Technical Topic

DRY TOST

Deposit Control Test Method

Introduction

Mitsubishi Heavy Industries (MHI) has become a leader in the gas and steam turbine market, gaining a significant market share in new turbine capacity.

MHI recognized that there is a continuing issue with varnish and sludge formation in turbine oil systems. Also, there is no standard test method for new turbine oils to define the tendency to form sludge and varnish in service. To this end, MHI developed a new test method and specifications for their turbines called Dry TOST.

Why Dry TOST?

Traditionally, ASTM D943 (Standard Test Method for Oxidation Characteristics of Inhibited Turbine Oils, otherwise known as TOST) and ASTM D2272 (Standard Test Method for Oxidation Stability of Steam Turbine Oils by Rotating Pressure Vessel, also known as RPVOT) have been used by some marketers and some oil companies to draw comparisons between products. In fact, neither of these tests are effective predictors of whether or not a turbine oil will form deposits or how long the oil will last in service.

Oils	RBOT Values (min)	Dry-TOST Test Judgment	Weight of Filter Residue (mg/kg) at 25% RBOT
A	285	o	30
B	350	o	35
C	350	x	680
D	365	x	800
E	430	x	200
F	595	x	550
G	620	o	30
H	640	x	930
I	660	x	270
J	820	o	41
K	1.300	x	200
L	1,480	x	772
M	1,510	o	52
N	1,520	x	150
O	1,620	x	520
P	1,770	x	1,700
Q	1,780	x	430
R	1,820	o	13
S	2,300	x	1,020
T	2,480	o	60
o: Good sludge resistance, x: poor sludge resistance			

Table 1

A recent study (Study on Sludge Formation during the Oxidation Process of Turbine Oils, Tribology Transactions, 47: 111-122, 2004) highlights the fact that there is no correlation between the RPVOT value of new oil and its ability to reduce the formation of sludge and varnish. In this study, several oils with very high new oil RPVOT values actually generated more residue than oils with significantly lower new oil RPVOT values.

The data from this study (see Table 1) demonstrated the need for other tests that could comprehend the formation of sludge and varnish in turbine oils as well as measure oxidation stability.

What is Dry TOST?

The Dry TOST test uses the same apparatus as the conventional ASTM D 943 TOST test but there are two important differences in the Dry TOST method. First, the absence of water, and second, the temperature of 120°C. ASTM D 943 is typically run with 17 percent water and at 95°C.

The oil sample subjected to these conditions is tested periodically for remaining resistance to oxidation by RPVOT and for sludge accumulation by a 1 micron filter patch test. The passing criteria for the test are to maintain less than 100 mg/kg of sludge at a RPVOT value 25 percent of new oil. The 100 mg/kg limit was

determined by MHI based on field experience with their turbines and hydraulic control systems. The 25 percent of new oil RPVOT value was derived from the condemning limit in ASTM D4378 (In Service Monitoring of Steam and Gas Turbine Oils). If the amount of sludge exceeds 100 mg/kg at any point before 25 percent of RPVOT value, the result is reported as a fail. The following graph demonstrates the pass/fail criteria (Figure 1):

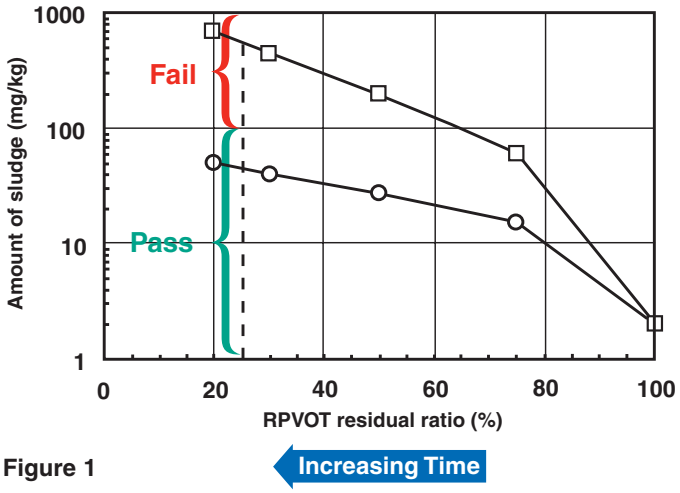


Figure 1

In addition to the Dry TOST Requirement, MHI has added a mixture stability test to their turbine oil specifications. The mixture stability test uses 50 percent new oil and 50 percent of used oil from a previous Dry TOST test. The combination of the two oils is subjected to the same test criteria as a standard Dry TOST test. That is, the combination of the new and used oil must maintain a sludge rating below 100 mg/kg of oil up to the 25 percent RPVOT value is reached.

MHI incorporated these newly established test methods into three new oil specifications for their turbines. A description of these specifications is shown in Table 2.

MHI Spec	Application	Critical Tests
1. MS04-MA- CL001	Steam Turbine, Low Temp. Gas Turbine, non geared	RPVOT by ASTM D2272: >220 Min, TOST by ASTM D943: >2,000 H, MHI 120°C dry-TOST
2. MS04-MA- CL002	High Temp. Gas Turbine, non geared	RPVOT by ASTM D2272: >700 Min, TOST by ASTM D943: >4,000 H, MHI 120°C dry-TOST
3. MS04-MA- CL003	High Temp. Gas Turbine, geared	RPVOT by ASTM D2272: >700 Min, TOST by ASTM D943: >4,000 H, MHI 120°C dry-TOST, FZG FLS 9

Table 2

Correlation of Results to Mobil Proprietary Rig Test

Mobil's proprietary dynamic rig test focuses on evaluating the overall balanced performance of turbine oil in a system that mimics actual operating conditions. Specifically, the key criteria measured in this test are 1) RPVOT Retention, 2) Ultra Centrifuge Rating, and 3) Filter and Reservoir Cleanliness.

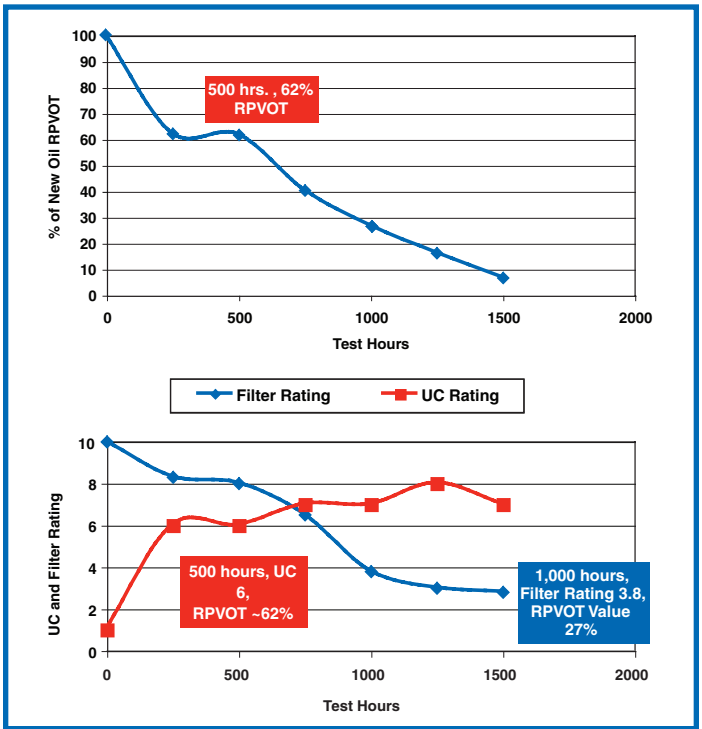
RPVOT Retention:
The typical limiting value of used oil is 25 percent of the new oil value per ASTM and many builder guidelines.

Ultra Centrifuge Rating:
The ultra centrifuge test measures the concentration of oxidation byproducts and insolubles in the oil. The test result is rated on a scale of 1 to 8, where 1 is the best rating and 8 is the worst. Ultra Centrifuge ratings provide a measure of the tendency of the oil to form oxidation byproducts that lead to varnish and sludge.

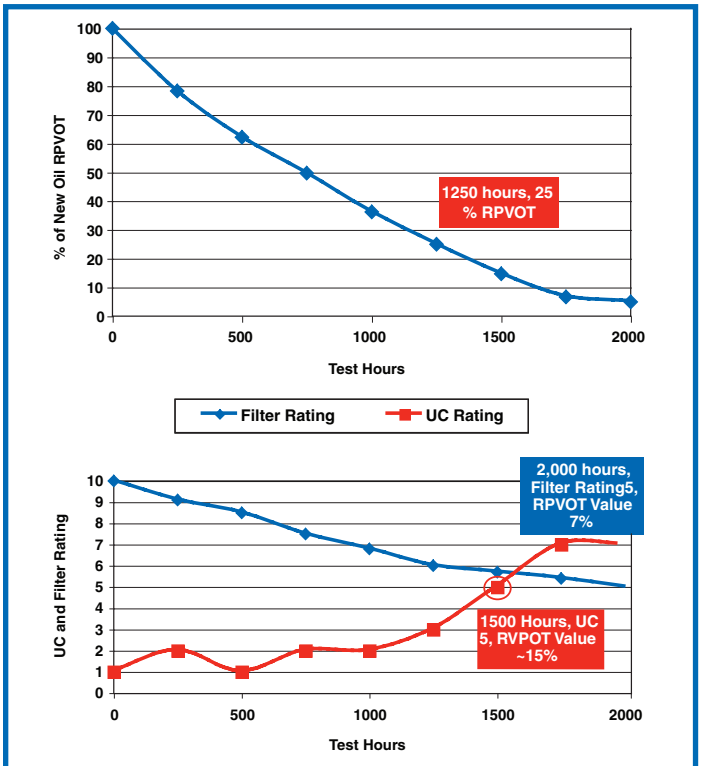
Filter and Reservoir Cleanliness:
Cleanliness of the filters and reservoirs during the course of the rig test measures the ability of the oil to resist the tendency to lay down deposits in the lubrication and control systems of the turbine.

The combination of the MHI Dry TOST Test and the Mobil Proprietary Rig Test yields an interesting result. Some oil formulations will form deposits even when the RPVOT value is much greater than 25 percent of new oil. Other formulations resist deposit formation until the 25 percent of new oil RPVOT value is reached (Figure 2).

Figure 2: The following graphs of data collected by the rig test demonstrate this relationship in two different oil formulations.



This product shows significant deposit tendency at 62 percent RPVOT value



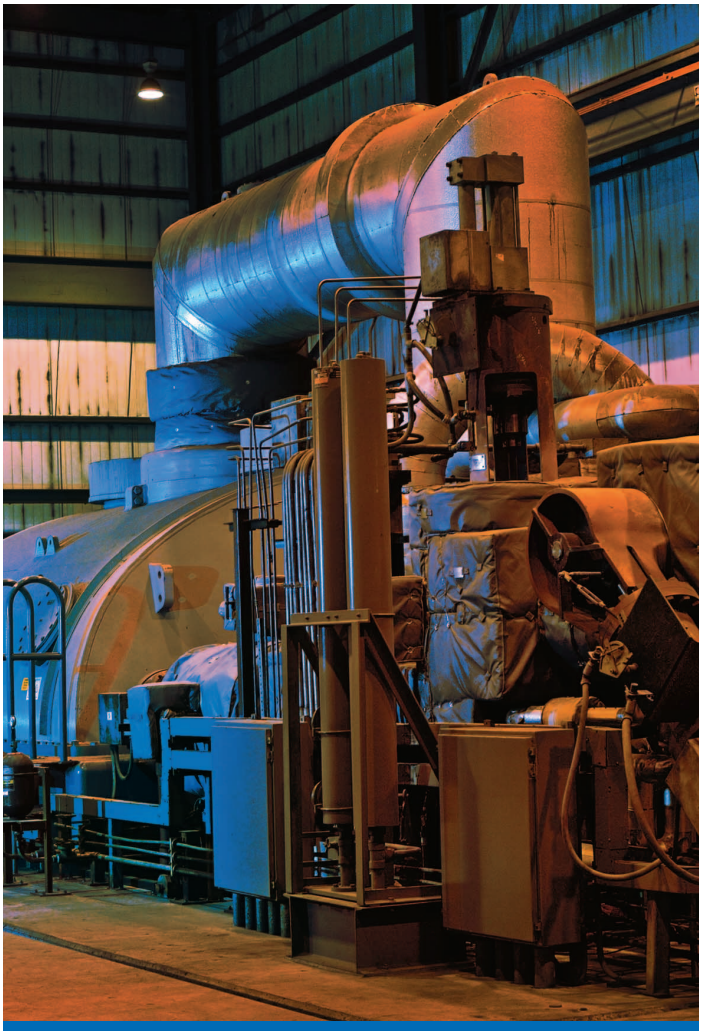
This product shows good correlation between RPVOT value and deposit tendency

Conclusion

The combination of the MHI Dry TOST and the Mobil Proprietary Rig Test enable the development of balanced turbine oils that are long lasting and clean running. For some oil formulations, the use of RPVOT combined with other used oil analyses will allow the user to accurately predict – and therefore to prevent – the onset of damaging deposits in the turbine lubrication system.

Reference:

- ASTM D943 – Standard Test Method for Oxidation Characteristics of Inhibited Mineral Oils
- ASTM D 2272 – Standard test Method for Oxidation Stability of Steam Turbine Oils by Rotating Pressure Vessel
- ASTM D4378 – In Service Monitoring of Mineral Turbine Oils for Steam and Gas Turbines
- Study on Sludge Formation during the Oxidation Process of Turbine Oils, Tribology Transactions, 47: 111-122, 2004
- MHI, Turbine Oil Specifications, MS04-MA-CL002



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