Hydraulic Fluid Care Guide

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The performance, life and reliability of hydraulic components is acutely sensitive to the quality and maintenance of the hydraulic fluid used in the system. That is why it pays to use a high- quality hydraulic fluid, inspect fluid samples at regular intervals, and practice regularly scheduled preventive maintenance. By observing these simple precautions system downtime will be reduced and the overall life of the hydraulic system will be increased.

This document provides guidelines for the selection and care of hydraulic fluid in high-performance hydraulic systems.

Why is fluid care important?

High-performance hydraulic systems require very clean oil to maximize performance and extend the life of system components.

While less sophisticated hydraulic systems may function acceptably with lower levels of oil cleanliness, high-performance hydraulic equipment will "silt up" and perform erratically when subjected to particulate levels that are greater than an ISO 4406 rating of 16/13/9. Servovalves must operate smoothly and predictably to deliver the tightly regulated pressures and fluid flow for which they are designed.

How is the life of a hydraulic system shortened?

Hydraulic fluid contamination and deterioration are normal consequences for most hydraulic systems. Failure to adequately remove contaminants, or to change hydraulic fluid before severe fluid breakdown occurs, will lead to poor system performance.

The most common hydraulic fluid contaminants are entrapped air and water, along with particles of metal, rubber or dirt. To maintain clean hydraulic fluid, samples must be taken regularly and appropriate mitigation should be immediate.

Fluid deterioration might more appropriately be called "additive deterioration." Additives give the oil its particular characteristics—and because these additives are most susceptible to chemical and physical change, their deterioration is what leads to fluid breakdown.

Fluid deterioration is often caused by operation at high temperatures. Fluid reservoir temperatures are best kept below 140° F (60° C). To keep fluid operating temperatures within the acceptable range of 100-125° F (38-52° C), standard hydraulic power units are equipped with full-motor-horsepower heat exchangers, over-temperature interlocks and temperature controls.

How can hydraulic system life be maximized?

Regular monitoring and maintenance of the hydraulic fluid promotes the maximum operating performance and service life of the servohydraulic system and its components. Two specific items must be checked regularly—contaminants in the fluid and the fluid's chemical makeup.

Fluid sampling and analysis **is the best way to determine whether the fluid and filters should be changed. Fluid analysis will provide an accurate viscosity reading while detecting specific contaminants such as water or foreign particles. It can also be used to check the chemical makeup of the fluid to identify whether the additive package is still able to perform as it was originally designed.**
A correct evaluation of the contaminants in the hydraulic system is important. When the contaminating material is identified, its source can be investigated to prevent future contamination.

How are fluid analysis samples taken?

Fluid analysis samples should be taken with the system running at normal operating temperatures. To insure that no foreign material enters the sample, tools and containers used for sampling must be very clean. It is best to use the sample bottles provided in fluid analysis kits.
When the system is installed, collect a fluid sample and label it "first test sample" or "benchmark sample." Have it analyzed by a laboratory, and keep the lab report on file.

Fluid samples should be submitted for analysis twice every year. More often if the system operates at higher temperatures or in abnormal ambient conditions. Compare new analyses with the report from the first or "benchmark" test sample. A schedule for changing fluid should be developed, based on the rate of fluid deterioration.

Where can a fluid sample be analyzed?

Many filter manufacturers offer services, giving special attention to particle counts and specific contaminants.

What are the expected fluid analysis results?

The following table identifies the specifications for common elements of hydraulic fluid, as used in servohydraulic applications.

Characteristic	Normal	Borderline	Unsatisfactory
Viscosity at 100°F (38°C), SUS	215-240	(Low) 183-193 (high) 256-276	(low) <183 (high)>276
Particle count	ISO 16/13/9	ISO 17/15/11	ISO 18/16/13
Water, % by wt.	<0.05	0.05-0.1	>0.1
Iron, ppm*	<30	30-50	>50
Silicon, ppm*	<15	15-30	>30
Copper, ppm*	<40	40-100	>100
TAN mg KOH/gm	<1.4	1.4 – 2.6	>2.6
Ultra Centifugation	1-3	4-6	7-8
Oxidation, A/cm	<3	3-4	>4

* These results should be trended to watch for changes in system condition. (see page 8)

If any fluid contamination indicators are borderline, the fluid condition might be improved by cleaning. If the indicators are unsatisfactory, the fluid must be replaced and the system may need to be flushed. In either case, the entire system needs attention—not just the fluid in the reservoir.

What does clean hydraulic fluid look like?

Looking at and smelling hydraulic fluid is the simplest and most effective way to determine the fluid's condition.

Clean fluid is amber in color. A milky, dark, or otherwise abnormal color may indicate the presence of one or more contaminants. A milky appearance implies contamination by water. *If the fluid looks milky, take immediate action to avoid severe damage to your hydraulic system.* Stop the influx of water and remove the water from the system immediately. Water can be removed by passing the fluid through water-absorbing filters, or by flushing or draining the entire hydraulic system.

A marked change in the smell of the hydraulic fluid can indicate a chemical breakdown. This type of breakdown is generally due to air that has become entrained in the fluid, which creates varnish-like nitrogen-oil compounds that contaminate the fluid. If a distinct change in the smell of hydraulic fluid is detected, have it chemically analyzed by the manufacturer. Also consult with the system's service engineer to determine if other changes or adjustments to the system are required.

What is viscosity?

Viscosity is a measure of the resistance of the fluid to flow. A low viscosity will not provide adequate lubrication to parts, resulting in increased wear on the parts. Many hydraulic fluids will shear or thin out with use.

A viscosity check should be made whenever fluid samples are analyzed. If the fluid's viscosity is outside of the specified flow limits, the fluid should be replaced.

(NOTE: Viscosity varies with temperature, so a numerical viscosity value is meaningless unless the temperature is specified.)

What is oxidation?

As hydraulic fluid deteriorates over time, it oxidizes and produces deposits that may cause servovalves to stick. Signs of this natural process include changes in fluid color, odor, or acidity level. Sludge, gum or varnish in the system are further evidence that oxidation has taken place.

A fluid analysis with an ultra-centrifuge test can detect the level of oxidization. The rate of oxidization increases significantly at operating temperatures higher than 150° F (66° C). Oxidation is irreversible, and fluid must be changed when oxidization is detected.

Why check for water content?

Water is highly undesirable in hydraulic systems. It can cause emulsions to form, and it can lead to corrosion. More than a trace of water may indicate an improper mechanical condition, poor performance of a heat exchanger or ingestion of water through the breather filter.

During system operation, gross contamination of hydraulic fluid is indicated by a milky color. If the system is not in operation, contamination can usually be detected by sampling the fluid at the bottom of the reservoir, where water normally settles as it separates from the hydraulic fluid.

A simple test for water contamination is the "spat" test: Place a few drops of oil on a hot plate heated to above boiling, but less than 350° F; if the oil bubbles or sizzles, there is an unacceptable amount of water in the oil.

If water contamination exists, fix the leakage and remove the water from the system immediately. Water can be removed by passing the fluid through water-absorbing filters, or by flushing or draining the entire hydraulic system.

Why check for iron, silicon and copper content?

These analyses are a valuable aid to troubleshooting. A high iron reading may indicate wear of hydraulic power unit parts. High silicon readings may indicate ingestion of dirt or compounds containing silicon (e.g., sealing compounds or defoamants). High copper readings may indicate component wear and/or faulty heat exchangers.

If fluid analysis shows high levels of iron, silicon or copper, identify the source and replace components as necessary. Fluid analysis should be a continuing process and sample results must be evaluated for trends that indicate a change in the condition of the hydraulic system.

What can be done to maintain the hydraulic system?

Regular monitoring and maintenance of the hydraulic fluid will provide maximum operating performance and service life for the hydraulic system and its components. Keeping a maintenance log that records:

- **Dates of fluid sampling**
- **Laboratory results**
- **Viscosity**
- **Particle Count**
- **Water, % by content**
- **Total Acid Number**
- **-UC**
- **-Oxidation**
- **Filter changes**
- **Fluid changes**
- **Operating temperature-test results**
- **pH test results**
- **Other inspections or maintenance**

This log will help to detect signs of deterioration and can be used to develop a schedule for changing fluid.

How do filters keep hydraulic fluid clean?

Filters provide the fluid cleanliness levels required by servohydraulic systems. These sizes and efficiency ratings have proven to be effective in controlling the silt particles that cause erratic servovalve operation.

Filters must be cleaned or replaced during routine maintenance of the hydraulic system.
Most filters supplied are not cleanable; refer to your manufacturer's product information for guidance on changing filters.

System filters must be capable of maintaining a normal ISO 4406 particle count of 16/13/9.

When a high particle count is identified the source of contamination should be located and corrected. Collecting samples from various system locations will help identify the source of contamination. Clean the hydraulic fluid by changing the system's filters and running the hydraulic power unit for a period of time. Filters will collect solid contaminants larger than a specified diameter

After filtering the hydraulic fluid, check it for cleanliness. An ISO 4406 particle count reading of 16/13/9 or better is required for test systems. Some critical test applications may require an ISO 4406 level of 14/12/8. If the appropriate level can't be achieved after cleaning, a change to the filtration plan must be considered.

When does the hydraulic system need to be flushed?

At installation, or after any of the system's hydraulic components have been replaced, flush the system to remove particle contamination. If the reservoir is very dirty, or if sludge or varnish is present, the system must be flushed with a flushing compound.

Flushing compounds are solvent free, oil soluble cleaners designed specifically for cleaning and flushing gummy oxidation deposits and insoluble materials from hydraulic systems. Solvent flushing is a costly, time-consuming process. Contact the system's service engineer before using a flushing compound.

Flushing the hydraulic system, with or without a flushing compound, dislodges conta-minants that are harmful to servovalves. For this reason, *it is extremely important to replace servovalves with flushing valves* before the flushing procedure. Filter elements should also be changed immediately before adding the flushing compound to prevent contaminants already in the elements from being reintroduced to the system. Refer to the manufacturer's documentation for more detailed information.

What can be done at system installation and initial start-upto prevent contamination?

The manufacturer should have designed, manufactured, shipped and installed your hydraulic distribution system to manage particulate contamination of the hydraulic fluid. After the system is installed and flushing operations are completed, the system should be trouble-free.
Precautions must always be taken to avoid contamination during installation or mainte-nance. When a plug, cap, hose or hydraulic component is removed, foreign matter can enter the system and eventually cause damage.

On complex systems with large fluid capacities, and in distribution systems that use welded carbon steel pipe, contamination risk is high. A complete system flush—before attaching actuators and servovalves—is imperative.

After the fluid is cleaned or the system is flushed, sample the fluid for cleanliness. The proper cleanliness level is an ISO 4406 particle count of 16/13/9 or better. If necessary, clean the fluid continuously until this level of cleanliness is achieved.