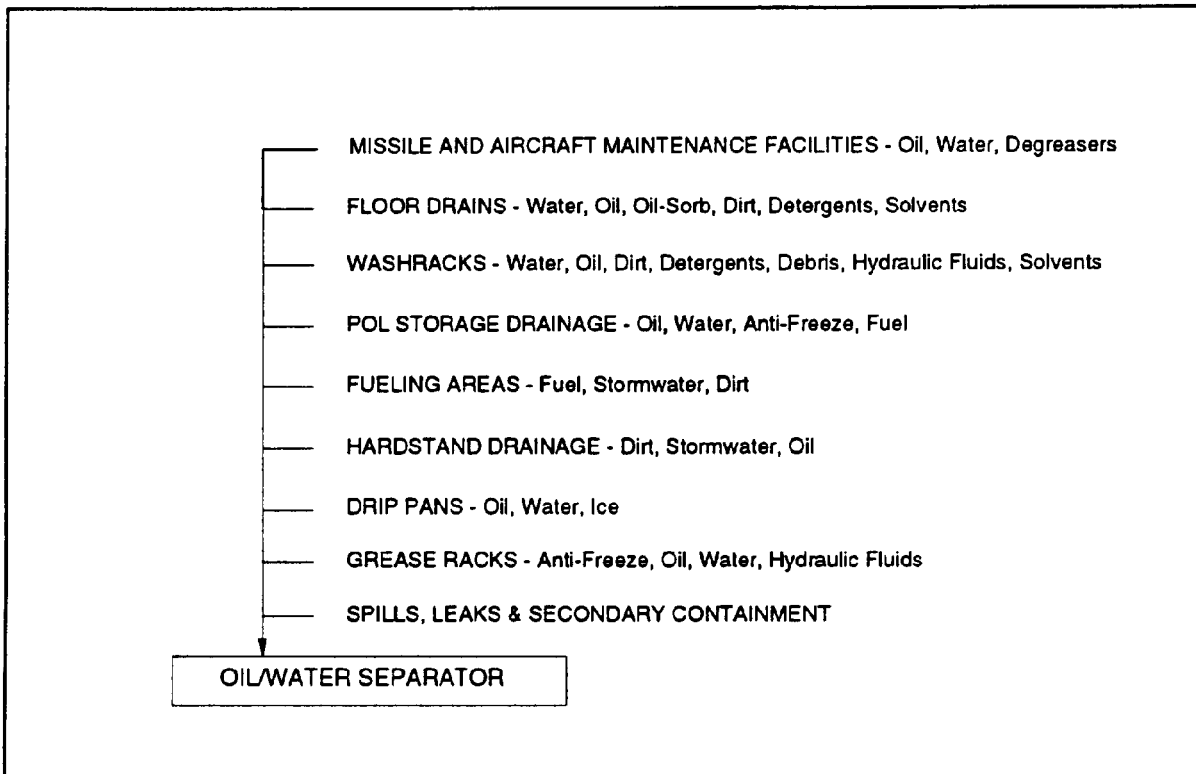


Figure 1-1 Sources of Waste

### 1.1.3 Fueling Areas

Waste streams from fueling areas may include fuel as a result of spills, and dirt and water from the surrounding hardstand. Also, troops may clean and flush fuel containers in this area. Purging and cleaning of fuel transport equipment is a major source of wastewaters requiring POL product separation at many Army installations. These activities result in large quantities of fuel and water entering the waste system.

### 1.1.4 POL Storage

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POL storage wastes result from spills, leaking containers, and stormwater intrusion. Waste oil and anti-freeze, normally stored in 55 gal drums, are the two most common substances found in POL storage areas. Often, these waste drums are stored without adequate protection from rainfall. Stormwater can then intrude, overflow the drums, and the resulting mixture will enter the drainage system.

#### 1.1.5 Grease Racks

Grease racks allow vehicles to be elevated for inspection and maintenance purposes. Maintenance performed typically involves radiator repairs, lubrication and oil changes. These processes may result in spilled anti-freeze and oil. Storm water will also contribute to the waste stream as most elevated grease racks are uncovered.

#### 1.1.6 Floor Drains

Drainage from floor drains in an indoor maintenance bay or hangar would typically result from either wet cleaning of the floor, wet maintenance cleaning of mechanical areas on vehicles, or spills. Oils and solvents are the most common substances spilled. Residuals of these spills, along with "oil-sorb" (both new and used) and dirt, will enter drains when the floors are cleaned. Also, detergents used by the troops to assist in cleaning will enter the drainage system.

#### 1.1.7 Washracks

Perhaps the most likely areas in which to find oil/water separators are vehicle washracks. Wastes produced from the washing process include water, dirt from the exterior of vehicles, oil that has spilled or leaked onto vehicle exterior surfaces, lubricants and other fluids from the interior, various floating debris resulting from poor housekeeping, and detergents used in the cleaning process.

### 1.2 Vehicle Cleaning and Maintenance

#### 1.2.1 Tactical Vehicles

Most major Army installations require maintenance and repair on large numbers of tactical vehicles. An important element of Army vehicle maintenance (both land and air) is interior and exterior cleaning. The exterior of a vehicle must be clean for inspection purposes, locating leaks or damaged parts, and to make necessary repairs. Many Army installations have central vehicle

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wash facilities which provide for exterior cleaning of tactical land vehicles. Even with central vehicle wash facilities, it is common for many installations to allow individual battalion and other motorpools to retain exterior washing facilities within the motor pool area. These are frequently used for both maintenance and exterior "final or cosmetic cleaning". Motorpool washracks, as stated earlier, are a very common location for oil/water separators.

Maintenance on tracked vehicles includes both interior and exterior washing, and lubricating fluid (POL) changes. During wet weather, a tracked vehicle may carry over 900 kgs (2000 lbs) of mud back from the training area. Typically, during maintenance, the engine pack is pulled, fluids are transferred, and the hull, engine, transmission, and other mechanical components are washed. Wheeled vehicles also require washing and fluid changes.

#### 1.2.2 CVWF scheduling and Use

The Central Vehicle Wash Facility (CVWF) was developed by CERL in the 1970's to allow the exterior of tactical vehicles to be cleaned in an efficient and environmentally safe manner. A CVWF consists of various structures for washing tactical vehicles and a wastewater treatment system for recycling the wash water. At installations with CVWFs, troops should make every effort to schedule and use the CVWF for all exterior cleaning. Prohibiting vehicle exterior washing in the motorpools can eliminate one entire wastewater stream. CVWF wastewater is generally of such poor quality that pretreatment is uneconomical and impractical. Exterior washing produces high volumes and sediment loadings, and both characteristics make pretreatment uneconomical at most installations. Reserve and National Guard activities are similar in nature, but are frequently much smaller in scale.

#### 1.2.3 Aircraft

The military has unique rotary-wing aircraft, specifically designed and manufactured for combat use. These aircraft have a special chemical agent resistant coating (CARC) paint on exterior surfaces which is porous and difficult to clean. The bucket-and-brush method is the most commonly used cleaning procedure for these aircraft, and often, spot painting and other maintenance activities are performed at the same site. The cleaning products used in combination with grease, oil, carbon, paint, and other materials washed from aircraft surfaces and mechanical components produce an extremely complex waste stream which may make pretreatment difficult.

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Waste streams produced from maintenance and cleaning of military fixed-wing aircraft can differ greatly from that of rotary-wing. Due to the type of flying, fixed-wing aircraft generally do not get as dirty as rotary-wing aircraft. In addition, they rarely have CARC paint on exterior surfaces. One would expect the waste water produced here to be much less complex.

#### 1.2.4 Cleaning Methods

Both low pressure, cold water (LPCW) and high pressure, hot water (HPHW) methods are used on military installations. Detergents are normally used in conjunction with the LPCW method, along with large volumes of water. HPHW washers can either reduce the use of cleaners or eliminate their need altogether. Some studies on hot water washers used for aircraft cleaning show that the use of solvents for cleaning can be reduced by as much as 80 percent. HPHW washers also decrease both cleaning time and water usage. This results in a significantly lower flow rate, and simpler wastewater for treatment.

#### 1.2.5 Chemicals and Cleaning Agents

Gravity oil/water separator performance will be dramatically reduced when wastewater contains chemically emulsified oils. Emulsification is usually due to the presence of detergents or other cleaning agents. Mechanical emulsification caused by agitation in washing is normally less of a problem for gravity separation. There are currently no organized, Army-wide efforts to reduce the type and amount of cleaning aids in use. However, it is anticipated that 2 recent Executive Orders, E.O. 12856, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements", and E.O. 12873, "Federal Acquisition, Recycling, and Waste Prevention", will force Army installations to reduce the use of cleaning agents which are harmful to the environment. In many instances, installations have motor pools which use cleaning products which are available through the GSA system, military procurement chain, or from local automotive suppliers. The informed use of HPHW cleaning systems can greatly reduce the use of cleaning aids.

### 1.3 Characterization of Sludge and Solids

The sludges and solids removed from oil/water separators exhibit certain characteristics, both of which the designer and operator should be aware. Inappropriate disposal of these sludges may create significant environmental problems. Most installations have disposal methods which consist of either

landfilling or uncontrolled dumping. Discussion of three regulated sludge characteristics follow. For further information, see Section 2 on Environmental Laws and Regulations.

#### 1.3.1 Total Petroleum Hydrocarbons

Legislation controlling the levels of Total Petroleum Hydrocarbons (TPH) in sludges to be land applied is becoming more strict. Some states are reducing maximum TPH levels to 10 mg/kg. Past studies have shown TPH levels are often more than 20,000 mg/kg in oil/water separator sludges. These regulations represent future trends. Most states are becoming more concerned with oil and groundwater contamination, and as they become aware of Army practices, they will in all probability tighten other standards as well.

#### 1.3.2 Free Liquids

Current regulations require that waste disposed of in a landfill, either hazardous or non-hazardous, have no free liquids. The presence of free liquids is determined by a "Paint Filter Liquids Test". (Reference for test) Most separator sludges have free liquid when they are removed for disposal and would not pass this test.

#### 1.3.3 Ignitibility

Current regulations also require that wastes have a flash point greater than 60°C (140°F). Past studies have shown that some separator sludges have a flash point less than 60°C, which is a hazardous waste characteristic. This is generally due to high levels of petroleum products found in the sludge.

#### 1.4 Stormwater Runoff

Historically, oil/water separators have been installed to treat runoff from military industrial areas having significant quantities of stormwater. While this may seem of insignificant concern, the following example is used to illustrate. Consider a separator with a surface area of 2.32 m<sup>2</sup> (25 ft<sup>2</sup>). During a 2.54 cm (1-inch) rainfall, the water that enters from the separator surface alone is insignificant in relation to the size and depth of the separator. However, if one takes into consideration the amount of surface area of the surrounding hardstand that drains into the separator, which may reach 2.83 hectares (7 acres) or more, one can easily see how quickly the volume of water multiplies.

Huge quantities of stormwater such as those described above create two problems. First, most separators do not have the capacity to handle large surges in flow. Therefore, water leaving the separator has not had adequate detention time, resulting in poor treatment. This can cause much of the previously accumulated oil to be flushed from the separator. The second problem comes from the flushing of large quantities of oily wastes into sanitary sewers, and the effect that has on wastewater treatment plants. Most regulatory agencies require that water leaving a separator be directed to a treatment plant for further treatment. While the discharge from one separator should not adversely affect a treatment plant, an installation with multiple separators can override the plant's capacity during a significant storm event. Rather than route stormwater through a separator, other methods of detention can be used for treatment. These methods are not a topic for this ETL. While the stormwater inflow problems described above are common at most installations, there are some areas where it would not be a problem. Areas where yearly precipitation is low would be an example.

### 1.5 New vs. Retrofit Design

In some cases, rather than purchase or design a new separator, an existing separator may be retrofitted. The designer should carefully consider the various options and weigh the costs before making this decision. One should take both maintenance and effluent requirements, as well as design costs, into account. The designer is cautioned regarding commercially available "performance enhancers", such as parallel plates, inclined tubes, coalescing filters, and other means of improving performance or increasing capacity of an existing separation chamber. Most of these performance or capacity enhancing options have severe operation and maintenance implications for the user.

## 2. ENVIRONMENTAL LAWS AND REGULATIONS

### 2.1 Federal Statutes and Regulations

The environmental regulations discussed in this section will focus on federal statutes and regulations. Federal regulations that are of primary interest include the Clean Water Act, the Clean Air Act, Federal Facilities Compliance Act of 1992, and the Resource Conservation and Recovery Act. The designer will be responsible for ensuring that all designs comply with federal, state and local regulations. It is likely that the designer will be required to comply with more stringent state or local regulations (e.g. some states classify used oil as a hazardous

waste even though federal regulations do not unless it exhibits a hazardous characteristic or is mixed with hazardous waste such as solvents).

The following list of environmental laws and regulations is not a complete and exhaustive list. State and local regulations are not included due to variability and space constraints.

- (1) Clean Water Act (CWA), Public Law (P.L.) 92-500, as amended by P.L. 95-217, P.L. 95-576, P.L. 96-483, P.L. 97-117, and P.L. 100-4; 33 U.S.C. 1251.
  - (a) 40 CFR 110: Discharge of Oil
  - (b) 40 CFR 112: Oil Pollution Prevention
  - (c) 40 CFR 122: EPA Administered Permit Programs: The National Pollutant Discharge Elimination System
  - (d) 40 CFR 125: Criteria and Standards for the National Pollutant Discharge Elimination System (NPDES)
  - (e) 40 CFR 403: General Pretreatment Regulations for Existing and New Sources of Pollution
- (2) Resource Conservation and Recovery Act (RCRA), P.L. 94-580:
  - (a) 40 CFR, Parts 260 through 268.
  - (b) 40 CFR 280: Underground Storage Tanks (USTs).
- (3) Hazardous and Solid Waste Act, P.L. 98-616.
- (4) Clean Air Act (CAA), P.L. 101-549.
- (5) Federal Facility Compliance Act (FFCA) of 1992, P.L. 102-386.
- (6) Army Regulation (AR) 200-1, Environmental Protection and Enhancement (Chapter 3).

## 2.2 Background

Oil/water separators are a very common treatment system and have variable applications on Army installations. In the last decade, a greater emphasis has been placed on the proper permitting and regulation of oil/water separators treating stormwater and non-stormwater discharges (40 Code of Federal Regulations (CFR) 122 & 125). The designer should be cognizant of the environmental regulations that may impact the design of an oil/water separator. Numeric effluent limits (e.g. oil & grease, COD, TOC, BOD, pH ) are not in-place nationally (federal standards) for storm water discharges except for some limited industrial activities. However, state and local regulations (with numeric limits) do exist and may be restrictive on the



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quality of effluent that may be discharged from an oil/water separator whether it is discharged to a NPDES permitted storm water system outfall, or to a publicly owned treatment works (POTW). The Federal Facility Compliance Act (FFCA) does not make federally owned treatment plants (FOTW's) totally equivalent to POTW's but has reduced the uncertainty of applicable regulations. The FFCA prohibits the introduction of any pollutants that are classified as hazardous wastes. Furthermore, AR 200-1, par. 3-3.e (1) requires that all Army installations comply with pretreatment regulations applicable to POTWs, even if the wastewater is treated by a FOTW. The designer should review this regulation and 40 CFR 403 for the specific requirements. Table 1-1 below lists the typical operating scenarios that may be encountered, and provides regulatory requirements for each.

**Table 1-1 Permit Requirements for Different Operating Scenarios.**

---

O/W Separator ==> Effluent		Discharge to ==> POTW/FOTW	Need Permission from POTW and meet pretreatment standards
O/W Separator ==> Effluent	Pretreatment of ==> Emulsions, Metals	Discharge to ==> POTW/FOTW	Permission & Pretreatment
O/W Separator ==> Effluent		Discharge to ==> NPDES Permit- ted Municipal Storm Sewer System	File Notice of Intent with certifications
O/W Separator ==> Effluent		Discharge to ==> Non-Municipal Storm Sewer System	Permit Req'ts up to Discretion of Regulator
O/W Separator ==> Effluent		Discharge to ==> Creek or Drain- age Way	NPDES Permit Required

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### 2.3 Source of Waste Streams

Flow to oil/water separators can be classified into two general types of waste streams for military applications.

a. Interior Waste. Interior waste streams are comprised entirely of industrial or process water, or washdown type

drainage with no sanitary or storm water included. Typical sources for this type of waste stream might include petroleum, oil and lubricants (POLs), and water and grit flushed down floor drains during equipment maintenance and washing activities. The flows from these sources are relatively small compared to outside sources impacted by rainfall and runoff. Appropriate discharge would be to a sanitary sewer system provided that acceptable treatment was provided by the oil/water separator, and there were no hazardous wastes present. The separator effluent will be subject to pretreatment requirements (40 CFR 403) if the sanitary sewer system is connected to a FOTW or POTW (AR 200-1, Chap. 3). A FOTW has typically been effluent regulated (biotoxicity and NPDES), and not as much emphasis was placed on pretreatment at the source unless it impacted the biosolids or treatment processes. Current regulations (FFCA & AR 200-1) no longer support the policy of regulating the treatment plant effluent only.

b. Outdoor Waste. Outdoor waste streams are composed of storm water flows that may or may not include non-storm water sources (e.g. motor pool parking with wash facility). The waste stream would be generated by outside maintenance activities (washdown) and would have the added disadvantage of the storm water flow. Waste would consist of a variety of POLs, grit and debris. It is questionable if regulators would permit discharge of oil/water separator effluent to a NPDES permitted storm water outfall since there would be non-storm water constituents.

Current federal regulations would indicate that stormwater discharge to a NPDES permitted storm water outfall is permissible from large parking areas (aircraft aprons, vehicle or tank parking areas) assuming the effluent has been certified as tested and evaluated for non-storm water flows [57FR41244 (Federal Register)]. Some non-storm water discharges are permissible if the water does not contain detergents, toxics, or hazardous materials [57FR41241]. This must be discussed in the storm water pollution prevention plan and approved by the state or federal regulators.

## 2.4 Characterization of Waste

It is essential that the designer attempt to determine the type of waste that will be entering the oil/water separator. Military installations are not typically permitted (RCRA Part B) to treat hazardous waste in oil/water separators whether the discharge is to a sanitary sewer or storm sewer system. Lack of available information on waste characteristics is the normal scenario faced by the designer. Engineering judgement should be

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used to design an oil/water separation system that will meet NPDES (40 CFR 122 & 125) and state and local regulations. If any doubt remains after initial investigations (field, interviews, literature) on the type of waste that will be discharged to the oil/water separator, testing should be conducted prior to design. The wastewater or storm water should be evaluated during design to ensure the liquids and/or solids entering the separator are not hazardous in accordance with 40 CFR 261 and state regulations. The liquid and/or solid may be hazardous if it exhibits a characteristic of ignitibility, corrosivity, reactivity, and/or toxicity (40 CFR 261.20-261.24). Furthermore these "wastes" may be hazardous if listed (F, K, P, U) according to 40 CFR 261.30-261.33 or if it is a mixture containing listed waste.

It is important to note that used oil is typically considered hazardous if it contains over 1000 ppm of halogens (40 CFR 279.11). Furthermore, if the liquid and/or solids fail the Toxicity Characteristic Leachate Procedure (TCLP) for metals (40 CFR 261 Appendix II), pesticides or solvents, the waste would be considered hazardous. If influent waste is hazardous, installation of an oil/water separator may not be appropriate. Oil/water separators may constitute hazardous waste treatment which requires a RCRA Treatment, Storage or Disposal Facility (TSDF) permit. Similarly, oil storage may be prohibited under RCRA unless the military installation is permitted under RCRA as a TSDF.

Underground Storage Tank (UST) regulations (40 CFR 280) exempt oil/water separators from being defined as an UST. The exemption does not apply to separate waste oil storage tanks. Waste oil tanks may be required to meet specific design standards. State regulators should be consulted on these issues.

The information provided may seem more appropriate for the installation or waste generator, but the designer is responsible for designing a treatment system which complies with federal and state regulations. The designer should ensure that the system will not add undue regulatory burden on the military installation.

## 2.5 Definitions

a. Municipal separate storm water system. A means of conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) which is designed to collect or convey stormwater. The storm water system

is publicly owned and is not a combined sewer or a part of a POTW (40 CFR 122.26).

b. Waters of the United States. The term "waters of the United States" is a very encompassing requirement and most bodies of water, (e.g. wetlands, rivers, streams and interstate waters) are covered by 40 CFR 122.

## 2.6 Point of Discharge

The designer must determine where the effluent from the oil/water separator will be discharged. Effluent discharged to a NPDES permitted stormwater system or outfall will not need an individual permit but the existing permit for the outfall may need to be amended to account for the new contribution. The following topics briefly outline the federal requirements for discharges to stormwater systems:

a. Non-municipal separate storm sewers [40 CFR 122.26 (a) (6)]. Storm water discharges associated with an industrial activity entering a storm water system that is not a separate municipal system may require a NPDES permit at the discretion of the regulatory agency. State programs may be even more restrictive on permitting requirements for storm water discharge.

b. Discharges through municipal separate storm sewer systems [40 CFR 122.26 (a)(4)] may not require a permit at the source (oil/water separator effluent) but the municipal outfall will be permitted. The government is not relieved of effluent standards simply because the discharge is to a separate municipal storm sewer system. There are still reporting requirements, site plans, hydrologic data, testing and certifications that will be necessary to ensure that the stormwater does not contain non-storm water discharges. The installation is required to file a Notice of Intent with the regulators for all storm water discharges associated with industrial activities [57FR41239].

If the oil/water separator discharges effluent to a sanitary sewer system treated by a POTW or a FOTW, there may be industrial pretreatment standards (40 CFR 403) that must be met. Most installations do not have the capacity to treat stormwater at the wastewater treatment plant. Therefore, it is essential to limit the wastes going into industrial or sanitary sewers to non-storm water.

## 2.7 Regulations Applying to Design

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a. Flow-through oil/water separators are not regulated as underground storage tanks (40 CFR 280.10 & 280.12) since they are regulated under section 402 & 307(b) of the Clean Water Act for wastewater.

b. Flow-through oil/water separators that have integral waste oil storage are not regulated under 40 CFR 280 as an underground storage tank (UST), because the storage is a part of the treatment unit. However, a separate underground waste oil tank over 416 liters (110 gal) would be regulated as a UST (40 CFR 280.10). Pumping to an aboveground waste oil storage tank should be considered by the designer as it would eliminate regulation as a UST.

## 2.8 Disposal of Waste Oil and Sludge

Disposal of waste oil and sludge is an installation or base responsibility. However, the designer should be aware of the regulations to ensure that the oil/water separator is not operating in violation of federal, state or local laws. Hazardous waste should not be allowed to discharge to the oil/water separator, and wastes generated by the oil/water separator must be managed in accordance with environmental regulations. This would include:

### 2.8.1 Non-hazardous Sludge

Bulk or non-containerized liquid waste may not be removed from the separator and placed in a municipal solid waste landfill in accordance with 40 CFR 258.28 unless the waste is household waste (excluding septic waste) or leachate or condensate derived from a landfill unit. Liquid waste means any material that is determined to contain "free liquids" as defined by the EPA's Paint Filter Liquids Test, Method 9095, EPA Publication SW-846. Therefore the liquid waste must be dewatered or solidified and disposed of in accordance with federal and state regulations.

### 2.8.2 Hazardous Sludge

Hazardous sludge generated by the oil/water separator cannot be land applied without first undergoing treatment to comply with the land disposal restrictions of 40 CFR 268.

### 2.8.3 Disposal of Oil and Petroleum Products

This is a base or installation function or responsibility. Used oil is typically excluded as a hazardous waste unless it fails the TCLP for metals, pesticides, or solvents. Ultimate

disposal or recycling is important in determining what regulations apply. Oil sent to a recycler has different requirements than oil that is sent for energy recovery or to a furnace or boiler for burning (40 CFR 279). This is beyond the scope of this ETL and responsibility rests with the installation or generator.

#### 2.8.4 Reportable Quantities

The installation is responsible for reporting releases of hazardous substances to the stormwater system in accordance with 40 CFR 117 and 40 CFR 302. Releases to navigable waters must be reported under 40 CFR 112 and 40 CFR 302. Permitted releases (releases within limits established in NPDES permits) do not need to be reported.

#### 2.9 Air Pollution Requirements

There are no federal regulations at this time which require that oil/water separators be covered or have off-gas treatment for volatile organic compounds. The state and local air quality regulators have been promulgating rules that might require vapor tight covers equipped with closed vent systems that direct vapors to an air pollution control device. The South Coast Air Quality Management District (SCAQMD) was contacted to determine if vapor control and treatment was required. Rule 1176 of the SCAQMD requires oil/water separators to have covers at oil production fields, refineries, chemical plants and industrial facilities handling petroleum liquids. A closed vent system with air treatment (e.g., a carbon column) would be required if volatile organic carbon emissions exceed 500 ppm. Jet fuel or gasoline might violate this criteria but diesel fuel would not be much of a concern. The designer shall contact the state and local air quality boards to determine the criteria for covers and vapor treatment needed at each installation.

#### 2.10 Spill Prevention Control and Countermeasure (SPCC) Plan

Designers should notify the installation that the SPCC plan may need to be amended when oil/water separators with waste oil storage are constructed. Revisions are required when conditions outlined in 40 CFR 112 are met.

### 3. SELECTION AND DESIGN

#### 3.1 Design Criteria

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As with any water treatment process, the designer must obtain the best possible information concerning wastewater influent, operation and maintenance of equipment, and the effluent requirements. These considerations will have impact on capital costs, performance, and operation and maintenance costs of the constructed system.

The information contained in this section concerns oil/water separators designed for the removal of oil and other liquids having a specific gravity less than that of water. The effluent will commonly require further treatment prior to final discharge. As noted earlier, design of oil/water separators for most military wastewaters will commonly require consideration of settleable solids and the use of cleaning aids or detergents. A designer will have two options; (a) design the separator, or (b) select from a myriad of commercially available prefabricated systems. Either choice involves a number of essential considerations:

(1) The separator must have capacity for settleable solids in most applications.

(2) It must be readily accessible for maintenance and inspection. Visual inspection and probing for solids levels is critical to good operation.

(3) Reliable oil removal from the surface of the separation chamber is a frequent problem with both commercially available units and specially designed separators. Currently, the most satisfactory method involves suction removal by installation personnel using equipment which is normally used for cleaning catch basins. This equipment is commonly referred to as a "vacuum or vac-all" truck.

(4) Accessibility is essential for removing and maintaining many of the performance enhancing configurations such as parallel plates, tubes, coalescing filters, and other devices inserted into the separation chamber. These devices will require frequent cleaning. Removal for cleaning with high pressure cleaning equipment is the procedure of choice. Cleaning in place requires taking significant health and safety risks, providing proper support equipment, and many other difficulties.

Some state regulatory agencies have recognized the impact of oil/water separators on biological treatment processes and have expanded installation NPDES permits to include effluent and pretreatment standards at individual separators. Environmental regulations are addressed in Section 2.

### 3.1.1 Influent Wastewater Characteristics

The characteristics of interest are flow rate, settleable solids content, quantity and type of oils and greases present, wastewater temperature and viscosity, and other contaminants affecting the operation of the treatment system. Specifically, one needs to know the form of the oil, (ie., free oil, emulsified oil, or dissolved oil), the specific gravity of the oil at design temperature, the specific gravity of the water at design temperature, the pH of the wastewater, the size of oil droplet to be removed, the quantity of settleable solids (grit and other heavy debris such as machine parts, ammunition casings) and the quantity of floating solids (plastic, grass, beverage containers, etc.). Wastewaters containing significant quantities of chemically emulsified oils cannot be successfully treated by gravity separation. These wastes require chemical treatment and flocculation followed by dissolved air floatation to adequately remove the oils. These systems are outside the scope of this ETL.

Obtaining actual data on influent characteristics for a specific design will be improbable if not impossible. Even if data were available, the information may not represent long term conditions due to the type of sampling procedures used (probably grab samples) and because of the obvious variable conditions at most sites. The designer must assume values for most of the parameters needed for the design. The type of facility generating the wastewater is of prime importance for estimating characteristics of the wastewater to be treated. Facilities will range from "very dirty" exterior wash racks for tracked vehicles to relatively "clean" oily wastewater from interior missile maintenance shops. Each facility will produce wastewaters with significantly different characteristics. This ETL will not identify all types of separators or provide absolute design parameters since the designer will encounter a broad range of applications for different facilities. Guidance will be provided for some of the more common types of applications (e.g. motor pools). However, it will be incumbent upon the designer to adequately define wastewater characteristics for design. It is the designer's responsibility to obtain the best available data from the user, the Directorate of Public Works (DPW), or the Base Civil Engineer (BCE), or to use sound engineering judgement in assuming values for those characteristics where data is unavailable or unattainable.

Because of the varying characteristics of wastewater, the design of a treatment facility must be tailored to the specific



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application. One should not simply estimate the flow rate and choose a prefabricated separator based on that parameter alone.

The designer is cautioned that removal of contaminants other than grit, oil and grease, and reasonable amounts of floating debris is not within the scope of this ETL. Grit, oil and grease will likely not be the only contaminants present in the wastewater. Some facilities requiring an oil/water separator will have very complex wastes. It is also important to remember that no gravity separation device will have a significant impact on dissolved organics, which create biochemical and chemical oxygen demand (BOD and COD). If there is evidence of this, or if the designer suspects that other regulated contaminants (eg., solvents, phenols, heavy metals, etc.) may be present, then those situations must be dealt with as a separate issue.

### 3.1.2 Flow Rate

The activities producing a wastewater stream requiring some form of pretreatment will normally be discontinuous in nature. Minimum flow rates will frequently be at or near zero. Peak flow rates can be encountered for several hours, and will normally be the flow rate of interest for design purposes. Extended periods of zero or low flow can create septicity problems with many separators. This is especially true for applications having dissolved organic material susceptible to biodegradation. It is not uncommon for pretreatment devices to receive low flows for several days, possibly weeks, while military units are deployed for training or other purposes.

The design influent flow rate will be determined by the larger of two contributing flows, stormwater run-off and oil contaminated wastewater. The stormwater flowrate can be calculated by the Rational Method using the appropriate "I" value for the area under consideration and a 10-year storm frequency, or other frequency as required by local regulatory authorities. The contaminated wastewater flowrate can be determined from the process generating it. At a wash rack for example, the number of wash points times the nozzle flowrate at each wash point is the total flow. The nozzle flowrate can be measured, using a bucket of known volume and a stopwatch, or estimated using the following formula:

$$Q = 29.7(d^2) (P^{\frac{1}{2}}) \quad \text{Equation 1}$$

Where:

Q = flowrate in gallons per minute,  
d = diameter of orifice in inches, and

P = pitot or velocity pressure in pounds per square inch.

Equation 1 is an empirical formula found in standard hydraulics textbooks. Remember that "d" is the diameter of the orifice of the nozzle or other restriction (such as a valve) and not the diameter of the hose or pipe.

At many Army installations, the flow from stormwater run-off is significantly higher than the process stream. Current environmental regulations related to stormwater discharges will greatly curtail the practice of designing oil/water separators (from industrial areas) to discharge effluent to storm sewers or drainage ditches. It will be required to discharge the effluent to sanitary or industrial sewers for further treatment. The discharge from even a single separator serving a large area during a significant storm event can have a profound effect on the treatment plant. One can see that the combined effects of multiple separators treating stormwater flows connected to a sewer system can be detrimental to treatment plant operation. Not only is extraneous water added to the sewer, but the high flow rates caused by stormwater tend to flush out the separators adding significant quantities of oils and greases to the sewer system, which then may cause problems at the treatment plant. On all future designs, it shall be Corps policy that storm water be excluded from the oil/water separator treatment system to the maximum extent practical. This statement obviously cannot apply where stormwater is contaminated with oils or other floatable material from parking lots, motor pools, airfields or similar sources. However, it can be accomplished by locating these facilities within buildings, as with interior maintenance bays, etc., by providing covered facilities, such as covered wash racks, and by providing trench drains, curbing, and grading to divert storm water from the area served by the separator. The use of valved diversion boxes, multi-level weirs, flow diversion channels, and orifice plates within separators is discouraged. Diversion valves operated by installation personnel are not recommended for most applications. Proper operating procedures cannot be ensured, and discharges of oily water to the environment may result. Likewise, without proper maintenance, weirs and orifice plates can become fouled with debris and thus become ineffective. Clogging of orifice plates by debris is the rule rather than the exception at most separators.

Past designs have utilized orifice control in shear gates, knife gate valves and small pipe diameter inlets as methods of limiting hydraulic overload of the oil/water separator. A problem observed at several installations was fouling of the flow restriction device by cups, bottles, and debris. Even orifice

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shear gates that are readily cleared of obstructions by lifting the handle are commonly be left unattended, or are wired into the open position. An associated problem with providing flow restriction is that the pipe ahead of the separator becomes a sediment basin instead of a carrier pipe.

It is therefore essential to limit the stormwater entering the oil/water separator to minimize the size. However, the designer is encouraged to provide a safety factor to accommodate unexpected flow variations. The designer should coordinate with the installation master planners on surrounding future use or expansions.

### 3.1.3 Solids Concentrations

An accurate measure of the total solids concentration will be rarely available. Estimates must be made from the type of facility the treatment equipment is to serve.

**The designer should expect sand and grit from any type of wash rack or cleaning activity and provide storage capacity within the separator for the accumulation of grit. Storage should accomodate the users anticipated frequency of cleaning, ie, if the user will clean the sediment from the unit on a monthly basis, then one months sediment storage should be provided.**

The estimated volume of sand and grit is to be based on the type of vehicle or equipment to be washed and the local soil conditions. Washing operations of tracked vehicles operated in a cohesive soil environment will produce much more grit than small wheeled vehicles operated in a sandy environment. In addition to sand and grit, the separator will also capture various other heavy solids such as machine parts and ammunition brass. There are cases where grit may not be a significant problem such as a missile maintenance facility or other facilities where equipment washing operations are not paramount. However, a means for removal of settleable solids must commonly be provided in any oil/water separator. The exact amount of grit and solids is not as important as the knowledge that they do enter the system and that one must design for removal from the separator. As will noted later, provisions of adequate detention time for removal of oils and greases by flotation will also allow for the settling of solids. It should be noted that certain sources such as washracks or vehicle maintenance cleaning activities using high pressure, low flow (either cold or hot water) equipment can have suspended solids concentrations as high as 20,000 mg/l or more.

At wash facilities, there may also be floating debris which if not removed will interfere with the proper operation of the separator by blocking weirs and pipes. Again, there is no way to accurately quantify the debris that may enter the treatment system, but the designer must be aware that the problem and design screening devices accordingly. Debris generally consists of items such as plastic cups, beverage bottles, plastic wrappers, rags, grass clippings and other forms of vegetation, and other discarded items.

### 3.1.4 Oils and Greases

There are various methods available for determining oil and grease content in a wastewater. There are testing and analysis procedures which allow determination of vegetable sources as distinguished from mineral sources. However, because of extremely variable conditions at most installations and the lack of commitment to long term sampling, the results may not be consistent or reliable. Again, the designer will probably be forced to estimate quantities, types, and conditions of the oils and greases contained in wastewaters based on the type of facility served. Condition of the oil indicates if it is emulsified, dissolved, or free. Free oil will be defined as that which is separable by gravity in a reasonable time period, normally a few hours. For gravity separation, the primary concern is free oil and grease because gravity separators are not effective in removing emulsified or dissolved oils. To be conservative, the designer should determine from installation users the heaviest oils which will be encountered. Frequently, a specific gravity greater than 0.90 will be appropriate for design. The greater the difference in specific gravity between the oil and water, the more efficient separation will be. The designer should also be aware that many manufacturers attempt to provide a scientific basis for their calculations by presenting an oil droplet size distribution, and then suggesting that such a determination can be made by using the Susceptibility to Separation (STS) Test described in American Petroleum Institute (API) Publication 421. The STS test does not produce such data. Data concerning the oil droplet size distribution will frequently be stated in manufacturers literature as follows:

Greater than 150 microns	[    ]	percent
Greater than 120 microns	[    ]	percent
Greater than 90 microns	[    ]	percent
Greater than 60 microns	[    ]	percent
Less than 60 microns	[    ]	percent

It should be noted that there is no known or recognized testing or analytical procedure that will provide the information required to complete the table above. Lack of adequate testing makes providing accurate and convenient design guidance difficult. This is an important consideration in that it makes many of the reported rating procedures for commercially available oil/water separators invalid for application to Army wastewaters specifically, and for most other applications as well. Also, much of the apparent theoretical basis for calculations in manufacturers "design manuals" is extremely suspect at best.

The API and most manufacturers use Stokes Law as a basis for theoretical computations regarding gravity separation of oil from water. Stokes Law has historically been used as a basis for understanding the principles of and significant factors impacting separation of settleable solids from wastewater by gravity. Equation 2 below is a simplified version of Stokes Law, and can be found in standard hydraulics textbooks. The equation predicts the terminal velocity of material suspended in liquid and having a density less than, or greater than, that of the liquid. The velocity at which suspended material rises or settles can be used as a basis for predicting the size and dimensions of the removal chamber. Simplifications used in developing Equation 2 are primarily constant acceleration due to gravity, laminar flow conditions around the rising or falling particles (low Reynolds number), and spherical particle shape.

$$V_p = \frac{54.48}{\mu} (D_p - D_w) d_p^2 \quad \text{Equation 2}$$

where:

$V_p$  = velocity of particle (cm/sec),  
 $\mu$  = absolute viscosity (poise),  
 $D_p$  = density of particle (g/cc),  
 $D_w$  = density of water (g/cc), and  
 $d_p$  = diameter of particle (cm).

The following is a brief summary of the influence of certain factors on the terminal velocity of particles suspended in wastewater requiring pretreatment by a gravity separator:

(1) As the diameter of particles increases, velocity increases,

- (2) As temperature increases, velocity increases,  
 (3) As the difference in specific gravity increases, velocity increases.

Obviously, as the terminal velocity increases, the period of time and size of the separation chamber can be decreased for a given flowrate. Manufacturers of oil/water separators frequently "rate" the capacity of their units using conditions which are not commonly found in military applications. For example, some manufacturers rate the capacity of their units at temperatures in excess of 37°C (100°F).

The following is intended to make the reader aware of the extent to which suspended solids having a density greater than water will accumulate in a separator designed for oil separation. Assume that the density of oil is 0.90 g/cc, suspended solids 2.65 g/cc, and that the wastewater temperature is 20°C. Then,  $\mu = 1.0087 \times 10^{-2}$  poise.

$$V_o = \frac{54.48}{1.0087 \times 10^{-2}} (0.90 - 1.0) d_o^2 \quad \text{Equation 3}$$

where:

$d_o$  = diameter of oil droplet (microns), and  
 $V_o$  = terminal velocity of oil droplet (cm/sec).

$$V_s = \frac{54.48}{1.0087 \times 10^{-2}} (2.65 - 1.0) d_s^2 \quad \text{Equation 4}$$

where:

$V_s$  = velocity of settling particles (cm/sec), and  
 $d_s$  = diameter of settling particles (microns).

$$V_o = \frac{54.48}{1.0087 \times 10^{-2}} (0.90 - 1.0) d_o^2 \quad \text{Equation 5}$$

Dividing (4) by (5):

$$\frac{V_s}{V_o} = \frac{1.65 d_s^2}{-0.10 d_o^2}, \text{ or}$$

$$\frac{V_s}{V_o} = -16.5 \frac{d_s^2}{d_o^2},$$

If  $V_s = V_o$  (rise rate of oil droplets equals settling rate of solid particles), then

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$$d_o^2 = 16.5 d_s^2$$

And if  $d_o = 1$ , then

$$d_s^2 = 1, \text{ and}$$

$$-16.5d_s = 0$$

Therefore, solids which have  $\frac{1}{4}$  the diameter of oil particles will settle at the same velocity as the oil rises.

If  $d_s = d_o$ , then

$$\frac{V_s}{V_o} = -1.65$$

Therefore, the solids will settle at a velocity 16.5 times that of the oil when  $d_s = d_o$ .

Table 2-1 (next page) is a summary of wastewater characteristics. The designer should note that this data is approximately ten years old. However, it is the most accurate data that is available at this time.

The specific gravity of oil to be removed should be determined using published data representative of the oil expected in the wastewater. In general, the specific gravity will range from 0.82 to 0.95. The heaviest oil expected should be used for calculations regarding separator sizing.

### 3.1.5 Wastewater Temperature and Viscosity

Information concerning wastewater temperature, and relevant density and viscosity data is available from many good references. The lowest wastewater temperature can be estimated from the ambient air temperatures experienced during washing operations, and considering the water source such as potable water mains or HPHW cleaning machines. The ambient ground temperature several feet below grade (where most separators will be located) is also a good indicator of the eventual wastewater temperature. In general, a conservative value within the 4.5-15.5 °C (40-60 °F) range should be used unless actual testing indicates differently. The lower the temperature the more difficult separation will be, therefore, the lowest temperatures should be used in sizing the separator. In cold climates, the use of insulation or a heating system may be justified.

### 3.1.6 Other Contaminates

Table 2-1  
Data Summary of Waste Water Characteristics

Activity	Constituent or Condition	Sample Type	Concentration (mg/L) or Unit
Engine Pack Cleaning (including filter removal)	Total Grease & Oil	Grab	17061
		Grab	18855
		Avg	17958
	pH	Grab	7.6
		Grab	8.0
		Grab	7.5
		Composite	7.5
	Tot. Suspended Solids Settleable Solids & Volatile Solids	Composite	2260
		Composite	6.2 (ml/L)
		Composite	27
Composite		135	
Composite		1020	
Tot. Dissolved Solids	Composite	1020	
	Temperature	N/A	17.5°C
Exterior Cleaning (M-60 tank)	Total Grease & Oil	Grab	412
		Grab	1022
		Avg	717
	pH	Grab	7.7
		Grab	7.7
	Tot. Suspended Solids	Grab	5900
		Grab	2975
		Avg	4438
	Exterior Cleaning (M-60 tank)	Total Grease & Oil	Grab
Grab			664
Avg			2056
pH		Grab	7.3
Tot. Suspended Solids		Grab	2375
		Grab	7.0 (ml/L)
Settleable Solids		Grab	2250
		Grab	250
COD		Grab	250
		Grab	160
BOD	Grab	250	
	Grab	160	
Tot. Dissolved Solids	Grab	160	
	Grab	160	



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Engine Compartment Cleaning (M-60 tank)	Total Grease & Oil	Grab	664				
	pH	Composite	7.5				
	Tot. Suspended Solids	Composite	957				
	Settleable Solids	Composite	0.25 (ml/L)				
	COD	Composite	1800				
	BOD	Composite	192				
	Tot. Dissolved Solids	Composite	160				
Engine Compartment Cleaning (M-60 tank for special run)	Total Grease & Oil	Grab	553				
	Emulsified Oil	Grab	557				
	Dissolved Oil	Grab	11				
<b>Heavy Metals</b>							
Sample	Cd	Cr	Ni	Pb	Zn	Fe	Basis
Total Heavy Metals	0.86	0.08	0.11	0.05	1.2	7.2	mg/L
Dissolved Heavy Metals	0.017	0.012	0.02	0.005	<0.005	2.5	mg/L

**Note:** Adapted from reference 8.

As mentioned previously, a very common problem with military oil/water separators is the presence of detergents and oil emulsifiers which inhibit the removal of oil by gravity separation. A gravity oil/water separator is designed to remove free oil, not emulsified or dissolved oil.

**Detergents will have a detrimental impact on the performance of gravity separators. It is imperative that the user and operator of an oil/water separator be informed that if emulsifiers (detergents) are allowed to enter the system, the effluent quality will be degraded.**

Stringent oil and grease standards may not be met if detergents are introduced into the waste stream. Therefore, the installation should prohibit the use of detergents. Chemical solutions, solvents, hydraulic fluids, and similar contaminants also have a detrimental effect on gravity separation. If the designer has reason to suspect these contaminants, testing should be performed to identify and quantify all materials. If it is determined that significant quantities of these contaminants exist in the waste stream, then further treatment may be necessary.

The pH of the wastewater will affect oil removal efficiency. If the water is alkaline (pH above 9.0), then additional treatment beyond gravity separation will be required.

### 3.1.7 Separator Design

Separator design will involve significant engineering judgement. The separation chamber may require provision of three separate storage volumes:

(1) A volume for separated oil storage at the top of the chamber.

(2) A volume for settleable solids accumulation at the bottom of the chamber.

(3) A volume required to give adequate flow-through detention time for separation of oil from the wastewater stream.

The most reliable way of determining the size of each volume is from some form of analysis of the actual wastewater flow to be treated. Simple separation testing can be accomplished with representative samples in graduated cylinders that are allowed to settle for variable periods of time. For example, allowing a one liter sample to settle for one hour will result in measurable quantities of oil and sediment in the cylinder. Sampling the water portion below the floating oil and above the settled solids, and then testing for oil and grease, dissolved organic content (COD and/or BOD), and suspended solids will provide a basis for predicting quality of the effluent from a separator allowing for one hour detention time. This assumes sufficient damping of turbulence in the inlet chamber, and other considerations. Sampling and testing under ideal circumstances would involve taking several samples representing the variable activities found at the wastewater source.

With information on the anticipated frequency of solids removal from the separator, the designer can size the volume required for settleable solids storage.

Another source of information is operational experience with existing separators treating similar wastes. Review of operation and maintenance records, conversation with maintenance personnel, and visits to installation on-site separators can provide valuable insight for the designer.

Regarding the separation zone or flow-through volume within a separator, there are numerous "rules of thumb" regarding the dimensions of this chamber. There are also two factors commonly considered in design; (1) surface loading rate, and (2) detention time at the appropriate peak flow rate. Many manufacturers and API relate the surface loading rate to the terminal rise velocity of oil droplets. As noted earlier, this does have theoretical merit **if the droplet size and distribution within a wastewater**

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**are known.** However, this is rarely the case with military wastewaters. Rules of thumb commonly used are: depths of chamber in the 1.22 to 2.44 meter (4 to 8 feet) range, length to width ratios of 3 to 5, and horizontal velocity through the chamber of 0.91 m/min (3 ft/min) or less. These "rules of thumb" have a practical basis. They attempt to limit turbulence within the separation zone and provide a reasonable depth for maintenance while considering construction costs.

Surface loading rates as low as 2.5 m<sup>3</sup>/day/m<sup>2</sup> (60 gpd/ft<sup>2</sup>), and as high as 42 m<sup>3</sup>/day/m<sup>2</sup> (1000 gpd/ft<sup>2</sup>) or more have been used. A common form of the equation relating surface area to terminal velocity is:

$$A_s = K_t Q_m / V_t \quad \text{Equation 6}$$

where:

$A_s$  = surface area of the separator, or horizontal projected area of parallel plates,

$K_t$  = a dimensionless factor describing turbulence and short circuiting (values range from 1.2 to 2.0)

$Q_m$  = maximum relative flow rate

$V_t$  = terminal rise of settling velocity

As noted earlier, this equation has limited application other than as a mathematical tool to understand the process. The limiting factor is the inability to accurately determine the terminal velocity which is critical to achieving a desired performance level.

Detention times from 45 minutes to 2 hours are common, but some waste streams have required up to 8 hours detention time. Of course with emulsified oil and grease gravity separation is impractical, and some process will be needed to break the emulsification.

## 3.2 Equipment Selection

### 3.2.1 General

There are two choices in the selection of oil/water separators: commercially available, prefabricated units and cast-in-place concrete separators. Prefabricated models can be furnished with some form of coalescing media. Usually, the prefabricated unit will have least capital cost when compared to a properly designed, cast-in-place separator. The designer should make the decision based on local conditions, performance requirements, project characteristics, budget constraints, and

user preference. Do not rely solely on manufacturer claims concerning the rated flow capacity of their equipment. To provide an adequate design, the engineer must specify minimum physical size or rated capacity of the separator to produce an effluent suitable for discharge to a sanitary or industrial sewer (50-100 mg/l oil and grease). The engineer should prepare an analysis showing required separation area and volume to achieve the specified performance under laminar flow conditions. Calculations based on the design flowrate, minimum wastewater temperature, specific gravities of the oil and wastewater, absolute viscosity, and minimum size oil particle to be removed, will be used to size the oil separation compartment. Typical hydraulic detention times at design flowrate will be 45 minutes to 2 hours.

The cast-in-place, concrete oil/water separator has been a standard design for many years in Corps Districts. However, there has been a lack of consistency in construction because many Districts have developed their own standard design. These standards do not include the many of the parameters discussed in this ETL. As an example, it is critical that the designer review the concrete design mix for all concrete separators to ensure a proper mix. The concrete mix should be evaluated to determine if pozzolans and silica fume should be added to improve the watertightness of the environmental structure according to ACI Manual of Concrete Practice, Standards 350R-89 and 515.1R-79. Lower water/cement ratios should be considered to improve the watertightness of the separator. Specific questions should be directed to the Waterway Experiment Station, CEWES-SC, 601-634-3277, or to CENPD-EN-G, O. Kiefer, 503-326-7359.

### 3.2.2 Design Principles

Whatever equipment is chosen, there are design principles that must be followed to obtain a system that will function properly. Clearly, hydraulic overloading and the lack of maintenance are the two most serious problems affecting the operation of separator systems. In many cases, maintenance problems are caused by poor access and lack of thought during design concerning maintenance procedures for solids and oil removal. The more difficult equipment is to clean and maintain, the less maintenance it will receive. Hydraulic overloading is most often caused by allowing storm water to pass through the system. The designer should observe the following principles:

a. General Separator Design. Open tankage for oil/water separators is recommended if not prohibited by air quality standards or weather conditions. The use of below grade,

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completely covered or enclosed separators with only manways for access is discouraged at most locations. (This does not apply to locations where vapor loss control or cold climate is a factor in separator design.) Separators below grade with access manholes and extension tubes to the surface (such as in horizontal, cylindrical units) are not recommended because of the obvious problems associated with visual inspection, cleaning, maintenance, and safety. The designer is encouraged to provide an open type unit with removable grates, covers, or guard rail in order to minimize safety problems and improve accessibility. The preferred design is a separator with the top at or above grade and open to the atmosphere, or if absolutely necessary, a cover which is completely removable. Access for routine sampling of wastewater should be provided. The cover should be designed so that it is easily removable by one person without the use of special hoists or other equipment. The system should be designed with consideration given to the personnel who must maintain and service the equipment. A separator that is completely open will require a guard rail around the top for personnel safety. The rail should be designed with a removable section for access during cleaning operations.

Supplemental heating may be justified for separators in cold regions if wastewater flows are intermittent and temperatures drop below freezing. Insulation of the separator can reduce heat loss, but if there is insufficient heat input from the influent wastewater or adjacent ground surfaces, the liquid inside will be susceptible to freezing. Submerged, explosion proof electric heater coils or steam coils may be necessary. However, this becomes an additional maintenance concern and coordination with the installation is mandatory. Freezing concerns are important where the customer has requested the separator be placed above ground.

A major problem associated with oil/water separators is lack of maintenance. The designer should attempt to simplify operation and maintenance procedures without sacrificing performance. Therefore, designs should include the minimum number of mechanical components necessary for proper operation. Other considerations include having replacement equipment commercially available in the area, and qualified manpower available to the user of the facility.

Soil and sediment has historically been a problem with oil/water separators, even those which are preceded by grit chambers. The inclusion of a sedimentation basin and storage compartment integral to the separator unit will be mandatory for all designs. The size of the sediment storage volume will be

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based on the expected influent solids loading and the anticipated frequency of cleanout. Pumpout connections or other appropriate means of sludge removal shall be provided.

b. Conventional Gravity Separation vs. Coalescing Designs.

Gravity is the primary force driving the separation of particles in both conventional and coalescing oil/water separators. The term "enhanced" or "coalescing" is often applied to separators which contain parallel plates, tubes, or media packs to aid the gravity process. For the purposes of this ETL, the term "conventional gravity" refers to separators without any of the above devices. The term "coalescing", when considered in terms of oil/water separation, refers to the agglomeration of oil particles along a flat surface, or on a medium constructed of a material having an oleophilic property, usually polypropylene. The theory is that the oil will agglomerate at the media surface, and then rise to the surface much quicker than by un-aided gravity separation. Several manufacturers produce separators with inclined plate or tube type coalescing packs. API Publication 421 does not contain data on oleophilic type, coalescing separators, but does have limited information on parallel plate separators. It states, "**petroleum industry data are insufficient to conclude that parallel-plate units offer overall superior performance.**"

The use of any type of coalescing device will complicate operation and maintenance of the separator. The devices tend to foul and become blocked with debris and suspended particles attached to the oil. If the coalescing pack is constructed of an oleophilic material, the problem is magnified. Therefore, the media will be removable and capable of being cleaned or replaced as required. The designer should consider the problems and safety issues (confined space entry) associated with these devices and design accordingly. It is recommended that conventional gravity-type, API cast-in-place separators be designed for sites producing wastewater with a high suspended solids or debris loading. If a coalescing separator is warranted, then particular attention should be paid to maintenance and safety design features. It is not likely that coalescing media separators will receive adequate maintenance at most military installations.

If coalescing separators are required, then only models which use the inclined plate (or tube type) coalescer pack with surface area designed using Stokes' Law, are recommended. Minimum spacing for inclined plates will be 1.9 cm (3/4 inch). Manufacturer's claims of greatly enhanced efficiencies based on the oleophilic properties of their media pack should be

investigated thoroughly before being accepted. The use of other types of media packs (other than inclined plate or tube type) such as coalescing or oleophillic filters or screens will not be allowed.

c. Stormwater Inflow. As mentioned previously, stormwater inflow must be eliminated to the maximum extent practical. (See the above discussion concerning wastewater flow rates.) In most cases, rainwater from a significant storm event will greatly exceed the normal wastewater flow from process operations. Excess flow causes water levels in undersized separators to rise and flood oil skimming devices such as rotating skimmers. The result is to fill the waste oil holding tank with stormwater at the first rainfall. The solution is to limit the influx of rainwater wherever possible. If this cannot be done, then the separator must be sized to handle the excess flow. This approach is discouraged because (1) the increased separator size will add significant costs, and (2) in some cases, separator effluent is routed to a sanitary sewer, resulting in increased treatment costs, and possible overloading of the WWTP.

d. Wastewater Conveyance. Oily wastewater will be conveyed to the oil/water separator by surface flow, open channels, gravity piping, force mains, or by a combination of the above. Pumping of wastewater will be avoided, if possible, to prevent mechanical emulsification. Where site restraints dictate pumping however, only progressing cavity pumps, pneumatic ejectors, or other low shear pumping devices will be considered. Centrifugal pumps will not be used. The use of closed underground piping will be kept to a minimum. The preferred method of transport shall be by open channel flow and left uncovered, if possible. If covered, a light duty grating or cover designed to handle the wheel or track loadings will be specified. The channels will be designed for cleaning by hand. They will be wide enough to use shovels, but not so deep that hand cleaning is impossible. Consideration should also be given to flushing the channels with water. The heavy solids loading should be considered during the design of closed piping. Adequate slope and sufficient cleanouts will be provided. Open channels in lieu of typical waste drain pipes must be evaluated in terms of cost, design needs, and practicality.

e. Separator Inlet. The inlet to the separator will be designed to minimize turbulence and to prevent short circuiting by distributing the flow equally across the separator. Energy dissipators will be provided at all separator inlets. The inlet will be designed for free-fall conditions with no flooding of the inlet at peak flow.

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f. Screening Devices. The designer will not use commercially available mechanical screening devices unless directed to do so by the user. The preferred design is a removable inlet trash screen with an approximate 1.9 cm to 3.8 cm (3/4 to 1-1/2 in) mesh opening. The screen should be fabricated using corrosion resistant materials. Removal of trash and floating debris will be a manual operation as needed.

g. Grit Removal Equipment. The designer may be tempted to use one of several types of commercially available grit removal devices. Unless grit removal is required by the user, it will not be allowed. Instead, the design should be based on gravity separation of grit with periodic removal by truck-mounted suction equipment. Mechanical grit removal systems are difficult to properly maintain and to keep operating at the typical military installation. The use of a ramp at one end of the grit chamber for equipment (small front end loader) access should only be considered if the material to be removed consists primarily of sand and dewaterers readily. If the designer expects the grit chamber to contain "soupy" material due to significant quantities of silt and clay, a ramp for equipment access will not be provided. In any case, grit removal methods and devices shall be compatible with the capabilities and equipment of the using agency.

h. Oil Skimming Device. A common skimming device used at military installations is the manually operated, rotating slotted pipe skimmer which has performed with varying degrees of success. Designer misconceptions, improper operation, separator flooding, and excessive quantities of floating debris have all contributed to the general failure of pipe skimmers. Proper design of a separator with respect to flow rates and the elimination of stormwater will solve the flooding problem. The designer must provide for skimmer access and ease of operation, and for screening of the influent to remove floating debris. If rotating skimmers are used, the hand wheel operated type shall be specified in lieu of the "lever" operated type. Rope skimmers or floating skimmers may also be considered and will be used where the liquid level cannot be controlled.

Strong consideration should be given to the elimination of oil skimming (removal) devices completely, although effluent quality is somewhat improved when oil is removed from the separator in this manner. Oil would then be allowed to accumulate on the water surface in the separator, and be removed by suction equipment on a periodic basis.



If skimmers are used, waste oil should be routed to a holding tank made integral with the separator tank. Detached waste oil holding tanks will not be used unless large volumes make the use of integral holding tanks impractical. The use of separate underground holding tanks will complicate the design and permitting procedures due to environmental regulations (see Section 2). Minimum holding tank volume shall equal the capacity of the separator in liters/ min (lpm) over some reasonable time period.

i. Weirs. Do not use fixed concrete weirs in cast-in-place separators or grit chambers. Provide an adjustable metal (aluminum) v-notch or broad crested weir attached to concrete baffles to allow for construction tolerances and field adjustment. The range of adjustment should be approximately 10-15 cm (4-6 in). Sufficient weir lengths should be provided to prevent oil short-circuiting due to excessive velocities over the weir.

j. Site Accessibility. Paved access to oil/water separators is essential to allow servicing and maintenance of equipment. The designer should evaluate maintenance requirements and lay out the separator site accordingly. Installation personnel should be able to accomplish the work with minimal labor and disruption of activities.

k. Aesthetics. The designer must inquire during the early design phase if there will be limitations placed on separator location. Aesthetics are usually more important near administrative areas than around maintenance areas. However, aesthetics should not preclude good engineering practice, and conformance with the design principles identified in this ETL, in order to provide the customer with a reliable oil/water separator. Visually screening the separator or installing a below-grade separator in a concrete vault can be used to meet both aesthetic and technical requirements.

l. Secondary Containment for Separator and/or Piping. Environmental regulations are becoming increasingly strict as they pertain to the design of oil/water separation systems. However, this ETL is not intended to anticipate all the future regulations pertaining to secondary containment. The designer should evaluate Federal, state and local requirements pertaining to secondary containment. Overly conservative and blanket assessments can lead to substantial expenditures that are not warranted and reduce available funds.

m. Cover/venting Requirements. The requirement for cover and venting is a site specific concern. Local fire officials at different installations have sometimes required compliance with National Fire Protection Association Standard 30 for venting of the oil/water separator and waste oil storage tanks due to a potential flammable atmosphere. Some local regulators in California require treatment of air emissions from separators (SCAQMD Rule 464). Separator covers are sealed to prevent leakage and enable off-gas treatment with a vapor recovery or disposal system. If the designer is faced with an air emission standard, the separator may need to be vapor tight and would preclude the use of open tankage.

n. Safety. The designer shall consider OSMA standards and the Corps of Engineers Safety and Health Requirements Manual (EM 385-1-1) as it pertains to the design of the oil/water separator. Any open tankage shall have adequate safety rails and grates to cover the design loadings. Installations typically have one person servicing an oil/water separator and the design should allow for lifting the necessary grates by a single individual. Confined space entry should be a concern for the designer when evaluating the operation and maintenance of the oil/water separator system. It is becoming more common for some users to place premanufactured separators in vaults to ensure a secondary containment and leak detection system. The vaults present problems with confined space entry, maintenance access, explosive atmospheres, and groundwater that must be considered.

### 3.3 Construction Considerations

#### 3.3.1 Construction Management

To insure that construction management personnel fully understand the design intent of the equipment specified by the design engineer, it is imperative that all submittals and shop drawings for prefabricated equipment be reviewed by engineers prior to approval.

#### 3.3.2 Performance Guarantees

The contract specifications for prefabricated units shall require minimum performance guarantees based on influent characteristics stated in the specifications. The Contractor shall be required to replace installed equipment not performing to the level required by the these specifications at no additional cost to the Government.

#### 3.3.3 Multiple Usage

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The designer is encouraged to review installation utility plans and minimize the installation of new separators if existing separators can be used, or combine flows from several sites into a single new separator. This assumes compatibility of waste streams and topographic features, and drainage can be accomplished without pumping and mechanically emulsifying the oil/petroleum. Fewer oil/water separators to maintain and operate may improve the overall operation for the installation.

#### 3.3.4 New vs. Retrofit

The designer should determine if stormwater is reducing the treatment efficiency of the oil/water separator. This may indicate that site improvements are required, and not replacement of the oil/water separator. Elimination of roof drain connections and surface runoff could dramatically improve the treatment efficiency of the oil/water separator. In addition to the reduction of stormwater inflow, existing oil/water separators may be upgraded with the addition of parallel plates, the redesign of influent and effluent baffling, or the redesign of skimming devices to improve treatment efficiency. The designer should use criteria contained in this ETL for existing separators that are not producing satisfactory effluent. New separators, however, should incorporate all applicable criteria to eliminate hydraulic overloading due to stormwater.

### 4. MATERIALS OF CONSTRUCTION

Oil/water separator units covered in this ETL will be constructed of reinforced concrete (RC), steel, or fiberglass reinforced plastic (FRP).

#### 4.1 Reinforced Concrete Tanks

As indicated in Section 3, RC tanks will generally be used at Army motor pools where large treatment units are required to remove the heavy concentrations of suspended solids, oils and greases from wastewaters generated by tactical and non-tactical vehicle washing and maintenance activities. RC tanks will be either cast-in-place or constructed of prefabricated concrete units. RC tanks will be open to the atmosphere with aluminum grated covers, and with galvanized steel or aluminum railing around the perimeter of the tank. All railing will have a removable section or sections for maintenance purposes.

#### 4.2 Steel and Fiberglass Reinforced Plastic Tanks

Open steel and FRP tanks will be provided with aluminum grated covers, and with galvanized steel or aluminum railing around the perimeter of the tank. All railing will have a removable section or sections for maintenance purposes. Underground tanks will be designed for horizontal installation only. Steel tank separators will be protected against corrosion by either: (1) a fiberglass reinforced plastic coating system, or (2) a STI-P3 corrosion control system. The STI-P3 system will provide an exterior protective coating, cathodic protection and electrical isolation for corrosion protection.

It should be re-emphasized from Section 3 that closed, underground oil/water separators are not recommended for motor pool areas due to the heavy solids loading, and excessive oil and grease generated by intensive vehicle washing and maintenance activities. The inherent problems related to inspection, sampling and removing accumulated sludge solids, oil and grease from closed underground tanks makes them undesirable for use. Where they must be installed however, the provision of adequate access openings for inspection, sampling and removing solids, oils and greases is required.

Some users, such as the Air Force, may require below grade separators to be enclosed in a reinforced concrete vault. The top of below-grade vaults will be open to the atmosphere and will be provided with aluminum grated covers, and with galvanized steel or aluminum railing around the perimeter of the tank. All railing will have a removable section or sections for maintenance purposes. Some users may also require that separators be installed above grade, either inside or outside buildings. In these situations, wastewater pumping may also be required to lift wastewater for treatment.

#### 4.3 Interior Protective Coating

Steel separators will be provided with an interior protective epoxy coating system. In some states, such as Illinois, concrete tanks used to store or collect petroleum products are required to have a liner system, or some other surface treatment designed to eliminate oil leakage through porous concrete surfaces.

#### 4.4 Components

Separator components will be compatible with the fuels, lubricating oils and wastes to be handled. These components will include inlet and outlet pipe connections, nozzles, diffusers, baffles, parallel plate coalescers, exterior piping, etc.

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Exterior piping and connections will be compatible with the fuels, lubricating oils and wastes to be handled. Piping will be non-corrosive, dielectric, non-biodegradable and resistant to microbial growth. Piping will be capable of withstanding an internal pressure of 0.35 kg/cm<sup>2</sup> (5 psi), and an external H-20 highway loading as defined in AASHTO's Standard Specification for Highway Bridges.

Where required, closed underground tanks will be provided with a cast iron, aluminum or FRP frame and cover for access. Below grade structures will be checked to see if buoyant forces are high enough to cause flotation. Calculations will be performed for empty-tank conditions. In order to prevent flotation, adequate measures will be taken to anchor structures to below-grade concrete slabs. Where required, tanks will be strapped to slabs using corrosion resistant materials.

## 5. OPERATION AND MAINTENANCE CONSIDERATIONS

Separator units will be provided with generous access openings to allow maintenance including cleaning and removal of parallel and coalescing plates, sampling and testing of waste effluent, periodic visual inspection, measurement of the depth of settled solids and oil floating on the surface, and periodic removal of accumulated solids and recovered oil products. Access covers will be easily removable and openings will be located such that maintenance personnel can easily enter and exit the unit. Access provisions will be such that sampling can be conducted in accordance with EPA or State testing regulations. Performance testing will be required after construction is complete and before the separator unit has been accepted by the using agency. Testing will be used to satisfy performance requirements found in the contract specifications. An operations and maintenance manual will be provided for each separator application.

## 6. WASTEWATER INFLUENT PUMPING

When lifting oily wastewater into the separator unit is required, one or more pumping units will be provided. Pump station construction will require adequate space for pumps, piping and equipment, along with storage volume for settled solids. Factory assembled or package type stations will generally be circular in design, and will be anchored to base slabs where warranted by subsurface conditions. Pump stations located in cold regions or in seismic zones will require special design considerations.

### 6.1 Types of Pumps

Only the following types of pumps will be allowed: pneumatic ejectors, screw pumps, plunger pumps and progressing-cavity pumps. Centrifugal pumps are not acceptable due to the high turbulence generated and the likelihood that physical emulsification of oil will result. Pump and pump station construction will be in accordance with TM 5-814-2. Where required, flow meters will be installed to indicate and record the discharge from the pump station.

## 6.2 Operation and Maintenance

The design of pumping facilities will include access hatches for the installation, removal, and replacement of equipment. Interior dimensions will provide minimum clearances between equipment. Eye bolts or trolley beams will be provided for hoisting and removing equipment from mountings. A suitable means will be provided to service and maintain all equipment. A drainage system will be provided for collection of wash down, seepage, and stuffing box leakage.

## 6.3 Personnel Safety

Guards will be placed on and around all equipment where operators may come in contact with moving parts. Warning signs will be placed at all hazardous locations. Pumping stations will require the use of vertical safety ladders. Adequate lighting and ventilation will be provided in conformance with TM 5-814-2. Where required for pumping facilities in cold regions, heating will be provided. Design for fire protection will be in accordance with DOD Manual 4270.1-M, and pumping stations will be classified as light hazard, industrial type occupancies.

## 6.4 Materials of Construction

Small, package type stations will be manufactured of steel or fiberglass. Where steel structures are used, cathodic protection or appropriate corrosion control measures will be provided for the underground steel shell in conformance with TM 5-811-7. Alternatively, steel structures may be protected by a concrete or gunite coating where proof can be furnished by the manufacturer of satisfactory design life. All structures will be designed to withstand flotation. The use of paints and protective coatings at pumping stations will be in accordance with the Water Environment Federation (WEF) Manual of Practice No. 17.

## 6.5 Electrical Equipment and Standby Power

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Pump station electrical equipment such as motor starters, controls, alarms, lighting, etc., will be designed in conformance with TM 5-811-1. The requirement for standby power at pumping stations will depend upon the type, location, and critical nature of the facility. Fixed standby power will be designed in conformance with TM 5-814-2.

## 7. REFERENCES

7.1 AASHTO Standard Specification for Highway Bridges, American Association of State Highway & Transportation Officials, 444 N. Capital Street, Washington, DC 20001, March 1992.

7.2 ACI Manual of Concrete Practice, Standards 350R-89 and 515.1R-79, American Concrete Institute, P.O. Box 19150, Redford Station, Detroit, MI 48219, May 1983.

7.3 API Publication 421, Monographs on Refinery Environmental Control/Management of Water Discharges--Design and Operation of Oil/Water Separators, American Petroleum Institute, 1220 L. Street, NW, Washington, DC 20462, February 1990.

7.4 Army Regulation (AR) 200-1, Environmental Protection and Enhancement, Headquarters, Department of the Army, Washington DC, 23 April 1990.

7.5 DOD Manual 4270.1-M, Defense Construction Criteria Manual, Deputy Assistant Secretary of Defense (Installations), Department of Defense, Washington DC, 15 December 1983.

7.6 Engineer Manual (EM) 385-1-1, Safety and Health Requirements Manual, Headquarters, U.S. Army Corps of Engineers, Washington, DC 20314, October 1992.

7.7 EPA Publication No. SW-846, Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods, Environmental Protection Agency, Washington, DC 20460, November 1986.

7.8 Fileccia R., S. Kloster, J. Benson, M. Kamiya, and J. Matherly, Pretreatment of Waste Discharges from Improved Arm Tactical Equipment Maintenance Facilities, Technical Report, N-107, U.S. Army Construction Engineering Research Laboratory (CERL), P.O. Box 9005, Champaign, IL 61826-9005, August 1981.

7.9 NFPA Standard 30, Flammable and Combustible Liquids Code, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101, December 1993.

7.10 South Coast Air Quality Management District, 21865 East Copley Drive, Diamond Bar, CA 91765-4182.

Rule 1176, Sumps and Wastewater Separators, 5 January 1990.  
Rule 464, Wastewater Separators, 4 April 1980.

7.11 STI-P3 Corrosion Control System Brochure, Steel Tank Institute, 570 Oakwood Road, Lake Zurich, IL 60047, January 1993.

7.12 Technical Manual (TM) 5-811-1, Electric Power Supply and Distribution, Headquarters, Department of the Army, Washington DC, 12 September 1984.

7.13 Technical Manual (TM) 5-811-7, Electrical Design, Cathodic Protection, Headquarters, Department of the Army, Washington DC, 22 April 1985.

7.14 Technical Manual (TM) 5-814-2, Sanitary and Industrial Wastewater Collection: Pumping Stations and Force Mains, Headquarters, Department of the Army, Washington DC, 15 March 1985.

7.15 WEF Manual of Practice No. 17, Paints and Protective Coatings for Wastewater Treatment Facilities, Water Environment Federation, 601 Wythe Street, Alexandria, VA 22314, May 1969.