TANNAS CO.
LABORATORY INSTRUMENTS

TEOST®

Thermo-oxidation Engine Oil Simulation Test

ASTM D6335, D7097, D8447

Principle

High Temperature Deposit Control — The three 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 33C and MHT®.

As engine designs have evolved over the years, particularly turbochargers, the need for an additional modification to the TEOST® platform became evident with the trends in increasing oil change intervals, improved fuel efficiency, and longer residence times for turbocharger cooling. Development began in 2017 on a new lower-temperature, high-duty cycle deposit test to accurately assess deposit formation in modern engines. This technique, known as TEOST Turbo®, became ASTM D8447 in 2022.

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®)

ASTM D8447
(TEOST Turbo®)

Required for :

- ILSAC GF-2 to GF-6 and IFC™ Engine Oil Specifications
- **TEOST® 33C:** API 'SJ', 'SN' and 'SP' 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, ability to collect volatilized material for further study, and other modification options to best simulate desired engine operating conditions.

Parameter	33C	MHT®	Turbo®
ASTM Method #	D6335	D7097	D8447
Rod Type	Non-Wound	Wire Wound	Wire Wound
Total Oil Volume	116 mL	10 mL	30 mL
Catalyst	6% Fe Naphthenate	MHT®	6% Fe Naphthenate
Gas Induction Location	Reservoir	Upper End Cap	Upper End Cap
Peak Rod Temp	480° C	285° C	320° C
Test Duration	<2 Hours	24 Hours	18 Hours

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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.

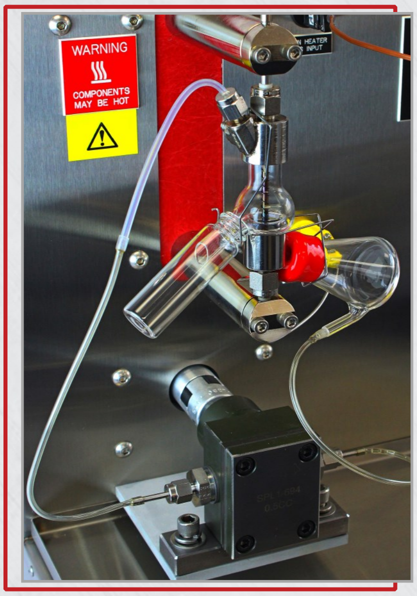
TEOST Turbo® | ASTM D8447

The original turbocharger deposit bench test (TEOST® 33C) was developed to screen engine oils by their tendency to form coking deposits within the elevated temperature zones of the turbocharger. While the 33C protocol remains relevant for this purpose, turbocharger deposits that are more oxidative in nature and occur at lower temperatures can also be a problem, driving the need for a lower temperature test that also retains volatile components. The TEOST Turbo® test method and instrument was developed to meet this need and was accepted as ASTM D8447 in 2022.

Development of this updated bench test began in 2017 to assist the industry with new oil formulations, screen engine oil formulations prior to running updated turbo engine tests, and provide on-going evidence of engine oil quality. The Turbo® technique combines the features of both 33C and MHT methods along with some added technology to better simulate modern turbocharger conditions and improve correlation with current turbocharged engine test results. Similar parameters to the 33C protocol include a 2-stage cyclic-static heating process (rod, reservoir) with Depositor Rod temperature of 290°C and periodic spikes to 320°C, and the use of moist air and catalyst material. Similarities to the MHT® test include top-down oil flow over a wire wound Depositor Rod, and gas induction location, but with a test duration of 18 hours. Turbo® tests align properly with results from the GMTC engine test, automotive fleet test, and historical bench tests. This new D8447 test method is an effective means to evaluate and predict the deposit forming tendencies of passenger car engine oils in present day turbochargers.

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 TEOST® 33C, MHT® and Turbo® 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 TEOST® Mass Flow Controller models. The MHTurbo® Mass Flow Controller operates with the D7097 and D8447 tests, while the 33C/Dual Mass Flow Controller is utilized for all three TEOST tests (D6335, D7097, & D8447). Contact Tannas Co. for more details on these new Mass Flow Controller systems.

TANNAS CO.
LABORATORY INSTRUMENTS

ISO 9001:2015 QMS

Parts & Accessories

Instruments:

500700: TEOST® Dual, 110V, 50/60 Hz Power
500800: TEOST® Dual, 220V, 50/60 Hz Power

Depositor Rods:

500020: TEOST® 33C Depositor Rods (10 rods/box)
500021: TEOST MHTurbo® Depositor Rods (10 rods/box)

Optional Accessories:

500990: 33C/Dual Mass Flow Controller
500995: MHTurbo® 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 all tests):

500033: TEOST® Filter Cartridges w/Caps (10/pack)
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)

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 **MHTurbo®:** 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) **Turbo®:** 20 mL plus 16 mL left in lines after flushing
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 **Turbo®:** Reactor Temperature: 100°C (±1°C) Depositor Temperature Cycle: 290°C to 320°C at designated time intervals
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
MHT® Test Parameters	Test Time: 24 hours Pump Rate: 0.25 g/min. Dry Air Flow Rate: 10mL/min. MHT Catalyst: Refer to bottle
Turbo® Test Parameters	Test Time: 18 hours Pump Rate: 0.25 g/min.. Moist Air Flow Rate: 10 mL/min.
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)	Dual, MHT® or 33C: 1 Pallet | 61 x 81 x 89 cm

Additional TANNAS CO. Precision Laboratory Instruments

Tannas Foam *Air* Bath (TFAB)
- ASTM D892, D6082, D1881, D7840, IP146
- Non-liquid bath
- 24°C to 150°C range

TBS 3000 HTHS Viscometer
- ASTM D4683, D6616, CEC L-36, IP370
- High-Temperature, High-Shear (HTHS)
- 80°C, 100°C, 150°C testing

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

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