Lubrication Guideline

Best Practices in Bulk Lubricant Storage and Handling

The health of lubricants is essential to extending the life of machinery and proper storage is critical to maintaining a clean and healthy fluid. Many things can happen to the lubricant between bulk delivery and dispensing to the machine application. This guideline is meant to provide general recommended practices for bulk lubricants relating to storage, handling, inspection, testing, and contamination control.

Contamination is a major factor in the life of the lubricant. This guideline gives particular attention to contamination control in order to fully maximize the life and preserve the condition of the lubricant.

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1.0 Factors Affecting the Life of the Lubricant

Lubricants can deteriorate in storage, usually as a result of one of the following causes:

1. Contamination, most frequently dirt and water
2. Exposure to excessively high and low temperatures
3. Long-term storage

Some contaminated or deteriorated lubricants can be reconditioned for use, while others must be degraded to inferior applications, destroyed or otherwise disposed of. In addition, portions of some contaminated products may be salvaged for use. The decision of which course of action to follow depends on such factors as the amount of product involved and its value compared to the cost of reconditioning or salvaging, the type and amount of contaminant present, the degree of deterioration that has occurred, and the effect of the contamination or deterioration on the functional characteristics of the product in the target application(s).

1.1 Contamination

The easiest way to control and particularly exclude contamination is to avoid using practices that risk exposing the lubrication to the environment and surfaces/objects that bear various forms and types of contaminants. Among other things, this guideline is designed to offer practical advice on how to exclude and monitor contaminants of various types from bulk lubricants in storage and handling.

Contamination of lubricants is one of the most significant factors affecting the storage stability and service life of bulk oils. Common types of contamination are discussed below:

1.1.1 Condition of Storage and Handling Equipment

Contamination of newly commissioned storage and handling equipment include preservatives, paint, moisture, rust particles and fabrication debris such as dust, dirt, or welding spatter, machining swarf, drill turnings, blasting sand and casting sand. To avoid contamination of bulk lubricants, appropriate care must be taken during manufacture, assembly, installation, servicing, repair, and conditioning of tanks and equipment.

Before use, storage tanks should be thoroughly cleaned, scale-free and treated internally with a protective coating or sealant that is compatible with the lubricants these surfaces will contact. Tanks and vessels should be carefully dried and cleaned before they are charged with a lubricant to be stored.

1.1.2 Solid Contamination

Solid contamination includes the additive residue (byproduct of degraded additives), paint chips, rust particles, and weld splatter that may pre-exist within the tank when first commissioned. Solid contaminants can also enter the tank through the breathers, inspection hatches, clean-out portals and through transfer hoses when filling the tank.

1.1.3 Liquid Contamination

Moisture, solvents, fuels, and other incompatible lubricants are harmful contaminants as well. Entrained water promotes base oil degradation and additive depletion. Dissolved, emulsified and free water all pose potential risks. In additions to distress imposed by water on additives and base oil oxidation, free water in bulk storage vessels provides a habitat for microbial contamination which is corrosive and harmful to lubricant performance properties. Lubricants in storage are most prone to become contaminated with water from headspace condensation. There are many other sources of water as well.

Emulsified water has a tendency to also impair air release properties of oil. When air fails to detrain (release air to the headspace) a common consequence is oil oxidation.

1.2 Thermal Degradation of Lubricants

Most good quality synthetic and conventional mineral oils are not affected by storage temperatures below 120°F (49°C). However, storing lubricants near furnaces, steam lines or direct sunlight in high temperature climates for a prolonged time period may cause additives and base oils to oxidize prematurely. A significant darkening of the oil color is an indicator of this condition. In greases, the oil may begin to separate from the thickener; this is known as bleeding. The separated oil will typically appear on the surface of the grease, depending on the type of thickener used. In certain cases, when there has been oil/thickener separation, working the grease (mechanical agitation) can return the oil to the bulk lubricant. However, this is not recommended if the top grease surface has an accumulation of dirt.

Lubricants that are potentially contaminated with volatile products, including diesel fuel, kerosene, or any other solvent, must never be stored in high temperatures. The presence of solvents can be identified by a test called the flash point test. In addition to evaporation and fire hazards, they can distort or even burst the storage vessel if tightly sealed.

1.3 Low-Temperature Degradation of Lubricants

Short duration cold temperature storage normally does not affect the quality of hydraulic fluids and conventional lubricating oils and greases. The major difficulty from cold storage temperature arises from the high viscosity of these fluids and the difficulty of pumping them to operating equipment and transport vessels. Products that contain significant amounts of water, like water-glycols and oil-water emulsions, should not be exposed to temperatures below 40°F (4°C). Freezing of wax emulsions with some paraffinic mineral oils will cause separation of the wax and water phases, giving the product a lumpy, curd-like appearance. Under these circumstances, the wax emulsions normally must be disposed of, because the products usually cannot be restored to their original condition.

Repeated freezing or long-term exposure to freezing temperatures may destroy the emulsifying properties of conventional soluble oils. Usually there is no change in the appearance of the product, although it may have a cloudy cast. However, after exposure to cold temperature the product may not emulsify properly with water. Under these conditions, the product must be disposed of.

Many highly additized hydraulic fluids and lubricating oils at low temperatures tend to lose their solvency in being able to retain additives. For these oils, the lower the storage temperature, the more likely the additives will stratify or settle out of the oil. Some examples of additives that will typically have this behavior include those that are organo-metallic (i.e., have metals such as sodium, barium, etc.) like detergents, antiwear additives, defoamants, EP additives, and some rust inhibitors.

Some oils, when subjected to repeated fluctuations of a few degrees above and below their pour point, may undergo an increase in their pour point (pour point reversion) of 15° to 30°F (8° to 17°C). As a result, dispensing may be extremely difficult even when the ambient temperature is above the specified pour point of the product. Oils that contain pour point depressants, like steam cylinder oils, or those that have a relatively high wax content are the most prone to pour point reversion. Although this problem does not occur frequently, products that may have this tendency should be stored at temperatures above pour points.

A product that has undergone pour point reversion may return to its normal pour point when stored for a time at normal room temperature. Cylinder oils may require 100°F (38°C) storage for reconditioning.

These and many other problems can be eliminated if lubricants are properly stored and maintained. If a change in properties (color, consistency, odor etc.) has been noticed, the oil supplier should be contacted to determine if the lubricant remains fit for purpose.

1.4 Storage Stability and Lubricant Storage Life Limits

As previously discussed lubricants degrade for a number of reasons, including heat and contamination. To avoid product deterioration, lubricants should only be stored for a limited amount of time as advised by your lubricant supplier. The amount of time that lubricants can be stored is dependant on various factors. Table 1 below provides a general description of factors that shorten the life of a lubricant:

Table 1. Variables That Influence the Storage Life of New Lubricants

Variable	Increase Storage Life	Shorten Storage Life
Base Oil	Highly refined mineral oils, synthetic hydrocarbons and inert synthetics like silicon-based oils	Lower-grade mineral oils and inorganic esters
Additives	R&O additives	EP additives
Thickener	No	Yes
Storage Temperature	Low	High
Temperature Variability	Low	High
Container	Plastic containers or liners	Metal drums, especially poorly conditioned ones
Humidity	Low	High
Agitation	Low	High
Outdoor Storage	No	Yes

Oxidation occurs in all oils that are in contact with air, including stored lubricants. The quality of the base oil and additives that are used affect the rate of oxidation. But the environmental and storage conditions, such as temperature and contamination, have the greatest influence on the rate at which the lubricant degrades by oxidation. Increasing the temperature at which the lubricant is stored by 10°C (18°F) doubles the oxidation rate, which cuts the usable life of the oil in half. The presence of water, usually introduced by condensation as a result of temperature variations, increases the rate of oxidation.

Some additives in new formulations are not properly dissolved in the oil. When the oil reaches service temperatures these additives may finally dissolve, a process known as “bedding in”. Other additives by design will never dissolve. For example, some gear oils may be formulated with solid additive suspensions such as graphite, molybdenum disulfide, as borates. These oils should not be stored for prolonged periods because the solid additives are prone to settle in the tank.

Long-term storage at moderate temperatures has little effect on certain premium lubrication oils, hydraulic fluids, and process oils. However, some products may deteriorate and become unsuitable for use if stored longer than three months to a year from the date of manufacture.

Table 2 below provides a general guideline for the maximum amount of time a lubricant should be stored to avoid performance degradation in normal conditions (clean and dry) and temperatures (40F – 100F). If a product exceeds its maximum recommended storage time, it should be sampled and tested to confirm fit-for-purpose, (see Chapter 6 and Appendix A):

Table 2

Product	General Maximum Recommended Storage Time, Months

Lithium Grease	12
Calcium Complex Grease	6
Motor Oils, Gear Oils	6
Fluids or Lubricants with Solid Additives	3
Turbine Oils, Hydraulic Fluids, R&O Oils	18
Emulsion-type Hydraulic fluids	6
Soluble oils	6
Custom blended soluble oils	3

2.0 Oil Storage Tank Design Features

A proper tank or vessel is necessary to avoid contamination and prolong the life of the lubricant in storage. Some tank design criteria are described below. However, it is recommended that the reader of this guideline consult the following guidelines relating to tank design, fabrication and commissioning:

1. API Standard 620 – Design and Construction of Large, Welded, Low-Pressure Storage Tanks

2. API Standard 650 – Welded Steel Tanks for Oil Storage

2.1 Tank Construction Materials

Storage tanks can be made from either stainless steel, mild steel plate, or anodized aluminum. Stainless steel and anodized aluminum have a relatively high material cost. In return, their maintenance costs are low. In certain cases, a thinner-gauge stainless steel may also be suitable to better contain the costs of construction.

Mild steel plates are more commonly used for bulk storage tanks. The material cost is relatively low, but they require more expensive cleaning and corrosion-resistant treatments. Some mild steel tank designs and fabrication processes require shot or sand blasting plus performing one of the following depending on the type of product to be stored: lanolin-based rust preventative, oil-resistant paint, coating with plastic or epoxy resins or, aluminum spraying.

Galvanized steels should not be used for tanks or piping due to risks associated with additive reactions in the formulated oil. Tank seams should be riveted or welded.

2.2 Aboveground and Underground Considerations

There are a number of federal regulations relating to bulk storage tanks.

1. Clean Water Act (CWA)
2. Clean Air Act (CAA)
3. Resource Conservation and Recovery Act (RCRA)
4. Underground Storage Tanks

Some U.S. states further regulate aboveground storage tanks (ASTs).

2.2.1 Aboveground

Aboveground tanks should be mounted on a concrete platform. The fill or supply lines should be arranged to eliminate the possibility of draining the contents of the tank. If the tank has multiple compartments, it is important that all lines be carefully identified corresponding to each compartment. It is equally common to find storage tanks resting either in the horizontal or the vertical position.

Fire and building codes for aboveground storage tanks vary from state to state. It is best to check regulations by consulting local authorities having jurisdiction of fire and building codes.

2.2.2 Underground

When tanks are installed below ground, care should be taken to keep the fill-line connection (curb box) in a location such that there will be no possibility of flooding in wet weather. Underground tanks should be avoided in sandy wet ground conditions.

Typically, aboveground tanks are much more common than underground storage tanks at least partly because the regulations for underground storage tanks are much more stringent. Sometimes, what appears to be an aboveground tank may actually be an underground tank according to federal regulations. According to 40 CRF 280.12, tanks that are 10% or more beneath the surface of the ground or, in other words, covered with earthen materials are considered underground tanks and are subject to those regulations. See Appendix B for more information and refer to the following guidelines for more information:

1. 40 CFR 280—Technical Standards and Correction Action Requirements for Owners and Operators of Underground Storage Tanks (USTs)

2. API 1604 – Closure of Underground Storage Tanks

3. API 1615 – Installation of Underground Storage Systems

4. API 1631 – Interior Lining of Underground Storage Tanks

5. API 1632 – Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems

2.3 Day Tanks

A day tank is a portable storage vessel which receives oil from a larger stationary vessel each day. The day tank is used to charging oil into new, rebuild, or in-serve equipment. A day tank can be as small as a 55-gallon drum or as large as common industrial tote bins or truck-mounted vessels holding hundreds of gallons. There are many suppliers of day tanks that equip them with a variety of accessories including transfer pumps, filters, breathers and various instruments. In general a day tank should have the following features:

- It should have a suitable breather that can handle air flow at least twice as high as the pump delivery rate. A bypass should be included. Particle size and capture efficiency should be compatible with the fluid cleanliness objectives (discussed later).
- It should have a dispensing pump and filter. The filter should have a particle size and capture efficiency compatible with the fluid cleanliness objectives (discussed later). The dispensing system should be plumbed to work in a closed lube (multipass) mode for off-line filtration (kidney loop) and valving to enable transfer of oil into the day tank through the filter. It pump should have a flow rate to enable turnover of the tank at least six times per hour.
- It should have an inline sampling port between the pump and the filter.
- Preferably, the tank bottom is conical with no settling zones.
- Level gauge provided

2.4 Breathers and Ventilators

Above the tank's oil level and beneath the roof of the same tank lies the headspace. Every tank produces different conditions within its headspace as the contents of oil mist, dirt and water vapor vary considerably. A high percentage of moisture and solid contaminants that enter lubricating oils and hydraulic fluids in storage vessels must pass through the headspace.

Breathers are necessary to exclude contamination. The breather needs to have a particle size and capture efficiency similar to what the transfer oil filter is expected to have. For example, if the oil filter that is used when discharging the lubricant out of the tank has a 90 percent capture efficiency at 10 microns (Beta 10 = 10), then the breather performance should be the same or better (see Figures 1 and 2). It does make sense to use a breather that is better or worse than the oil filter in terms of Beta or capture efficiency. If the lubricant is a hydraulic fluid, then the breather usually requires fine breather filtration - around 3 microns. Gear oils by comparison may only need 10-20 micron filters at 90 percent capture efficiency.

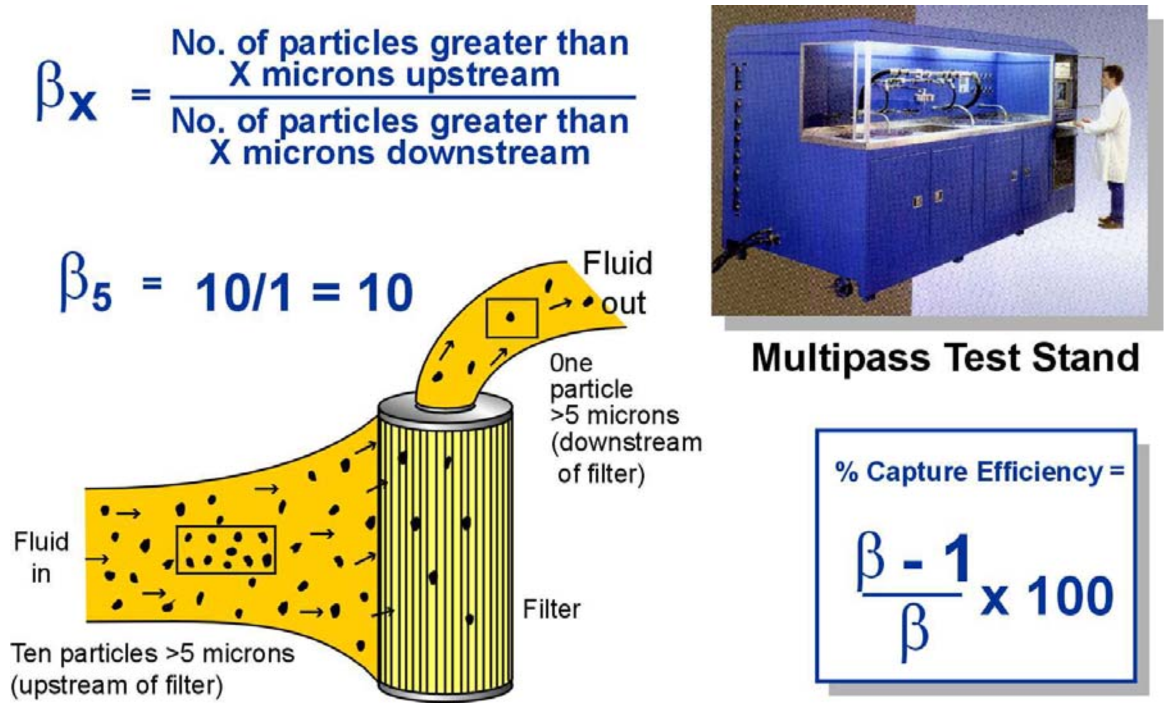

βx = No. of particles greater than X microns upstream / No. of particles greater than X microns downstream
β5 = 10/1 = 10
Fluid out
One particle >5 microns (downstream of filter)
Fluid in
Filter
Ten particles >5 microns (upstream of filter)
Multipass Test Stand
% Capture Efficiency =
β - 1 / β x 100

Figure 1

Beta (X)	Capture Efficiency (%)
1	0
2	50
4	75
16	93.8
20	95
50	98
75	98.7
200	99.5
1000	99.9

Figure 2

If the air in the environment is humid or if there is substantial temperature differences throughout the day, then there is a need to control condensation on the walls of the tank in the headspace. Otherwise, the condensate will often drip and settle at the bottom of the tank and accumulate. The collection over time can result in a water phase of several inches or even one to two feet.

Bulk storage tanks should be equipped with breathers positioned at least eight feet aboveground. The lower the breather is to the ground the more rapidly it will plug with dirt. If the location is humid, it is a good idea to use desiccating breathers to exclude moisture.
For instance, if a tank is only five feet high a three foot standpipe should be used to raise the breather's height

Headspace water vapor and suspended water within the lube-oil continuously seek equilibrium. By controlling headspace moisture, water residing within the oil will move into the headspace, thereby reducing the water content of the lube oil. The continuous process is called headspace dehumidification. It is a filter-less process designed to keep water in lube oils within safe limits.

Vapor extraction fans, or forced ventilators, are sometimes used to purge volatile hydrocarbon products and water vapor from the headspace. Good designs include the use of quality HVAC (Heating Ventilation and Air Conditioning) filters to remove dirt from incoming air. Vacuum fans are sometimes used to pull a slight vacuum in the headspace. This reduces the relative humidity, which can aid in controlling condensation. Headspace dehumidifiers are sold commercially and are similar to air conditioning units and mount above the tank. In typical configurations, air passes out of the headspace through the dehumidifier and then returns back to the headspace. An alternate method involves metering dry and clean instrument air into and through the headspace (purging to atmosphere through a port across the tank). This also helps keep the oil dry and clean.

2.5 Water-phase Floaters

Some bulk oils constantly build up water at the bottom of the tank. In these cases, a floater can be used to both provide an indication of the amount of free water and facilitate purging of the free water phase. The densities differences between the water and oil are such that a properly designed floater can sit on top of the water and settles in the oil. When the oil is discharged from the tank, the oil suction can be taken from above the water phase.

Using a very similar technology, the water can be purged from the tank using a floater valve arrangement (see figure3). The valve remains open until most of the water in the tank has been discharged at which point the falling floater lever closes the valve.

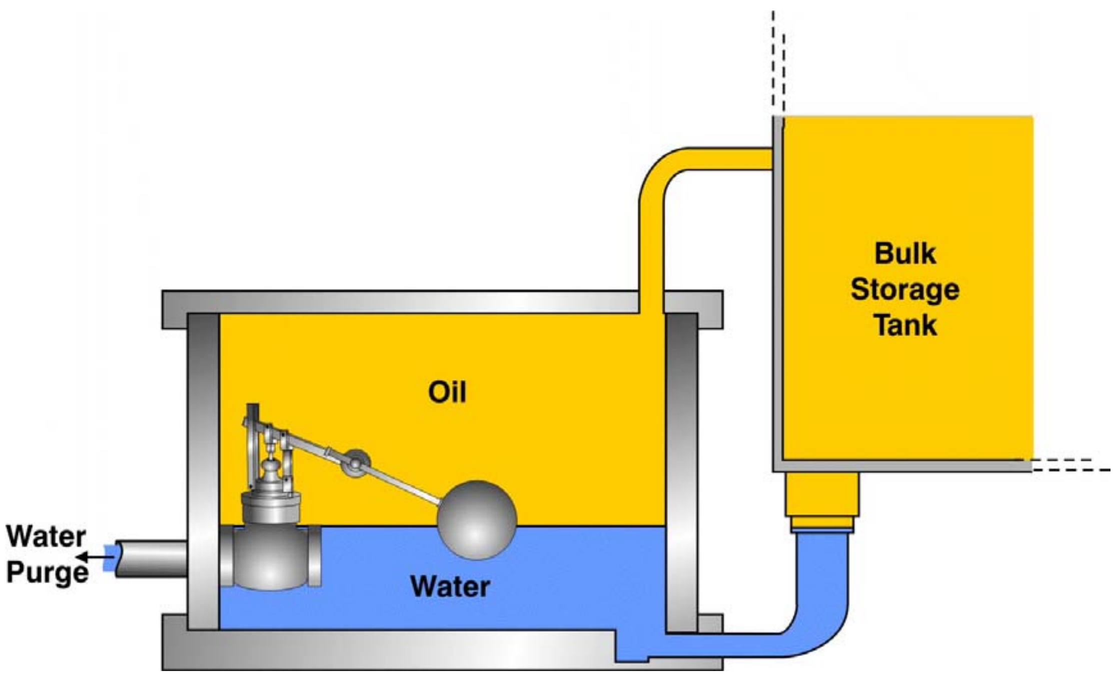
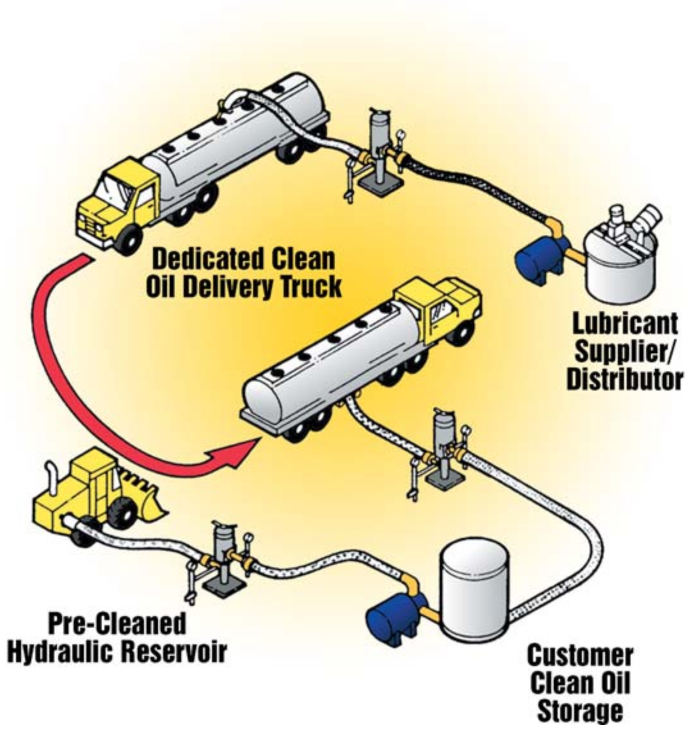


Figure 3

2.6 Filtration and Separation

The lubricant should be filtered before it enters and leaves the storage tank. The fluid cleanliness should be brought up to a level of one to two ISO 4406 range numbers below alarm levels. For example if the alarm level is an ISO 19/15, the filter should clean to a level of ISO 17/13. The filters need to be selected with the ability to maintain this target cleanliness level. New oil should be filled through a transfer filter or other suitable filtration technology. For small tanks a filter cart can also be used to clean the oil before it enters the tank. Some filter carts come fitted with an online particle counter to monitor



performance. A good general practice is to filter the lubricant whenever it is transferred as shown in figure 4 below:

Figure 4

In general it is advised to use filters that have performance rates per ISO 16889 (formerly ISO 4572), known as the Beta Rating. The Beta Rating can then be translated into a capture-efficiency at different micron sizes.

Large high-flow rate filters generally provide the best economy from the standpoint of the cost of a gram of dirt removed. For instance, when you double the size of a filter element you often triple its dirt-holding capacity. High-integrity Beta Rated filters are typically pleated cellulose or microglass media.

Temperature extremes have a major impact on the filter performance. For example, the viscosity of motor oils can vary greatly depending on the temperature. In the summer, when the temperature is about 100°F, the viscosity may be about 150 cSt (centistokes). [As a point of reference, water has a viscosity of 1 cSt.] In the winter when temperatures are about 10°F, the viscosity can be between 1,500 to 15,000 cSt if a heater is not used in the tank. The filter must be able to handle the viscosity extremes of the lubricant.

Super absorbent filters can be used where low concentrations of free or emulsified water exist. Super absorbent filters typically contain starch-based polymers that can absorb as much as 500 times their weight in water. Most large filter suppliers will carry these filters. However, these filters may cost significantly more than particle-retention filters

2.7 Tank Bottoms and Drainage Points

The drain port should be located at the lowest point of the tank. This will prevent oil at the bottom of the tank from becoming stagnant and collecting heavy contaminants, sediment and water. It is helpful if the bottom slope is between 1:10 to 1:30. While sloped or flat-bottom tanks are the most common, conical or funnel bottom tanks are the best to prevent accumulation of sludge and water and are preferred by many.

Placing a baffle over the drain helps to remove the bottom layer of fluid first. The size and position of the drain must be designed to allow access for fittings to be removed for repair and easy cleaning. Manholes and ladders may be needed for large tanks.

2.8 Heaters

Sometimes heating stored lubricants is necessary in cold climates or when fluids are very viscous. Heating lowers an oil's viscosity which makes it easier to flow or pump from the tank. For heaters in a bulk storage tank, the watt density should not exceed 15 $Watts/in^2$ for circulating fluids and 10 Watts/ in^2 static fluids. If the watt density exceeds this threshold, the oil can begin to thermally fail. This often results in heavy sludge forming around the heating elements and volatiles forming in the oil (from cracking the oil) leading to sharp decrease in viscosity (closer to that of water).

2.9 Stiffeners

Stiffeners prevent rectangular tanks with flat walls from bulging at the sides and reduce stresses at the edges in large tanks. External stiffening is often preferred to simplify tank cleaning by avoiding dirt traps. If internal baffles or compartment walls are used in the storage tank, separate stiffening may not be necessary.

2.10 Hoses, Tubing, Pumps and Valves

When hoses and other tank hardware are not being used, exposed hose ends and hardware ports should be sealed from environmental contamination. In the event that the hoses or lines become contaminated, they should be flushed or pneumatically pigged-out using sponge-like projectiles.

3.0 Tank Gauges and Instrumentation

3.1 Oil Level Determining Devices

One of the key responsibilities in inspection and maintenance is checking and maintaining proper fluid levels in supply tanks. A drop below a buffer level in a storage tank may result in insufficient availability of lubricants to critical machinery. The consequence could be machines that do not get serviced on time and perhaps temporarily starved of the appropriate amount of oil to keep it running properly and reliably.

Overfilling the storage tanks can also be harmful too. Spillage is one of the most overlooked issues in bulk storage management. Many small spills can remain in the ground for several years.

Federal regulations in guideline 40 CFR 280.20(c) defines the use of tank overfill prevention instruments. According to guideline, the equipment must (a) automatically shut off the supply flow when the tank is 95 percent full, (b) alert the operator when the tank is more than 90 percent full, or (c) restrict flow 30 minutes prior to overfilling and alert operator with a high-level alarm one minute before overfilling. Various simple oil level devices are available on the market.

See Appendix B for more information on overspill prevention. In addition, consult API Recommended Practice 2350 – Overfill Protection for Storage Tanks in Petroleum Facilities for more information on this.

3.1.1 Dipstick & Water-level Detection

A dipstick is a basic visual oil level check device that must be designed into a system and typically is only used in smaller tanks. Assessing oil level with a dipstick is easy. The dipstick seat should be kept clean and the o-ring maintained in good condition. The typical disadvantage of using a dipstick is the risk of contaminant ingression during the level inspection process. Both the tank and the dipstick are momentarily exposed to terrain dust. Use of a dipstick is often inconvenient and time consuming.

One way to check for a phase of water in the bottom of a tank is to use a water-level indicator paste (e.g., McCabe Water Paste). It is a fairly simple process; the paste is applied to the end of the dipstick, and then lowered to the bottom of the tank. If water is present, the white paste will become a dark pink, reddish color. The height of reddish color appearing on the dipstick directly corresponds to the height of the water level in the tank bottom.

It is not possible to completely clean a dipstick with a shop rag pulled from the pocket of a lubrication technician going through the daily tank inspection rounds. However, the dipstick should be cleaned of excess oil and dirt prior to inspection. Lint-free paper towel can be helpful; however, the extra level of attention typically is not always followed. For this reason alone, other non-intrusive methods of determining oil level are often preferred.

3.1.2 Visual Sight Glasses and Level Gauges

Tanks should have a visual sight glass or level gauge with reference marks. This gives an immediate level indication to the operator or maintenance technician. Routine observations should be made through the sight glass. A noticeable change in the appearance is an indication of contamination, particularly water, air or sediment.

The sight gauge should be mounted in a protective metal jacket for safety reasons and to avoid catastrophic lubricant loss. The location should be in a protected area to avoid accidental damage from any activity near the tank, yet it must also be easily accessible for checking and occasional cleaning. The protective metal sleeve allows the level scale to be stamped to prevent external accumulations of oil and dirt on the scale from making the markings illegible. It is best to locate level gauges near fill ports so that the gauge can be observed during filling and discharge operations.

The next step is to calibrate the level graduations with reference marks. On small tanks, the intervals will be around 10, 20 or 50 gallons. Work out the volume internally, then calculate the interval graduations required. Calculate the height on the sight gauge where these marks are required. This is an important factor for recording the volume of oil either delivered to or used from the storage tank.

3.1.3 Level Sensors and Alarm Options

While visual inspection should be a priority, automated level meters offer a number of benefits. Utilizing low-cost level gauges and switches - capacitance-based, magnetic, optical or mechanical (float type) - signals can be sent to generate either a purchase order for new delivery or a work order for a top-up. On a more advanced level, these can be set to activate a pump that will automatically replenish lubricant from a bulk store to the machine reservoir.

These switches can then reset when the required volume has been supplied. Other depth finder-type level sensors are available, using acoustic technology to determine the precise oil level. Like a fuel tank on mobile equipment, the level switch must have some damping to avoid constantly fluctuating level changes from fluid movement and turbulence. Additionally, where an automated tank volume-registering device is in use it should incorporate an alarm for a sudden change of fluid volume, such as from a hose burst or ingress of water.

3.2 Other Instruments

Thermometers and temperature gauges are important when heaters are used in order to ensure that temperatures inside the tank do not exceed critical alarm levels.

4.0 Bulk Transports

Prior to the receipt of bulk deliveries of lubricants, whether they are in tank cars, tank trucks, or special grease transports, certain precautions should be observed. The storage tanks should be gauged to ensure that there is sufficient capacity available for the scheduled delivery. Empty tanks should be inspected and flushed or cleaned if necessary. Where large tanks must be entered for manual cleaning, applicable safety rules should always be observed.

Before the delivery is unloaded, ensure that the correct fill pipe or hose is being used, the valves are set correctly, and any crossover valves between storage tanks are locked shut.

4.1 Tank Cars

Tank cars are large storage vessels that come by rail. Only trained employees should unload tank cars. The car brakes should be set, wheels blocked (chocked), and stop signs set out. Before attaching the unloading connection, the dome cover should be opened and the bottom outlet valve checked for leakage. After unloading is complete, the hose should be disconnected, the dome cover closed, and the valve closed immediately.

4.2 Tank Trucks

Another way to transport bulk lubricants is with tank trucks. Tank trucks are commonly used to transport lubricating oils and hydraulic fluids. While tank trucks have been used successfully to carry bulk grease, especially semi-fluids greases, cleaning problems are considerable because they often must be used for more than one type of lubricant or grease. A more satisfactory approach has been the use of specially designed and constructed bulk grease vehicles. These vehicles are capable of carrying 38,900 lbs. (17,645 kg) of grease in two 19,000 lbs. (86118 kg) compartments. The tanks are fully insulated for heat retention in long hauls. Power pods equipped with their own pumping unit can unload the grease at a rate of up to 1,000 lbs. (454 kg) per minute.

Special designed bulk grease vehicles usually are deployed for transporting pumpable greases in the consistency range up to and including NGLI No. 1. Other greases can be handled in bulk; however, each application requires careful study and engineering to assure satisfactory operation.

4.3 Safety Precautions

When tank cars or tank trucks unload petroleum products, standard industry safety guidelines should be followed. Here are some safety precautions that should be considered:

(1) Do not have any open flame or unguarded electric lights nearby.
(2) No smoking in the area.
(3) Relieve internal pressure before removing the dome cover.
(4) Be sure the dome cover is in place, but loose when unloading.
(5) Do not use air pressure to force the contents out of the car.
(6) When heat must be used to remove the car's contents during cold weather or for viscous fluids, avoid introducing full pressure of steam until the coils have the chance to heat up.
(7) Use a separate draw-off hose for each product in the case of compartment tank-car shipments. Extreme care should be taken to avoid mixing products or getting them in the wrong storage tank.

5.0 Tanker Up-Load and Off-Load Sequence Based on Lubricant Type: Avoiding Cross-Contamination

Oils that cross-contaminate or mix can substantially alter properties of the oils. For instance, a very small amount of motor oil can change certain important properties of hydraulic fluids, turbine oils, and gear oils.

Cross contamination often occurs in the tank car or truck carrying the lubricant if it is used to transport more than one type of lubricant sequentially or if tank compartments internally leak. It is difficult to clean these tanks and ensure that all of the hoses and other hardware are thoroughly cleaned. In critical applications, it is best to ensure that transports are dedicated to only one type of lubricant. For example, tank cars or trucks containing motor oil should only transport motor oil.

5.1 Loading/Unloading Sequence

Any cross mixing of lubricants constitutes a risk. Therefore for critical applications, where risk cannot be tolerated, always load the lubricant into a pre-cleaned tank car or truck. However, as a practical matter, such rigorous cleaning may not be possible, necessary and economically justified.

Therefore, if your company receives shipments of various types of fluids using the same bulk transport, the specific sequence should be followed when loading or unloading bulk lubricants. The purpose of the sequence is to mitigate the harmful mixing of incompatible oils. In the list below, turbine oils (or base oils) are only loaded into pre-cleaned transports. They aren't loaded into a tank truck that contains a heel of a previous lubricant. However, an R&O industrial bearing oil is allowed to follow on the heel of a turbine oil and so forth. By following the sequence below, risk of cross contamination can be largely controlled, assuming very low residual fluid heels reside in the transport tanks.

1. Turbine oils
2. Industrial oils (except gear lubes and cutting fluids)
3. Industrial gas engine oils
4. Engine oils
5. Automotive transmission oils
6. Gear lubes
7. Cutting oils

5.2 Group descriptions

A general list of the kind of oils that fall into each of the categories above is provided:

Turbine Oils Product Group

Turbine oils
Turbine/circulating oils

Industrial Oils Product Group

Hydraulics zinc-free
Hydraulics
Circulation oils
Paper machine oils
Heat transfer oils
Quench oils
Spindle oils
Way oils
R&O Oils

Industrial Gas Engine Oils Product Group

Gas engine oils

Engine Oils Product Group

Passenger car motor oils
Diesel engine oils
Marine engine oils

Automotive Transmission Fluids Group

Power transmission

Gear Lubricants Product Group

Industrial

Automotive

6.0 Tank Sampling Best Practices

6.1 Sampling and Testing of New Oil Deliveries

New oil should be inspected as it comes in. Bulk oil is often delivered in tank cars and trucks that are not reserved for carrying a single product as described in the above section. Although tankers are often washed between shipments, in many cases it is a good idea to analyze a sample from each tank car or truck. The article in Appendix A, *Should New Lubricant Deliveries be Tested,* goes into more details on this subject. Here are just some of the possibilities that can lead to off-spec lubricant deliveries:

(1) Formulation error
(2) Blending error
(3) Cross-contamination
(4) Contaminated or off-quality feedstocks (base oils or additives)
(5) Contaminated transports
(6) Mislabeling

Testing the oil as it comes in will help detect these conditions. It is important that the personnel responsible for sampling and testing have the necessary experience and skills. According to ASTM D6224, the required and optional tests to perform on new samples are provided in Table 3:

Table 3

Test	***Common Methods***	***Gear/ Circulating Oils***	***Hydraulic Oils***	***Diesel Engine Oils***	***Turbine-Type Oils***	***Air Compressor Oils***	***EHC (PO_4 Esters)***	***EHC Mineral Oils***
Appearance	Visual	1	1		1	1	1	1
Viscosity at 40°C	D445	1	1	2	1	1	1	1
Viscosity at 100°C	D445			1				
Acid No.	D664 D974	1	1		1	1	1	1
Water	D1744/ D95	2	2	1	2	2	1	2
Oxidation Inhibitor	D2668				2			
Oxidation Stability (RPVOT)	D2272		2		2	2		
API gravity or density	D1298 D4052						2	
Flash point (COC)	D92			2				
Water Separability	D1401		2		2			
Particle Counts	Equipment Manufacturer's Method		1				2	2
Base Number	D974/ D2896 D4739			1				
Electrical Resistivity	D257/ D1169						1	
Elemental Analysis	D5185	2	2	2	2	2	2	2

1—Required 2—Optional

New bulk lubricant shipments should be supplied with a *certificate of analysis* from the blend plant. The product specifications for new oils should be clearly communicated between the user and supplier. If a sample of oil fails to meet the product specifications agreed upon by user and supplier, the sample should be retested to verify the initial test result. A resample should be taken and retested if needed to verify that the sample is representative of the shipment. If the retest of resampled fluid still fails to meet product specifications, an investigation should be conducted. The only way to ensure a lubricant has adequate quality is to sample it upon delivery and run every appropriate test (See Appendix A). When testing samples, the user must recognize the difference between typical values and purchase specifications.

The samples taken should be representative of the fluid being examined. However, it should target points most likely to contain sludge, water and solid contamination, typically at the bottom of the tanker compartment. Each tanker compartment should be sampled. A common practice is to take a sample from the first few gallons and the last few gallons from a transport compartment or tank.

It is also a common practice to sample the hose end of the transport before the oil reaches the on-site staging tank for two reasons: First, this is where the product becomes your property and secondly, the hose itself is a potential source of contamination. Ask if you are not sure whether your oil distributor is equipped to take samples at the hose end.

6.2 Routine Tank Sampling

Samples should also be taken from lubricants in bulk storage tanks at scheduled intervals. As with operating equipment, when taking lubricant samples from storage tanks it is important that proper sampling procedures are followed consistently. This includes the sample location.

For large tanks, take equal samples of upper, middle, and lower oil zones (see figure 5 below). The fluids can be combined to get an average result or analyzed individually with the same method and then averaged. For small tanks, equal samples should be taken from the upper and lower zones. They can also be combined for average results or analyzed individually. Once you establish suitable sampling procedures, always take future samples from the exact same depth within the tank using the exact same sampling hardware and procedures.

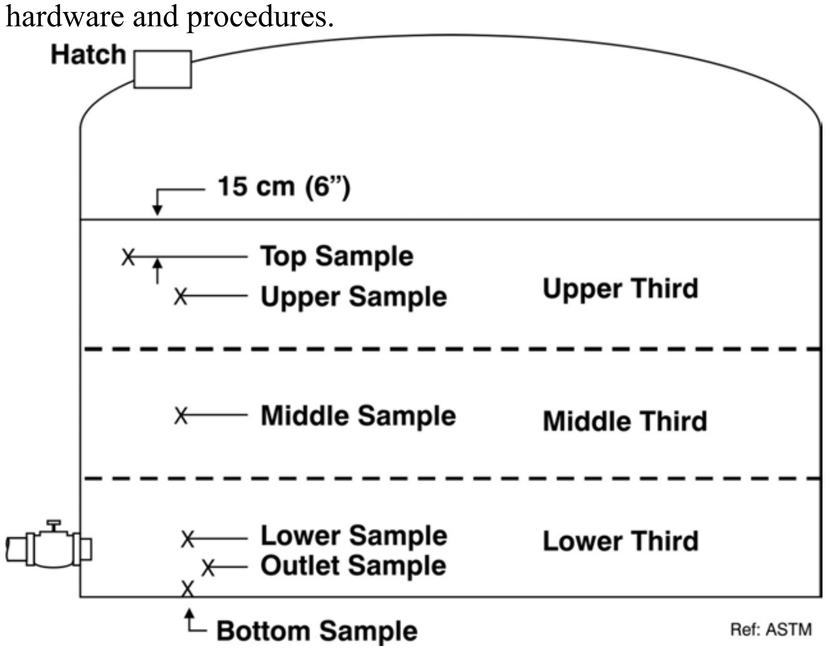


Figure 5

Occasionally, a non-representative sample is requested. For example, a sample may be requested from the top or bottom of a tank to check for contamination and additive stability. In all cases, the location of the sample should be noted on the sample container. Always avoid taking samples from standpipes and isolated zones that would be unrepresentative of the bulk fluid.

6.3 Sampling Devices

ASTM D 4057 (Standard Practice for Manual Sampling of Petroleum and Petroleum Products) provides extensive detailed descriptions of sampling devices in bulk storage tanks. Because of variation in hardware and methodology, the narrative on sampling hardware and use is not repeated here.

6.4 Miscellaneous Sampling Practices and Procedures

All sampling devices and containers should be thoroughly cleaned prior to use to avoid contamination of the sample. When testing for water, contamination and wear debris, special care should be taken to ensure the cleanliness of the bottle. If the cleanliness of the sample container is questionable, use a different container with a certified or otherwise verified cleanliness level. Refer to ISO 3722 for sample bottle cleanliness guidelines. If that is not possible, flush the sample container with the fluid to be sampled thoroughly.

The sample container must also be resistant to the fluid being sampled. For example, fire-resistant phosphate ester fluids will dissolve certain plastics. (This includes the liner in the bottle caps.) To verify the container's chemical compatibility, allow the sample to stand in the container and observe its effects. Aluminum foil or polytetrafluoroethylene (PTFE) makes good, chemically-resistant cap liners. The sample bottle must also be appropriate for the testing required in size and composition.

A sample bottle should be properly marked and should include the following information as appropriate:
(a) Customer name
(b) Site (or plant name)
(c) Location (unit number, tank number, compartment number, and so on)
(d) Tank asset serial number (or other ID)
(e) Oil batch number and born-on date
(f) Description of fluid sampled
(g) Sampling point/location
(h) Date sample taken

When developing sampling procedures, consider the following factors:

- The sampling procedures, required volume of sample, as well as other sample-handling requirements will be dependent on the physical and chemical property tests to be performed as well as contamination analysis.

- Disturbing the material in the tank may affect characteristics of the sample. For this reason, the sample should be taken before any gauging, temperature determination or similar activity could disturb the tank.

- To avoid contamination of the oil column during the sample operation, samples should be retrieved in the following order: surface, top, upper, middle, lower, outlet, clearance, all-levels, bottom and running sample.

- Samples should be tested as soon as possible. Waiting to send samples off for testing will risk contamination of the sample. Store the samples away from strong light and as close to room temperature as possible. If the samples are stored for an extended period of time, special arrangements should be made to ensure that the integrity of the sample is not compromised. The special arrangement may include storing in dark amber glass bottles in a cool area.

6.5 Safety Considerations during Sampling

Most lubricants are not considered to be hazardous. However, prolonged contact with the skin may me harmful and should be avoided. For example, phosphate ester hydraulic fluids are regarded by some people in the lubricant industry to be a carcinogen.
Some waste oils, particularly waste motor oil, are believed to also be carcinogenic. If the waste oils are contaminated with a coolant containing ethylene glycol, care should be taken to avoid any contact with this fluid.

Safety considerations need to be customized depending on the kinds of lubricant stored. Material Safety Data Sheets should be referred to when determining safety hazards of the lubricant. Here are some safety considerations that should be included:

(1) Wear working overalls, impermeable apron and gloves to eliminate unnecessary contact with oil.
(2) Avoid using dirty rags to wipe skin.
(3) If your skin comes in contact with the fluid, seek first-aid treatment immediately for any injury and report any skin complaint without delay.
(4) Wash regularly and use non hazardous cleansers, barrier and conditioning creams.
(5) Change and dry-clean work clothes regularly.
(6) Use, if possible, separate lockers for street clothes and working clothes.
(7) Ensure that the tank is clearly labeled and includes safety precautions.

7.0 Tank Inspection Procedures

In order to extend the life of a lubricant in storage, the tank must be clean and in good condition. Proper maintenance inspections of the tank must be done at least once a year to determine whether cleaning or flushing the tank is needed.

7.1 How to Inspect the Tank

According to CFR 112.8(c) (6), aboveground tanks should be frequently inspected from the outside for signs of deterioration, discharges, or accumulation of oil inside diked areas. In addition to visual inspection, another recommended nondestructive testing techniques method must also be used. Some techniques include hydrostatics, radiography, and acoustic emissions tests.

The frequency of and type of testing should take into account the size and design of the tank. API Standard 653 provides specific criteria for internal inspections based on the calculated corrosion rate rather than an arbitrary time period. The regulation and guideline below should be referenced for more information on tank inspections:

1. 40 CFR 112.8(C) (6): Oil Pollution Prevention

2. API 653: Tank Inspection, Repair, Alteration, and Reconstruction

Only authorized personnel should inspect the tank. All persons should know the risks involved with the lubricants in storage. Materials Safety Data Sheets and other relevant information on the lubricants should be consulted before examining the tank.

Some tanks have manholes, inspection hatches, or cleanout ports. If such a port is available, they can be hinged open to inspect the tank. When opening such a cover, always use caution and follow all safety precautions. Only intrinsically safe flashlights should be used in the tank to avoid the possibility of sparks or potential ignition sources. Refer to the following EPA and OSHA guidelines for entering a confined space for details on protective clothing and other guidelines.

1. EPCRA Section 313: Petroleum terminals and bulk storage facilities (from EPA Website)

2. OSHA 1915 Subpart I, App A: "Non-mandatory Guidelines for Hazard Assessment, Personal Protective Equipment (PPE) selection, and PPE Training Program"

3. OSHA 1910.146 Permit-Required Confined Spaces

4. OSHA 1915.12 Precautions and the order of testing before entering confined and enclosed spaces and other dangerous atmospheres

5. OSHA 1910.110: Storage and Handling of liquefied petroleum gases

7.2 What to Look For

7.2.1 Rust and Water Contamination

Inspect the tank walls and verify that coatings and epoxies are in good condition. If these coatings are showing signs of wear or chemical attack, rust may begin to form along the sides of the tank. Also inspect the roof of the tank for rust or condensed moisture.

Water directly attacks iron and low-alloy steel surfaces to produce iron oxides which compromise the structural integrity of the tank. Water can be avoided by using headspace dehumidification as previously discussed.

7.2.2 Sludge and Varnish

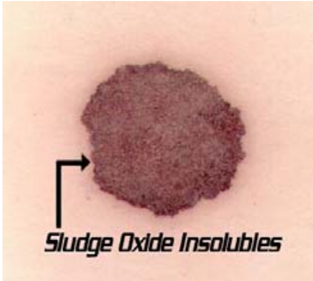
Inspect the sides of the tank for oil-level rings of sludge and waxy deposits (similar to bathtub rings). These are also known as deposits, lacquers, tars, pigments, gums and resins. Varnish is typically a tough, adherent oxide or carbonaceous material that coats internal surfaces. Hot surfaces often cure varnish to a hard/brittle consistency.

In contrast, sludge, which is sometimes a precursor to varnish, is soft and sticky and can move about the tank until finally resting on the bottom of tanks, filters, strainers or narrow passages. Varnish and sludge can form for many different reasons. Physical observations can be made during inspections. During inspections be alert to the following:

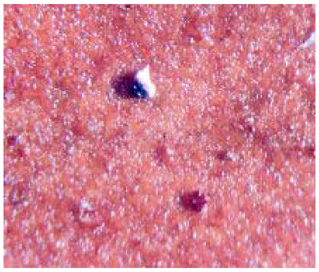
1. Continuous accumulations of sludge and sediment on the tank
2. Fouling of sight glasses and level gauges (yellow to dark brown residue)
3. Filters and strainers coated with sludgy brown film
4. Darkening oil color

The following are simple field tests that can be performed to assess oil degradation, sediment and varnish potential:

1. **Blotter Spot Test:** Place a couple of drops of used oil on common blotter paper or on the back of a business card. Let the drops soak into the paper for a couple of hours. If a dark or brownish stain is left in the center after the oil absorbs outward, then this could be carbon or oxide insolubles. A dark stain with a well-defined periphery is cause for concern. Other oil-related problems can also cause a blotter stain. However, if no stain appears, the risk of varnishing is minimal.



2. **Patch Test:** When passing a small amount of solvent-diluted oil through a one-micron membrane you will often see sludge and amber-colored polymers present on the membrane surface. The use of a hand-held 30-power microscope can help in the examination of the material present. Field patch test kits are available from several suppliers. Note: if the membrane pore size is too large (>3 microns) much of the sludge and insolubles will pass through.



7.3.3 Foam and Floating Debris

Examine the oil's surface for foam and floating debris. Persistent foam problems are usually a symptom of mixed incompatible fluids or contamination.

7.3.4 Leakage

Carefully inspect the exterior of the tanks for leakage at weld seams, ports, fittings, etc. Tag and report any evidence of leakage. According to the Environmental Protection Agency, underground storage tanks (UST) must be checked for leaks every thirty days. Proper leak detection procedures are covered in EPA 40 CFR 280.43. Some states regulate aboveground storage tanks. These laws are typically under the Uniform Fire Code or other fire protection standards.

8.0 Tank Cleaning, Flushing and Maintenance Procedures

Cleaning tank interior or exterior surfaces after commissioning or modifications of bulk storage tanks is generally required. Older system may also need cleaning after years of dirt and sludge accumulation. Lack of proper filtration intensifies the accumulation of contaminants, sludge and varnish which later will have to be removed.

It is important to consider the time and cost associated with cleaning and flushing. Often, due to various constraints, as little as one-third of the total time is spent on the flushing activity itself. Two-thirds of the time is used to mobilize flushing equipment and workers, disassemble sensitive components, assemble by-pass lines, connect flushing hoses, pre clean the flushing fluid, fill up the system and heat the flushing fluid and piping. Generally well-planned and well-performed flushing practices yield considerable return on investment.

8.1 General Cleaning and Flushing Requirements to Achieve and Retain Satisfactory Initial Cleanliness Level

The information given below does not cover all of the elements necessary for cleaning and flushing a tank. Instead, this guideline is meant to give only an overview of best practices and procedures to clean, flush and maintain a bulk storage tank. For detailed information, it is recommended that the following American Petroleum Institute standards be consulted:

1. API 2015 – Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks

2. API 2016 – Guidelines and Procedures for Entering and Cleaning of Petroleum Storage Tanks

8.2 Cleaning Requirements and Procedures

Cleaning or flushing a tank requires many steps in order to insure safety and suitable final cleanliness. All personnel put in charge of this task should use extreme caution throughout the entire procedure. API 2015 provides a list of some protective equipment to follow when cleaning storage tanks.

8.2.1 Isolating, Ventilating and Degassing Equipment

Degassing and ventilating equipment like eductors, air blowers, flexible tubing for suction and exhaust air, air compressors, hoses and connectors, tank opening covering, and degassing vapor treatment equipment may be required.

8.2.2 Personal Protection

Hearing protection, respiratory protection, and clothing specifically for tank entry and cleaning must be provided. OSHA 29 CFR 1910, Subpart I includes details on these requirements.

8.2.3 Respiratory Protection

Respiratory protection and air supply equipment will be necessary. Some items needed are approved breathing air compressors, air cylinders, air hoses, air purifying and supplied air respirators. All persons entering or cleaning tanks should be medically examined and trained to use all respiratory equipment. See OSHA 29 CFR 1910.134 for details.

8.2.4 Tank Cleaning Equipment and Materials

Tank cleaning equipment includes vacuum equipment, pumps, approved explosion-proof electrical equipment (where permitted), transfer hoses and connections, approved low-voltage lighting and flashlights, hoses, ladders, disposal containers, shovels, scrapers, wipers, brushes, squeegees, rags and sponges.

Tank cleaning materials will vary depending on the tank and the lubricants stored. Items for cleaning may include water, steam, fuel oils, soap, solvents and approved chemicals.

There should also be safety equipment including barriers, locks and tags, isolation equipment including approved blinds and blanks, gaskets, flanges and bolts; grounding and bonding cables and connections; tank opening covers, screens and protective devices; and fire extinguishers and/or fire hoses.

8.2.5 Emergency Response and Communications Equipment

Approved communication equipment, warning devices and emergency response equipment should be used when someone is inside the tank.

8.3 Preparing the Tank for Entry and Cleaning

Before anyone can enter the tank, at least the following must be reviewed to determine possible cleaning dangers:

- ✓ Review drawings of internal and external tank configurations, valves, pipes, etc. for potential physical hazards
- ✓ Review MSDS sheets and equivalent information on current and previously stored products in the tank to be cleaned to determine potential hazards from these products, sludge, and residue.

The results of the evaluation will help to determine the proper procedure and plans to clean the tank.

Permits should be required to enter and clean the tank, and only qualified personnel should be given permits. API 2015 provides more details on permit requirements.

8.4 Basic Cleaning Guidelines

8.4.1 Eliminate Sources of Ignition

Once all possible hazards have been considered, equipment used for cleaning and protective clothing have been inspected, and all personnel involved in the cleaning process are fully trained on the possible hazards, the cleaning process can be started.

Before any work that might release vapors can be done, roads should be blocked and have warning signs posted. Welding or any other work that might cause ignition should be stopped from the time cleaning starts until the sludge has been removed.

No artificial lights other than dry-cell-powered flashlights, safety lanterns or cap lamps should be used. If vacuum trucks are used to remove sludge, beware of any risks associated with vapors reaching the engine as an ignition source.

8.4.2 Empty the Tank

Drain the tank to the lowest possible level by pumping or gravity draining. Water can be used to help drain as long as it is brought in through the pipe connections to float up any remaining oil. Do not bring in water from the roof.

8.4.3 Blind-off the Tank

Close all of the valves nearest to the tank. Break the connections and place blinds in all of the lines that are strong and thick enough to withstand pressure that might come through the line. All fluid in the connections should be drained before placing the blinds.

8.4.4 Vapor-Free the Tank

If possible, free any flammable vapors before other steps are taken. Vapor-freeing implies the complete replacement of the hydrocarbon vapors in the tank with fresh air. Vapors can be removed by mechanical, steam and natural ventilation. Determine the progress of vapor-freeing frequently. Once the vapor in the tank is less than 50 percent of the lower flammable limit and air is entering, personnel restrictions around the tank are no longer necessary.

8.5 Cleaning the Tank from Outside

Once the tank is temporarily vapor-free, the remaining covers can be removed to clean. The initial cleaning should be done outside the tank. A water hose stream can be directed through the open manways, rotating nozzles pointing inward from the tank shell. Ventilation should be continued and test should be conducted occasionally to test for flammable vapors because stirring the sludge may release some vapors. If the concentration reaches above 50 percent, washing should be stopped until the concentration of vapor reaches safe limits again. It is better, if possible, to discharge the sludge into a closed sewer or a guarded sump to avoid ignition. Any pump used to remove sludge should be powered by air, or an approved intrinsically safe electrical drive suitable for the area.

Sludge can be removed using various methods. The simplest method it to wash the tank with a water hose stream and shovel it in buckets. If doors have been removed or manways from the floor are present, then sludge can be flushed out.

8.6 Safety Requirements for Cleaning the Tank from the Inside

Once most of the sludge has been removed from the tank, it can be cleaned from the inside. Before anyone enters the tank for cleaning, the atmosphere in the tank should be tested for toxic vapors and oxygen levels. If the vapor concentration levels are not within established threshold limits, personnel should be required to wear respiratory masks. The oxygen content in the tank must be at least 19.5 % by volume for it to be safe enough to enter without respiratory equipment.

As long as oil and sludge remain in the tank, toxic vapors may still be present. Forced ventilation should be continued regardless of whether test results indicate safe toxic levels. Test should be continued frequently to test the toxic vapor and oxygen levels.

8.7 Cleaning and Flushing Procedures

Depending on the condition of the tank, cleaning may require steam, special chemical washes and/or abrasives to remove varnish or other adherent materials. Once the tank has been cleaned, it may need to be thoroughly flushed to remove the solid and liquid contaminants remaining in the tank as well as the cleaning materials. Flushing is the circulation of liquid through the tank and transfer of the flushing medium to a waste container for disposal. ASTM 6439 provides information regarding flushing procedures for maintaining cleanliness of lubricating oils.

8.7.1 Flushing Fluid

A flushing oil can either be an amount of the oil being stored or a special flushing oil. The selection of the type of oil should be made based on the judgment of experienced personnel after thoroughly inspecting the tank. If the fluid being flushed contains additives, especially acids and bases, special care should be taken to select a compatible flushing oil. When acidic and basic materials react, they can form insoluble soaps which can deposit on the walls of the tank.

Rust-inhibiting oils or special flushing fluids can be used to flush the tank. These fluids are special blends with good solvency containing rust inhibitors and additives (and perhaps detergents) for the removal of sludge and various other tank contaminants. Flushing oils blended with carbon tetrachloride solutions containing water, caustic compounds or other active materials should not be used.

When selecting a flushing fluid, know the mechanical and chemical compatibility with the tank and related instruments, gauges and hardware. This includes:

(a) all components of the lubrication and flushing systems
(b) final charge of lubricating fluid
(c) permanent or temporary flushing hose lining at temperatures up to 190°F
(d) rust-preventative paints used in pedestal and guard piping

(e) preservatives used on pipes during shipping, storage, and installation that normally may not be removed prior to flushing

The table below provides a guide to selecting a flushing oil.

System	Solids	Rust	Deterioration Products and Sludge
New	1,2	1,2,3	-
In Service	1,2	1,2,3	2,3
After Lay-up	1,2	1,2,3	2,3

1) Regular hydraulic oil
2) Rust-inhibited mineral oil (viscosity less than 40 cSt at 40°C)
3) Special flushing oil

8.7.2 Basic Flushing Guidelines

Flushing for both new and used tanks is essentially the same procedure.

One important requirement for successfully flushing storage tank of residual debris is a high oil velocity. If possible, turbulent flow should be achieved. Outside pumps can be used to achieve this flow. Increasing the temperature of the oil and flow pulsations will also help to remove the contaminants in the tank. Hammering or vibration at key points will loosen the debris if required. Once the solid contaminants are loosened, they can be flushed out.

A common practice is to gradually heat the flushing fluid to 150°F to 170°F using a purifier oil heater. Refer to ASTM D6439 – Standard Guide for Cleaning, Flushing, and Purification of Steam, Gas, and Hydroelectric Turbine Lubrication Systems for more details on this.

Next, continue purifying the reservoir until the desired cleanliness level is reached. Afterwards, drain the flushing fluid as soon as it is safe and practical. If the fluid is first allowed to cool before draining, sediment and other contaminants may settle. Once the oil has been drained, the tank should be manually cleaned with lint-free rags to remove all traces of residual contamination.

If the flushing fluid is the lubricant that is normally stored in the tank (or highly compatible), then displacement oil is not required. If a special flushing fluid is used, displacement oil should be used to displace residual amounts of the flushing fluid from the tank. Displacement oil must be compatible with the fluid normally stored in the tank and about the same viscosity. Strainers and filter housings should be drained and cleaned and all filter elements replaced. Pump the displacement oil in as soon as possible and heat it to 140°F to 160°F with purification. The oil should be circulated until there are no signs of contamination (refer back to the patch test and blotter spot test). The new oil can be pumped in now.

8.8 Maintaining Cleanliness to Minimize Contamination

Preventing contamination and maintaining a clean tank is crucial. Often times, the length of time between system flushes is too long. The tank should be inspected regularly by a trained technician for signs of contamination.

It may be more cost-efficient to perform periodic cleaning (for example, on a yearly basis) instead of a costly upgrade or a complete modification of the system. Note that it is often possible to perform a power flush without draining the tank. Turning the tank over six times rapidly through a fine filter can often accomplish the removal of over 95 percent of the contaminants in the fluid—depending on the capture efficiency of the filter.

9.0 Tank and Container Labeling Best Practices

One way to ensure that any smaller amounts taken from the tank (say into drums, totes, and pails) are labeled properly is to have pre-made, peel-off labels ready and easily accessible at the bulk tank. A good way to do this is to attach a durable plastic envelope to the tank. The labels should be kept in the plastic so that when oil is transferred to smaller containers like drums or totes, one of the labels can be removed from the plastic casing and put on the drum or tote so that the product information transfers with it.

On each of the labels, include the essential pedigree information about the lubricant. Such information can include, but is not limited to, the following:

(1) Type and viscosity of the lubricant
(2) Cleanliness level to be maintained
(3) Batch number
(4) Supplier information
(5) Born-on date
(6) Expiration/use by date
(7) Viscosity

For dispensing purposes, lines leading from bulk storage should have metal tags or signs identifying the contents. Do not use colors alone for this purpose because some people are color blind. Well labeled tags and signs also help to avoid mixing different products when taking in stock.

10.0 Dispensing from Bulk Tanks

Often times, contamination occurs when the lubricant is dispensed. The following guidelines will reduce problems related to contamination during dispensing processes:

(1) All devices used to transfer lubricants (such as oil cans, pumps, grease guns and tools, etc.) must be kept clean at all times and wiped and inspected before using.
(2) Clearly label all containers and dispensing devices for their use. They should be used only for that purpose; this will avoid contamination of a lubricant by another

incompatible fluid. Maintenance and operations personnel must be trained in proper equipment care procedures.

(3) All oil should be filtered during transfer using a quality filter having similar capture efficiency to that deployed on the machines where the fluid will be ultimately be used (although the size and construction of the filter may be considerably different). This can be accomplished using a filter cart or similar equipment. The filter capture efficiency requirement will depends on the type of fluid and its application.

(4) If lubricants are dispensed directly from a stationary bulk oil tank, the outlet lines must have filters installed as well. Attached to the filter should be a monitoring device like a flow meter or pressure gauge. This will indicate if the filter is plugged and requiring a change-out.

11.0 Spills, Containment and Fire Prevention Considerations

Spills, containment and fire prevention are critical safety and environmental concerns. Depending on the lubricant used, the dangers and environmental impact associated with spills or the likelihood of ignition will vary greatly. See appendix B for more details on spill containment prevention. The following federal document should be followed for spill and containment considerations:

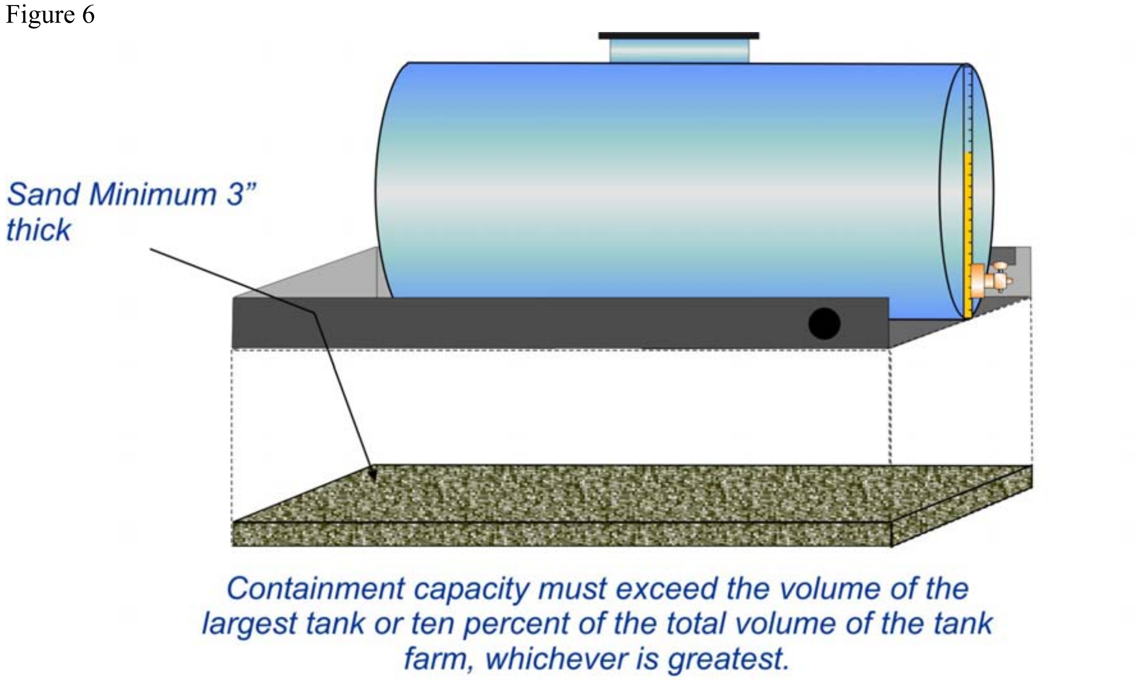
1. EPA guideline 40 CFR 280: Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)

Also review the following API standards for more information:

1. API Recommended Practice 2350 – Overfill Protection for Storage Tanks in Petroleum Facilities

2. API Recommended Practice 2021 – Fight Fires in and Around Flammable and Combustible Liquid Atmospheric Storage Tanks

Figure 6



It is always advised to place signs on or near the tank should be posted so that personnel are fully aware of the risks associated with the storage tank area. When lubricant is delivered, it is extremely important to be cautious of fire and spill hazards. Plugs and caps should be kept on all hoses and pipes to prevent any dirt or water from contaminating the lubricant at the connection points.

Appendix A: Should New Lubricant Deliveries be Tested?

Jim Fitch

To me, the answer to this question is sweepingly simple. Lubricants are formulated by humans. They are blended by humans. They are inspected by humans. They are transported and packaged by humans.

They are labeled and stored by humans. When it comes to humans, there is one inalterable constant - we make mistakes. Sometimes this is due to lack of vigilance. Sometimes it's lack of knowledge. It might even be because of indifference.

Case in point: in 2001, the American Petroleum Institute (API) audited 562 motor oils that were licensed to bear the API marks - approximately one-third of its licensees (83 percent originating from the United States). The tests were performed to determine compliance with API performance standards. This is what the audit reported:

- 4 percent of the motor oils were classified as having significant deviations (one out of every 25 oils tested). Many had the wrong concentration of additives while others failed to meet low-temperature specifications.
- 16 percent were classified as having marginal deviations (one out of every six oils tested).

I view new lubricant quality as a collaborative process - like teamwork. While lubricant suppliers, distributors and transport companies bear the brunt of the responsibility, users influence quality as well. For instance, when users foster a cavalier attitude about the importance of lubrication in general, efforts made to improve lubricant quality go unnoticed and certainly unappreciated. Perhaps users underestimate the degree of risk associated with poor lubricant quality. Some users may even fear being perceived as distrustful if they question quality. In my mind, this is muddled thinking.

We at Noria want to do everything possible to bolster and support excellence in lubrication - for suppliers and users alike. On one hand, we don't want to raise unwarranted alarm. On the other hand, we don't want to live in a state of denial by saying everything is fine, don't worry.

I've served on numerous failure investigations in recent years in which defective lubricants contributed to expensive and unfortunate repairs and downtime. These were regrettable situations. They were also the exceptions, not the norm. And fortunately today, used oil analysis frequently catches many problems before serious failures develop. However, for certain machines, deviations in lubricant quality can lead to disastrous consequences. This punctuates the need to confirm the quality of new lubricant deliveries, especially when the need for reliability is particularly important. Likewise, a quality-minded lubricant supplier will appreciate receiving feedback, both good and bad, from users who run such tests.

Let's take a look at how deviations in new lubricant quality can occur:

Formulation Error

Changes to lubricant formulations are sometimes made on the run, that is, without advanced performance testing by the additive supplier or formulator. This can contribute to additives that clash in service or simply fail to properly dissolve in the base oil. The risk is greatest for blend-to-order jobs or when formulations have been modified in a rush to solve a particular problem.

Blending Error

Blending a lubricant is a lot like making soup. You prepare a confection of essential ingredients. For a lubricant, these ingredients include one or more base oils and an assortment of additives (some are pre-blended, known as adpacs). The blending is done by either batch or inline. For a variety of reasons, the concentration of these ingredients can be off-formulation and alter performance. So too, a particular ingredient might be left out entirely or added by mistake.

Cross-Contamination

Cross-contamination relates to the accidental mixing of different and incompatible lubricant formulations. At times the effects can be negligible, but in other cases, lubricant performance can be impaired. Cross-contamination can occur many different ways. Because many blend plants don't used dedicated tanks, hoses, lines, pumps or filters, there is always risk of product carry-over from an earlier batch. Holding tanks are often only gravity drained between batches (no flushing). For many plants, there is generally an attempt to pig-out lines of residual oil and/or flush them with base oil. Still, even the best efforts might still leave trace concentrations of nonconforming additives. For lubricants shipped in bulk transports, uncleaned tanks and tank compartments (or leaky compartments) can result in cross-contamination.

Contaminated or Off-quality Feedstocks

Many blend plants check the quality of their feedstocks (raw materials such as additives and base oils) regularly. However, not all plants have the analytical ability to cover the range of potential nonconforming properties and contaminants that can occur. For instance, it is rather uncommon to find a particle counter at a blend plant laboratory. Even elemental emission spectrometers may not be available onsite. Some blend plants perform only physical properties testing on each batch (viscosity, flash point, etc.).

Contaminated Packages or Transports

The cleanliness of new lubricants varies considerably. New lubricants often exceed recommended cleanliness levels for in-service lubricants. I've seen high-performance filters used by some blend plants to clean new lubricants. I've also seen no (or coarse) filters used. It is also common to find containers (drums, pails, bottles) on packaging lines and conveyors left open (exposed to atmospheric dust) for extended periods of time before they are filled and sealed. Bulk transport trucks may sit with their top bungs open before, during and after loading. All of these conditions can lead to both particle and moisture contamination.

Mislabeling
This can occur by human agency as well. Due to the many different lube products that are handled, dispensed and packaged by blend plants and distributors, a lubricant can accidentally be introduced into the wrong package or a package might be mislabeled.

It is good to ask your lubricant supplier to provide you with a certificate of analysis (COA) for lubricants that will be used in critical applications. The COA, depending on the application, would confirm the following:

1. Quality of the base stock(s). These are generally physical properties tests, including viscosity and flash point.
2. Additive quality and concentration (treat rate). Knowing that the right additives are in the blend at the correct concentration can be determined by specific tests.
3. Lubricant performance. This relates to the collective influence of base oil(s), additives and contaminants and their physical and chemical interactions. For instance, the right additive can improve demulsibility while the wrong additive or contaminant can impair this important property.
4. Thickener performance properties. For grease products there are specific properties and tests that relate to the thickener and its interaction with the base oil and additives.
5. Presence of contaminants and foreign additives. It is just as important to test for what's not supposed to be in a lubricant as it is to test for what you are expecting. Batch inspection tests by blend plants may test only for properties they expect - not those they don't expect. For instance, if elemental analysis is not performed on new turbine oil (because no organo-metallic additives are used and therefore not expected), accidental cross-contamination by a motor oil may not be detected.

Table 1

Test or Property	Base Oil Quality	Additive Treat	Overall Lubricant Performance	Thickener Properties (grease)	Contamination and Cross Mixing Between Lubricants
Viscosity (40°C and 100°C, high temp/shear, etc.)	X	X	X	X	X
Cold cranking and pumping viscosity	X	X	X		
Flash point	X		X		X
Pour point	X	X	X		
Cloud point	X	X	X		
Aniline point	X		X		X
Nitrogen	X	X			
Color	X				X
Interfacial tension	X		X		X
Acid number/base number		X			X
Elemental spectroscopy		X		X	X
Oxidation stability	X	X	X		X
Rust tendency		X	X		
Copper strip		X	X		X
Foam stability/tendency		X	X		X
Air release	X		X		X
Hydrolytic stability			X		
Thermal stability	X		X		
Shear stability			X	X	
Demulsibility	X	X	X		X
Film strength (4-ball, etc.)		X	X		
Filterability	X		X		X
Bleed resistance			X	X	
Dropping point			X	X	
Grease consistency			X	X	
Particle count					X
Moisture analysis					X
Storage stability	X		X		

An "X" denotes that this test might supply useful information relating to the corresponding quality characteristic.

Table 1 lists specific lubricant tests that can be applied to assess these five quality characteristics of a newly formulated lubricant. The selection of these tests, either for inspection of incoming lubricant deliveries or as a part of the COA supplied by the blend plant/distributor or both, needs to be carefully and judiciously considered. Not only must the tests be selected but also the condemning limits. Because testing is expensive, the scale of the testing of new lubricants needs to be "right sized" and factored into the cost of lubricant procurement.

Following are some suggestions and strategies for selecting new-lubricant inspection tests:

1. Consider tests that can screen a variety of properties and performance characteristics all at once. Good examples are elemental analysis, demulsibility and FTIR.
2. Prioritize those tests and properties that are essential to lubricant performance and machine reliability in the target application. Good examples include viscosity, viscosity index, oxidation stability, cleanliness and dryness.
3. Consider tests that would quickly reveal a property relating to a specific quality concern, if any.

4. Keep testing streamlined and efficient. Run expensive and/or time-consuming tests only on exception, triggered by a nonconforming result from a screening test.
5. Develop a consensus with your lubricant supplier on which tests will be performed and what the condemning limits will be.

Another important benefit for testing new lubricants is to establish a baseline for routine used-lubricant analysis. Even when new lubricants are well within acceptable quality limits, there may be considerable variations in physical and chemical properties (batch to batch). For instance, viscosity can vary +/-10 percent from the ISO VG midpoint (46 or 68, for instance) and still be “in grade.” Cautionary limits are sometimes set at +/-5 percent from new lubricant viscosity. Hence, the specific new lubricant viscosity must be known.

By taking an active role in testing new lubricants and giving constructive feedback to your supplier, incremental improvements in lubricant quality are bound to result. Lubrication excellence is a collaborative process. Lubricant quality is a measurable property. If it’s important . . . measure it.

Appendix B: Has Your Tank Been Assessed for Compliance? [Taken From Reference 30]

Assessing compliance with petroleum, oils, and lubricants (POL) and storage tanks management requirements consists of reviewing an installation's operations and records relative to legal requirements. Any discrepancies between the two are findings. Assessing compliance with these protocols is somewhat unusual in terms of the array of federal laws that govern different aspects of POL and storage tanks management. Legal authorities include the Clean Water Act (CWA), applicable aspects of the Clean Air Act (CAA), and underground storage tank (UST) and used oil requirements under the resource Conservation and Recovery Act (RCRA). In addition, some U.S. states regulate aboveground storage tanks (ASTs) under the Uniform Fire Code or other fire protection standards. Another unique aspect of the POL and storage tanks compliance assessment is that overlapping requirements of the two protocols make it inefficient to assess them separately.

The Environmental Assessment and Management (TEAM) Guide identifies some key requirements based on federal and state regulations. For example, installations are subject to federal spill prevention, control, and countermeasures (SPCC) Plan requirements administered through the U.S. Environmental Protection Agency (EPA) regional offices.

States that have met EPA's minimum CAA and RCRA program requirements have primary responsibility to enforce CAA and RCRA compliance. States that have primacy may establish requirements more stringent than, or in addition to, those in the federal regulations. States may also implement additional spill planning and AST requirements that are not counterparts of federal regulations.

Key Regulatory Requirements for ASTs

Federal Regulations

Federal regulations [40 Code of Federal Regulations (CFR) 112] implemented under the CWA authority (33 USC 1321 and 1361) specify spill prevention and planning requirements for facilities at risk of discharging oil to navigable waterways.

There are some subtleties of the SPCC regulation that are commonly misunderstood. These three elements are (1) the regulatory thresholds above which facilities must comply with SPCC Plan requirements, (2) the concept of navigable waters, and (3) the use of "should" in the regulatory language.

First, onshore and offshore facilities that could reasonably be expected to discharge oil in harmful quantities to navigable waters of the United States and that exceed the following threshold quantities of oil storage must meet SPCC Plan Requirements (40 CRF 112.1):

- Cumulative buried undergrounds storage capacity of the facility is 42,000 gal or more,
- Cumulative storage capacity that is not buried is 1,320 gal or more, or
- A single container exceeds 660 gal.

As EPA states: “If your facility meets at least one of the three oil storage capacity criteria stated above, then all tanks, aboveground and underground, are subject to SPCC requirements. For example, if you store over 42, 000 gal of oil product in USTs, then, even if you have only one 500-gal AST, all tanks are subject to SPCC requirements” (EPA’s Compliance Assistance Guide, SPCC Requirements and Pollution Prevention Practices for Vehicle Service Facilities.”

Second, the term “navigable waters” has been expansively interpreted in case law and may even include dry draws, if they lead to navigable water during the rainy season. So many situations that might not be viewed as navigable waters are in fact navigable waters under the law.

Third, SPCC Plan regulations include “should” in some passages. EPA takes “should” to be “must” if an installation’s SPCC specifies any of the controls associated with “should” in the regulation or if the control is necessary to meet the legal requirements of preventing discharge to navigable waters. Therefore, SPCC Plan requirements cannot be ignored simply because they include the word “should.” Key regulatory requirements under CWA include developing and implementing a SPCC Plan.

For more information on these regulatory requirements, refer to POL Management/2000-1 posted under “Resources,” POL/Storage Tanks, on www.ecamp-online.net and EPA’s oil spill web site, www.epa.gov/oilspill/spcc/index.htm.

The glossary at the end of this document includes definitions for key terms that are important in SPCC Plan compliance. These terms include “Facility,” “oil,” “harmful quantities,” “navigable,” and distinctions between onshore and offshore facilities.

U.S. State Requirements

Not all states have AST regulations. However, review the checklist posted on ecamp-online to determine whether any state-specific AST requirements have been identified for the assessments. Typical state requirements include:

- Registration of ASTs,
- Secondary containment,
- Overfill protection,
- Leak detection (usually visual monitoring at a set interval),
- State-specific spill prevention and reporting, and
- Fire protection.

Key Regulatory Requirements for USTs

Federal Requirements

RCRA governs POL and hazardous substance storage in USTs. TEAM Guide Sections ST.05 through ST.12 address these specific requirements, which include notification and recordkeeping, installation and design standards, changes in service, release detection and reporting, corrosion protection, repairs, and corrective action. Applicable regulations are accessible through several web sites, such as EPA's at www.epa.gov/.

The glossary at the end of this document includes the definition of UST, which is important in understanding the applicability of these regulations. The glossary also includes definitions for other key terms in this section. UST regulations apply to tanks that are 10% or more beneath the surface of the ground where "beneath the surface of the ground" means beneath the ground surface or otherwise covered with earthen materials (40CFR 280.12). Thus, tanks that are about grade but below dirt (e.g., covered with soil for fire protection) are USTs.

UST regulations do not apply to the following because they are not within the regulatory definition of USTs (40 CFR 280.12):

- Farm or residential tanks of 1,100-gal capacity or less used for storing motor fuel for noncommercial purposes;
- Tanks used to store heating oil for consumptive use on the premises where stored;
- Septic tanks;
- Pipeline facilities regulated under specified pipeline requirements;
- Surface impoundments, pits, ponds, or lagoons (these may be subject to CWA or RCRA requirements);
- Storm water or wastewater collection systems;
- Flow-through process tanks; or
- Storage tanks situated in an underground area (such as basement or cellar), if the storage tank is situated on or above the surface of the floor.

The applicability section, 40 CFR 280.10, exempts certain UST systems, defers certain UST systems from sections of the regulation, and defers other UST systems from the leak detection requirements only. According to 40 CFR 280.10(b), the following UST systems are exempt:

- USTs holding hazardous wastes subject to hazardous wastes management standards,
- Wastewater treatment tank systems that are part of a wastewater treatment facility regulated under the CWA National Pollutant Discharge Elimination System or pretreatment programs [CWA Public Law Sections 402 or 307(b)],
- Equipment or machinery that contains regulated substances for operational purposes such as hydraulic lifts,
- USTs with capacities of 110 gal or less,
- USTs containing a de minimis concentration of regulated substances, and
- Emergency spill or overflow containment UST systems that are expeditiously emptied after use.

40 CFR 280.10 (c) defers the following UST systems from all requirements except those for release response and corrective action:

- Wastewater treatment tank systems,

- Airport hydrant fuel distribution systems, and
- UST systems with field-constructed tanks.

EPA has a variety of information about USTs on its Office of Underground Storage Tanks web site, www.epa.gov/oust/.

State Requirements

Unlike AST regulations, there are U.S. state specific requirements for USTs. The good news is that almost all states incorporate the federal requirements with few changes. When preparing for the compliance assessment, it is important to determine the differences between state and federal requirements.

The applicability section, usually the first section in the state UST regulations, is sometimes different from UST regulations, is sometimes different from 40 CFR 280.10 provided above. States most frequently change requirements related to hydrant system tanks. Verify that the state in which you are working does not regulate these systems.

The other section that must be checked for changes is the state definition of a UST. States sometimes remove heating oil tanks from the list of exemptions. States may amend other UST provisions. So check the checklist prepared for the specific assessment closely for changes.

Key Regulatory Requirements for Used Oil Management

Federal Requirements

RCRA also governs used oil management. Used oil and used oil-contaminated items destined for disposal are subject to 40 CFR 262.11 requirements for determining whether solid wastes qualify as hazardous wastes. Generators of hazardous waste oil destined for disposal must comply with all hazardous waste management standards.

Used oil (refer to the definition in the Glossary) destined for recycling is subject to 40 CFR 279. Such used oil may exceed thresholds for hazardous waste contaminants and still be managed as used oil, provided the contaminants resulted from normal use of the oil. The reference standard to determine whether the used oil is on or off-specification is that in 40 CFR 279.11.

Mixtures of used oil and other wastes (such as spent petroleum naphtha solvent mixed with used oil and alcohol/brake fluid mixture added to used oil) must first be evaluated in accordance with 40 CFR 262.11 (the requirement to determine whether wastes are hazardous wastes). Mixtures of used oil and other materials or wastes may or may not be subject to 40 CFR 279 standards, depending on the properties of the mixture. Therefore, assessors must determine whether used oil has been mixed with other materials or waste to determine which regulatory requirements apply. This aspect of the used oil regulations is frequently misunderstood.

Mixtures of used oil and hazardous wastes listed under 40 CFR 261 Subpart D must be managed as hazardous wastes. Mixtures of used oil and ignitable wastes are regulated as used oil if the mixture does not exhibit the characteristic of ignitability. Mixtures of used oil and characteristic hazardous waste are regulated as used oil if the mixture exhibits no hazardous waste characteristic.

Used oil is subject to generator, transporter, collection or aggregation point, processor, marketer, and burner requirements.

State Requirements

Some U.S. states have developed specific used oil requirements, but they do not tend to vary much from the federal requirements. Review the state regulations or state-specific POL management checklist on ecamp-online to determine whether the state requires more specific labels or compliance with additional oil handling requirements.

Compliance Discrepancies

Approximately 75% of POL findings involve deficient SPCC Plans, inadequate fuel loading and unloading areas, and inadequate used oil management. Approximately 60% of the storage tank findings involve inadequate secondary containment for ASTs.

Common SPCC Planning Pitfalls

Inadequate spill planning and implementation are common deficiencies identified in external compliance assessments. A major contributing factor to the inadequate SPCC Plans is a misunderstanding of the applicability of the SPCC Plan requirements. Here are some common mistakes made:

(1) Some installation personnel believe that they can segment their installation into many "facilities" that then may be below the SPCC Plan thresholds for oil storage. Then the installation only develops SPCC for those facilities that are not below the thresholds. All structures and activities subject to the same emergency response planning and procedures must be manages as one facility.

(2) Some installation personnel believe that the thresholds for developing a SPCC Plan outlined under "Key Requirements for ASTs" are exclusions rather than thresholds. In other words, they believe the regulation exempts tanks less than 660-gal capacity from SPCC Plan requirements regardless of where the tank is located.

(3) Some installation personnel misinterpret the definition of "bulk storage." Because all bulk storage locations must be included in the SPCC Plan, it is important to understand the interpretation of "bulk storage." Most Regions agree that bulk storage is storage of oil in a vessel of any capacity at "non-[oil] production facilities." EPA Region II describes bulk storage as any container that contains oil, even 1-quart cans. However, an acceptable spill prevention mechanism for 1-quart cans could be absorbent materials. Region X interprets bulk storage as any container greater than or equal to 55-gal and to address (at least generically) containers less than 55-gal. Small, mobile containers should be stored in a storage area, and this storage area should be

addressed in the SPCC Plan and provided with appropriate secondary containment. EPA also interprets equipment containing oil such as hydraulic tanks and transformers as "bulk storage."

(4) Because 40 CFR 112.7 (e)(4)(ii) states: "Where rack drainage does not flow into a catchment basin or treatment facility designed to handle spills, a quick drainage system should be used for tank truck loading and unloading areas. The containment system should be signed to hold at least the maximum capacity of any single compartment of tank car or tank truck loaded or unloaded at the facility." Personnel often interpret this to mean that only areas with loading "racks," such as those at bulk fueling yards, must meet these requirements. EPA has not concurred with this interpretation saying that this requirement applies to all fuel and oil loading and unloading areas regardless of the presence of a "rack" device. Under this interpretation, a fill port attached to an AST that receives fuel by tanker truck would be considered a loading rack.

Reviewing the SPCC Plan

Make sure that your SPCC Plan meets the following requirements:

- Was it prepared for all installations subject to SPCC Plan requirements?
- Does it include an inventory of all oil and fuel storage (including tanks less than 660-gal capacity, fuel truck parking areas, fuel bowsers, and oil-filled transformers), handling, and transfer locations that could produce a spill with potential to reach surface waters or storm drains?
- Does it include a prediction of directions and rate of flow and quantities of oil that could be spilled?
- Does it include a description of recent spills, corrective actions taken, and corrective actions to prevent recurrence?
- Was it submitted to EPA following the discharge of 1,000 or more gallons of oil into navigable waters during one spill even or following two spill events within the past 12 months that caused a sheen on surface water?
- Was it approved at a sufficiently high level of authority to commit installation resources?
- Is it reviewed every three years and amended when needed?
- Was it approved by a Registered Professional Engineer every time the plan was revised to change the amount of fuel stored at the installation or the spill response capabilities?
- Does it include accurate calculations of containment capacity?
- Does it address spill training?
- Does it address procedures for spill response personnel?
- Is it available at facilities normally staffed 8 hours/day?
- Does it outline spill cleanup materials and equipment that are available at potential spill sites?
- Does it include an accurate description of secondary containment for bulk storage?

While reviewing the SPCC Plan to ensure that it has all of the required items, make not of all the requirements that have been written into the plan. 40 CFR 112.3 (a) requires that installations fully implement the SPCC Plan. Items needing special attention include:

- Training requirements: Determine who will be trained, how often personnel must have refresher training, and what will be included in the training course
- Secondary containment: Determine which storage areas will have secondary containment and how impermeable those structures must be (e.g., sealed concrete, earthen berms, etc.)
- Draining of storm water: Determine which procedures will be used to drain storm water from secondary containment areas, whether or not the valves need to be locked, and which records will be kept.
- Facility response procedures: Determine who will respond, what actions will be taken, and the responsibilities for all parties.
- Corrosion protections: Determine whether the SPCC Plan identifies requirements fro protecting underground metal piping or tanks from corrosion.
- Mobile storage tanks: Determine the requirements that the SPCC Plan places on mobile storage tanks.
- Overfill protection: Determine whether the SPCC Plan has any requirements for preventing tanks from being overfilled. Overfill protection can be in the form of loading procedures of electronic equipment.

Assessors will verify that the SPCC Plan is fully implemented. It is important to make sure that requirements written into the plan are actually met. Check to make sure the following are met:

- Verify that the tank is included in the SPCC Plan
- Determine how fuel or oil is delivered to the tank and where the tanker truck parks. Assess the proximity of surface water or storm drains to this location If a spill from the tanker truck (up to 1500 gal) could reasonably reach this location, verify that the SPCC Plan includes procedures for diverting or containing the spill. As a “rule of thumb,” loading locations that are used often should have secondary containment for the tanker truck, but locations not used as often can implement procedures for diverting oil away from the storm drain or surface water. Because this is not a set rule, any location may implement procedures to keep oil from entering the waterway. Verify that he SPCC Plan outlines these procedures
- Determine what procedures or equipment are in place to ensure that spills cannot occur from overfilling the tank. Verify that these procedures are consistent with the requirements of the SPCC plan.
- Determine the secondary containment features for the tank. Verify that the features of the containment area match those required by the SPCC Plan. For example, if the SPCC Plan requires that containment structures be constructed of concrete and that the concrete impermeable to oil, ensure that the containment structure does not have any cracks.

- Verify that personnel who operate the tank receive training required by the SPCC Plan. Check the training records to determine the last time training was received.
- Review spill equipment. Verify that it is adequate to prevent discharge to surface water if the spill occurred at the particular location and meet spill prevention measures specified in the SPCC Plan.
- Verify that all dike valves are kept locked if required by the SPCC Plan. Verify that records are being kept, if required by the SPCC Plan.
- Determine whether any underground structures are located at the storage tank site. If the tank is underground or touching the ground or if the piping is underground, verify that the structures are constructed of plastic or fiber glass or, for steel structures, that corrosion protection is installed.
- Determine whether any mobile tanks or bowsers are located in the area. If so, verify that these equipment are included in the SPCC Plan and that the plan identifies requirements for ensuring spills from these tanks do not enter a storm drain or surface water. If the SPCC Plan requires that bowsers or other mobile equipment be maintained empty or parked within a certain location, verify that those procedures are followed.
- Make sure that tanks undergo a periodic inspection. Determine who conducts the inspections and make sure that adequate records are kept. Verify that this information is consistent in the SPCC Plan.
- Determine whether any smaller day tanks are associated with the storage tank. Many generator sets are built with day tanks. Determine how many day tanks are filled. If the tank is filled automatically by level gauges, verify that the devices are in place to detect a spill from the day tank and shut off the pump. Otherwise, a leak in the day tank or piping could result in the pump continuously running and draining the entire contents of the storage tank into the location of the day tank If the entire contents of the larger storage tank can enter the location of the day tank, determine whether that spill has potential to reach a floor drain, storm drain, or surface waters.

AST Locations

ASTs can be regulated by U.S. state and federal regulations. Make sure that you have the following information in the SPCC Plan and that they are being implemented:

- Oil-filled transformers
- Heat plant
- Used oil tanks
- Parking areas for tanker trucks
- Mobile tanks such as bowsers
- Temporary contractor storage areas
- Heating oil tanks
- Emergency generator tanks
- Other organizational fuel tanks

Make sure that you have reviewed these questions about you storage tank:

- Is the containment adequate to contain the entire contents of the largest tank plus sufficient freeboard to allow for precipitation?
- Is the containments sufficiently impervious to contain spilled oil. Dike walls that have been damaged or breached for activities such as construction are not sufficiently impervious to contain spilled oil.
- Are dike drainage valves closed? The secondary containment system becomes inadequate when the valves are open. Does your SPCC Plan require valves to be locked? If so, make sure that this is followed.
- If double-walled tanks are used, are there periodic inspections of the interstitial space between to inspect for leaks? If not, the inner tank could rupture and cause the tank to act as a single-walled tank without warning.
- If the tank is single-walled, where is the nearest storm drain or surface water? Using the maximum capacity of the tank, could a release from the tank enter the storm drain or water surface? Make sure that there are periodic tank inspections and proper placement of spill kits.
- Is the tank subject to air emissions requirements? Make sure that these requirements have been met.
- Are hazardous wastes disposed of from fuel tanks appropriately?
- Are "No Smoking" signs and tank contents provided on all ASTs?

UST Locations

The UST requirements for active tanks can be broken down into five categories:

- Corrosion protection,
- Spill protection,
- Overfill protection,
- Leak detection on the tank, and
- Leak detection on the piping.

Some states have requirements for secondary containment of UST systems, but this is not very common. This section outlines the basic requirements following the federal requirements, but the state regulations must also be checked to verify compliance. When assessing UST systems for compliance, it is important to look at the tanks and piping separately. Just because the tank has everything it needs to be in compliance does not mean that the piping also does. In some cases, a UST was replaced with a new tank that met the 1998 requirements, but the old steel piping was left in place.

<u>Corrosion Protection</u>

USTs and piping must be protected from corrosion. There are four basic ways this can be accomplished:

- The tank and/or piping is constructed of fiberglass;
- The tank and/.or piping is constructed or a steel-fiberglass-plastic composite;

- The tank and/or piping is steel and protected by impressed current cathodic protection; or
- The tank and/or piping is steel and protected by a sacrificial anode cathode protection system.

If the tank and/or piping is constructed of fiberglass or a fiberglass composite, then all the requirements are met. If steel is used, then a form of cathodic protection must be used. Impressed current systems utilize a rectifier to provide a low-amperage amount of power to the protected structure. Sacrificial anode systems are created to slowly give off an electrical current over time before they wear out and must be replaced.

- If a sacrificial anode system is used, verify that a qualified cathodic protection tester tests the system at least once every three years and records are available of the last two inspections
- If an impressed current system is used, verify that a qualified cathodic protection tester inspects the system at least once every 3 years and the records of the last two inspections are available. Also make sure that the system is inspected every 60 days and that records are kept for the last three inspections.

One exemption applies to the corrosion protection requirements. If a corrosion expert determines that the soil is not corrosive enough to cause the system to have a release due to corrosion for its operating life, then no corrosion protection is necessary. If this determination has been made, verify that records are available to support this claim.

<u>Spill Protection</u>

USTs filled by transfers of oil or fuel greater than 25 gal at any given time must have spill protection. A spill catchment basin or dike around the fill pipe that can capture any spilled fluids when the hose is detached can be used to meet this requirement. It does not need to have much capacity because these types of spills are small. Usually a below-grade bucket is used to meet this requirement. Make sure a spill bucket is in place around the fill pipe and verify it is in good condition.

<u>Overfill Protection</u>

USTs filled by transfers of oil or fuel greater than 25 gal at any given time must have overfill protection equipment. Overfill protection must do one of the following:

- Automatically shut off flow to the tank when it is no more than 95% full; or
- Alert the transfer operator when that tank is no more than 90% full by restricting flow to the tank or triggering an audible or visual high-level alarm; or
- Restrict flow 30 minutes prior to overfilling, alert the operator with a high-level alarm 1 minute before overfilling, or automatically shut off flow into the tank.

<u>Leak Detection on the Tank</u>

The leak detection requirements are the most misunderstood portions of the UST regulations. All USTs, except those that supply fuel only to emergency generator tanks, must have leak detection. Only tanks with a capacity of 550 gal or less may use weekly manual tank gauging. Larger tanks must monitor for leaks once every 30 days using one of the following methods:

Automatic tank gauging with monthly inventory control: Automatic tank gauging systems must be able to detect a 0.2 gal/hour leak from any portion of the tank. Additionally, daily inventory control records that show fuel inputs and dispensed amounts must be reconciled monthly to show whether the tank lost 1% or more of the flow-through plus 130 gal.

Vapor monitoring: Wells meeting the specifications of 40 CFR 280.43(e) must be installed in the tank excavation area. Vapor samples must be taken from these wells as least once every 30 days.

Groundwater monitoring: Wells meeting the specifications in 40CFR 280.43(f) must be installed in the tank excavation area. Groundwater samples must be taken from these wells at least once every thirty days.

Interstitial Monitoring: A monitor must be installed in the space between the two walls of a double-walled tank and its secondary containment barrier. The monitors must be tested at least once every 30 days. Most leak detection systems provide a means for testing the monitors (usually a test button on the control panel.)

Records must be kept of all leak detection tests for at least 1 year.

Leak Detection on the Piping

The leak detection requirements for piping are even more misunderstood. The most important distinction to make when determining the requirements for leak detection on piping systems is to determine whether the pipe is pressurized or not.

For pressurized piping, the piping must be equipped with automatic line leak detector that automatically detects a leak in the piping and shuts off the pump or triggers an audible or visual alarm. The line leak detector must be tested annually for proper operation and the pumping must have an annual line tightness text that can detect 0.1 gal/hour leak rate or must be checked for leaks at least once every 30 days using a vapor monitoring system, groundwater monitoring system, or interstitial monitoring system that meets the requirements for tanks.

For suction piping, the piping must undergo a pressure test that can detect a leak rate of 0.1 gal/hour once every three years; or the piping must be checked for leaks once every 30 days using a vapor monitoring system, groundwater monitoring system that meets the requirements for tanks. Suction piping may be exempt from all leak detection requirements if it is documented that the piping is configured in a way to meet the requirements of 40 CFR 280.41(b)(2). Maintain records for at least a year.

USTs are also subject to the SPCC requirements. Use the same methodology used for ASTs to verify that the USTs are included in the SPCC Plan and that procedures have been written to ensure spilled oil does not enter navigable waters.

Appendix C: Relevant ISO, ASTM, SAE, and ANSI Standards

1. ANSI/API 2015: Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks

2. ANSI/API 2016: Guidelines and Procedures for Entering and Cleaning Petroleum Storage Tanks

3. API 1604 – Closure of Underground Storage Tanks

4. API 1615 – Installation of Underground Storage Systems

5. API 1615 – Installation of Underground Storage Systems

6. API 1631 – Interior Lining of Underground Storage Tanks

7. API 1632 – Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems

8. API Recommended Practice 2021 – Fight Fires in and Around Flammable and Combustible Liquid Atmospheric Storage Tanks

9. API Recommended Practice 2350 – Overfill Protection for Storage Tanks in Petroleum Facilities

10. API Standard 620 – Design and Construction of Large, Welded, Low-Pressure Storage Tanks

11. API Standard 650 – Welded Steel Tanks for Oil Storage

12. API Standard 653—Tank Inspection, Repair, Alteration, and Reconstruction

13. ASTM D 4057 (Standard Practice for Manual Sampling of Petroleum and Petroleum Products)

14. ASTM D4057: Sampling Consignments of Oil in Drums

15. ASTM D6224: In-Service Monitoring of Lubricating Oil for Auxiliary Power Plant Equipment

16. ASTM D6439 Standard Guide for Cleaning, Flushing and Purification of Steam, Gas and Hydroelectric Turbine Lubrication Systems

17. ISO 16889: Hydraulic fluid power filters -- Multi-pass method for evaluating filtration performance of a filter element

18. ISO 3722: Hydraulic fluid power -- Fluid sample containers -- Qualifying and controlling cleaning methods

19. ISO 4406:1999 Hydraulic fluid power -- Fluids -- Method for coding the level of contamination by solid particles

Appendix D: Relevant Federal Regulations and Guidelines

1. Clean Air Act (CAA)

2. Clean Water Act (CWA)

3. EPA 40 CFR 280.43--Methods of release detection for tanks.

4. EPA 40 CFR PART 280--Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks.

5. EPCRA Section 313: Petroleum terminals and bulk storage facilities (from EPA Website)

6. NFPA 30: Flammable and Combustible Liquids Code

7. OSHA 1910.110: Storage and Handling of liquefied petroleum gases

8. OSHA 1910.134: Respiratory Protection

9. OSHA 1910.146 Permit-Required Confined Spaces

10. OSHA 1915 Subpart I, App A: "Non-mandatory Guidelines for Hazard Assessment, Personal Protective Equipment (PPE) selection, and PPE Training Program"

11. OSHA 1915.12 Precautions and the order of testing before entering confined and enclosed spaces and other dangerous atmospheres

12. OSHA 29 CFR 1910, subpart I: Non mandatory Guidelines for Hazard Assessment, Personal Protective Equipment (PPE) Selection, and PPE Training Program

13. *Petroleum, Oils, and Lubricants/ Storage Tanks Compliance Assessment Guide* (2001, December) retrieved September 2003 from <http://www.ecamp-online.net/docs/POL_Compliance_Guide_2001.pdf>

14. Resource Conservation and Recovery Act

15. Underground Storage Tanks (UST)

References

1. *Advice on Lubricants, Storage and Handling*-A Trainee's Guide. TPC USA: TPC Training Systems, 1985.

2. API 620 – Design and Construction of Large, Welded, Low-Pressure Storage Tanks

3. API 650 – Welded Steel Tanks for Oil Storage

4. API 653—Tank Inspection, Repair, Alteration, and Reconstruction

5. API 1604 – Closure of Underground Storage Tanks

6. API 1615 – Installation of Underground Storage Systems

7. API 1631 – Interior Lining of Underground Storage Tanks

8. API 1632 – Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems

9. API 2015 – Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks

10. API 2016 – Guidelines and Procedures for Entering and Cleaning of Petroleum Storage Tanks

11. API Recommended Practice 2021 – Fight Fires in and Around Flammable and Combustible Liquid Atmospheric Storage Tanks

12. API Recommended Practice 2350 – Overfill Protection for Storage Tanks in Petroleum Facilities

13. ASTM D 4057-- (Standard Practice for Manual Sampling of Petroleum and Petroleum Products)

14. ASTM D 6224--Standard Practice for In-Service Monitoring of Lubricating Oil for Auxiliary Power Plant Equipment

15. ASTM D 6439 – Standard Guide for Cleaning, Flushing, and Purification of Steam, Gas, and Hydroelectric Turbine Lubrication Systems

16. Booser, E. Richard, PhD. *CRC Handbook of Lubrication (Theory and Practice of Tribology)*. Vol. 1. Boston: CRC Press, Inc., 2000.

17. EPA 40 CFR PART 280—Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks.

18. EPA 40 CFR 280.43-- Methods of release detection for tanks.

19. EPCRA Section 313: Petroleum terminals and bulk storage facilities

20. Exxon Mobil Unloading/Loading Sequence: Internal Document

21. General Lubrication Engineering Practice: Handling and Storage by W.H. Fowler, Jr. (Ch 29): Standard Handbook of Lubrication Engineering; James O'Conner and John Boyd; McGraw Hill; New York; 1968;

22. ISO 3722: Hydraulic fluid power -- Fluid sample containers -- Qualifying and controlling cleaning methods

23. ISO 16889: Hydraulic fluid power filters -- Multi-pass method for evaluating filtration performance of a filter element

24. Marks, Alex. *Petroleum Storage Principles*. Tulsa: Pennwell Publishing Co, 1983.

25. Neale, M J. *Lubrication-A Tribology Handbook*. Oxford: Butterworth Heinemann, 1995

26. OSHA 1910.110: Storage and Handling of liquefied petroleum gases

27. OSHA 1910.134: Respiratory Protection

28. OSHA 1910.146 Permit-Required Confined Spaces

29. OSHA 1915 Subpart I, App A: "Non-mandatory Guidelines for Hazard Assessment, Personal Protective Equipment (PPE) selection, and PPE Training Program"

30. OSHA 1915.12 Precautions and the order of testing before entering confined and enclosed spaces and other dangerous atmospheres

31. *Petroleum, Oils, and Lubricants/ Storage Tanks Compliance Assessment Guide* (2001, December) retrieved September 2003 from <http://www.ecamp-online.net/docs/POL_Compliance_Guide_2001.pdf>

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Glossary

Absorbent filter: a filter medium primarily intended to hold soluble and insoluble contaminants on its surface by molecular adhesion.

ANSI: American National Standards Institute

API: American Petroleum Institute

AST: Aboveground storage tank

ASTM: American Society for Testing Materials. They are a society for developing standards for materials and test methods.

Baffle: A device to prevent direct fluid flow or impingement on a surface.

Beta Rating: the method of comparing filter performance based on efficiency. This is done using the Multi-Pass Test which counts the number of particles of a given size before and after fluid passes through a filter.

Bleeding: The separation of some of the liquid phase from a grease

Blotter Spot Test: A procedure used to determine whether a significant amount of sludge or varnish is present in the fluid.

Breathers: A device which permits air to move in and out of a container or component to maintain atmospheric pressure.

Bypass Filtration: a system of filtration in which only a portion of the total flow of a circulating fluid system passes through a filter at any instant or in which a filter having its own circulating pump operates in parallel to the main flow.

CAA: Clean Air Act

Carcinogen: A cancer-causing substance. Certain petroleum products are classified as potential carcinogens OSHA criteria. Suppliers are required to identify such products as potential carcinogens on package labels and Material Safety Data Sheets.

Cathodic Protection: A technique to prevent corrosion of a metal surface by making the surface the cathode of an electrochemical cell. For example, a tank system can be cathodically protected through the application of either galvanic (sacrificial) anodes or impressed current (40 CFR 280.12)

CFR: Code of Federal Regulations

Contaminant: any foreign or unwanted substance that can have a negative effect on system operation, life or reliability.

Cutting Oil: A lubricant used in machining operations for lubricating the tool in contact with the workpiece, and to remove heat. The fluid can be petroleum based, water based, or an emulsion of the two. The term "emulsifiable cutting oil" normally indicates a petroleum-based concentrate to which water is added to form an emulsion which is the actual cutting fluid.

CWA: Clean Water Act

Cylinder oil: A lubricant for independently lubricated cylinders, such as those of steam engines and air compressors; also for lubrication of valves and other elements in the cylinder area. Steam cylinder oils are available in a range of grades with high viscosities to compensate for the thinning effect of high temperatures; of these, the heavier grades are formulated for super-heated and high-pressure steam, and the less heavy grades for wet, saturated, or low-pressure steam. Some grades are compounded for service in excessive moisture; see compounded oil. Cylinder oils lubricate on a once-through basis.

Day Tanks: a portable storage vessel which receives oil from a larger stationary vessel

Dipstick: A graduated rod for measuring the depth or amount of liquid in a container

DOT: Department of Transportation

ECAMP: Environmental Compliance Assessment and Management Program

EPA: U.S. Environmental Protection Agency

ESOHCAMP: Environmental, Safety, and Occupational Health Compliance Assessment and Management Program

Facility: Any mobile or fixed onshore or offshore building, structure, installation, equipment pipe, or pipeline used in oil storage, and waste treatment. The boundaries or a facility may depend on several site-specific factors, including, but not limited to, the ownership or operation of buildings, structures, and equipment on the same site and the types of activities at the site (EPA's Glossary of Terms Relating to Oil Pollution and Prevention, www.epa.gov/oilspills).

Filter: any device or porous substance used for cleaning and removing suspended matter from a gas or fluid.

Filtration: the physical or mechanical process of separating insoluble particulate matter from a fluid, such as air or liquid, by passing the fluid through a filter medium that will not allow the particulates to pass through it.

Filtration (Beta) Ratio: the ratio of the number of particles greater than a given size in the influent fluid to the number of particles greater than the same size in the effluent fluid.

Fire Resistant Fluid: lubricant used especially in high-temperature or hazardous hydraulic applications. Three common types of fire-resistant fluids are: (1) water-petroleum oil emulsions, in which the water prevents burning of the petroleum constituent; (2) water-glycol fluids; and (3) non-aqueous fluids of low volatility, such as phosphate esters, silicones, and halogenated hydrocarbon-type fluids.

Fluid: a general classification including liquids, gases or combination thereof.

Flushing: a fluid circulation process designed to remove contamination from the wetted surfaces of a fluid system.

Foam: an agglomeration of gas bubbles separated from each other by a thin liquid film. If an oil is said to not foam, the small air bubbles will quickly combine, become larger bubbles, and then break to vent to the atmosphere. If this action occurs slowly, the oil is said to foam.

Free Water: Water droplets or globules in the system fluid that tend to accumulate at the bottom or top of the system fluid depending on the fluid's specific gravity.

FRP: Facility Response Plan

Full-Flow Filtration: A system of filtration in which the total flow of a circulating fluid system passes through a filter prior to component delivery.

Gear Oil: A high-quality oil with good oxidation stability, load-carrying capacity, rust protection, and resistance to foaming, for service in gear housings and enclosed chain drives. Specially formulated industrial EP gear oils are used where highly loaded gear sets or excessive sliding action (as in worm gears) is encountered.

Harmful Quantities: Quantities that violate a water quality standard, cause a visible sheen, or cause a sludge or emulsion to be deposited beneath water or on an adjoining shoreline (40 CFR 110.3). A "sheen" is an iridescent appearance on the water's surface (40 CFR 110.1).]

Hydraulic Fluid: fluid serving as the power transmission medium in a hydraulic system. The most commonly used fluids are petroleum oils, synthetic lubricants, oil-water emulsions, and water-glycol mixtures. The principal requirements of a premium hydraulic fluid are proper viscosity, high viscosity index, anti-wear protection (if needed), good oxidation stability, adequate pour point, good demulsibility, rust inhibition, resistance to foaming, and compatibility with seal materials. Anti-wear oils are frequently used in compact, high-pressure, and capacity pumps that require extra lubrication protection.

Industrial Lubricant: Any petroleum or synthetic-base fluid or grease commonly used in lubricating industrial equipment, such as gears, turbines, and compressors.

ISO: International Standards Organization, sets viscosity reference scales.

Lubricant: any substance interposed between two surfaces in relative motion for the purpose of reducing the friction and/or the wear between them.

Lubrication: The control of friction and wear by the introduction of a friction-reducing film between moving surfaces in contact. The lubricant used can be a fluid, solid, or plastic substance.

Materials Safety Data Sheets: A publication containing health and safety information on a hazardous product (including petroleum). The OSHA Hazard Communication Standard requires that an MSDS be provided by manufacturers to distributors or purchasers prior to or at the time of product shipment. An MSDS must include the chemical and common names of all ingredients that have been determined to be health hazards if they constitute 1% or greater of the product's composition (0.1% for carcinogens). An MSDS also included precautionary guidelines and emergency procedures.

Micron: a unit of length equal to one millionth of a meter, or 0.0000394 inch.

Mineral Oil: Oil derived from a mineral source, as opposed to oil derived from plants or animals. The term is applied to a wide range of products that is typically used when referring to petroleum-based lubricants.

Navigable Waters: Any waters determined to be navigable in judicial decisions made before enactment of the CWA of 1972, interstate waters, and intrastate lakes, rivers, and streams used by travelers, used for recreation, or used for obtaining fish or shellfish sold in interstate commerce (40 CFR 112.2). The CWA interprets it to also include wetlands, sloughs, prairie potholes, wet meadows, playa lakes, and natural ponds.

Offshore Facility: Any facility of any kind located in, on, or under any of the navigable waters of the United States, which is not a transportation-related facility (40 CFR 112.2).

Oil: Oil of any kind or in any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil (33 USC 1321).

Onshore Facility: Any facility of any kind located in, on, or under any land within the United States, other than submerged lands, that is not a transportation-related facility (40 CFR 112.2). (Note: DOT regulates transportation activities.)

OSHA: Occupational Safety and Health Administration

Oxidation: occurs when oxygen attacks petroleum fluids. The process is accelerated by heat, light, metal catalysts and the presence of water, acids, or solid contaminants. It leads to increased viscosity and deposit formation.

Patch Test: a method by which a specified volume of fluid is filtered through a membrane filter of known pore structure. All particulate matter in excess of an "average size," determined by the membrane characteristics, is retained on its surface. Thus, the membrane is discolored by an amount proportional to the particulate level of the fluid sample. Visually comparing the test filter with standard patches of known contamination levels determines acceptability for a given fluid.

POL: Petroleum, Oils, and Lubricants

Pour Point: lowest temperature at which an oil or distillate fuel is observed to flow, when cooled under conditions prescribed by test method ASTM D 97. The pour point is 3°C (5°F) above the temperature at which the oil in a test vessel shows no movement when the container is held horizontally for five seconds.

RCRA: Resource Conservation and Recovery Act

Release: Any spilling, leaking, emitting, discharging, escaping, leaching, or disposing from an UST into groundwater, surface water, or subsurface soils (40 CFR 280.12).

Release Detection: Determining whether a release of a regulated substance has occurred from the UST system into the environment or into the interstitial space between the UST system and its secondary barrier or secondary containment around it (40 CFR 280.12).

REO: Regional Environmental Office

Sight Glass: A glass tube, or a glass faced section of a process line, used for sighting liquid levels or taking manometer readings

Sludge: insoluble material formed as a result either of deterioration reactions in an oil or of contamination of an oil, or both.

SPCC: Spill Prevention, Control, and Countermeasures

Stiffener: device preventing tanks with flat walls from bulging at the sides and reduce stresses at the edges in large tanks.

Stoke (St): kinematic measurement of a fluid's resistance to flow defined by the ratio of the fluid's dynamic viscosity to its density.

Synthetic Lubricant: a lubricant produced by chemical synthesis rather than by extraction or refinement of petroleum to produce a compound with planned and predictable properties.

TEAM Guide: The Environmental Assessment and Managements (TEAM) Guide, which includes DoD's U.S. TEAM Guide, and state supplements. These documents are available on the Defense Environmental Network Information Exchange. The TEAM Guide is available to ACC and AMC installations in the Environmental requirements and Checklist System, which is used to prepare assessment checklists for internal and external ECAMP/ESOHCAMP assessments. The checklists are also available at www.ecamp-online.net.

Turbine Oil: A top-quality rust- and oxidation-inhibited (R&O) oil that meets the rigid requirements traditionally imposed on steam-turbine lubrication. Quality turbine oils are also distinguished by good demulsibility, a requisite of effective oil-water separation. Turbine oils are widely used in other exacting applications for which long service life and dependable lubrication are mandatory. Such compressors, hydraulic systems, gear drives, and other equipment. Turbine oils can also be used as heat transfer fluids in open systems, where oxidation stability is of primary importance.

USC: United States Code

Underground Storage Tank or UST: Any one or combination of tanks (including underground pipes connected thereto) that is used to contain an accumulation of regulated substances, and the volume of which (including the volume of underground pipes connected thereto) is 10% or more beneath the surface of the ground. It does not include any exceptions made in page 39(40 CFR 280.12)

UST System or Tank System: An UST, connected underground piping, underground ancillary equipment, and containment system, if any (40 CFR 280.12)

Varnish: when applied to lubrication, a thin, insoluble, nonwipeable film deposit occurring on interior parts, resulting from the oxidation and polymerization of fuels and lubricants. Can cause sticking and malfunction of close-clearance moving parts. It is similar to, but softer, than lacquer.

Ventilator: device that introduces fresh air into the system

Viscosity: measurement of a fluid's resistance to flow. The common metric unit of absolute viscosity is the poise, which is defined as the force in dynes required to move a surface one square centimeter in area past a parallel surface at a speed of one centimeter per second, with the surfaces separated by a fluid film one centimeter thick. In addition to kinematic viscosity, there are other methods for determining viscosity, including Saybolt Universal Viscosity (SUV), Saybolt Furol viscosity, Engier viscosity, and Redwood viscosity. Since viscosity varies in inversely with temperature, its value is meaningless until the temperature at which it is determined is reported.