A Technical Brief from Savant Labs:

Thermo-oxidation Engine Oil Simulation Test Overview

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EXECUTIVE SUMMARY

A key component to automotive engine performance and longevity is the ability of lubricants to resist varnish and deposit formation at operating temperatures. As the number of new base stocks and additives increase to meet more demanding oil specifications, the need for accurate, efficient bench tests that correlate with engine and turbocharger performance have become essential.

INTRODUCTION

Two Thermo-oxidation Engine Oil Simulation Tests have been developed to reduce the need for increasingly erratic, costly and difficult engine tests in determining the deposit-forming tendencies of engine oils.

These two TEOST methods have shown good correlation with both field experience and existing engine tests. TEOST 33C was developed to simulate deposit formation found in the turbocharger and was correlated to existing field data (see Figure 1); while the TEOST MHT (Moderately High Temperature) very closely correlates with the Peugeot TU3M piston ring-belt deposit test. (see Figure 2).

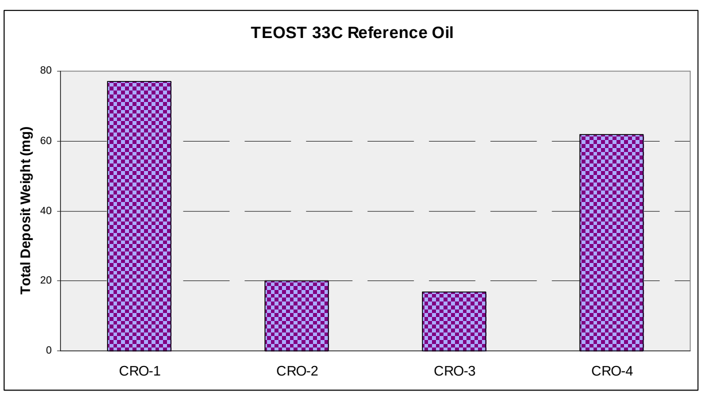

Figure 1: TEOST 33C Field Correlation with Turbocharger field-failures. CRO-1 & CRO-4 both experienced a considerable number of turbocharger failures where CRO-2 and CRO-3 gave no problems.

Both TEOST tests generate objective, physical measurements of deposit mass to determine an oil's susceptibility to deposit formation. Higher temperature oxidation phenomena that occur more quickly above 300°C are well simulated by the TEOST 33C method. On the other hand, a phenomena like build up of carbonaceous deposits that happens over a longer time and at lower temperatures fit with the MHT method.

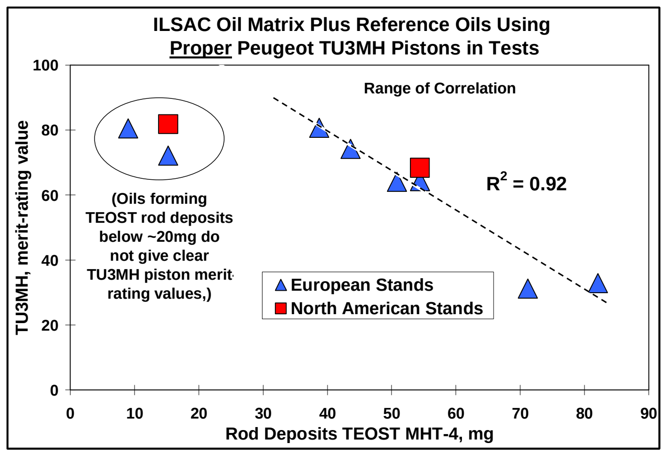

Figure 2: Correlation of TEOST MHT Test with Peugeot TU3M Piston Ring-Belt Deposit Test

TEOST BENCH TESTS – PERTINENT DETAIL

An important aspect of the TEOST 33C test is the use of two progressive zones of the oxidation process. In order to set up the oxidation resistance of an engine oil to reflect its response in the turbocharger, the TEOST 33C platform breaks down the oxidation process into two specific environments highly different in temperature.

1) The 33C Reactor Zone: Where oxidation precursors are formed at engine operating temperatures.

2) The Depositor Rod Zone: A very high temperature zone reflecting that of the turbocharger rotor shaft which completes the oxidation process and deposit formation.

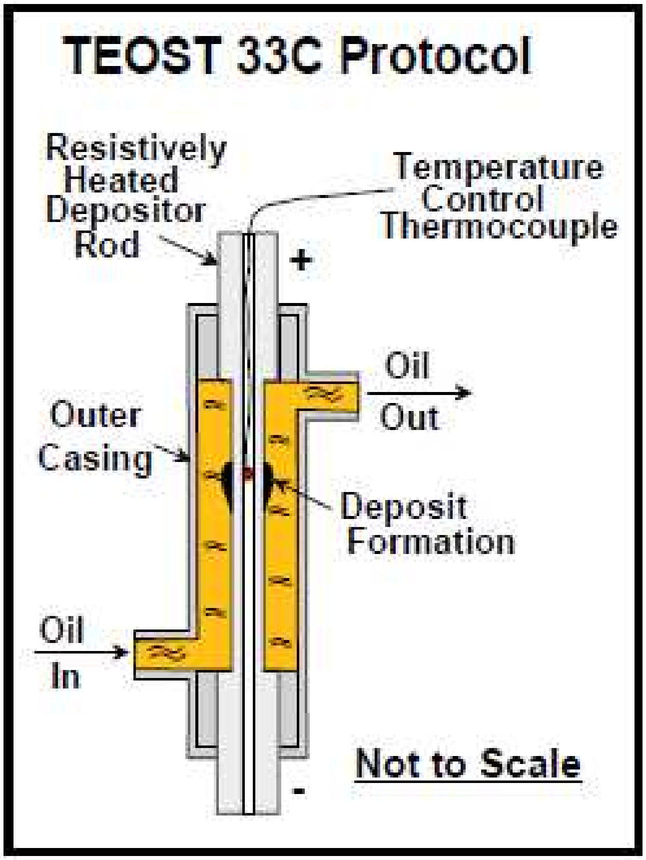

Figure 3: Sketch of Depositor Rod Component of TEOST 33C Instrument

Development of this two-stage test environment gave an interesting further view of different oxidation response to temperature and time. It was of particular interest to find how important additives used in formulated engines oils are affected by the very high temperature environment of the Depositor Rod.

The Depositor Rod and its deposit zone of the TEOST 33C test are shown in Figure 3. A test oil volume of 116 mL is required which contains a very small amount of an organo-metallic catalyst. This test sample is heated to 100℃ in the constant temperature reactor. Moreover , to encourage reaction during test, the oil in the reactor is exposed to a mixture of moist air and nitrous oxide to simulate the engine crankcase's gaseous atmosphere.

This test oil is then pumped at a constant rate through the casing containing the Depositor Rod shown in Figure 3 which applies cyclic heating between 200 and 480°C to mimic the temperature changes encountered in the turbocharger and engine. During this cyclic heating, deposits are formed on the rod. Change in Depositor Rod mass before and after test relates to the test oil's oxidative resistance in the turbocharger.

Success in developing TEOST 33C won the Chrysler Engineering Award of the Year in 1993.

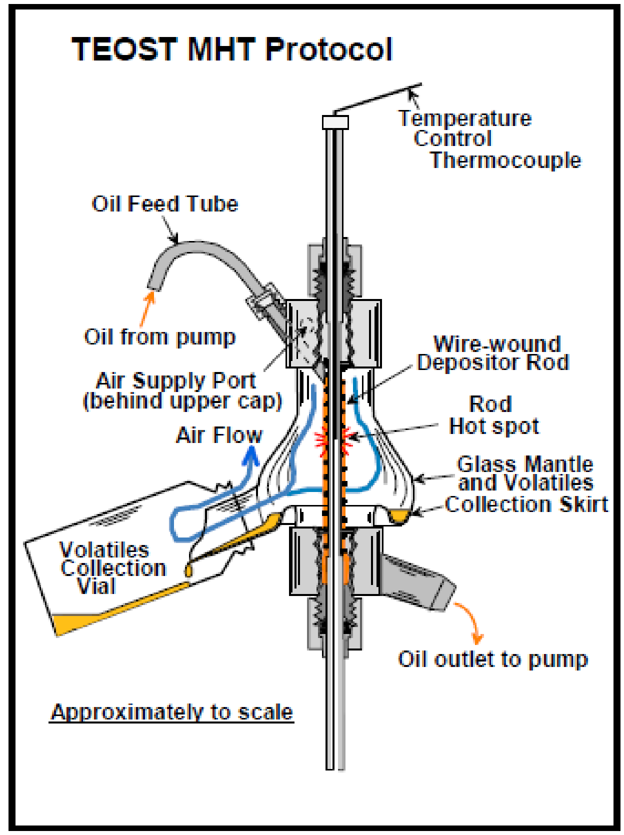

Figure 4: Sketch of TEOST MHT Apparatus Detail

The TEOST MHT approach (sketched in Figure 4) was designed to simulate the deposit-forming tendencies of an engine oil in the piston-ring belt and upper piston-crown area. In this test method an eight-gram sample of test oil containing a very small amount of an organo-metallic catalyst is forced to continuously flow down a wire-wound Depositor Rod heated to the moderately high temperature of 285ºC while exposed to air for 24 hours.

Volatility of the test oil also plays a role in deposit formation in the ring-belt area and in the TEOST MHT test. Loss of volatile components effectively reduces an oil's volume, increasing thermal stress on the remaining oil. To simulate this, volatilized oil produced during sample heating is condensed on the glass mantle and collected in a separate vial. This increases the number of passes the remaining oil must make over the Depositor Rod and, thus, the likelihood of forming deposits. Change in Rod mass is then determined by difference over the test period and indicates an oil's oxidative resistance in the piston-ring belt area. A maximum mass of 35 mg is often used in specifications.

PATH FORWARD

One of the most useful tools in method development is the ability to examine key variables systemically. The TEOST tests have been found to correlate with actual engine oil performance. Moreover, as engines are modified the tests are well suited to maintain good correlation by ease in modifying variables, such as time, temperature, sample size and catalyst load to predict how changes in engine oil formulation could affect deposit formation.

As automotive engines become smaller and required to give more power and fuel efficiency, the thermal stress on the engine oil will continue to increase. These more challenging conditions have opened the way for a new generation of base stocks and additive packages that can offer high temperature oxidative resistance to meet these conditions.

Savant Labs is equipped to respond quickly to customer needs for ASTM D6335 TEOST 33C and ASTM D7097 TEOST MHT data with experienced chemists and informative reports of the data. Beyond this, as developer of both methods, Savant Labs has the expertise to modify the conditions of test to emulate advanced engine needs and effects on engine oils. Such customized projects and testing protocols can thus be developed to advance understanding of oxidation resistance of engine oils of the future.

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