LABORATORY AND PLANT

APPARATUS FOR THE EXAMINATION AND STUDY OF THE BEHAVIOR OF VALVE AND CYLINDER OILS AND OTHER PETROLEUM LUBRICATING OILS IN SATURATED AND SUPERHEATED STEAM, CARBON DIOXIDE, AIR AND OTHER GASES.¹

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The introduction of a high degree of superheated steam in locomotive and stationary engine practice has brought about the necessity of adding tests to the ones usually made of cylinder oils, whether straight petroleum stock, or mixture of the same with smaller or larger amounts of saponifiable fats.

The writer has constructed and used an apparatus for some time in the investigation of cylinder oils suitable for the lubrication of valves and cylinders in connection with the use of highly superheated steam in locomotive service.

The apparatus is essentially as follows (see photographic cut):

ointment box about 55 mm. in diameter, 18-20 mm. high) into which the oil to be examined is fed drop by drop from the sight feed lubricator C (or a given amount of oil is poured into the cup I). Through the lid is inserted an armored thermometer, T, reaching down into the dish. The steam vessel thus arranged and connected is surrounded and covered by a suitable asbestos hood.

L, pipe connections for the gases used.

E, heavy glass cylinder about 200 mm. long and 18-20 mm. inside diameter containing a small rectangular boat or dish; beyond E is a glass tubing system, F, connected up as shown with brass fittings; each glass tube is about 500 mm. long and 8-9 mm. inside diameter; at the further end is attached a steam separator and oil collecting vessel, G, consisting of an ordinary glass chimney fitted up with brass caps; to this condenser H is connected by means of copper tubing

In this apparatus any desired temperature may be

A, small steam boiler with gas, steam gauges and pipe conditions.

B, superheater with armored thermometer, T, and steam connections (a small circulating water heater with double copper coils, answers very well).

C, sight feed lubricator with connections.

D, steam vessel (a conical cast iron retort for distilling mercury, about 95 mm. deep and about 75 mm. in diameter at top provided with two strong screw clamps to keep the lid tight, answers very well) surrounded on the outside, as indicated, by a coil of copper pipe 5-6 mm. inside diameter, for further heating of the steam and gases used in the tests: this coil is tapped into the bottom of the steam vessel containing a suitably supported dish of about 25 cc. capacity (an

maintained at least up to 1000° F.; this is 300°-400° higher than is required under the most exacting service conditions as far as superheated steam temperature is concerned.

In studying the behavior of valve and cylinder oils in an atmosphere of superheated steam, the steam is passed from the small steam boiler through the superheater B and into the steam vessel D through its pipe coil (lamp being lit under D), and out through E, F, G and H.

When the temperature reaches and is regulated in D to 400° F., oil is fed drop by drop from sight feed lubricator C (or the cup I is filled); the steam is shut off and the valve in C (or I) opened, letting the oil run into the dish in D; the steam valve is then very gradually and carefully opened so as to let through any desired amount of steam.

¹ Paper presented at the Eighth International Congress of Applied Chemistry, New York, September, 1912.

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The temperature in D is maintained for a given length of time at or near 400° F., noting if any oil vapors are coming over; by shutting and opening the steam valve it is easy to see if any vapors are coming over with the steam.

The temperature is increased in increments of 25°-50° F., at a time, until the desired temperature is reached, noting the behavior of the oil vapors passing on with the steam through the glass pipe system, etc. It is interesting to note that cylinder oils containing rather a large percentage of saponifiable fats or fat oils generally come over at much lower temperatures than the main portions of the petroleum stock oils that are commonly used in compounding first class cylinder oils.

In further study of the behavior of oils, the boat in the glass cylinder E may be filled through the cup I to the left, and subjected at various temperatures to slow currents of superheated steam, carbon dioxide and air or mixtures of the same. The glass cylinder

bottom iron dishes exposed six hours at 540° F. in a specially designed air bath.

Gasoline Test = 10 cc. oil, 90 cc. petroleum ether 0.65 sp. gr. (from Pennsylvania crude) in graduated flat precipitating tubes, taking reading after 1 hour's standing.

Carbon Test using 35 grams Oil, according to Conradson's apparatus and method.

Superheated Steam Test = 13 grams of oil used.

Sample "A" in a superheated steam test at 800° F. (427° C.) left no residue. Sample "C" left 2.5 per cent. dry carbonaceous residue.

Sample "E" containing 15 per cent. of saponifiable fats subjected to the superheated steam test lost 26.5 per cent. up to 600° F.; the oil residue from this test contained 17.5 per cent. saponifiable fats; this indicates that the petroleum oil stock ("B" used) goes off with the steam somewhat faster in proportion to the fat oil up to 600° F. (350° C.).

The steam pressures used in these tests were about

	A.	B.	C.	D.	E.	F.
Flash point (open cup).....	545° F.	550° F.	605° F.	595° F.	550° F.	365° F.
Burning point.....	610° F.	630° F.	695° F.	680° F.	630° F.	415° F.
Gravity at 60° F. Baumé.....	26.4	26.1	24.7	25.9	...	33.5
Sp. gr. at 15° C.....	0.895	0.897	0.905	0.898	...	0.856
Color.....	Light	Dark	Dark	Very dark	...	Yellow
Gas, test before fire test.....	Good	Good	0.5 cc.	4.0 cc.	...	...
Gas, test after fire test.....	Good	Good	Good	3.0 cc.	...	...
Cold test flows.....	+55° F.	+32° F.	+45° F.	+34° F.	+30° F.	Zero
Saponifiable fats.....	Trace	Trace	Trace	Trace	15 per cent.	None
Vis. Saybolt at 212° F. (60 cc.).	133 sec.	146 sec.	215 sec.	216 sec.	...	...
Barbey Ixomet 500° F. (180 units = 30 cc.).....	45 sec.	51 sec.	61 sec.	60 sec.	...	...
Hot air test at 540° F. (loss)...	15 per cent.	11 per cent.	2.5 per cent.	5.5 per cent.	...	...
Gas, test after.....	Good	Good	0.5 cc.	3.5 cc.	...	...
Carbon test residue.....	2.15 per cent.	2.70 per cent.	4.90 per cent.	5.10 per cent.	...	...
SO ₂ in residue.....	0.023 per cent.	0.03 per cent.	0.03 per cent.	0.04 per cent.	...	...
Loss in superheated steam at						
400° F.....	0.0 per cent.	0.0 per cent.	0.0 per cent.	0.0 per cent.	0.0 per cent.	32 per cent.
500° F.....	5.0 per cent.	4.0 per cent.	1.5 per cent.	1.0 per cent.	5.0 per cent.	67.0 per cent.
600° F.....	18.5 per cent.	18.0 per cent.	6.5 per cent.	8.5 per cent.	21.5 per cent.	...
700° F.....	44.0 per cent.	34.0 per cent.	32.5 per cent.	40.5 per cent.	...	...
Total loss up to 700° F.....	67.5 per cent.	56.5 per cent.	40.5 per cent.	50.0 per cent.	26.5 per cent.	99.0 per cent.
Gas test of oil:						
Residue from 700° test...	Good	Good	1.5 cc.	3.0 cc.	...	...

E during the last test is surrounded by a heavy asbestos covering to prevent radiation.

The cylinder oils may leave a residue in the dish in D at steam temperatures below 700° F.; if so, such residue should give a clear solution in 90 cc. of 0.65 sp. gr. (87° B.) petroleum ether (Pennsylvania) and show no precipitate on standing. At steam temperatures of 850°-900° F., all the oil has usually volatilized with the steam; good oils should leave no carbonaceous or coky residue.

While this apparatus was designed principally for the study and behavior of valve and cylinder oils in atmospheres of steam at various temperatures, it can be adapted very readily for the study of other oils at various temperatures in currents of air, carbon dioxide or other gases or mixtures of same with and without steam.

The accompanying table of comparative tests of five samples of cylinder oils, A, B, C, D, E and F, a petroleum distillate of interest in connection with the study of cylinder oils in superheated steam:

Hot Air Test = 13 grams oil in shallow round flat

ten to twelve pounds per sq. in. A large volume of superheated steam passed through the apparatus during the tests (about 40 cc. condensed steam per minute).

In these superheated steam evaporating tests about 13 grams of oil were weighed into the small dish placed inside the steam vessel D. (The capacity of the small iron dish is 50 cc. having a diameter of about 48 mm. and 30 mm. high, with flat bottom.)

The steam vessel with the oil in the dish was heated up to about 350° F. (176° C.), passing a slow current of natural gas through the apparatus, then superheated steam was admitted, the gas shut off, and the temperature raised up to the required degree and kept constant for about 75 minutes; the volatile matter in the oils at the given test temperature generally were carried over with the steam inside of 60 minutes, allowing about 15 minutes' extra steaming. At the end of each given temperature test the steam and heat were shut off; after cooling, the dish containing the oil was weighed and replaced in the steam vessel and the operation repeated for the next temperature test.