

REPORT NO. P-2320

DATE June 1944

FR-2320

SUBJECT

Small Scale Gasoline Engine Tests Using the Carbide and
Carbon Chemical Corporation's New Synthetic Lubricant
250B-C-100

by

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DECLASSIFIED by NRL Contract
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Date: 17 Aug 2016

Reviewer's name(s): H. Do, P. MANNA

Declassification authority: NAVY DECLASS
GUIDE, 11 DEC 2012, PGS 6-7, PARA 3C2

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Serial No. 42

June 1944

NRL Report No. P-2320

NAVY DEPARTMENT

report

on

SMALL SCALE GASOLINE ENGINE TESTS USING THE CARBIDE AND CARBON
CHEMICAL CORPORATION'S NEW SYNTHETIC LUBRICANT
250B-0-100

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

Number of Pages: Text - 12 Tables - 6 Plates - 10

Authorization: BuShips Project Order No. 1121/42

Date of Tests: November 1, 1943 to May 15, 1944

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ABSTRACT

The results are reported of exploratory tests on the use of the Carbide and Carbon Chemical Corporation's new synthetic polymer 250B-0-100 fluid for lubricating small scale gasoline test engines.

Fourteen engines of two different types were used for the tests. The effects of duration of run, low and high octane fuels, added water, overheating and limited oil circulation were examined. Comparisons were made between the synthetic lubricant and three well known Navy Symbol petroleum lubricants.

The synthetic lubricant was found to lubricate effectively such engines except when poor oil circulation occurred resulting from faulty engine design. Under conditions of poor circulation and artificial local overheating, results were obtained which were similar to those found by the Experimental Engineering Station in tests on diesel engines.

The new lubricant is recommended for use where low temperature starting and freedom from excessive engine deposits are of value, but only in properly cooled engines designed for adequate flow of lubricant.

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INTRODUCTION

(a) Authorization

1. This investigation was authorized as part of the Bureau of Ships Project Order No. 1121/42 concerning the investigation of lubricating oils and greases for naval purposes, and it is part of a research program outlined in a conference of August 19, 1943 with the Research and Standards Division of the Bureau of Ships.

(b) Statement of Problem

2. The purpose of these tests was to observe the internal combustion engine performance of the Carbide and Carbon Chemicals Corporation's new synthetic lubricant designated by the manufacturers as 250B-O-100 fluid. More specifically, the performance in two types of small scale gasoline engines was to be investigated in an exploratory manner.

KNOWN FACTS BEARING ON THE PROBLEM

3. The B-O-100 fluids are a recent development by the manufacturer and are not yet commercially available. Patent applications have just been filed by the inventors and it is understood that a secrecy order will be placed on it in the near future. Since this fluid does not contain petroleum and can be readily produced by the enemy, it is evident why the Army and Navy have decided to have its composition and properties maintained secret.

4. An extensive series of tests on the properties of the 250B-O-100 fluids relative to their application to the lubrication of automotive engines were made at the laboratory in Tonawanda, New York of the Linde Air Products Division of the Union Carbide and Carbon Corporation, and they have been summarized in the confidential Research Memorandum No. 37 by J. C. Kratzer dated August 6, 1943 and made available to this Laboratory through the Research Division of the Bureau of Ships.

5. The properties of the 250B-O-100 fluid relative to use in lubricating diesel engines have been investigated by the Experimental Engineering Station at Annapolis, Md. Results of these tests were made available to this Laboratory and the Bureau of Ships through the Experimental Engineering Station confidential report NPL6/L5/5514(495-J) Test C-275-A(2) of 24 January 1944. A report by the same laboratory on the corrosive effect of the 250B-O-100 fluid upon various bearing materials was also made available through Experimental Engineering Station

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confidential report (12870-J) Test C-273 NP16/L5/S43-2 of December 1, 1943.

6. An extended investigation of the chemical and physical properties of interest in lubrication and hydraulics has been made by this Laboratory, and a first progress report concerning the results has been forwarded to the Navy Department as NRL confidential report No. P-2273 of February 1944. This investigation revealed that the B-O-100 fluids deserved serious consideration for use as lubricants in internal combustion engines especially where good low temperature starting properties were essential. It was also found that, due to the volatility of the oxidation products, it should be of value for use as an aircraft engine lubricant. It was pointed out that these fluids possessed the ability to dissolve from 3% to 6% of water the amount decreasing as the temperature increased. This requires the use of rust inhibitors in many applications. Finally it was recommended that these fluids be tested for engine lubricants in the small scale 2-1/2 H.P. stationary Onan and Delco engines at this Laboratory.

7. No other viscosity grade of this fluid has been tested in these small engines due to the fact that the 250 Saybolt second viscosity at 100°F characteristic of the 250B-O-100 fluid was the only one of the available viscosity grades suitable for use in these two types of test engines.

RESULTS OBTAINED BY THIS LABORATORY

(a) Method of Test

8. The method employed to test this lubricant was to compare the results of a series of runs using the Carbide and Carbon lubricants with engine runs using a Navy Symbol heavy-duty detergent-type petroleum oil, a Navy Symbol low viscosity index naphthenic-base petroleum oil, and a high-viscosity index paraffinic-base petroleum oil.

9. Observations were made as to the condition of the bearings, piston, valves and combustion chamber. Although the cleanliness of the sump was noted, too much comparative value should not be given this property as the detergent-type oil is intended to hold the dirt in suspension giving the appearance of a very clean engine.

(b) Engines Used in Tests

10. Eight Onan 10-L.S. single cylinder air cooled gasoline engines manufactured by D. W. Onan and Sons of Minneapolis, Minnesota and six Delco 8-B-3 single cylinder, air cooled,

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gasoline engines manufactured by the Delco Appliance Company, Division of General Motors, Rochester, New York were employed throughout the tests. These are approximately 2-1/2 H.P. engines each directly coupled to a small generator which serves as the variable test load. They were designed by the manufacturers for use as auxiliary power plants, the former being put on the market early in the war and the latter being a well-known unit especially recommended for small rural and auxiliary power plants.

11. The construction and operational characteristics of the Onan test engine used are fully described in NRL report No. P-1857 of March 1942, but may be summarized as follows. It is a 2-1/2 H.P. single cylinder, four cycle, "L" head, air cooled type gasoline engine. Bore 2-3/4", stroke 2-3/4", piston displacement 16.3 cu.in., piston speed 825 ft./min., engine speed 1800 r.p.m. It has an aluminum cylinder head, chrome-nickel alloy cylinder, and a cast iron crankcase. The aluminum piston has three compression rings and one oil ring. An aluminum connecting rod is used forming the wrist pin and connecting rod bearings. High-lead bronze steel backed main bearings and Babbitt camshaft bearings are pressed into the engine housing and finished in this position.

12. The engine is lubricated by a plunger type pump supplying oil under pressure to the main and connecting rod bearings. All other parts are lubricated by the spray of oil forced out between the connecting rod and crank throw. The valve stems project through the housing into the crankcase and are fully lubricated by spray. The top of the intake valve is lubricated by crankcase vapors carried over in a breather tube connected to the carburetor air intake filter.

13. A 1000 watt, 110 volt, 60 cycle, self excited A.C. generator is mounted on an extension of the crankshaft. Frequency is controlled by a flyball type governor on the engine.

14. The Delco 8-B-3 unit is a single cylinder, four cycle, "L" head, air cooled type gasoline engine. Bore 2-3/4", stroke 2-9/16". Cylinder, cylinder head and crankcase are made of cast iron. A tin plated cast iron piston with two compression rings and one oil ring is used. Two steel backed Babbitt main bearings support the counterweighted crankshaft. The connecting rod is steel with a Babbitt bearing at the crank end and a bronze bushing for the wrist-pin bearing. The engine speed is 1650 to 1800 r.p.m.

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15. Lubrication of the engine is of the controlled splash type. Oil spray is created by a crankshaft driven fibre oil throwing gear. The exhaust valve stem is lubricated by oil vapors from the oil working by the valve push-pin. The intake valve stem is lubricated by the vapors as in the case of the exhaust valve and also by the carry over of vapors from the crankcase to the carburetor air intake by a breather tube.

16. The engine and generator are cooled by the air blast of a combination flywheel and fan. An 800 watt, 32 volt D.C., six pole shunt wound generator is mounted on an extension of the crankshaft.

(c) Material Under Test

17. 1. Carbide and Carbon Corporation's synthetic lubricant 250B-0-100
2. Navy Symbol 9250 petroleum oil (detergent type) manufactured by Standard Oil Company of New Jersey
3. Navy Symbol 2135 petroleum oil (low V.I., naphthenic base) manufactured by Socony Vacuum Oil Company
4. Standard Oil Company of New Jersey Essolube S.A.E. 20 (high V.I., paraffinic base)

(d) Technique

18. To guarantee fair and comparative tests on these fluids a definite procedure was outlined at the start and rigorously followed. Each engine was disassembled and thoroughly cleaned with solvents. Bearings, shafts, and cylinder walls were carefully examined for scratches or other marks of wear. If any part was found undesirable for a fair test, it was replaced. Parts requiring lubrication were wetted with the fluid to be tested and the engine was then reassembled.

19. Since no method of adjusting the clearances peculiar to each engine existed, it was found necessary to make several runs with each fluid using different engines of the same make. This made it possible to give an average result which should not be seriously affected by uncontrolled mechanical circumstances.

20. The fuel used for all tests was a 62 octane rating aviation base stock. This was used because in its combustion in these engines practically no solids were produced which would contaminate the oil.

21. The test load adopted for all engine tests was to load the generator to two-thirds rated capacity. For the Onan engine with a 1000 watt output, a standard 660 watt heater coil was

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used. In the case of the Delco engine with the 800 watt generator, a resistor of 2.42 ohms was wound to give a load of 565 watts at 37 volts D.C.

22. The speed of the Delco engine was controlled by locking the throttle in a position to allow the engine to turn over at 1700 r.p.m., or 37 volts output.

23. The speed of the Onan engine was controlled by a flyball type governor operating the throttle and was set at 1800 r.p.m. for all runs.

24. Oil samples of 100 cc. were drawn from the crankcase at 100 hour intervals. The oil level in the sump was checked every 48 hours to prevent the engine from ever operating with less than 1200 cc. in the crankcase. The volume of the sump of the Delco is 1800 cc. compared with 2200 cc. for the Onan. The 1200 cc. limit insures proper lubrication in both engines.

25. An attempt was made to avoid adding oil before a sample had been drawn from the sump but this was impossible due to the excessive rate of consumption in some cases. In no case, however, was a sample drawn in which the added oil had less than 24 hours in the engine.

26. Photographs of the piston, rings, and valves of the engine were taken to record the results of the test. Several attempts were made to photograph the various bearing surfaces. This proved unsuccessful for two reasons. It is impossible to remove the bushing type main and camshaft bearings from the housing because they are pressed into place and line reamed to fit the shaft. Removing the bushings would destroy them. The attempts at photographing the connecting rod bearing failed due to trouble with high-lights. Catching the true high spots of the curved bearing surface was impossible. Another method is being considered for photographing the various bearings, but the equipment was not available for these tests.

27. Neutralization numbers were taken of the various oil samples by the colorimetric method. A modification of the method used for dark or colored materials as given in the Physical and Chemical Examination of Paint, Varnish, Lacquers, and Colors by Henry A. Gardner, ninth edition, 1939, page 287 was used. Viscosities of the samples were determined by the A.S.T.M. test number D445-42T, Method B. Miss Helen Fobes of the Lubrication Section cooperated by determining the viscosities and neutralization numbers referred to in this report.

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(e) Results of Tests

28. The first tests made in the Onan engine were for 500 hours duration. This is an extremely long run as far as an engine of this type is concerned. The long runs were made to determine if the 250B-0-100 fluid had any undesirable characteristics which would show up in an endurance test. Later tests were made of 300 hours duration, the test period being chosen in order that results obtained at this Laboratory could be compared with tests made at the Experimental Engineering Station at Annapolis, Md.

29. The Carbide and Carbon Chemicals Corporation's 250B-0-100 fluid with 2% wt. anti-oxidant proved highly satisfactory as a lubricant when given a test of 500 hours duration in an Onan engine. There was some slight discoloration of the piston in the ring area. All of the rings were free as were all other parts of the engine. The interior of the engine and sump was relatively clean. Plate I shows the red-brown varnish on the piston around the wrist pin base. It can be noted also that the oil return holes in the piston are open and the rings are comparatively clean. The neutralization number ranged from 0.5 to 2.0 after 100 hours operation depending on the test conditions. The viscosity in centistokes at 100°F varied from 57 at the start to 78 after 150 hours operation.

30. The Carbide and Carbon Chemicals Corporation's 250B-0-100 fluid with the 2% wt. anti-oxidant was unsatisfactory when used in a Delco engine. Three out of four test runs did not complete the 300 hour test period. The cause of engine failure in all cases was the formation of a black lacquer-like deposit on one or more of the following parts: the valve stems and guides, piston skirt, cylinder wall and crankshaft bearings. Plates II and III show this deposit. The piston shown in Plate II seized in the cylinder after 254 hours run. The piston shown in Plate III was free, but the valves stuck in the guides after 221 hours. The black gummy deposit had strength enough to support the tension of the valve springs.

31. The only differences between the Onan and the Delco engines that could be observed were the methods of lubrication as noted in paragraphs 12 and 15 and the fact that the Delco valves seemed to operate at a higher temperature than those in the Onan. Temperatures were taken of the Delco valve stems by drilling a small hole through the valve guide and inserting a small Iron-Constantan thermocouple. Temperatures recorded were 325°F for the intake and 270°F for the exhaust valve. These temperatures were taken in the region where the lacquering occurred. The sump temperature was found to be 195°F.

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32. Using the above data, an Onan cylinder barrel and valve guide housing was partially covered (spaces between the cooling fins) with asbestos cement. An electric heating element was inserted into the sump to bring the temperature of the oil up to 192°F. After the engine was operating normally, the valve guide temperature was found to be 340°F for the intake valve and 375°F for the exhaust valve.

33. With the Onan operating under the above conditions, the characteristic black lacquer-like deposit found in the Delco was produced in the Onan. As noted on Table II, run number B-427, the piston seized, while on run number B-425 the valves stuck. The gumming was responsible in both cases for the failure of the engine to complete the test. Plates IX and X show this deposit, especially on the valve stems. Another product of the over-heating was the formation of a resinous coating which covered the entire interior of the engine, even the journals and bearing surfaces. This resinous coating was not soluble in 62 octane gasoline, but was soluble in benzene, acetone, and alcohol. The resinous formation was also produced in the laboratory by Ensign D. C. Atkins using an accelerated oxidation test made in a Norma Hoffman bomb at 100°C. A coating similar to that found in the engine was deposited on a copper strip placed in the bomb. A report will be made available at a later date giving more information relative to accelerated oxidation of the 250B-O-100 fluid.

34. The results obtained from the Delco and overheated Onan runs would indicate that the gummy formation is due to the temperature of the surface and the limited quantity of oil flowing over the surface. That is, if a more copious supply of the fluid is passed over such a surface, no difficulties from gum formation should be encountered.

35. Tests were made using 250B-O-100 fluid with no anti-oxidant. The purpose of these runs was to determine if the gumming was caused by the anti-oxidant added or the fluid itself, and also what effect the uninhibited fluid would have on the various metals used in the engine. Results as shown in Table III were poor. The characteristic black lacquer was produced but in a much shorter time than when anti-oxidant was added. All brass and bronze parts were corroded. Paint used to seal the engine housing was dissolved into the oil leaving a very dirty sump. The neutralization number reached a value of 56 in 72 hours of operation. The viscosity in centistokes at 100°F dropped from 57 at the start to 42 after 150 hours operation.

36. As determined earlier at this Laboratory and discussed in the report referred to in paragraph 7, the 250B-O-100 fluid has an affinity for water. In a very humid climate it would be possible to condense a considerable amount of water in a crankcase. This moisture would probably be driven off by the heat when using a petroleum oil. As a certain percentage of

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water is soluble in the 250B-O-100 fluid (depending on the temperature), a run was made in which 10% v. distilled water was added to the crankcase. Except for a slight rusting of the exhaust valve head an Onan engine was in excellent condition after a test of 500 hours duration. The piston in particular and the engine in general were much cleaner than any of the runs with no water added. The amount of moisture did not remain at 10% by volume due to the temperature increase when operating, but the effect would be the same as in the field, that is, driving off the moisture to a constant percentage depending upon the engine operating temperature.

37. A test run using 100 octane leaded fuel was made to determine what effect the lead had on the 250B-O-100 fluid. This fuel is very unsatisfactory for use in the small test engines. The interior of the engine became coated with a very heavy lead deposit. The spark plug was fouled, valves were stuck, the engine was very dirty in general. It was suspected before this run was made that the lead might act as a catalyst and cause the fluid to become very active as far as corrosion was concerned. This suspicion was not verified. Aside from being dirty from the lead deposit, no other trouble was encountered. There was no noticeable corrosion of any of the engine parts.

38. No attempt was made to determine the cause of the actions of the three well studied petroleum oils. Routine tests were made and the results recorded in Tables IV, V, and VI.

39. The Navy Symbol 9250 oil proved to be a very satisfactory lubricant in both the Onan and Delco engines. Tests were made for 500 hours duration in the Onan and 300 hours in the Delco, but the results were the same. All moving parts of the engines were free. As shown on Plates III and IV, the piston and rings were very clean. No discoloration was noted. The engines in general were in very good condition. Neutralization numbers of 0.06 to 0.11 were found found after 100 hours engine operation. The viscosity in centistokes at 100°F changed from 101 at the start to 115 after 150 hours use in engines.

40. Although the engines ran for the duration of the test, the Onan showed slightly different results from the Delco, when using Navy Symbol 2135 oil. From Plate V it can be seen that the piston rings of the Onan were heavily coated with a heavy dark brown gum. The rings were tight in the grooves and were not operating properly. There was a heavy brown varnish on the piston and valves. The engine sump was very dirty. As in the Onan, the rings and piston of the Delco were very dirty but the deposit was of a different nature. The deposit was of a black soft sooty type, not gummy as in the Onan. Plate VI shows the amount

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of this deposit on the piston and valves. In line with the Onan, the Delco sump was very dirty. Neutralization numbers of approximately 0.3 were found after 100 hours operation in either type of test engine. The viscosity in centistokes at 100°F changed from 65 at the start to 112 after 150 hours operation.

41. When using S.A.E. 20, high V.I., paraffinic base oil the results were most unsatisfactory. Four out of five engines failed to complete the test. The results in each engine were the same. Plates VII and VIII show the reason for failure. The rings, piston, and valves of all the engines were covered with a very heavy varnish-like deposit. The rings were stuck in several runs causing blow-by of the combustion gases. The sumps of the engines were very dirty. Neutralization numbers of 0.7 to 1.7 were noted after 150 hours of operation in the two types of engines. The viscosity in centistokes at 100°F varied from 82 at the beginning to 110 after 150 hours use in the engine.

DISCUSSION

42. When used in a well lubricated, properly air cooled test engine, the 250B-0-100 inhibited fluid performed very well. In the Onan engine with a sump temperature approximately 145°F and a good supply of oil to all parts no trouble was encountered. The synthetic fluid has a slight amount of detergency keeping this well lubricated engine very clean. The color of the piston varnish seemed to be affected by the condition of the anti-oxidant, for oil inhibited at the Experimental Engineering Station and sent to this Laboratory for test produced the same results except for varnish color as fluid inhibited by this Laboratory. This result is not surprising since the inhibited oil changes color rapidly with oxidation.

43. The probability that trouble might be encountered in a poorly lubricated engine was observed when the inhibited 250B-0-100 fluid was used in the Delco engine. As pointed out in paragraph No. 30 the engine performed very poorly. This model Delco engine has proved very reliable when the proper type of lubricant is used. It is a known fact to the manufacturer that the engine is very sensitive to the type of lubricant used. Kendall oil, a well-known petroleum oil, has been reported as giving poor results. This would indicate that the 250B-0-100 fluid should be given a thorough test in each type of full scale engine before final judgment is made.

44. As observed at the Experimental Engineering Station and this Laboratory, bearing corrosion from the inhibited 250B-0-100 fluid was negligible. Of the various bearing materials,

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copper-lead was the most affected. With no anti-oxidant the 250B-0-100 fluid was very corrosive to all copper alloys.

45. The black gummy deposit found in the Delco engine using inhibited 250B-0-100 fluid, and produced in the Onan engine by overheating, was noted at the Experimental Engineering Station when the 250B-0-100 fluid was used to lubricate a Caterpillar and a General Motors single cylinder diesel engine.

46. The relative ratings of the lubricants tested at this Laboratory would place the Navy Symbol 9250 oil first as far as lubrication, anti-corrosion, and cleanliness of the engine are concerned. The inhibited 250B-0-100 fluid is second with the Navy Symbol 2135 and the S.A.E. 20 high V.I. oil a poor third and fourth in that order.

47. The inhibited 250B-0-100 fluid, with the 10% by volume distilled water added, lubricated as well as the fluid with no moisture. This run was for 500 hours continuous operation so no anti-rust compound was needed. In the field, where an engine would be started and stopped as well as allowed to stand idle many times in that operating period, an anti-rust compound might be required to prevent excessive rusting. These tests do not cover the anti-rust compounds but several with promising characteristics are available.

48. Caution must be taken when handling and disposing of the used 250B-0-100 fluids. The used uninhibited fluid is an especially good paint and varnish solvent. All the sealing compound used in the cast iron engine housings was removed after the oil was used for 48 hours.

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CONCLUSIONS

49. From these exploratory tests with the small scale engines it is concluded that the inhibited 250B-O-100 fluid is a promising lubricant for internal combustion engines having a pressure feed lubrication system and properly designed to avoid overheated surfaces upon which stagnant or insufficient amounts of lubricant can accumulate. Therefore, it should be an excellent lubricant for present automotive water cooled engines. This supports the conclusions made by J. C. Kratzer of the Linde Air Products Laboratory referred to in the introduction of this report. It has been shown here that overheating of the stagnant oil can occur and an accumulation of sticky deposits can form resulting in scoring and sticking.

50. The rate of oil consumption of the 250B-O-100 fluid is somewhat greater than that of the detergent type oil but about the same as the non-detergent type. Oil consumption in general seems to be more dependent upon the condition of the engine than the type of oil used.

51. It is concluded that the overall engine performance of the N.S. 9250 oil was best, with the 250B-O-100 fluid next best and the N.S. 2135 and high V.I. oils following in that order. As far as Onan engine cleanliness was concerned the 250B-O-100 fluid was nearer in performance to the N.S. 9250 oil than to the other two petroleum oils.

52. It was concluded that ethyl fluid in the fuel had no detrimental effect on the lubrication performance of the inhibited 250B-O-100 fluid.

53. When used without the anti-oxidant recommended by the manufacturer the 250B-O-100 fluid was found to be very corrosive to brass and bronze although no effect was noticed on the Babbitt bearings. The oil consumption was excessive and resulted in high neutralization numbers. The used, uninhibited 250B-O-100 fluid was found to be a good paint solvent. The paint used to seal the engine casting was especially soluble.

54. The engine test confirmed laboratory work presented in NRL report No. P-2273 with respect to oxidation stability of the lubricant. Even in runs lasting as long as 500 hours the lubricant was found to be adequately stabilized toward oxidation by the 2% by weight of anti-oxidant recommended by the producer.

55. It was found that as much as 10% by volume distilled water added to the inhibited 250B-O-100 fluid did not impair its lubricating properties, although an anti-rust compound should

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be used to prevent rusting.

RECOMMENDATIONS

56. The inhibited 250B-O-100 fluid is recommended for use in any well cooled, adequately lubricated gasoline engine where its low temperature starting characteristics, its relative cleanliness as compared to non-additive petroleum oils, and its good load carrying capacity are of sufficient value. However, due to the probability that in some types of engines the design of the lubricating and cooling system may lead to the formation of the troublesome oxidation product, it is urged that each new type of engine be given a rigorous service life and performance test.

57. In a very humid climate where the 250B-O-100 fluid could dissolve moisture easily it is recommended that an anti-rust compound be added to prevent excessive rusting of the equipment.

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Table I

Test Runs on Inhibited Carbide and Carbon Corporation's
250B-0-100 Synthetic Lubricating Fluid

Engine make & model	Run No.	Time of run in hours	Lubri- cant consump- tion cc/100 hours	Sump temp. of	Engine speed r.p.m.	% rated load	Results
Onan 10-LS	B-402	500	1000	145	1860	65	(C)
Onan 10-LS	B-411	500	910	145	1845	65	(C)
Delco 8B3	B-409	221 (A)	657	195	1700	70	(D-1)(E)
Delco 8B3	B-413 (B)	102 (A)	1375	195	1700	70	(F)(D-1) (C-1-2) (E)
Delco 8B3	B-414 (B)	328	503	195	1700	70	(C)
Delco 8B3	B-416 (B)	254 (A)	866	195	1700	70	(C-1-2) (D)(E)

- (A) Engine stopped before completing run
- (B) Anti-oxidant added at N.R.L.
- (C) Varnish or lacquer on piston
(1) Rings stuck
(2) Piston seized
- (D) Varnish or lacquer on valve stems
(1) Valves stuck
- (E) Dirty sump
- (F) Main bearing seized

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Table II

Test Runs made on Altered Onan Engines for the Purpose of Inducing Breakdown in the Carbide and Carbon Corporation's 250B-0-100 Inhibited Lubricant

Engine make & model	Run No.	Conditions of test	Time of run in hours	Lubricant consumption cc/100 hrs.	Sump temp. °F.	Engine speed R.P.M.	% rated load	Results
Onan 10-LS	B-418 (B)	Temp. in sump raised	300	1433	192	1800	65	(C)(D)(E)
Onan 10-LS	B-421 (B)	High sump and valve stem temperatures	300	492	192	1800	65	(C)(D)(E)
Onan 10-LS	B-425 (B)	High temperatures - valves, cylinder, and sump	202 (B)	1100	192	1530 to 1800	65	(C)(D-1)(E)
Onan 10-LS	B-427 (B)	High temperatures - valves, cylinder and sump	201 (B)	950	192	1800	65	(C-1-2)(D)(E)

- (A) Engine stopped before completing run
- (B) Anti-oxidant added at N.R.L.
- (C) Varnish or lacquer on piston
 - (1) Rings stuck
 - (2) Piston seized
- (D) Varnish or lacquer on valve stems
 - (1) Valves stuck
- (E) Dirty sump
- (F) Main bearing seized
- (G) Engine clean and in good condition

DECLASSIFIED

Table III

Test Runs of a Miscellaneous Nature Made on Carbide
and Carbon Corporation's 250B-0-100 Lubricant

Engine make & model	Run No.	Conditions of test	Time of run in hours	Lubricant consumption cc/100 hrs.	Sump temp. °F	Engine speed r.p.m.	% rated load	Results
Onan 10-LS Delco 8B3	B-401 B-420	no inhibitor no inhibitor	72 60 (A)	1100 3750	145 ---	1830 1700	65 65	(F)(G) (D-1)(C) (E)
Onan 10-LS	B-404	inhibited plus 10% H ₂ O (B)	500	460	145	1830	65	(C)(E) Better than B-402 & B-411 (D-1)(E)
Onan 10-LS	B-405	inhibited 100 octane fuel used (B)	246 (A)	813	145	1800	65	(D-1)(E)
Onan Twin OTC-2	B-407	inhibited (B)	200	550	131	1800	33	(F)

- (A) Engine stopped before completing run
 (B) Anti-oxidant added at N.R.L.
 (C) Varnish or lacquer on piston
 (1) Rings stuck
 (2) Piston seized
 (D) Varnish or lacquer on valve stems
 (1) Valves stuck
 (E) Dirty sump
 (F) Clean engine
 (G) Corroded copper and brass

DECLASSIFIED

Table IV

Test Runs on Navy Symbol 9250 Detergent Oil
Standard Oil Co. of N. J.

Engine make & model	Run No.	Time of run in hours	Lubri-cant consumption cc/100 hours	Sump temp. °F	Engine speed r.p.m.	% rated load	Results
Onan 10-LS	B-403	500	485	145	1800	65	(G)
Onan 10-LS	B-408	500	320	145	1800	65	(G)
Delco 8B3	B-410	339	236	195	1700	70	(G)
Delco 8B3	B-412	329	425	195	1700	70	(G)
Delco 8B3	B-415	200 (A)	720	195	1700	70	Engine failed due to generator dropping the load

(G) Engine clean and in good condition

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DECLASSIFIED

Table V

Test Runs made on Socony Vacuum Oil Co., Navy Symbol 2135
Naphthenic Base Oil

Engine make & model	Run No.	Time of run in hours	Lubricant consumption cc/100 hours	Sump temp. °F	Engine speed r.p.m.	% rated load	Results
Onan 10-LS	B-406	500	1020	145	1800	65	(C-1)(D)(E)
Delco 8B3	B-417	300	823	---	1700	65	(C)(D)
Delco 8B3	B-419	300	1842	---	1700	65	(C)(D)

- (C) Varnish or lacquer on piston
(1) Rings stuck
- (D) Varnish or lacquer on valve stems
- (E) Sump dirty

Table VI

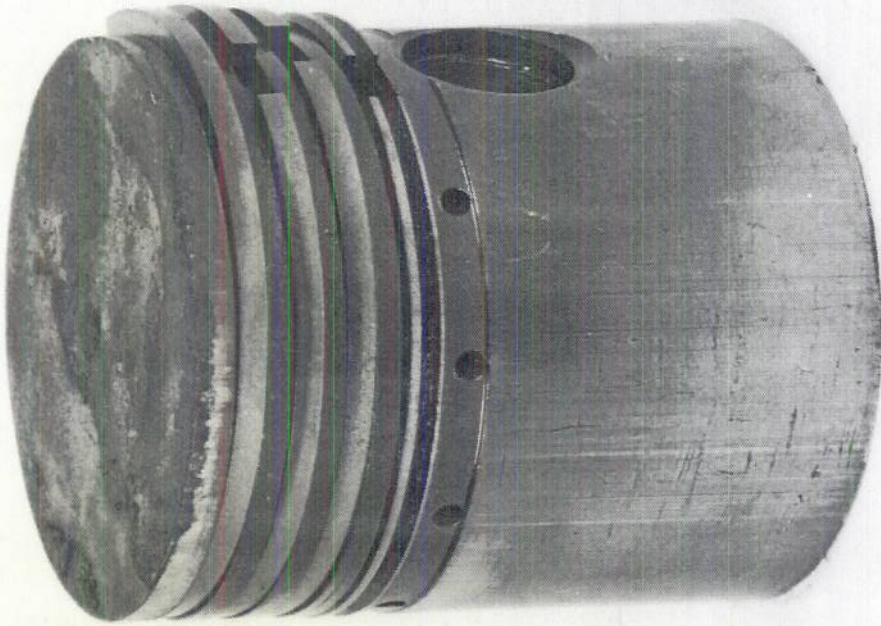
Test Runs on Standard Oil Co. of New Jersey, S.A.E. 20
100 V.I. Paraffin Base Oil

Engine make & model	Run No.	Time of run in hours	Lubricant consumption cc/100 hours	Sump temp. °F	Engine speed r.p.m.	% rated load	Results
Onan 10-LS	B-424	150 (A)	600	145	1800	65	(C-1-2)(E)(D)
Onan 10-LS	B-428	102 (A)	612	145	1800	65	(C-1-2)(D)(E)
Delco 8B3	B-422	150 (A)	2050	132	1700	65	(C)(D-1)(E)
Delco 8B3	B-423	262 (A)	1040	135	1700	65	(C-1-2)(D)(E)
Delco 8B3	B-426	300	1597	135	1700	65	(C)(D)(E)

- (A) Engine stopped before completing run
- (C) Varnish or lacquer on piston
(1) Rings stuck
(2) Piston seized
- (D) Varnish or lacquer on valve stems
(1) Valves stuck
- (E) Dirty sump

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ONAN ENGINE * * 250B-0-100 INHIBITED FLUID

RUN NO B-402 --- DURATION OF RUN 500 HOURS

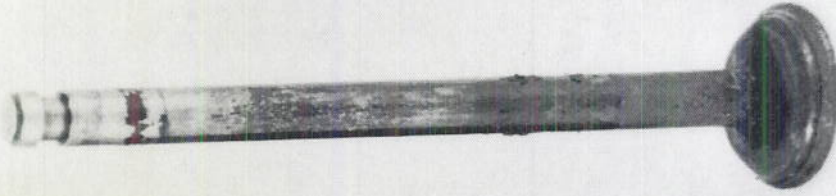
DECLASSIFIED

DECLASSIFIED

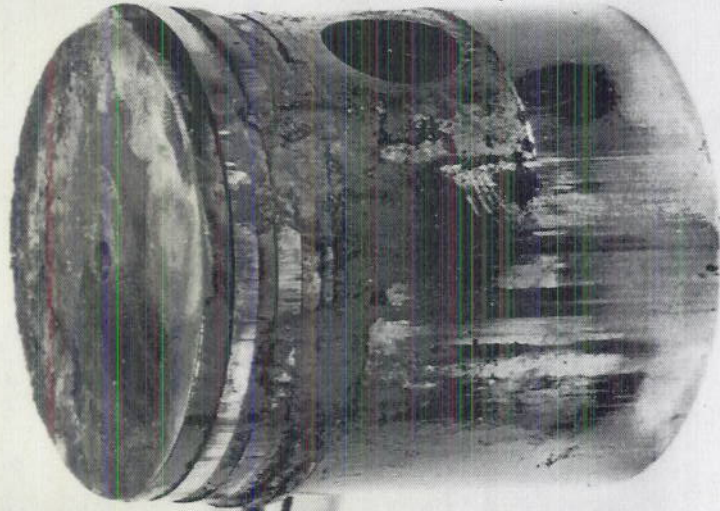
PLATE I

DECLASSIFIED

EXHAUST



INTAKE

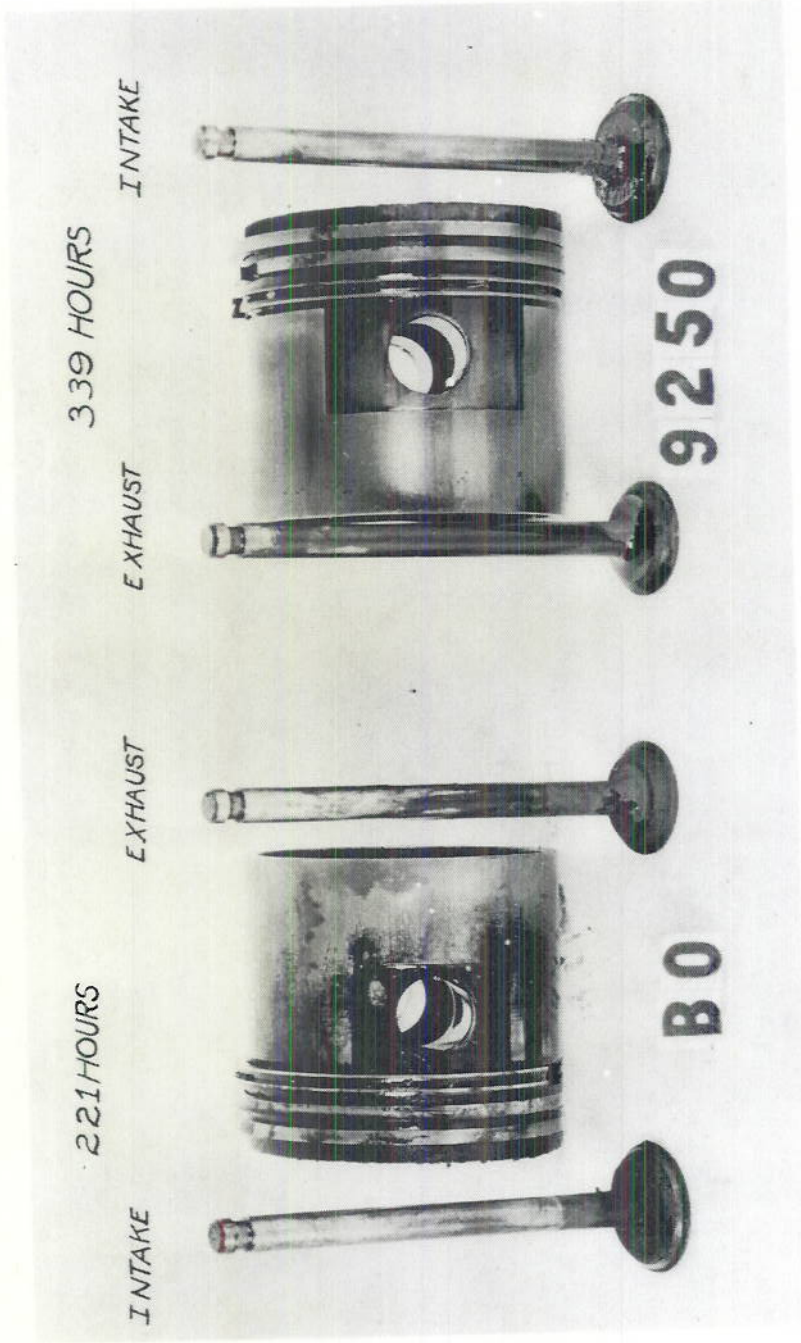


DELCO ENGINE * * 250B-O-100 INHIBITED FLUID

RUN NO B-416 -- DURATION OF RUN 254 HOURS

DECLASSIFIED

DECLASSIFIED



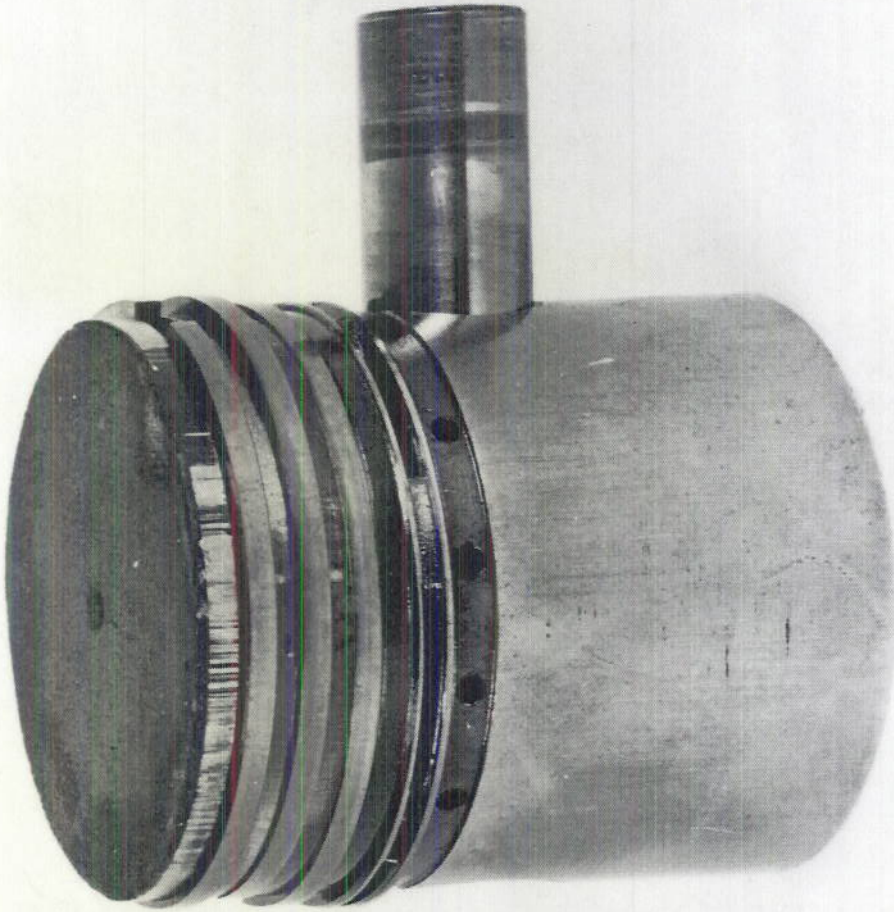
DELCO ENGINE * * COMPARISON OF PISTON AND
VALVES USING N. S. 9250 AND 250B-0-100
INHIBITED FLUID

RUN NO 409
DURATION OF TEST 221 HOURS

RUN NO 410
DURATION OF TEST 339 HOURS

DECLASSIFIED

DECLASSIFIED



ONAN ENGINE * * NAVY SYMBOL 9250 OIL

RUN NO B-403 DURATION OF TEST 500 HOURS

DECLASSIFIED

DECLASSIFIED



ONAN ENGINE * * NAVY SYMBOL 2135 OIL

RUN NO B-406 DURATION OF RUN 500 HOURS

DECLASSIFIED

DECLASSIFIED

EXHAUST



INTAKE

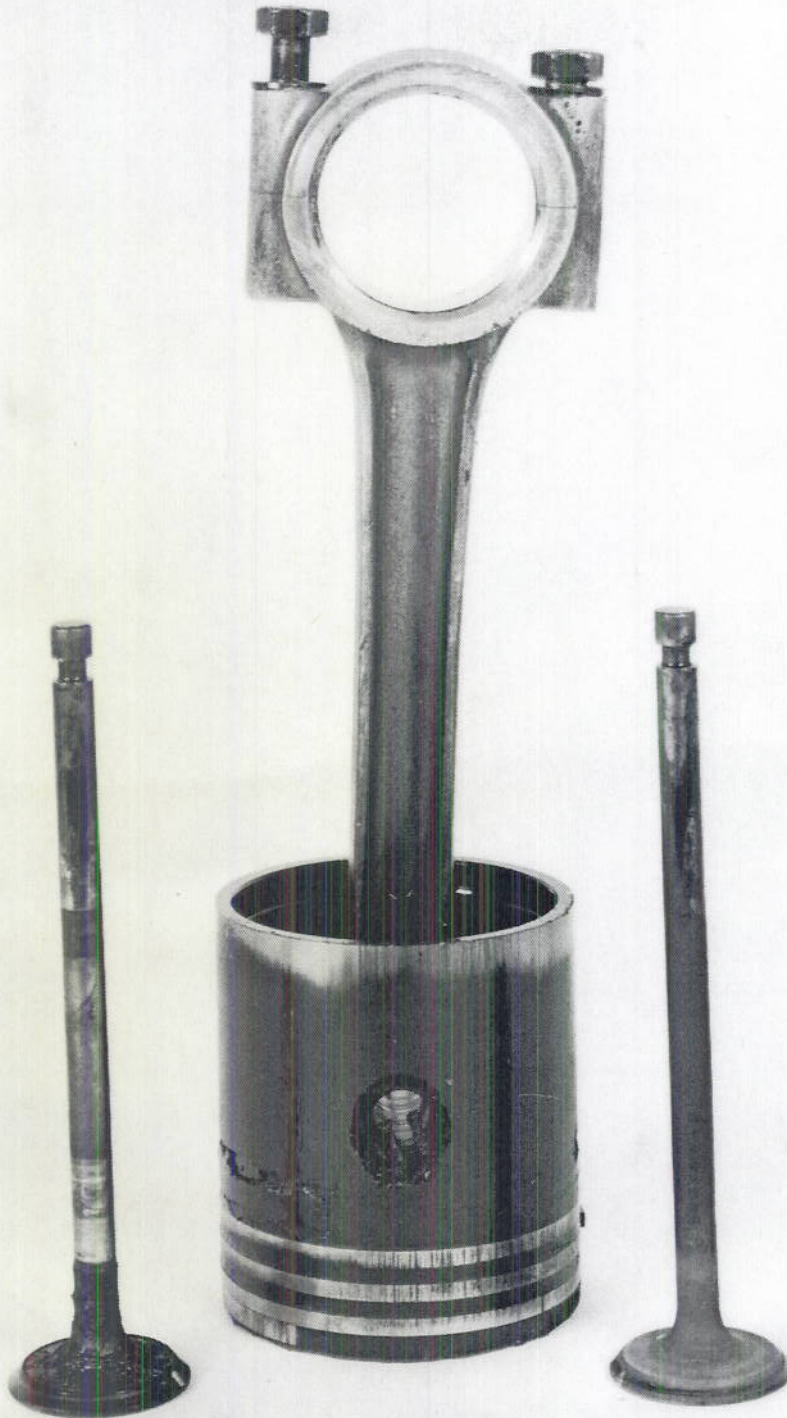


DELCO ENGINE * * NAVY SYMBOL 2135 OIL

RUN NO B-417 DURATION OF TEST 300 HOURS

DECLASSIFIED

DECLASSIFIED



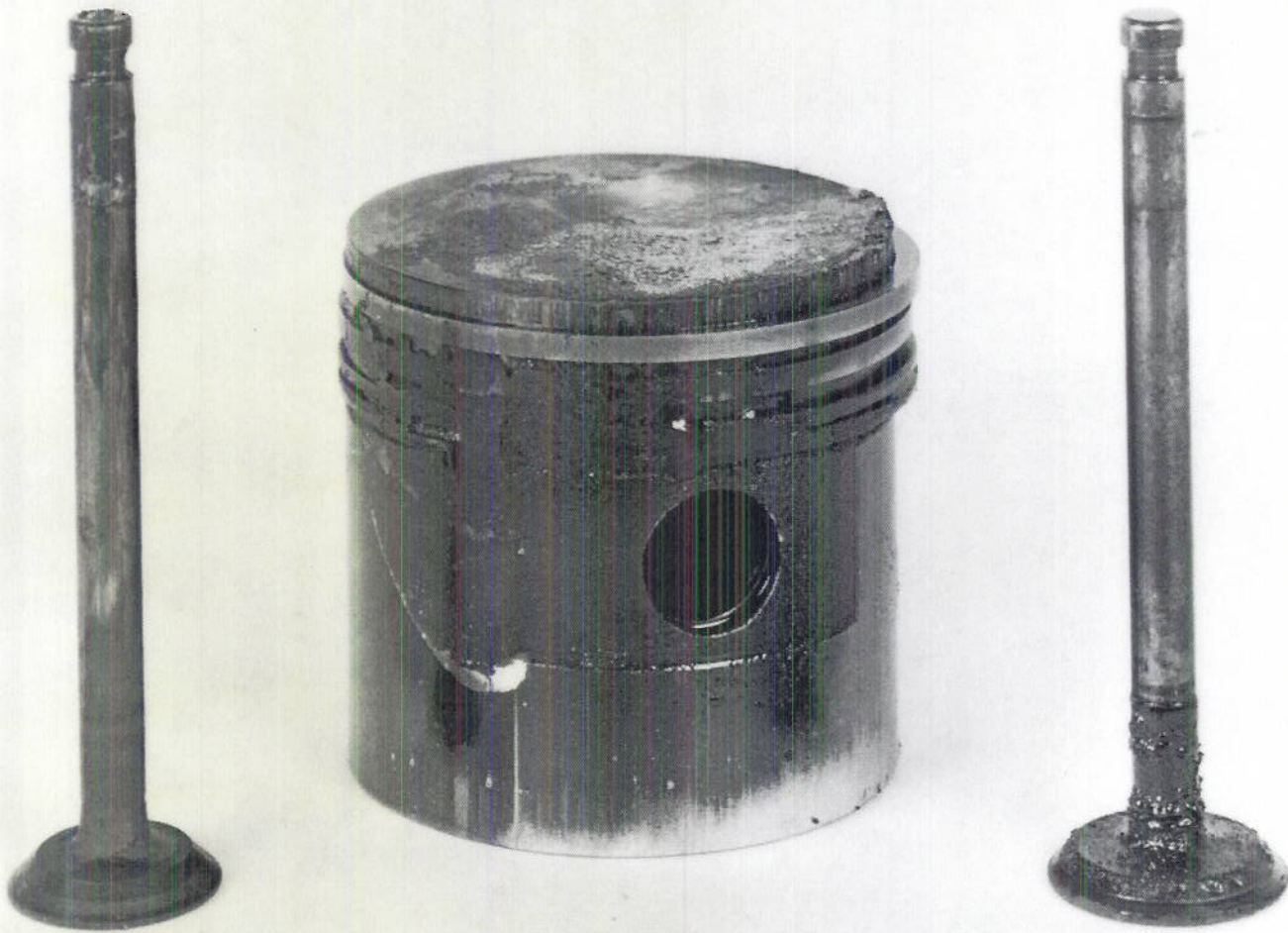
ONAN ENGINE * * S.A.E. 20 HIGH V.I. OIL

RUN NO B-424 DURATION OF RUN 150 HOURS

DECLASSIFIED

PI A T F 7

DECLASSIFIED



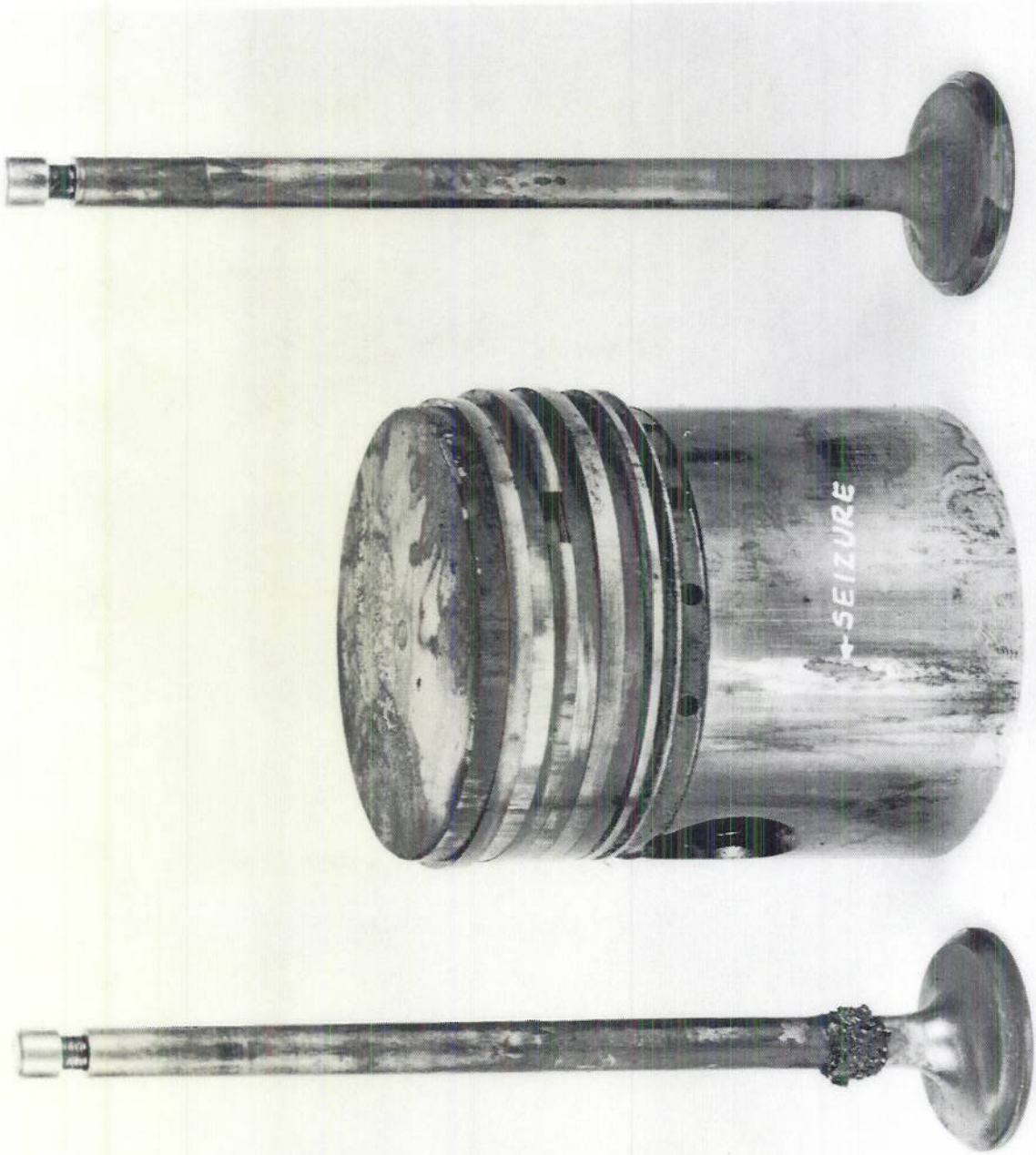
DELCO ENGINE * * S.A.E. 20 HIGH V.I. OIL

RUN NO B-423

DURATION OF TEST 262 HOURS

DECLASSIFIED

DECLASSIFIED

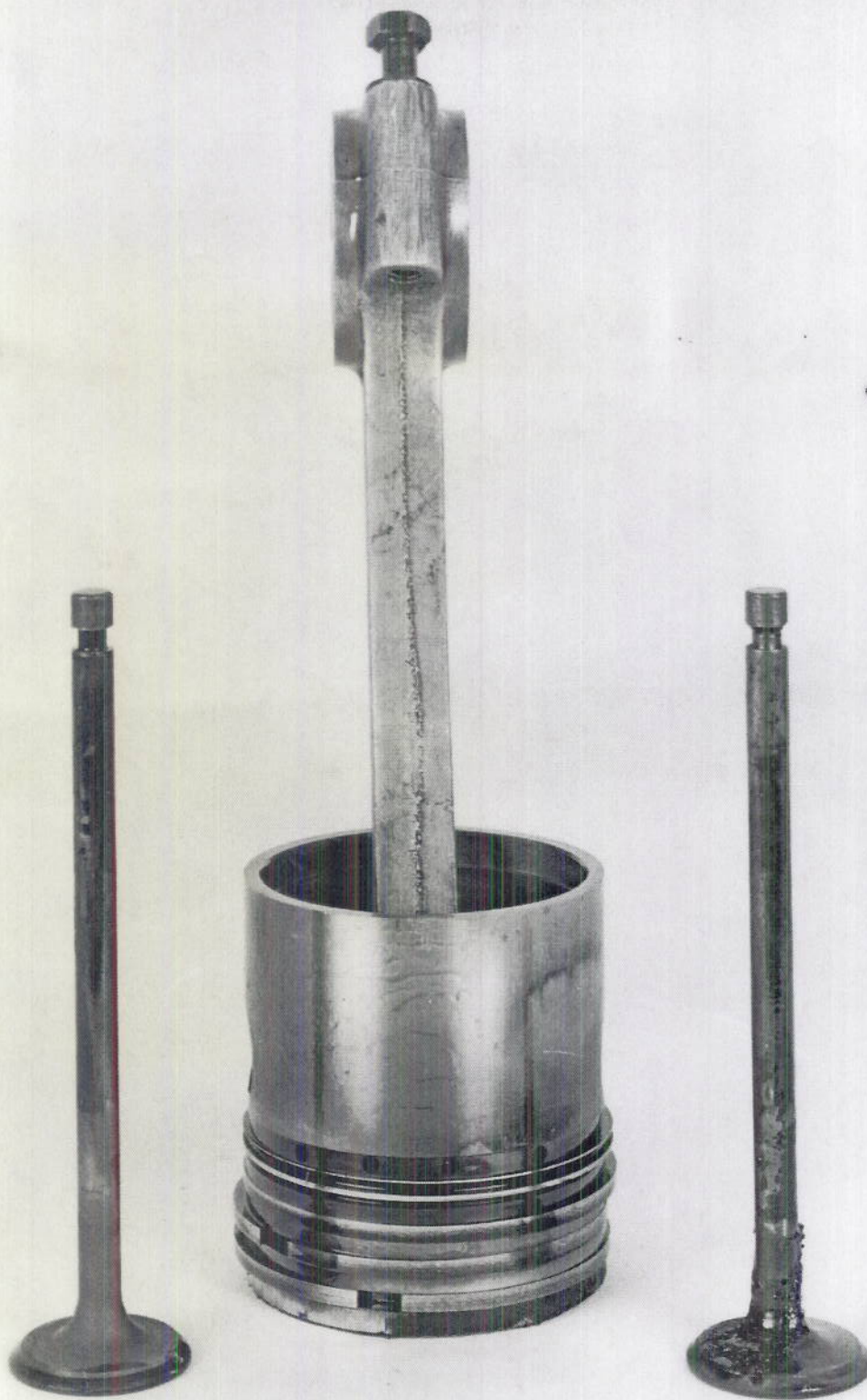


OMAN ENGINE * 250B-0-100 INHIBITED FLUID
(ENGINE OPERATING TEMPERATURE RAISED)

RUN NO B-427 DURATION OF RUN 201 HOURS

DECLASSIFIED

DECLASSIFIED



ONAN ENGINE * * 250B-0-100 INHIBITED FLUID
(ENGINE OPERATING TEMPERATURE RAISED)

RUN NO B-425

DURATION OF RUN 202 HOURS

DECLASSIFIED

PLATE 10