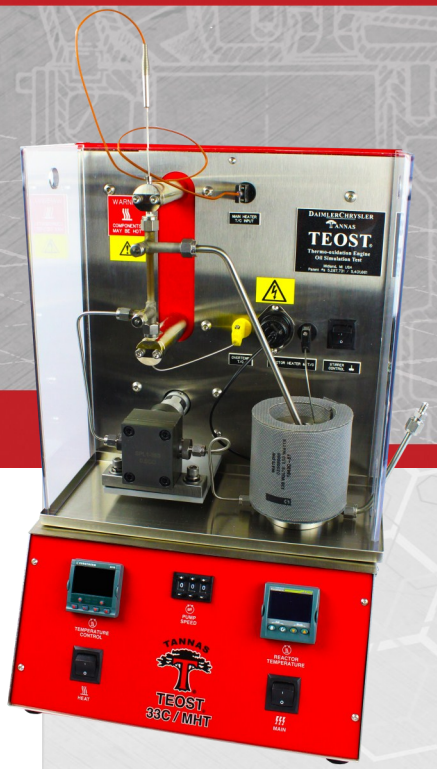
TANNAS CO.
LABORATORY INSTRUMENTS

TEOST™

Thermo-oxidation Engine Oil Simulation Test

ASTM D6335, D7097



Principle

High Temperature Deposit Control — The two current TEOST™ tests operate under temperatures and environmental conditions identified as significant in internal combustion engines to simulate the oxidation and deposit-forming tendencies of engine oils. Oil samples, treated with catalyst, are pumped over a heated steel Depositor Rod on which deposits form. The weight of the Depositor Rod after the test is subtracted from its pre-test weight and added to the particulate weight collected by filtering the remaining oil. The results are reported in milligrams.

History

In the mid-1980's, Savant Labs developed a unique two-stage oxidation/deposition test technique for engine oils formulated for high temperature performance. Joint cooperation with Chrysler Corporation resulted in a modified, very high temperature cyclic technique successfully applied to oils blended for turbocharger lubrication temperatures. The technique, known as TEOST™ 33C, became ASTM D6335, and Savant Labs received a Chrysler Technology Award in 1993.

Additional work proved successful in modifying the TEOST™ to measure deposits on a thin-film of circulating oil. This lower, but constant temperature application, correlated to the piston ring belt area of the combustion engine. The TEOST MHT™ (Moderately High Temperature) protocol later became ASTM D7097. International engine oil specifications now include both the 33C and MHT™ tests.

Innovation

In contrast to oxidation tests based on visual color perceptions and variable human judgment, TEOST™ testing produces results based on gravimetric analysis of the mass of deposits formed on the Depositor Rod, plus the mass of deposits otherwise generated within the circulating oil.

The development of the TEOST™ tests benefit OEM's and oil & additive manufacturers due to the precise, correlative data and the relatively fast testing speed. The bench-top design makes the TEOST™ an affordable option for simulating engine operating environments and certain field performance conditions.

ASTM D6335
SH/T0750
(TEOST™ 33C)

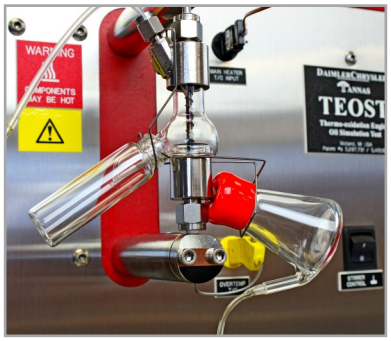
ASTM D7097
(TEOST MHT™)

Required for :

- ILSAC GF-2 to GF-5 Engine Oil Specifications
- **TEOST™ 33C:** API 'SJ' and 'SN' categories for modern engine oils
- **TEOST MHT™:** API 'SL', 'SM' and 'SN' categories for modern engine oils
- Chinese National Standard: GB-11121

Features

The TEOST™ offers adjustable temperature zones, pump speeds, catalytic materials, and other modification options to simulate desired engine operating conditions.



TEOST™ 33C

- Considered a 'bulk oil' test technique as found in the turbocharger bearing area.
- Reactor sump held at 100°C to form precursors at high-normal operating conditions.
- Cyclic heating of deposit-inducing zone from 200°C to 480°C at designated intervals to simulate the deposit-forming conditions in the engine turbocharger.

TEOST MHT™

- Single thin-film heating zone: wire-wound Depositor Rod held at 285°C for 24 hours.
- Clear Glass Mantle for easy viewing of depositor area during test.
- Ability to collect the volatilized material for further analysis and investigation.

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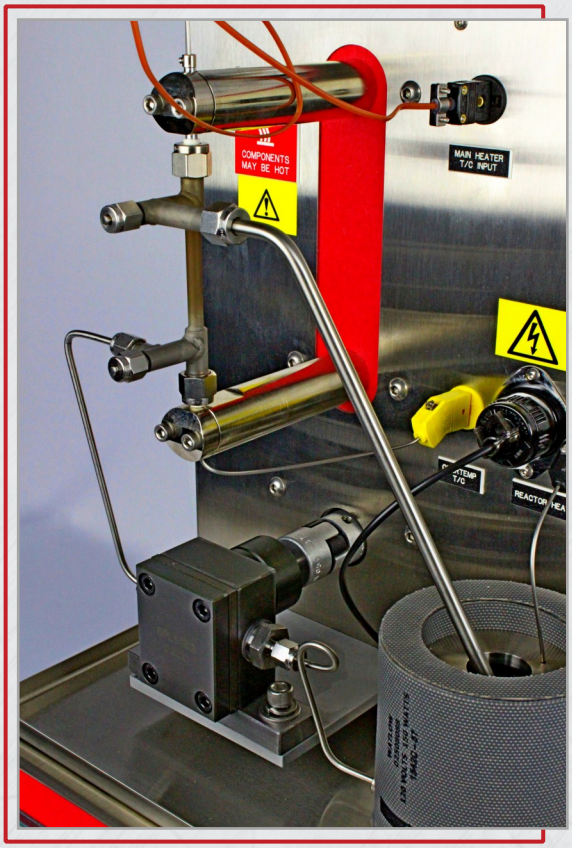
TEOST™ 33C | ASTM D6335



In response to an OEM request for a bench test to determine the depositing tendencies of lubricating oils in the engine turbocharger-bearing area, Savant Labs developed the TEOST™ 33C method in the early 1990's. This method is considered a 'bulk oil' test technique due to the amount and thickness of the oil passing over the Depositor Rod. As practiced, the oil is circulated slowly past a pre-weighed tube for 114 minutes while the tube is cyclically-heated from 200° to 480°C every 9.5 minutes, thus simulating the deposit-forming conditions in the engine turbocharger.

Coking deposits can affect the turbocharger components of an engine. These deposits, generally un-combusted or incompletely combusted hydrocarbons, can form on system components and eventually cause expensive parts to fail.

When the turbocharger bearing area reaches temperatures of 400° to 600°C, most mineral base oils will volatilize and leave little deposits. However, the additives used in formulated engine oils may contribute to the formation of deposits when base oils catalyze. This may lead to additional deposit formation because earlier deposits deplete the antioxidant additives. Further research can help formulate other desirable additives that will remove or prevent deposits.

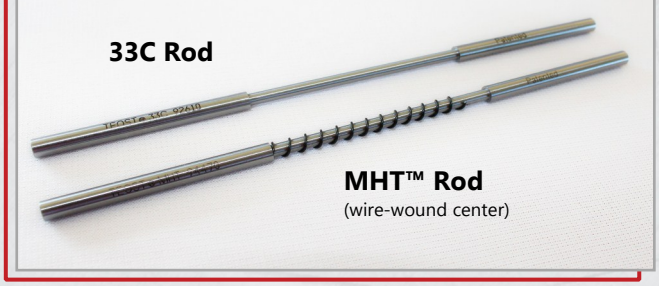
The TEOST™ 33C method has indicated that deposit-formation in the turbocharger is additive-sensitive (additive-free refined mineral base oils of relatively high paraffin content form little deposits by themselves in the TEOST™ 33C). The test has become a required standard for engine oils by OEMs.

TEOST™ Depositor Rods

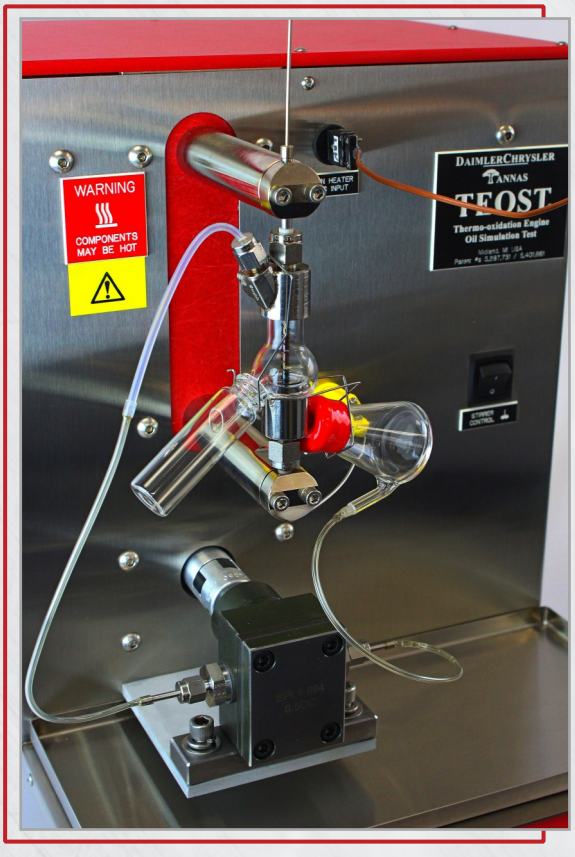
Depositor Rods crafted from precision machined steel meet Tannas specifications for exclusive use in TEOST™ tests. The choice of steel reflects the various iron surfaces in the engine. All rods undergo a rigorous inspection and measurement process prior to acceptance, and then receive serial numbers for identification purposes.

After placement in the instrument depositor area, the rods are heated via a pre-set low-voltage, high-amperage resistive heating system while exposed to test oil. Oils leave a unique 'thermogram' on the rod along with a level of carbonaceous deposits related to the various reactive stages it goes through as it passes over progressively hotter sections of the rod. The deposit level relates to both the chemistry and composition of the oil formulation and its additives.

For continuing research capability, adjustments made to the depositor can simulate other high-temperature areas of the engine susceptible to deposit formation.



TEOST MHT™ | ASTM D7097



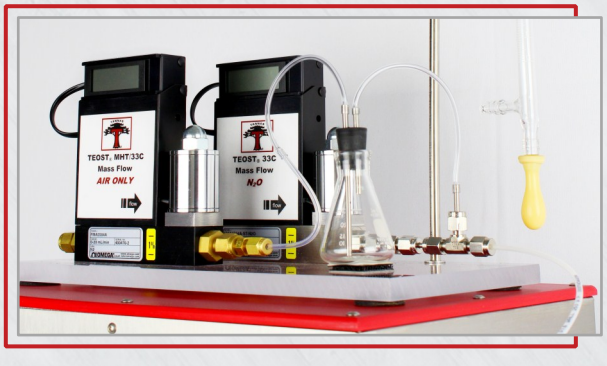
Since the beginning of the reciprocating engine, lubricating oils have formed deposits and piston varnish, while various and expensive engine tests sought to address these problems.

In the mid-1990s, Savant Laboratories researched and produced a bench test for piston deposits. Correlation was shown between the TEOST MHT™ method and the Peugeot TU3MH engine varnish test ($R^2 \geq 0.90$). This resulted in a required OEM standard for specifying engine oils.

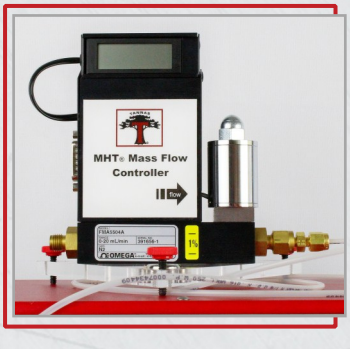
Deposit formation in the piston belt area occurs through a 'thin film' oxidation process. The TEOST MHT™ replicates this process by exposing a thin film of lubricant to passing gases, similar to the oxidation that occurs in an engine when large surfaces of oil are exposed to passing gases. The temperature of the test holds constant at 285°C, with a 24 hour test duration to simulate ring belt temperatures, although research continues on higher and additional temperatures.

The thin-film deposit forming nature of the TEOST MHT™ test may also correlate with deposit forming tendencies of oils entering the exhaust stream. Additional research studies might utilize higher temperatures and larger test samples.

Mass Flow Controller



Mass Flow Controllers, utilized for both TEOST™ 33C and MHT™ tests, introduce various components to the test oil such as reactive gases and air. These materials help characterize the oxidation resistance of engine oils by simulating the combustion chamber blow-by gases and the ongoing exposure of the engine oil to this environment at engine and turbocharger operating temperatures.



Tannas offers two types of TEOST™ Mass Flow Controllers. The MHT™ Mass Flow Controller solely operates with the D7097 test, while the newly introduced 33C/Dual Mass Flow Controller conveniently operates for both the D6335 and D7097 tests. This dual controller eliminates the Rotometer Stand device with its cumbersome flow tubes previously sold through Tannas for 33C tests. Contact Tannas for more details on the new Dual Mass Flow Controller.

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LABORATORY INSTRUMENTS

ISO 9001:2008 QMS

Parts & Accessories

Depositor Rods:

500012: TEOST™ 33C Depositor Rods (10 rods/box)
500993: TEOST MHT™ Depositor Rods (10 rods/box)

Optional Accessories:

500990: 33C/Dual Mass Flow Controller
500995: MHT™ Mass Flow Controller
500075: Thermocouple Depth Gauge
500070: Two-Channel Chart Recorder - R
500065: Chart Recorder Paper - R
500024: Chart Recorder Pen - Black
500067: Chart Recorder Pen - Red

Spare Parts & Consumables (for either Test):

500030: TEOST Filter Cartridges w/Caps
500612: T/C Main (J-type)
500614: T/C Over-Temp. (K-type)
500409: Depositor Rod O-Rings (20/pack)
500892: Filtering Flask Funnel
500856: Filter Tube Assembly
500016: Steel Wool
500019: Pipe Cleaners (100/box)
500084: Disposable Pipette
500428: #8 Rubber Stopper
300995: Combination Wrench 7/16
500872: Thermocouple Collar Assembly
020044: TPC Calibration Oil (0.47 L | pint)
200103: Syringe (100 microliter)
500076: Weighing Boats
300815: Tool Box
500822: Spare Fuse Set *(for either 110V or 220V)*
500085: Plastic Depositor Rod Holder
500715: Protective Shield
Allen Keys for cabinet (P/Ns 500610, 500611, 500613)

Contact Tannas for additional spare parts, reference oils, and accessories to operate the MHT™ and 33C tests.

Instrument Specifications

Dimensions (W x D x H)	Bench-top: 33 x 50 x 56 cm 13 x 19.5 x 22 inches
Weight	30 kg | (64 lbs.)
Voltage	120 or 220 VAC , Single Phase Power Draw - 5 amp.
Frequency	50/60 Hz.
Depositor Rods	**33C:** Precision steel **MHT™:** Precision steel with specially treated wire winding
Sample Volume	**33C:** Total - 250 mL — Actual Volume Tested - 116 mL (100 mL plus 16 mL left in lines after flushing) **MHT™:** 8.5 grams (± 0.001 g)
Operating Temperatures	**33C:** Reactor Temperature: 100°C (±1°C) Depositor Temperature Cycle: 200°C to 480°C at designated time intervals **MHT™:** Constant 285°C
33C Test Parameters	12 Heating Cycles: 9.5 minutes/cycle 114 minute total test time Pump Rate: 0.45 mL/min. or 0.40 g/min. Moist Air Flow Rate: 3.6 mL/min. through H_2O N_2O Flow Rate: 3.6 mL/min. through H_2O Iron Naphthenate: 100 ppm
MHT™ Test Parameters	Test Time: 24 hours Pump Rate: 0.25 g/min. Dry Air Flow Rate: 10mL/min. MHT Catalyst: Refer to bottle
Safety	*CE* Mark Current Limiting Fuses & Over-temperature Cut-out Fuse Protective Heat Shield
Shipping Weight	MHT™ or 33C: ~60 kg | (132 lbs.) Dual: ~82 kg | (180 lbs.)
Shipping Dimensions (W x D x H)	MHT™ or 33C: 1 Pallet | 61 x 81 x 89 cm Dual: 2 Pallets | 84 x 61 x 84 cm | 79 x 61 x 71 cm

Additional TANNAS CO. Precision Laboratory Instruments

Tannas Foam *Air* Bath (TFAB™)
- ASTM D892, D6082, IP146
- Non-liquid bath
- 24°C to 150°C range

Tapered Bearing Simulator (TBS™) Viscometer
- ASTM D4683, D6616, CEC L-036, IP370
- High-Temperature, High-Shear (HTHS) Viscosity

***Quantum*® Oxidation Tester**
- ASTM D2272, D2112, D4742, D942, IP229
- RPVOT, TFOUT, Grease Oxidation
- Non-liquid 'dry cylinder' sample heating

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