Burned TOST

Don't let the TOST test burn your hydraulic oil decision

ASTM D943, commonly referred to as the Turbine Oil Oxidation Stability Test (TOST), is widely used in the lubrication industry to evaluate the oxidation stability of various industrial lubricants in the presence of water. It may be an adequate indicator of oxidation stability for steam turbine and some circulating oils (rust and oxidation or R&O inhibited), which continually operate with water contamination. However, TOST test data should not be misinterpreted as a general indicator of in-service oil life, especially for hydraulic fluids. Contamination control and overall oil durability are more appropriate performance indicators for in-service hydraulic oil life. ExxonMobil used oil analysis data shows that greater than 90% of hydraulic oil alerts, recommending an oil change, are due to contamination.

In addition to documented performance in key hydraulic glassware and industry recognized builder pump tests, Mobil DTE premium hydraulic oils were developed using a proprietary pump test that simulates/correlates to in-service use, providing a well-balanced formulation with an overall optimized performance.

TOST Test Results ***Do Not Equate*** to Hydraulic Oil Life

Hydraulic oils in service almost never fail due to oxidation, let alone by the unrealistic conditions of the TOST test (see Figure 1). Based on nearly 50,000 ExxonMobil used hydraulic oil samples, which upon testing generated notices (alerts) identifying them to be either borderline or unsuited for further service, only 2.5% were related to oxidation (Figure 2). None of the alerts were due to oxidation alone. Furthermore, out of the 2.5% of samples alerting on oxidation, statistically none failed on high acid number (TOST failure criteria). The TOST test, therefore, is not an accurate indicator of in-service oxidation stability or lubricant life for hydraulic oils. As defined in the "Significance and Use" section of ASTM D943-04, "[TOST] is widely used for specification purposes and is considered of value in estimating the oxidation stability of lubricants, especially those that are prone to water contamination. It should be recognized, however, that correlation between results of this method and the oxidation stability of a lubricant in field service may vary markedly with field service conditions and with various lubricants."

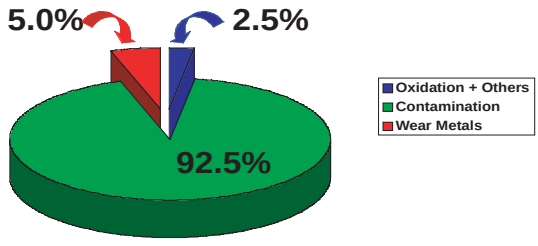
Figure 1

TOST and Its Failure Mechanism

TOST was first developed by the American Society for Testing and Materials (ASTM) in 1943, with the current method approved in 2004. It was designed to force lubricants to fail by a specific failure mechanism related to the extreme conditions of high temperature, gross water contamination, and substantial air entrainment. The test, therefore, is designed to evaluate oils under a very specific failure mode. Each reactant and catalyst is exaggerated: the test oil is mixed with an additional 17% water, heated to 95°C (203°F), and agitated by an oxygen flow, in the presence of iron and copper catalysts. Under these conditions, the lubricant will oxidize or hydrolyze, increasing its acidity or acid number. Acid Number (AN), therefore, is the metric used to measure the oxidation stability. The life of the oil is measured as the time to reach an AN of 2 mgKOH/g. If a lubricant is continuously exposed to gross water contamination, high temperatures, and air entrainment in field service, TOST can be used as a potential indicator of lubricant life.

Figure 2

ExxonMobil Used Hydraulic Oil Alerts

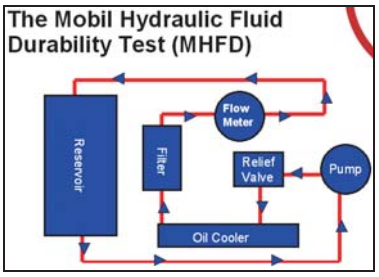


Based on 12 Years of Used Hydraulic Oil Data (49,389 Data Points)

Contamination, the Primary Failure Mechanism of Hydraulic Oils

Accounting for greater than 90 percent of the hydraulic oil alerts, contamination of the lubricant with water, dirt and other particulates is the primary condemnation mechanism. No matter how oxidatively stable a hydraulic oil is, if it cannot control contamination and keep the system clean, its oil life will be compromised. Outstanding oil durability, an oil's ability to control contamination and keep the system clean, while protecting the equipment and operation, is required to achieve long in-service oil life for hydraulic systems.

Figure 3



The MHFD test is a hydraulic system containing the typical hydraulic components, such as a pump, relief valve, filter, and reservoir (Figure 3). It is a comprehensive hydraulic oil performance test with elevated testing temperatures of greater than 71° C (160° F), moderate pressure, and very short reservoir oil residence time. Several hydraulic failure mechanisms are monitored, including failure by lack of contamination control and oil degradation. 500 hours of MHFD testing puts a hydraulic oil through the rigors of about 18 months of typical field service. Through decades of experience, ExxonMobil has proven the correlation of the MHFD test to field service. For a comparison of the TOST test and MHFD test conditions, see Figure 4.

Figure 4

Comparison of TOST Test vs. Mobil Hydraulic Fluid Durability Test

■ Closely Replicates a Typical Hydraulic System ■ Does Not Closely Replicate a Typical Hydraulic System

	Typical Hydraulic System	MHFD Test	TOST Test (D 943)
Vessel Composition	Iron & hose	Iron & hose	Glass
Fluid Temperature, °F (°C)	125 (52)	>160°F (>71°C)	203 (95)
Water Level, %	< 1.0	< 1.0	17.0
Catalysts	Water, debris, airborne particulate	Water, debris, airborne particulate, metal catalyst	Iron & copper
System Condition	Fluid subject to pressure fluctuations and flow	Fluid subject to pressure fluctuations and flow	Fluid stirred with oxygen flow
Failure Mode	Equipment Condition	Equipment Condition	Acid Number increase,

Three competitive hydraulic oils were put through the rigors of the MHFD hydraulic system test. All three failed the test at 750 hours with significant filter deposits and sludging. However, Mobil DTE 25 kept going to 1250 hours. The test filters are shown in Figure 5. In contrast, D943 TOST test results (Figure 6) would predict a very different outcome for relative fluid life - What criteria would you rather use to give you confidence in how a hydraulic oil will protect your equipment? Mobil DTE 20's and Mobil DTE Excel show exceptional overall performance in the MHFD, and have been proven extensively in field service.

Figure 5

The data underscores the point that competitors A, B, and C, with good glassware results, did not perform as well as Mobil DTE25 in a controlled hydraulic circuit that more closely replicates commercial operational demands.

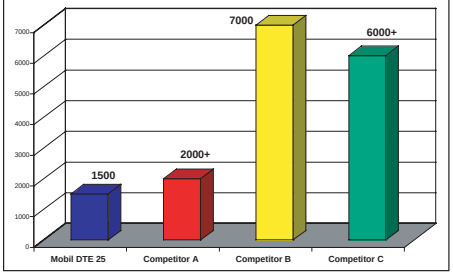
MHFD Filter at 750 hours

Mobil DTE 25 | Competitor A | Competitor B | Competitor C

Mobil DTE 20 Series is often challenged on composition or inexpensive analytical methods. For actual hydraulic requirements, Mobil DTE 20 Series continues to be a performance leader.

Figure 6

ASTM D943 (TOST) Comparison



Conclusion

- Although TOST is a valuable test for indicating oxidation stability of steam turbine oils and other R&O oils prone to gross water contamination, it does not indicate in-service oil life of hydraulic oils.
- Contamination is the primary failure mode of hydraulic fluids; therefore, contamination control and keep clean performance should be the leading performance indicators for hydraulic oil life/durability.
- The MHFD is the comprehensive proprietary hydraulic system test used within ExxonMobil to demonstrate hydraulic system component protection, keep clean performance (system cleanliness), and in-service oil life.
- Mobil DTE 20 and DTE Excel Series hydraulic oils show superb performance in the MHFD and continue to be performance leaders.

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