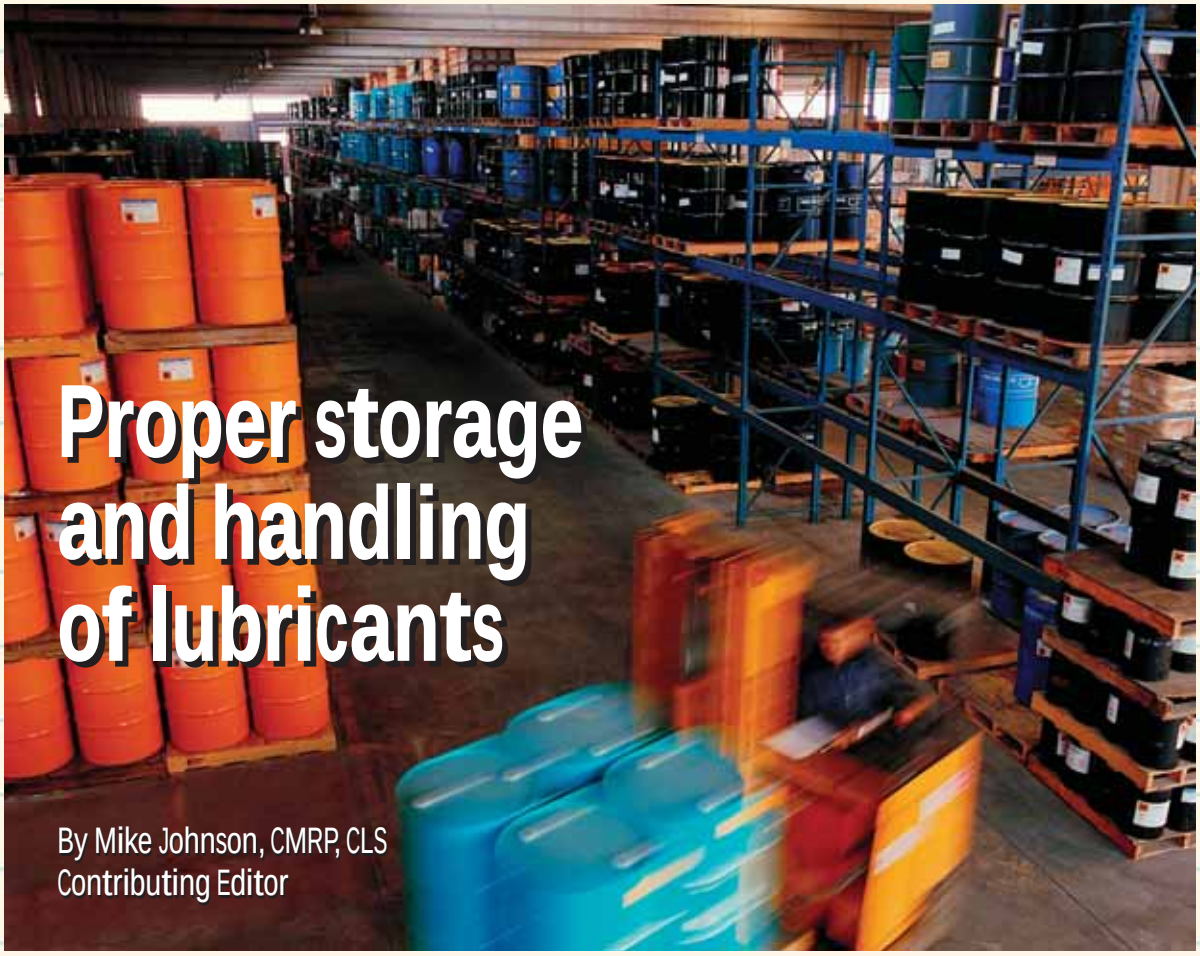

Proper storage and handling of lubricants

By Mike Johnson, CMRP, CLS
Contributing Editor

A lot can go wrong from the time a lubricant leaves the manufacturer until it's used in a machine. Here's how to ensure everything goes right.

Article highlights:

- Standards for inspecting trucks and vessels.
- Tracking lubricant transport, storage and delivery.
- 8 key measures for topping reservoirs.

With all the different ways that equipment owners can invest in more effective lubrication practices, perhaps the most easily overlooked improvement is the product storage and handling practice. Although improvements in this area are not free, the actual cost to make obvious, significant and lasting improvements is low.

There are actually two distinct aspects to this issue. The first aspect, the transport and intermediate storage of lubricants, is outside the direct control of the end-user, and, even though a strong working relationship between the local marketer and the end-user may give the latter some level of influence over this activity, the end-user should be prepared to verify and improve product cleanliness after it arrives at the plant site.

The heart of this article deals with the second aspect: end-user storage and handling practices.

Regardless of the lubricant's performance capabilities, the manner in which lubricants are received, stored and dispatched to machines is a strong indicator of the importance of machine lubrication practices to plant management.

The practices described in this article are intended to provide a general frame of reference through which lubricant users can understand the complicated business of lubricant transport and delivery. The described practices are reflective of those that would be adopted by quality-conscious lubricant manufacturers, of which there are many. It would be useful for end-users to adopt a curious attitude, and each respectively draw a well informed understanding of the state of practices following a thorough review of their own lubricant supplier's processes.

General information

Quality-conscious lubricant manufacturers commit appreciable time and effort to maintain the purity and integrity of their products between blend plant and customer site. Each batch of lubricant is tested prior to packaging or decanting to the lubricant transport tanker. Upon request, the physical and chemical fingerprint of the lubricant can be recorded on a document called the Certificate of Analysis or COA and provided to the purchaser. This becomes the start of the quality paper trail for each and every product shipment. The paper trail is important to protect all the interests involved in the manufacture, movement and use of the lubricant over time for one simple reason: lubricant transport, storage and delivery is the responsibility of many different people and organizations, and is not subject to strict controls.

Most lubricant manufacturers do not own or control the vessels used to pick up and deliver lubricants to the distribution network, and while organizations such as the American Society of Testing and Materials, the Department of Transportation (DOT), and the American Petroleum Institute provide standards about test methods, tank construction and material shipping, there aren't any standards that pertain to the condition that the material should arrive at the end-user. Additionally, there are no objective standards or hard limits for the cleanliness of the containers used to package (totes, drums, kegs, pails) the lubricant.

Accordingly, suppliers cannot guarantee that each stage of the handling process is completely free of chemical, solid and moisture contaminants. STLE member Chuck Barrett, president of Consultive Services Co., a lubrication and marketing consulting agency in Hoffman Estates, Ill., suggests that the final responsibility for the quality and cleanliness of the lubricant is shared between both manufacturer and user interests.

According to Barrett: "Lubricant consumers always seem to wish to put the risk and accountability onto the lubricant supplier, and lubricant suppliers want the end-user to take responsibility for lubricant contamination levels upon their acceptance of delivery. I believe the middle ground is for end-users to establish minimum acceptable physical, chemical and performance specifications for the lubricants they purchase and invest in the (minimally) random sampling of all products upon their receipt. Then they must follow-up with their suppliers if and when they do discover out-of-specification products."

Fortunately, national brands do have clearly defined in-house expectations for their respective licensed distribution networks that, when followed closely, help limit the degree of chemical and atmospheric contamination errors that occur.

Let's take a quick look at how the several million gallons per month of finished lubricants and circulation oils are moved from manufacturing point to the distribution network.

Stage 1:

From the lubricant manufacturer to the local marketer.

The route for lubricant delivery from point of manufacture to eventual delivery at the plant site is similar for each of the major brands. Following receipt of an order from the marketer, the blend plant schedules the marketer to collect the shipment within a stated time frame. The marketer dispatches a transport truck to collect the shipment. Sometimes the truck is company (marketer) owned, and sometimes it is a third party transport.

There is no objective quality standard for the condition of the truck compartment prior to fill. For some manufacturers the truck bulk compartment must be clean and dry. For some the truck compartments must be strictly dedicated to lubricant use and must be completely drained down, although it does not necessarily have to be dry. For some, the truck may arrive in a "diesel-wet," completely drained state. Diesel-wet means the vessel last contained, or was rinsed down with, nondyed, low-sulfur diesel fuel.

Manufacturer guidelines require the truck loader, an employee of the lubricant manufacturing plant, conduct a visual inspection and use a "sniffer" to conduct any gasoline or other chemical/hydrocarbon vapors prior to filling the truck compartment. If the truck fails the inspection it will

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be rejected and must be cleaned and retested before it can be filled.

The truck's compartments will be filled and sealed with the assistance of the driver, and the shipping manifest will identify each product that was placed into each compartment. The transport load is delivered to the local marketer site where, according to the lubricant manufacturer's directions, the truck driver and the site warehousemen work in conjunction to off-load the compartments.

Prior to the off-loading process, all common headers and pumps are typically flushed to remove any residue remaining from previous activities. Additional flushing may also occur any time there is a product change for a shared pump or header. The amount of oil that must be flushed through a line or a pump differs between products and is based upon the degree of incompatibility that exists between the two products (the product that was last passed through the line vs. the product that will be next passed through the line). Lubricant manufacturers have well-defined requirements for the various possible product off-loading combinations.

All offloaded products are sampled following the flush process, and the retained sample is stored for six to 12 months, which is generally long enough for that specific batch to have cleared the marketer warehouse. The retained sample is used, if necessary, to demonstrate that the lubricant product entering the warehouse bulk tank was at maximum integrity.

Stage 2:

From the local marketer tank farm and warehouse to the customer plant site.

Once the local licensed marketer accepts the product into the tank farm and/or warehouse, responsibility for product integrity shifts to the local marketer. The marketer is expected to follow a rigorously defined handling procedure for all products that are delivered and resold in bulk or packaged in totes, drums, kegs or pails and sold accordingly.

Some portions of the products received by bulk transport are packaged into totes, drums, kegs and pails to accommodate customer order requirements. The balance is loaded into a local delivery truck and taken to the customer site for bulk delivery.

Practices for lubricant repackaging and offloading from the tank farm to the bulk delivery truck are clearly defined by the lubricant manufacturer and are expected to be closely followed by marketers. These practices mirror the manufacturer's concern for lubricant integrity during transport and transfer between trucks and tanks, including specific recommendations for the sequential order for product loading and packaging and for transfer system flushing requirements. Additionally, marketers are expected to collect samples following the flushing activities and prior to either repackaging and/or offloading lubricants at the customer site.

In addition to these concerns, marketers also are expected to follow rigorous guidelines for handling drums and pails used in repackaging activities. Totes and new or reconditioned 55-gallon drums all must be tested and show the DOT/UN safety label indicating the containers are safe for interstate transport. Once the totes and drums are received onto the marketer's site, the containers are expected to be stored in a weather-proof manner (out of the rain), and some companies require the empty drums to be stored upside down. When empty drums are pulled from inventory they are inspected with a bright light or an in-drum droplight for any collection of moisture or solid debris. This is a subjective inspection only, with the key point of observation being for evidence of standing water or visible accumulation of solid rust, debris or residual soap film.

Pails are purchased new (pails are not reconditioned) and are to be stored in their original packaging until they are ready to be used. Once the pail packaging is open, the pails are to be stored upside down until pulled and filled.

Product storage guidelines are provided to assure that packaged lubricants do not remain in inventory long enough for the product to degrade. Synthetic and mineral oils and greases have shelf lives between two and five years with a few exceptions. Lubricants that contain suspended solids have shelf life limits between one and two years. There are special-use products (water-soluble

Prior to the off-loading process, all common headers and pumps are typically flushed to remove any residue remaining from previous activities.

products, emulsions) that have product-specific shelf life limits.

The end-user should always verify shelf life limits with the OEM for any products that have been packaged and in storage for more than one year.

The date and location where the lubricant is packaged always should be noted on the product label.

Handling exceptions

The preceding sequence of handling and delivery steps applies to national brand lubricant suppliers for products handled in large volumes through distribution networks. There are plenty of exceptions to these handling practices. For instance, products that end-users purchase in relatively small annual volumes must be either repackaged at the local marketer site or packaged and shipped in the small volume containers (drums, kegs and pails) from the blend plant. Many of the packaged lubricants maintained at a local marketer's locations are packaged at the blend plant and shipped via common carrier to the marketer site.

Synthetic lubricants, for instance, are typically packaged in new five- to 55-gallon containers at the point of manufacture. A few companies allow their premium quality synthetic products to be packaged in larger semibulk (five- and 10-drum sized) containers, but this is not a common practice. Synthetics are rarely allowed to be packaged in reconditioned containers or, for practical commercial reasons, shipped via bulk transport truck.

In addition, there are a few products that are manufactured with highly specialized additive chemistry concerns. Large commercial combustion engines used in shipping (railroad, marine applications) are manufactured using components that are degraded upon contact with zinc-based antiwear additive technologies. These specialized products must be handled in such a way that there is absolutely no potential for any mixture with commonly used zinc-fortified lubricants. These products are identified by specific name and number and are handled with completely dedicated systems and storage containers. The lubricant manufacturer clearly identifies these products to their marketers and end-users so there is little chance that the end-user might unknowingly mishandle them.

In-plant receipt and storage

It is evident from the sequence of delivery steps from the lubricant manufacturer to the end-user storage vessel that most national brand named lubricants are transferred from vessel to vessel several times prior to receipt at an end-user's facility. Even though significant controls and guidelines are in place, given the nature of the shipping and handling process, the lubricant manufacturer is not in a position to guarantee product qualities beyond the physical (visco-metrics) and chemical (additive) characteristics throughout the supply chain.

Recognizing the potential for container (truck, tote, drum, pail) conditions and human error to influence the final cleanliness and quality of the lubricant delivered to the plant site, plant reliability and lubrication managers are right to apply systematic quality control measures to all lubricants received into the plant site.

According to Chuck Barrett, degradation of lubricant between the shipping point and the use point is a common problem: "The top three in-plant lubricant handling and storage problems that I see in my ongoing work with manufacturing plants include (1.) plants allowing lubricants that have become contaminated by previously delivered bulk products (in transport containers/vehicles) into the consumption stream, (2.) plants allowing acceptable incoming lubricants to be transferred into unacceptable/contaminated intermediate storage containers such as bulk oil and grease tanks and (3.) the use of transfer delivery containers or systems that are poorly maintained and have become contaminated with environmental debris and/or other materials. Each of these common problems renders lubricants unacceptable for use."

There are a variety of practices that plants can adopt to improve the integrity of the lubricant from initial delivery to final use, including:

- Incoming lubricant QC testing.
- Long-term storage.
- Contamination control for open stores.

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Once the local licensed marketer accepts the product into the tank farm and/or warehouse, responsibility for product integrity shifts to the local marketer.

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- Pre-filtering lubricants in storage.
- Use sealable, cleanable top-up containers.
- Precautions during top-up activities.
- Stock rotation.

Let's examine these in depth.

Incoming lubricant (QC testing). A best practice in product storage and handling begins with verifying the lubricant qualities for both bulk and packaged products as they are delivered to the plant site. It is a good idea to discuss this intention with the local marketer prior to testing in order to give the marketer time to make adjustments in practices that might enhance delivered product quality. An acknowledgement of, if not a tacit agreement with, a pending test practice also should help minimize organization stress that could occur if any shipments are ever rejected.

As is the case with any QC testing program, sample collection practices should be defined in a standardized operating procedure. Sample collection also should be simple enough to be highly repeatable, regardless of who is taking the sample. Test methods should be rigorously defined and repeatable, and the instruments routinely calibrated to a recognized standard. The instrument calibration and operation practices suggested by the instrument suppliers should be adequate for these purposes.

The following are some sampling guidelines.

1. When checking lubricant physical properties (viscosity, color):

(a.) For packaged goods, take the sample from the middle (center of the container, midway up from the bottom) of the container.

(b.) For bulk deliveries, collect the sample after the standard line flush process has been completed.

(c.) If the center of the vessel cannot be reached, allow sufficient flushing oil to flow through the discharge valve and pipe configuration such that three times the volume off the valve/discharge pipe area has cleared the valve.

2. When checking lubricant for evidence of moisture or settled solid contaminants:

Table 1. ASTM D6224 – Recommended New Oil Quality Control Tests[1]

Test	Test Methods	Engine	Circulating		EP	AW	EHC	
		Diesel	Turbine	Compressor	Gear	Hydraulic	Mineral	PhosEster
Appearance[C]	Visual		A	A	A	A	A	A
Viscosity at 40°C	D445	B	A	A	A	A	A	A
Viscosity at 100°C[C]	D445	A						
Acid No.	D664		A	A	A	A	A	A
	D974							
Water[C, D]	D1744/ D95	A	B	B	B	B	B	A
Oxidation Inhibitor	D2668		B					
Oxidation Stability (RPVOT)	D2272		B	B		B		
API gravity or density[C]	D1298							B
	D4052							
Flash point (COC)	D92	B						
Water Separability[C]	D1401		B			B		
Particle Counts[C]	Per Instrument					A	B	B
	Manufacturer							
Base Number	D974/ D2896	A						
	D4739							
Electrical Resistivity	D257/ D1169							A
Elemental Analysis	D5185	B	B	B	B	B	B	B

A = Required, B = Optional, C = Performed with/without on-site instrument, D = Substitute 'Crackle' Test for quick on-site response.
Note: Items C and D have been added by the author. These are not part of the ASTM procedure.

[1]ASTM D6224 is the Standard Practice for In-service Monitoring of Lubricating Oil for Auxiliary Power Plant Equipment

(a.) For packaged goods, collect sample from the bottom of the container.

(b.) For bulk deliveries, collect the sample after the standard line flush process has been completed.

There are many common used-oil tests that could be conducted, but those that can be conducted on-site would be most useful for QC analysis, particularly for bulk deliveries. Table 1 provides a list of proposed tests recommended for QC testing of lubricants by ASTM D6224.[i] Those noted with the superscript 'C' pertain to tests that may be conducted on-site. The key test parameters, the physical properties and contamination levels, could be measured fairly easily with relatively inexpensive on-site instruments. Chemical properties measurements will be more difficult to accomplish on-site, given the appreciably higher cost of instrumentation. Table 2 provides general guidance for condemning parameters for those on-site tests. Time permitting, it would be best to verify on-site results against those provided by a professional oil analysis laboratory before condemning large shipments.

Long-term storage. For packaged goods, it is appropriate to follow the advice of lubricant manufacturers to their respective distribution warehouses. Packaged lubricants (semibulk, drums, kegs, pails, case lots) should be stored under cover and away from exposure to the elements. The best-case condition would be a climate-controlled room away from direct exposure to sunlight.

End-users often store lubricants outside, in a vertical orientation, on concrete and asphalt pads and parking lots and in direct exposure to sunlight and significant temperature swings. Vertical storage in these conditions all but assures that rainwater will settle on the drums and cover the sealed openings. As the containers heat and cool the contents expand and contract, causing the containers to breathe. Manufacturers that reside in geographical areas that experience significant daily temperature swings should be particularly careful to avoid storage in direct sunlight. These circumstances can contribute to the chemical degradation of the lubricant before it is ever placed into service.

For bulk lubricant storage, the advice to the local marketer (from the lubricant manufacturer) represents a good starting point. Bulk tanks should be staged on paved or concrete pads and all piping and fittings should be either stainless steel or black iron. The mesh screen requirement for the tank vents is inadequate and should be upgraded to a high quality (rated) breather filter.

Additionally, bulk tanks should have permanently mounted filtration systems designed to filter continuously. Filter-element quality for dedicated bulk tanks should coincide with the most stringent cleanliness standards for the machines into which the lubricant type is placed. Elements rated at $\beta_{10} = 75$ represent a minimum quality standard. Bulk tanks staged in cold-weather climates should be either heat traced or staged in climate-controlled conditions to enable filtration during low temperature periods.

Contamination control for open stores. Regardless of the state of lubricant cleanliness upon delivery, unless there are specific measures in place to improve lubricant cleanliness the state of cleanliness likely will begin to degrade the moment the container is opened. This creates a bit of a catch-22 situation with raising expectations for the lubricant manufacturer to meet delivered

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[i] *ASTM D6224: Standard Practice for In-service Monitoring of Lubricating Oil for Auxiliary Power Plant Equipment.*

Table 2. Proposed Condeming Limits for On-Site QC Testing

Test	Formal Test Methods	Engine	Circulating		EP	AW	EHC	
		Diesel	Turbine	Compressor	Gear	Hydraulic	Mineral	PhosEster
Appearance	Visual	If there is any evidence of haze, conduct additional testing.						
Viscosity at 40°C	D445	Greater than or less than 10% baseline reading.						
Water	D1744/D95							
API gravity or density	D1298	0.1 above or below baseline or published values.						
	D4052							
Water Separability	D1401	If field test produces questionable results, test by ASTM D1401. Condem if 1401 results are poorer than either baseline or results denoted in product data sheet.						
Particle Counts[1]	Per Instrument	>22/20/18	>18/16/13		>21/19/17	>18/16/13		
	Manufacturer							

[1] PC Proposed Limits are based on typical results for new lubricant delivered cleanliness measurements from a field study. *Uptime*, March 2006.

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cleanliness targets. There is little reason for the lubricant manufacturer to put forth more effort and accept higher delivery costs if an improved cleanliness state is not preserved at the plant site.

Setting up the storage plan should follow a few key objectives:

1. Create and maintain clean, brightly lighted, climate-controlled main and substorage areas.
2. All lubricants, particularly those in open stores, should be maintained in climate-controlled enclosures. Where climate control is not an option, at least maintain the open stores away from direct exposure to the weather.
3. Minimize human contact with the lubricant during storage and handling as much as possible.
4. Each lubricant package (tote, drum, keg, pail) should be staged for protection from the environment at a minimum through the use of quality breathers and by maintaining closure on all openings (valves, hoses and pipes) when not in use.

Since plants have vastly differing in-plant operating environments and differing tolerances for machine reliability, the steps for accomplishing these objectives will differ.

Pre-filtering lubricants. Whenever the concentration of solid contaminants in the lubricant exceeds the QC target limits for allowable contaminants, the lubricant should be filtered before use.

Filtering lubricants prior to use can be done easily and relatively inexpensively. Filter elements should have high dirt-holding characteristics, low back-pressure limits and at least $\beta_{10} = 75$ quality performance. The equipment selected should be capable of filtering high viscosity oils (up to ISO 680 would be best) at a fairly low rate of flow (one to five gallons per minute). Filter systems for larger bulk tanks (five drums or greater) should have flow characteristics at five gallons per minute or greater. High flow rates and high pressures can impede the effectiveness of some filter elements. There are many companies manufacturing filter units for these kinds of purposes, as in Figure 1.

Figure 1.

(Courtesy of Trico Corp.)

A prefabricated portable filter unit designed for pre-filtering lubricants.

The amount of time the lubricant should run for each package depends on the flow rate of the filter and the package size. At a minimum, the filter unit should run long enough to pass eight times the container volume through the filter unit, regardless of the amount of time involved in achieving this target. The return line should be plumbed to be as far as possible away from the suction line.

Lastly, and this is a very important detail, if one filter unit is going to be used to filter multiple products, whether the products are in the machine or are still in the storage container, any time the filter is moved from one product type to another the element should be replaced and the piping should be flushed with three times the cumulative pipe/hose and housing capacity before the filter unit is attached to the next reservoir/package to be filtered. If the unit is being moved to another viscosity grade within the same product type (i.e., the same brand and product designation), the flush volume can be reduced to only one times the cumulative pipe/hose and housing capacity prior to reuse.

Once the package (typically a five- to 10-drum semibulk tank or a 55-gallon drum) has been opened and pre-filtered, the container should remain stationary and be equipped to breathe through a vent filter instead of an open pipe.

Use sealable, cleanable top-up containers. After the effort of testing and pre-filtering the products to assure they are capable of performing in the desired manner, the end-user certainly wants to preserve the improved quality state of the lubricant while it is being transported around the plant in the possession of the lubrication technician or operator. This can be challenging.

Any surface that is wetted with oil becomes a magnet for atmospheric contaminants. Funnels, new oil cans, dip-sticks, transfer container, etc., all eventually become grossly contaminated if they are not isolated from the atmosphere following use. For items small enough to fit in a plastic bag, such as a funnel, once used the items should go immediately into a zip-loc type resealable plastic bag.

Open metal cans should be replaced with oil-handling containers designed for this purpose. There is a variety of sealable and cleanable handling containers available to transport the pre-filtered lubricant to the machine center. Discharge nozzles range in size, opening diameter and type, from

pump-type quarter-inch nozzles to gravity flow one-inch, twist-to-seal type nozzles. The containers also come in a variety of colors, as shown in Figure 2.

Some organizations construct agreements with their suppliers to receive lubricants in single-use one-gallon containers. These containers may be delivered to predesignated storage areas and maintained at a pre-established inventory level by a weekly inventory check and replenishment. (*see Figure 3*).

Precautions during top-up activities. Providing the lubricant is delivered according to quality expectations and maintained in a clean state while in inventory, the remaining opportunity for corruption occurs at the time that the lubricant is placed into the machine sump. The act of filling the machine is the last chance to inadvertently harm the lubricant and the machine. A few simple precautions can eliminate the remaining threat.

When topping reservoirs with a high volume of lubricant (10 gallons or more), equip the sump drain and fill ports with fluid quick-connectors that, matched with the quick-connectors on the filter cart, allow the prefiltering process to take place from the lubricant package directly into the lubricant sump. The amount of precleaning of the fitting that must be done before each use is simple and quick if the equipment owner keeps the connector covered with a rubber or metal cap while the machine is in normal run mode. Observe the same consideration for flow rate and filter quality as was previously discussed.

When topping reservoirs with a low volume of lubricant (10 gallons or less), follow these guidelines:

1. Use a soft bristle brush to completely displace any atmospheric dust or dirt that has accumulated around the port plug since the last top-up event.
2. If there is wet residue, use a clean, lint-free cloth to physically wipe down the area around the port plug.
3. Loosen the plug and repeat Step 1 if solid debris is observed.
4. Remove the plug and place it in a clean and dry container or location while topping the port.
5. Reinspect and try to remove any contaminant that may fall into the sump during top-up.
6. Use a top-up reservoir that has a piston-type displacement pump supplying lubricant through a narrow opening discharge fitting. Place the fitting into the reservoir and fill the sump to the appropriate level.
7. Replace the plug and wipe down any residual oil on the housing.
8. Drain any excess, if necessary.

This is not clinical type work but simple precautions to minimize the kind of ingression that can greatly support the long-term reliability objectives for the production machinery.

Stock rotation. Lubricants have shelf life limits. As noted previously in this article, the limits vary from

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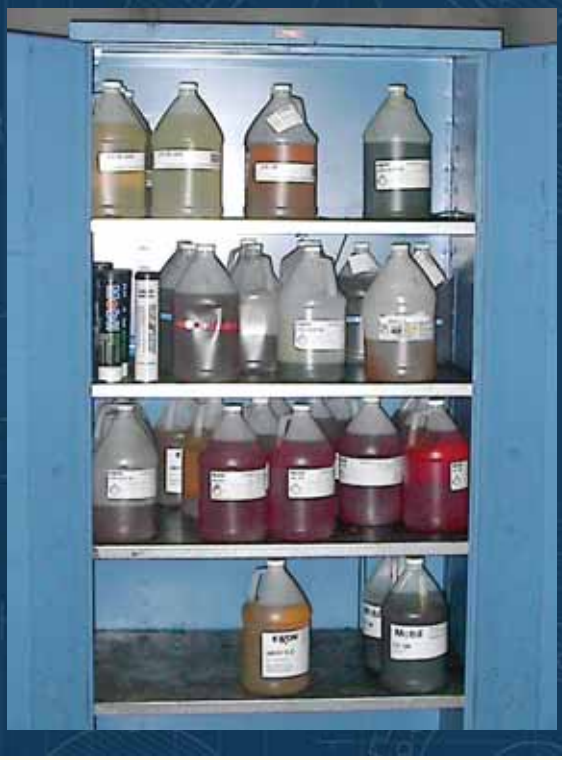
Figure 2.

(Courtesy of Trico Corp.)

Examples of sealable, cleanable lubricant handling containers designed for in-plant use.

Figure 3.



(Courtesy of Electric Energy, Inc., Joppa, Ill.)

An example of custom delivery through single-use, one-gallon containers delivered directly to predesignated in-plant storage lockers.

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product to product and from manufacturer to manufacturer. Several things can have a negative effect on the shelf life of the lubricant. The effectiveness of the blend process has an impact on whether additives are fully dissolved or whether they are susceptible to settling during transport and storage. A dark or off-colored highly viscous layer at the bottom of the shipping container is an indicator of additive settling. Contamination from rainwater/melting snow, large temperature swings and high temperature storage methods also shorten shelf life.

To avoid shelf life issues for petroleum products, the lubricant inventory volume should be maintained at a low enough level such that the whole inventory is turned over at least once annually. The interval for specialized and custom-blended products may be shorter and should be addressed individually by the manufacturer.

Conclusions

There are three distinct stages of the lubricant transport, storage and handling process. Each of these stages represents some level of risk to the lubricant. The first two stages belong to the lubricant manufacturer and the lubricant wholesale supplier and are, for all practical purposes, outside of the reach of the end-user/equipment owner.

Precision practices in receipt and storage follow what is largely a common-sense approach. Verify that the lubricant is what it is supposed to be (QC). Once verified, make changes in the handling practice to preserve the chemical and physical qualities and improve the overall cleanliness of the lubricant. Store the lubricant in such a way that it cannot be corrupted by either the production or atmospheric environment while the packages are being emptied. Use simple filtration methods to pre-filter all stored lubricants. In some instances the same devices can be use to top-up the reservoir directly through the filter itself.

Lastly, the vast majority of the handling and top-up practices are manual. Simple precautions and cleaning around the openings before removing fittings and applying the lubricant can provide substantial long-term benefits. TLT

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