

First edition
2002-04-01

Road vehicles — Heat rating of spark plugs

*Véhicules routiers — Évaluation du degré thermique des bougies
d'allumage*



Reference number
ISO/TR 15409:2002(E)

AVA Documents
© ISO 2002
Document Sharing Hub

PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

© ISO 2002

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

Printed in Switzerland

Contents		Page
Foreword.....		iv
Introduction		v
1	Scope	1
2	Reference	1
3	Terms and definitions	1
4	Heat-rating methods.....	2
Annex A (informative) The SAE heat-rating method		3
Annex B (informative) Description of the SAE heat-rating engine.....		8
Annex C (informative) A French heat-rating method.....		71
Annex D (informative) A German heat-rating method		74
Annex E (informative) A Japanese heat-rating method		81
Annex F (informative) A U.K. heat-rating method		88

© ISO 2002. All rights reserved.

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this Technical Report may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 15409 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 1, *Ignition equipment*.

Introduction

ISO/TC22/SC1, *Ignition equipment*, has studied different methods of spark-plug heat rating. It noted that there exist different measuring methods, each of them requiring costly equipment and a lot of experience, but each of these methods seems to produce sufficient results, one as satisfactory as the others.

The discussions showed no substantial support of any of these methods.

The Subcommittee 1 decided therefore to propose the publication of this information as a Technical Report.

Copyright International Organization for Standardization

Road vehicles — Heat rating of spark plugs

1 Scope

This Technical Report describes the heat-rating methods of spark plugs used with spark-ignition engines.

2 Reference

ISO 2542:1980, *Internal combustion engines — Spark plug ignition — Terminology*

3 Terms and definitions

For the purposes of this Technical Report, the following terms and definitions apply.

3.1

heat rating

measurement of the thermal characteristics of a spark-plug under operating conditions

3.2

heat-rating value

the outcome of heat rating

NOTE This will be expressed in units corresponding to the heat transfer from a spark plug's firing end or insulator tip.

3.3

heat-rating identifier

numbers, letters or a combination of these, relative to the heat-rating value depending on the spark-plug manufacturer's classification system

3.4

heat range

ability of a spark plug to avoid depositions of soot and carbon as well as to avoid auto-ignition in the vehicle engine application

NOTE 1 That is, a given spark-plug type should operate at as hot a temperature as possible at slow engine speeds and light load conditions, and as cool as possible at wide-open throttle.

NOTE 2 The heat range of a spark plug depends on the design of the electrodes, the insulator nose, the shell and the materials of construction, and the engine used.

4 Heat-rating methods

4.1 For heat rating using the SAE 17,6 in³ spark-plug heat-rating engine, see annexes A and B.

4.2 For heat rating using vehicle engines, see the methods below.

a) For heat rating by measuring pre- and/or post-ignition and temperature, see annex C.

b) For heat rating by measuring pre- and/or post-ignition and comparison with master spark-plugs, see annex D.

4.3 For heat rating by measuring pre- and/or post-ignition and comparison with master spark-plugs measured in the SAE 17,6 in³ engine, see annex E.

Annex A
(informative)

The SAE heat-rating method

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J549

REV.
MAR95

Issued 1947-12
Revised 1995-03

Superseding J549 JUN90

Submitted for recognition as an American National Standard

PREIGNITION RATING OF SPARK PLUGS

Foreword—This Document has not changed other than to put it into the new SAE Technical Standards Board Format.

1. Scope—This SAE Recommended Practice describes the equipment and procedures used in obtaining preignition ratings of spark plugs.

1.1 The spark plug preignition ratings obtained with the equipment and procedure specified herein are useful for comparative purposes and are not to be considered as absolute values since different numerical values may be obtained in different laboratories.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J2203—SAE 17.6 Cubic Inch Spark Plug Rating Engine

2.1.2 U.S. GOVERNMENT PUBLICATION—Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robins Avenue, Philadelphia, PA 19111-5094.

MIL-L-6082D

3. Equipment—SAE 17.6 engine (see SAE J2203) with the cylinder barrel having knurled and chemically treated surface and compression piston rings chromium plated.

4. Speed—The nominal speed is to be 2700 rpm, but is not to be over 2765 rpm when firing, nor below 2670 rpm when motoring.

5. Compression Ratio—5.6:1.

6. Spark Advance—30 degrees Before Top Dead Center (BTDC) for nonaviation plugs, 40 degrees BTDC for aviation plugs or nonaviation plugs that cannot be rated at 30 degrees BTDC.

7. Ignition Source—Magneto or approved alternate.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

QUESTIONS REGARDING THIS DOCUMENT: (412) 772-8512 FAX: (412) 776-0243
TO PLACE A DOCUMENT ORDER: (412) 776-4970 FAX: (412) 776-0790
SAE WEB ADDRESS <http://www.sae.org>

Copyright 1995 Society of Automotive Engineers, Inc.
All rights reserved.

SAE J549 Revised MAR95

- 8. Spark Plug Installation**—The thread in the spark plug hole opening should conform in size and length to the standards established by SAE for the rating engine.
- 8.1** SAE recommended torque values should be used when installing plugs in the engine.
 - 8.1.1** Reducer bushings or adaptors should not be used.
- 9. Fuel**—98%—one degree Benzene, 2%—Specification MIL-L-6082D Grade 1100 SAE 60 Nonadditive aviation oil, with 0.8 mL/L (3 cc/gal) T.E.L. added.
- 10. Fuel Injection Timing**—The fuel injection pump port shall begin to close 60 degrees $\pm$ 5 degrees of crankshaft angle After Top Dead Center (ATDC) on the intake stroke.
- 11. Fuel Circulation Rate**—2 L/min $\pm$ 1 L/min (1/2 gal/min $\pm$ 1/4 gal/min).
- 12. Fuel Injection Pump**—The gallery pressure of the fuel injection pump is to be 100 kPa $\pm$ 10 kPa (15 psi $\pm$ 2 psi).
- 13. Fuel Pressures-Injection**—5170 kPa (750 psi) minimum.
- 14. Mixture Strength**—The mixture strength is that which gives maximum thermal plug temperature.
- 15. Inlet Air Temperature**—107 °C $\pm$ 3 °C (225 °F $\pm$ 5 °F).
- 16. Inlet Air Humidity**—0.453 kg (75 g $\pm$ 25 g of moisture/lb) of dry air.
- 17. Coolant**—The coolant should be water plus 3 L (1 g/gal) of an inhibitor. The total dissolved and suspended solids should not exceed 120 ppm.
- 18. Jacket Inlet Temperature**
 - a. With pressure cooling control—107 °C $\pm$ 3 °C (225 °F $\pm$ 5 °F)
 - b. With insert head engine—88 °C $\pm$ 1 °C (190 °F $\pm$ 2 °F)
- 19. Coolant Flow**—20 L/min $\pm$ 2 L/min (5 gal/min $\pm$ 1/2 gal/min).
- 20. Crankcase Oil**—Oil is to be nonadditive SAE 120 aviation oil.
- 21. Oil Pressure**
 - a. In main bearings, 650 kPa $\pm$ 40 kPa (95 psi $\pm$ 5 psi)
 - b. In valve gear, 100 kPa (15 psi) minimum at operating temperature
- 22. Oil Temperature**—88 °C $\pm$ 5 °C (190 °F $\pm$ 10 °F).
- 23. Oil Quantity**—Oil level is maintained at the center of the oil level sight glass.
- 24. Operating Conditions**—The plug rating is that Indicated Mean Effective Pressure (IMEP) value obtained on the engine at a point when the supercharge pressure is 3.37 kPa (1 in Hg) below the preignition point.

SAE J549 Revised MAR95

24.1 Preignition Point—The following steps are recommended to attain the preignition point.

- 24.1.1 The supercharge pressure is increased in 13.5 kPa (4 in Hg) increments until preignition occurs as indicated by a rapid rise in thermal plug temperature. At each setting, the mixture strength is adjusted such that a maximum thermal plug temperature is obtained and held for 3 min.
- 24.1.2 When preignition occurs, the fuel supply is instantly cut off and the supercharge pressure is decreased 6.7 kPa (2 in Hg) at which point the fuel is turned on and again adjusted for maximum thermal plug temperature. This condition should be held for 3 min or until preignition again occurs.
- 24.1.3 If preignition occurs after Step 24.1.2, the supercharge pressure should be reduced by 3.37 kPa (1 in Hg) again adjusting for optimum thermal temperature until stable engine operation for 3 min is obtained or preignition occurs. If preignition occurs, refer to Step 24.1.5.
- 24.1.4 If, after Step 24.1.2 stable engine operation is obtained, the supercharge pressure should be increased by 3.37 kPa (1 in Hg), again adjusting for optimum thermal plug temperature until stable engine operation for 3 min is obtained or preignition occurs. If preignition occurs, refer to Step 24.1.5.
- 24.1.5 Friction torque should be measured at supercharge pressure 3.37 kPa (1 in Hg) below the preignition point (or previous stabilized setting prior to preignition), and within 30 s after the engine ceases to fire.
- 24.1.6 Rating data may be verified using a plug that has a rating point at least 50 IMEP above the plugs that have been rated.

25. Calculation of IMEP

$$\text{Indicated HP} = \text{Friction HP} + \text{Brake HP} \quad (\text{Eq. 1})$$

$$\text{IHP} = \frac{2700}{5252} T_F + \frac{2700}{5252} T_B$$

$$\text{IHP} = 0.51(T_F + T_B) = \frac{\text{Plan}}{33000}$$

$$0.51(T_F + T_B) - (0.04)(0.01)P = \text{IMEP}$$

$$\text{IMEP} = 8.65(T_F + T_B)$$

T_F - Friction Torque

T_B - Brake Torque

IMEP - Indicated Mean Effective Pressure

26. Notes

- 26.1 Marginal Indicia.** The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE IGNITION STANDARDS COMMITTEE

SAE J549 Revised MAR95

Rationale—Not applicable.

Relationship of SAE Standard to ISO Standard—Not applicable.

Application—This SAE Recommended Practice describes the equipment and procedures used in obtaining preignition ratings of spark plugs.

Reference Section

SAE J2203—SAE 17.6 Cubic Inch Spark Plug Rating Engine

MIL-L-6082D

Developed by the SAE Ignition Standards Committee

Annex B
(informative)

Description of the SAE heat-rating engine

www.iso.org



400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE STANDARD

SAE J2203

REAF.
NOV1999

Issued 1991-06
Reaffirmed 1999-11

Superseding J2203 MAY1995

Submitted for recognition as an American National Standard

SAE 17.6 Cubic Inch Spark Plug Rating Engine

Foreword—This Document has also changed to comply with the new SAE Technical Standards Board Format. Abbreviations have changed to Section 3. All other section numbers have changed accordingly.

This manual was originally prepared under the auspices of the SAE Ignition Research Committee by the Spark Plug Rating Engine Standardization Panel of the Aircraft Piston Engine Ignition Subcommittee. In 1974, the Spark Plug Rating Engine Standardization Panel was placed under the jurisdiction of the SAE Electrical Equipment Committee.

This manual defines the standard engine to be used in determining spark plug preignition ratings. The engine is known as the SAE 17.6 Cubic Inch¹ Spark Plug Rating Engine. The background of its design, development, and applications is contained in SAE publication SP-243.

In addition to describing the engine, this manual deals with maintenance and overhaul instructions for the engine. Appendices providing engine manufacturing tolerances, replacement limits, and engine bill of materials are included. The manual also includes the procedure for rating spark plugs.

The 17.6 engine has been used for many years in the spark plug industry to classify spark plugs by their preignition rating. Correlation of these ratings among the various test agencies has been accomplished with limited success primarily due to engine variations. This correlation difficulty prompted the Aircraft Piston Engine Ignition Subcommittee of the SAE Ignition Research Committee to investigate methods of standardizing and improving this engine. The Ethyl Corporation (which originated the 17.6 engine) consented to the incorporation of improvements in the engine by SAE.

The Spark Plug Rating Engine Standardization Panel, which was established to standardize and improve this engine, consists of persons who are closely associated with the use or manufacture of the engine. The sum of their individual experiences and the many special projects conducted by the panel have been gathered into this manual.

Conformance with the engine description and rating procedure included in this manual and the diligent following of the Maintenance, Overhaul, and Operation instructions will result in more uniform spark plug rating data from each engine and a closer rating correlation between engines.

-
1. With the advent of the metric system, the metric notation should be 288.6 cc for the ending displacement. However, since the term "17.6" is quite familiar in the industry, it will be retained in that form.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS <http://www.sae.org>

Copyright 1999 Society of Automotive Engineers, Inc.
All rights reserved.

© ISO 2002. All rights reserved.
Copyright International Organization for Standardization
Provided by IHS under license with ISO

No reproduction or networking permitted without license from IHS

Full document details: ISO TR 15409-2002

Not for Resale

SAE J2203 Reaffirmed NOV1999

This manual will be revised periodically to reflect engine improvements that have been developed and thoroughly evaluated. Comments, advice, or recommendations concerning the manual or the engine that it defines will be welcomed by this panel and should be sent to SAE Headquarters for consideration.

An engine of this type may be obtained from the Laboratory Equipment Corp. (Labeco), Mooresville, Indiana, and all part numbers herein mentioned are those of Labeco, unless otherwise specifically stated.

This Edition of the manual includes only the 16047 series engine since it is the only type that has been manufactured in the last few years. The older type 5000 series was covered thoroughly in a previous edition of the manual (publication date, July 1964). The 16047 series engine (Figures 1a and 1b) differs from the 5000 series in that it incorporates a Lanchester-type of balancing system consisting of two counter-rotating, chain-driven, counterbalancing shafts, rotating at crankshaft speed, to dampen the unbalanced portion of the connecting rod and piston assembly.

NOTE—Shown for illustrative purposes only. Detailed drawings may be obtained from Laboratory Equipment Corp., Mooresville, Indiana.

10

SAE J2203 Reaffirmed NOV1999

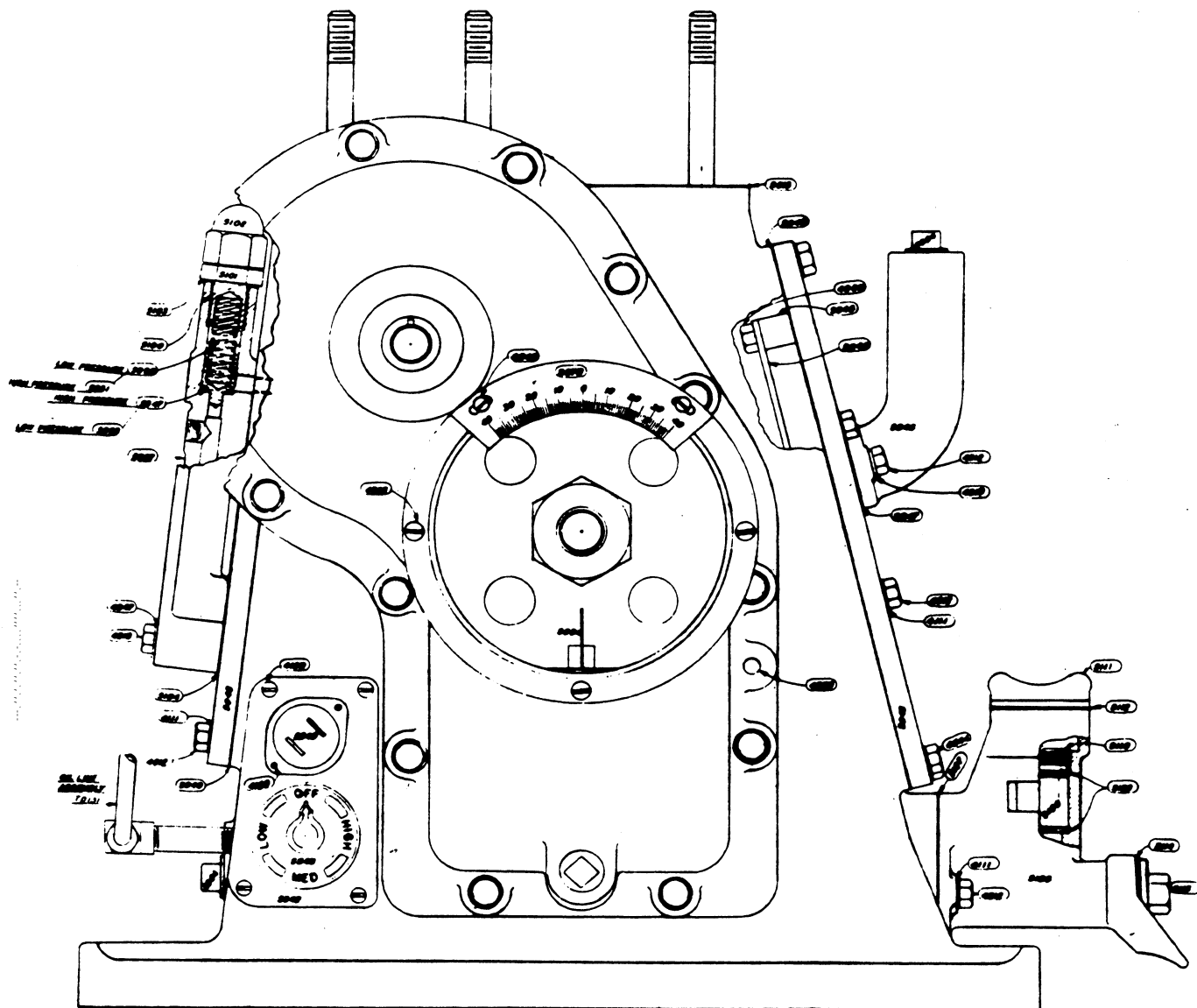


FIGURE 1A—THE 5000 ENGINE

NOTE—Shown for illustrative purposes only. Detailed drawings may be obtained from Laboratory Equipment Corp., Mooresville, Indiana.

[illegible]

FIGURE 1B—THE 5000 ENGINE

SAE J2203 Reaffirmed NOV1999

TABLE OF CONTENTS

1.	Scope.....	6
2.	References	6
2.1	Applicable Publications	6
3.	Abbreviations	6
4.	Cylinder Assembly	7
5.	Crankcase Assembly	9
6.	Air Induction System	10
7.	Ignition System	11
7.1	Magneto Ignition System	11
7.2	Alternate Ignition Systems	11
8.	Fuel System	11
9.	Cooling System.....	12
10.	Lubrication System	13
10.1	Oil Filter	14
10.2	Alternate Oil Filter	14
11.	Exhaust System	15
12.	Crankcase Breather System.....	15
12.1	Standard System	15
13.	Air Supply System	16
14.	Maintenance and Overhaul Procedure	18
14.1	General	18
14.2	Detailed Disassembly of 16047 Engine	20
14.3	Detailed Inspection of 5750 Engine	22
15.	Engine Run-In Schedule	31
16.	Operating Instructions.....	32
16.1	Operating Instructions Conditions.....	32
16.2	Step-by-Step Procedure	32
16.3	Plug Rating	33
17.	Notes	34
	Appendix A Manufacturing Tolerances and Replacement Limits.....	35
	Appendix B Standard Spark Plug Inserts.....	39
	Appendix C Spark Plug Installation Torque.....	40
	Appendix D Bill of Material for 16047 Engine Assembly, SAE Spark Plug Rating w/Insert Type Head.....	41

SAE J2203 Reaffirmed NOV1999

1. Scope—This SAE Standard defines the standard engine to be used in determining spark plug preignition ratings. The engine is known as the SAE 17.6 Cubic Inch Spark Plug Rating Engine.

2. References

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J973—Ignition System Measurement Procedure

SAE SP-243—Proceedings of the 28th Automotive Technology Development Contractors Coordination Meeting, 27

AS840—Manual, July 1964

3. Abbreviations

abc	after bottom center
abs.	absolute
assy.	assembly
atc	after top center
bbc	before bottom center
bdc	bottom dead center
bp	boiling point
brg.	bearing
brkt	bracket
btc	before top center
cap	capscrew
°C	degrees Centigrade
C.B.	counterbalance
cc	cubic centimeters
cyl	cylinder
cm	centimeter
deg.	degrees
Dia.	diameter
etc.	and so forth
°F	degrees Fahrenheit
gal	gallons
HD	head
hex	hexagon
h	hours
Hg	mercury
/	per
ID	inside diameter
IMEP	indicated mean effective pressure
in	inches
K.O.	knock out
lb-ft	pounds-feet
M	Meter
mm	millimeter
Mach.	machine
Mfg.	manufacturer
min	minimum or minute
misc	miscellaneous

SAE J2203 Reaffirmed NOV1999

mnt.	mounting
No.	number
NPT	National pipe thread
O.A.L.	overall length
OD	outside diameter
oz	ounces
P.F.	press fit
PSI	pounds per square inch
qt	quart
rd.	round
rpm	revolutions per minute
SAE	Society of Automotive Engineers, Inc.
s	seconds
soc	socket
spkt.	sprocket
std	standard
tdc	top dead center
V	volts
w	watts
X	by

4. **Cylinder Assembly**—The cylinder assembly consists of a cast iron barrel assembly and a detachable cast iron cylinder head assembly; the latter including integral rocker arm housings and covers completely enclosing the valve gear. The barrel assembly has a removable, centrifugally cast iron cylinder sleeve mounted in a cylinder housing and is attached to the head by ten 12.7 mm (1/2 in) diameter bolts that extend the length of the barrel. Coolant transfer from barrel jacket to head is through ten holes drilled in the head and communicating with water passages between the cylinder sleeve and the jacket. The head is located on the upper end of the barrel by a pilot extension on the barrel. The combustion chamber is sealed by a copper ring gasket that is compressed to a predetermined thickness when the ten bolts are tightened.

The combustion chamber is hemispherical in shape with the axis of the two valves intersecting at the center of the sphere. Valve seat inserts for both valves are expanded in the head.

A revision of the cylinder head has been made in the past few years and both the older 5573 integral type (Figure 2) and the newer 16001 insert-type (Figure 4) will be described. On the 5573 type, which is still being used at some agencies, two tapped holes for spark plugs are provided on opposite sides of the dome and in a plane at right angles to the plane through the valves. The included angle between the holes is 110 degrees. Standard combinations of spark plug thread diameters and reaches are shown on Labeco drawing No. 16100.

NOTE—The thermal plug used during spark plug rating is installed in one of the spark plug holes and contains a chromel-alumel thermocouple having a response rate of 7-1/2 s for a change from ambient room temperature to 620 °C ± 28 °C (1150 °F ± 50 °F) when dipped in a molten tin bath at 815 °C ± 5.6 °C (1500 °F ± 10 °F). The thermal plug temperature has a 4.5 s (max) travel time for the range of -18 to 860 °C (0 to 1500 °F).

SAE J2203 Reaffirmed NOV1999

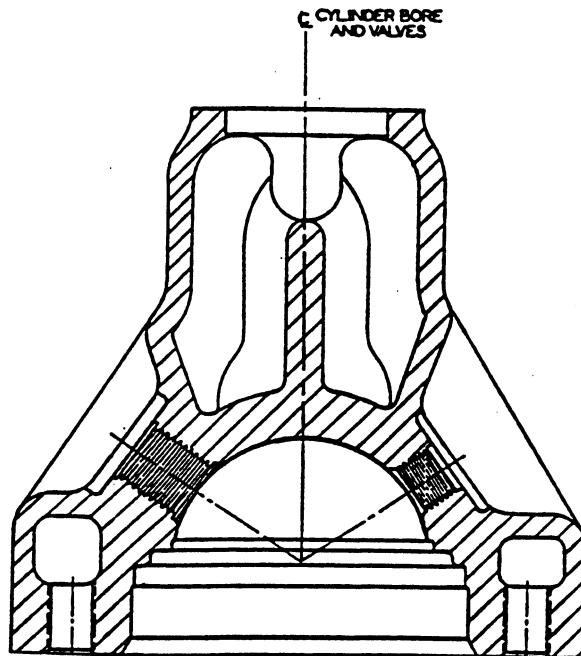


FIGURE 2—INTEGRAL TYPE HEAD (PART # 5573)

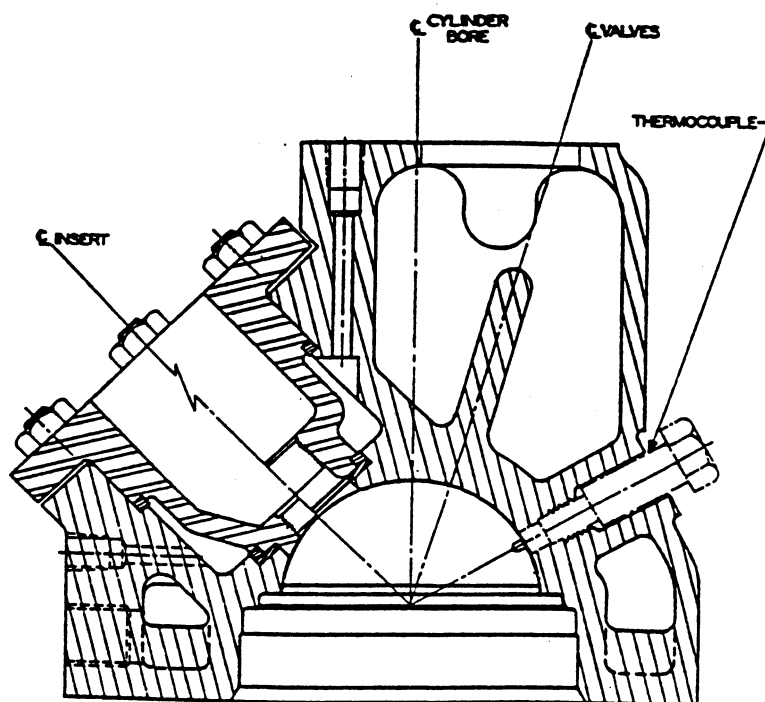


FIGURE 3—INSERT TYPE HEAD (PART # 16001)

SAE J2203 Reaffirmed NOV1999

The 16001 head, which is now standard, incorporates spark plug boss inserts that are mounted into the cylinder head with six 8 mm (1/16 in) studs. This spark plug insert is sealed into the combustion chamber and from the atmosphere with two "O" rings. This provides a separate water jacket for the spark plug boss from the cylinder and head water jacket. This insert makes it possible to change from one size of spark plug to another size in a matter of minutes without disturbing the cylinder, cylinder head, or piston, which was necessary in the former 5573 head design. With the 16001 type head, the single thermal plug remains installed at all times.

The cylinder sleeve is of generally uniform thickness from top to bottom, except for a small outer flange near the lower end of the sleeve. This flange engages a steel ring flange that seals the sleeve to the cylinder housing and the head by gaskets and the same ten bolts that hold the barrel assembly to the head. The inner surface of the cylinder is knurled before finish honing; and after final honing, the surface is Parco-Lubrizo treated.

Coolant enters the lower end of the cylinder housing at the timing gear end and leaves the assembly at the top of the head between the rocker boxes. Coolant for the spark plug boss insert in the type 16001 cylinder head enters the insert jacket immediately below the insert and leaves the insert jacket directly above the insert.

The cast iron rocker arms, providing an 8 mm (5/16 in) valve lift for a 6.33 mm (1/4 in) lift of the camshaft, are equipped with needle bearings operating on floating case-hardened solid steel rocker shafts, secured by cover plates bolted to the rocker box housings. Each rocker has a roller at the valve end and an adjusting screw at the push rod end. The valve gear is lubricated by pressure oil from the valve tappets, through a hole in the adjusting screw, with affords splash lubrication, supplemented by additional exhaust valve lubrication effected by projecting the push rod housing 12.7 mm (1/2 in) into the exhaust rocker box.

The valves, one intake and one exhaust, have valve stem diameters and lengths considerably greater than those generally provided for the valve head diameters used. Each valve is operated by two valve springs that provide satisfactory operation up to and including 3200 rpm.

5. **Crankcase Assembly**—The gear end is considered the front end of the crankcase and the flywheel end, the rear of the crankcase. The crankcase consists of an extremely rigid iron casting with drilled oil passages allowing pressure lubrication to all bearing surfaces. The crankcase from the main bearing to the base houses the two counter-rotating, chain-driven counterbalance shafts. The timing gear case cover encloses the timing gears, the chain drive for the counterbalance shafts and the chain tension idler sprocket. An oil pump is mounted on the outside of the timing gear case cover and is driven through an Oldham coupling by the left-hand counterbalance shaft. Two large covers bolted to the sides of the crankcase provide means for inspection of the crankcase interior.

There are three main bearings; the front main bearing is pressed into the front supporting section of the crankcase deck and the rear two main bearings are pressed into a removable adapter. All three are locked in place by taper pins. All main bearings are of the one-piece, babbit type and are precision bored in place; no adjustment is provided to compensate for wear. The end play of the crankshaft is controlled by dimensional machining of the thrust faces of the two inner main bearings, with the adapter secured in place on the crankcase with the proper gasket.

The crankshaft is a very rigid steel forging, has hardened bearing journals to insure minimum wear, and is counterweighted to balance the centrifugal weight in accordance with standard practice. Keyways are provided for flywheel and all the front end drives. Threads are provided for the crankshaft front lock nut. The rear end is machined to use a radial lip seal. The front ring seal is also a radial lip seal, sealing against the timing disc spacer sleeve.

SAE J2203 Reaffirmed NOV1999

The lead weighted counterbalance shafts are mounted in the lower part of the case. Their unbalance weight dampens out the unbalanced forces generated by the upper portion of the rod and piston assembly. These shafts are mounted on bronze bushings pressed into the rear of the case and front bushings pressed into a piloted bearing adapter. They are driven in opposite directions at crankshaft speed by a triple chain drive. The tension of the chain is adjusted by an idler sprocket mounted on an eccentric bushing that may be locked in the position giving the desired tension. The forged steel flywheel bears directly on a tapered and hardened section at the rear of the crankshaft and is held by key and lock nut.

The camshaft, driven through helical gears, is carburized steel with case-hardened bearing journals and cams. The front of the camshaft extends through the timing gear case for an auxiliary drive. An oil seal is used at this point.

There are two bronze camshaft bearings: (a) the front bearing, which absorbs the camshaft end thrust, is bolted by a flange to the front supporting section of the crankcase; (b) the rear bearing is a bushing that is pressed into the rear crankcase supporting section. End play can be adjusted by removing metal from the inner face of the front bearing.

The valve lifters are of the roller-type. The guides are iron castings and are held to the top deck of the crankcase by capscrews, positive vertical alignment being assured by shoulders that fit in piloting holes drilled in the crankcase deck.

The connecting rod is a steel forging that has a precision shell-type split bearing, the cap being held by two bolts of generous proportions. The bearings are precision bored steel backed silver grid and no adjustment is possible for wear. The wrist pin bushing is a press fit in the rod and is hard cast bronze.

The piston pin is hardened carburized steel, is solid, employs a full diameter, and has 32.50 mm (1-9/32 in) spherical radii.

The piston is cast iron, has four compression rings and one oil control ring, all located above the piston pin boss, and incorporates a sodium-filled capsule in the head. This capsule, cooled by an oil spray from the small end of the connecting rod, is used to prevent localized overheating of the piston by more uniformly dissipating the heat to the cylinder wall through the rings and skirt and to the oil. The capsule consists of a two-piece, copper brazed chamber that totally encloses the sodium and is shrunk into the outer casting. Pressure on the middle of the piston head is directly transmitted to the piston bosses by the inner member of the capsule. The compression ratio of the engine is 5.6:1.

6. **Air Induction System**—The induction system consists of an air receiver assembly and an intake pipe basically. The air receiver, a cylindrical aluminum casting, is mounted at the top of the intake pipe and functions as an equalizing chamber to provide a constant pressure at the entrance to the induction system. It contains a standpipe whose inside diameter, 22.2 mm (7/8 in), is equal to the pipe passage diameter and an air filter consisting of four layers of bronze screen (two of 110 mesh, and two of 22 mesh) to prevent pipe scale and the like from entering the cylinder. The air enters the receiver tangentially and is drawn off at the standpipe entrance near the top of the receiver. Two thermocouples are located in the air receiver; one is connected to a controller to maintain the air inlet temperature at $107.2\text{ }^{\circ}\text{C} \pm 2.8\text{ }^{\circ}\text{C}$ ($225\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$) (see Section 12), and the other is used for indicating the temperature.

The intake pipe is an iron casting in the form of a 90 degree bend and is held to the cylinder head by four studs. Surrounding the pipe is a jacket that gives great rigidity to the section. Provisions are made for the mounting of the fuel injection nozzle on either side of the intake pipe between the cylinder head and the air receiver.

SAE J2203 Reaffirmed NOV1999

- 7. Ignition System**—The ignition system may consist of two alternate systems; one a magneto system and the other a condenser discharge ignition system.

- 7.1 Magneto Ignition System**—The magneto ignition system consists of a low tension magneto, one high tension coil, and magneto drive coupling assembly. The magneto, mounted independently of the engine on a mounting bracket, is driven at engine speed through a drive coupling assembly connected to the front extension of the crankshaft. The magneto rotation is counterclockwise as viewed from the magneto drive end. The magneto generates and distributes low voltage current through low tension cables to the high tension coil. The low voltage by this coil is transformed to high voltage by this coil and is conducted through a short length of high tension cable to the spark plug in the engine. Negative polarity impulses shall be delivered to the spark plug.

The magneto drive coupling assembly consists of one adjustable coupling flange assembly, two flexible couplings, and a driving coupling flange that is keyed to the crankshaft. The adjustable coupling flange assembly has one disc with two fixed screws that can be positioned in the two circumferential slots in the other disc.

In timing the magneto to the engine, remove the breaker cover and the timing inspection plug from the magneto. With the crankshaft set at the desired spark advance on the compression stroke, position the adjustable coupling flange assembly so that the white dot on the chamfered tooth of the large distributor gear lines up with the pointer as seen through the inspection hole. In this position, the breaker points of the magneto are just opening.

- 7.2 Alternate Ignition Systems**—Any commercially available automotive ignition system such as a capacitive discharge system, electronic breakerless system, or an inductive breaker type system will be satisfactory as long as it fulfills the following system specifications:

Open Circuit Voltage: 24 KV (minimum)
 Rise Time: 50 μ s (maximum)
 Arc Duration: 60 μ s (minimum)
 Polarity: Negative

All measurements are to be taken with the spark plug firing at the following conditions:

Spark plug gap at 0.635 mm (0.025 in)
 Engine running as follows: 2700 rpm
 2540 mm (100 in) Hg-Supercharge
 Spark Timing-30 degree B.T.D.C.

Voltage measurements are to be made in accordance with SAE J973.

- 8. Fuel System**—The fuel system consists of a fuel supply pump, filter, fuel cooler, fuel injection pump assembly, injection nozzle, and fuel tank as shown in Figure 4.

The gear type, positive displacement fuel supply pump is driven at 600 rpm and has a capacity of 2.0 L/min $\pm$ 1.0 L/min (1/2 gal/min $\pm$ 1/4 gal/min) at this speed.

The filter is a multiple disc edge type with 0.038 mm (0.0015 in) spacing. To reduce difficulty during engine operation due to fuel contamination, it is suggested that the fuel be filtered through a 2 μ m filter before delivery to the fuel system.

SAE J2203 Reaffirmed NOV1999

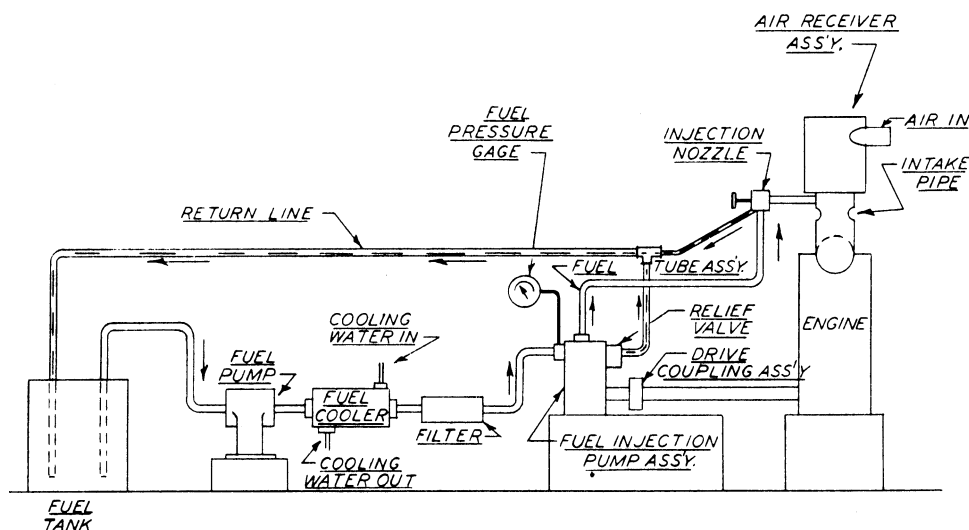


FIGURE 4—SUGGESTED FUEL SYSTEM

The fuel injection pump assembly, a single cylinder Robert Bosch type PES1A80C 300/3RSX01 (ref. Labeco 200026-1) is mounted on the same mounting bracket that supports the magneto. The pump has a variable delivery rate and is driven at half engine speed through a drive coupling assembly (similar to that used for the magneto) connected to the front extension of the engine camshaft. The pump outlet connection contains a spring loaded relief valve to maintain a pressure in the pump gallery of $100 \text{ kPa} \pm 15 \text{ kPa}$ ($15 \text{ psi} \pm 2 \text{ psi}$) to reduce vapor locking. A water cooling element is installed in the pump gallery through which cold water is circulated to maintain the fuel temperature within the desired range of 16 to 32°C (60 to 90°F).

A portion of the fuel, determined by the injection pump control rod setting, is passed to the injection nozzle and the balance is returned to the fuel tank. The injection pump lubricant, SAE 30 oil or castor oil, should be changed at least every 50 h. The timing of the injection pump is accomplished by setting the engine flywheel at 60 degree atc on the intake stroke, and coupling the injection pump to the engine camshaft with the scribed line on the tapered shaft of the pump aligned with the "R" line on the pump endplate, for clockwise rotation of the pump as viewed from the drive end. When aligned, the bypass port of the pump is closed and fuel delivery to the nozzle begins.

The injection nozzle is mounted on the upper end of the intake pipe and sprays fuel directly across the passage at right angles to the air flow direction.

9. **Cooling System**—With those agencies that still utilize the older integral type cylinder head wherein the coolant temperature must be maintained at 130°C (265°F), a pressure type cooling system is used. A detailed description of a suggested type when using the integral head is well documented in the AS840 Manual published in July 1964.

Where the spark plug insert type cylinder head configuration is utilized, the previously mentioned pressurized system may be used. However, experience has shown that since coolant temperatures required on this type head are only 88°C (190°F), a system operated at atmospheric pressure is the more desirable. Figure 5 illustrates a suggested cooling system of this type. It consists basically of a coolant pump, heat exchanger, and expansion tank with auxiliary plumbing to effect coolant distribution to both the spark plug insert and the combustion chamber jacket. The coolant pump may be of the centrifugal type with enough capacity to circulate coolant at a rate of approximately 19 L/min (5 gal/min) under operating conditions.

SAE J2203 Reaffirmed NOV1999

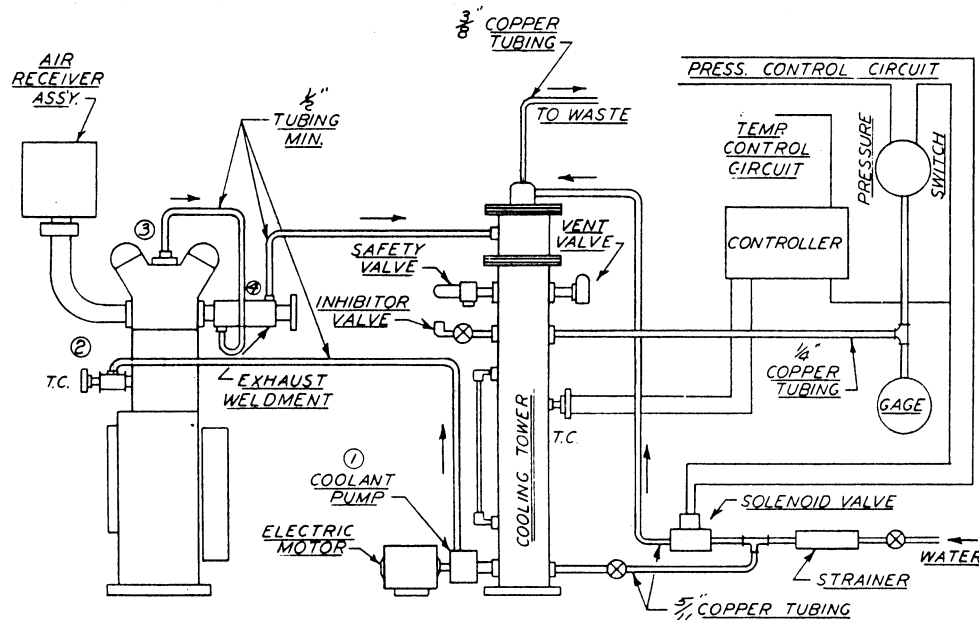


FIGURE 5—SUGGESTED COOLING SYSTEM

The heat exchanger may be a commercial unit which has a rating of approximately 95 000 Btu/h (6650 gr.-cal/s) to heat up tap water entering at room temperature to the required 88 °C (190 °F).

Adequate temperature controllers are to be placed at the inlet points to both the cylinder head jacket and the spark plug insert such that 88 °C (190 °F) inlet temperatures are maintained.

Distilled or treated water is used for the coolant to prevent formation of mineral deposits in the cooling system. Since this system operates at atmospheric pressure, the expansion tank should be elevated to a position such that the coolant level is above the highest point in the engine. Make-up coolant may be added as required.

- 10. Lubrication System**—The schematic layout of the complete lubrication system for the 5750 engine is shown in Figure 6. The oil pump is mounted externally on the front timing gear case cover and driven through an Oldham coupling by the left-hand counterbalance shaft. All bearings are pressure lubricated through a single pressure relief valve set to 690 kPa $\pm$ 35 kPa (100 psi $\pm$ 5 psi). The timing gears and the counterbalance drive chain are lubricated by splash from a metered hole in the right-hand counterbalance driveshaft sprocket. The valves and rocker arms are lubricated by bleed-off oil that comes through the camshaft to the valve lifters and through the pushrod to the rocker arms. The pressure to the valve gear is 70 to 105 kPa (10 to 15 psi) depending on the clearance in the camshaft bearings and between the valve lifter and valve lifter guide.

The oil cooler is fabricated with steel tubing and is identical in detail to the coolant heat exchanger (Figure 5) with the exception of length.

SAE J2203 Reaffirmed NOV1999

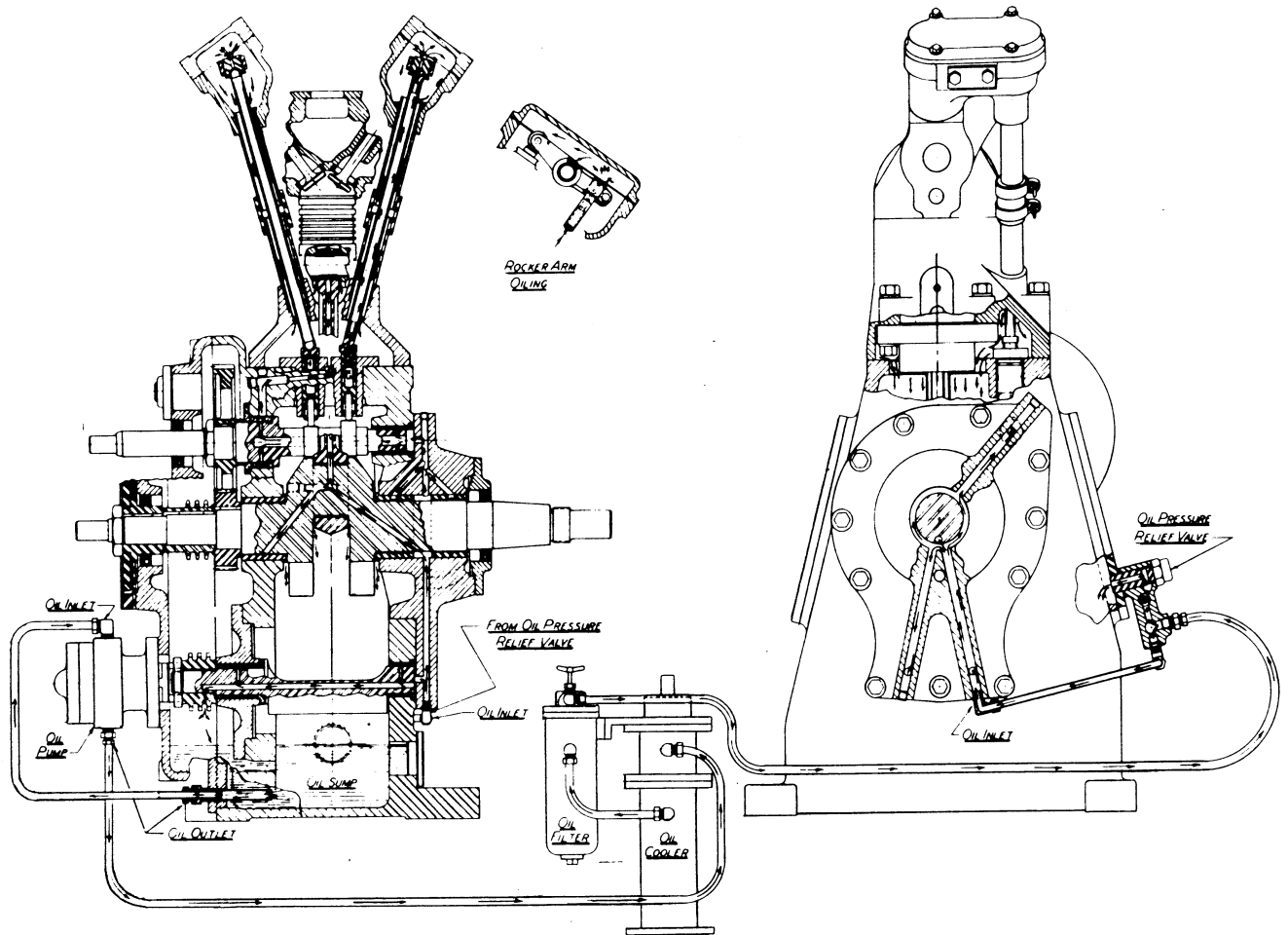


FIGURE 6—#5750 ENGINE LUBRICATION SYSTEM

- 10.1** The oil filter is a heavy-duty edge type design 0.1 mm (0.0035 in) spacing between discs to withstand high pressures and so made that the disc edges may be cleaned without disassembly. Three taps are provided for oil drain, oil entrance, and oil exit, respectively.
- 10.2 Alternate Oil Filter**—An aircraft-style oil filter in conjunction with a remote filter head assembly may be used as an alternate to the disc-type originally supplied with the rating engine. The filter should have a burst pressure test value of 2760 kPa (400 psi) minimum and should not have an internal bypass system. The filter head should have a bypass system with a visual and electrical indicator to indicate when filter is being bypassed. These filters are a spin-on type and should be replaced at regular intervals. It is recommended these filters have a 45 µm or less particulate restriction.

Four tubular cartridge-type oil heaters are located on the front of the crankcase and extend into the base of the crankcase. Three crankcase heating capacities (285, 570, and 1140W) are available.

The lubricating oil is nonadditive aviation SAE 120 type. Twenty cc of DAG Dispersion NO. 2404 to each 2.2 L (2.5 qt) of oil may be used to reduce varnish formation on moving engine parts. The crankcase oil level indicator is incorporated in a casting that is bolted to the side of the crankcase, the oil level being maintained halfway up the sight glass with the engine at rest. (Crankcase capacity 2.2 L (2.5 qt)—entire system, approximately 5.7 L (6 qts). The oil sump should be drained, completely cleaned, and refilled every 50 h.

SAE J2203 Reaffirmed NOV1999

- 11. Exhaust System**—The exhaust pipe weldment, held to the cylinder head by four studs, consists of a 25.4 cm (10 in) long steel tube with steel flanges brazed to each end. The tube is jacketed approximately two-thirds of its length by another steel tube, the assembly to serve as a coolant heat exchanger.

Although the primary purpose of this coolant heat exchanger is to aid in maintaining cylinder jacket coolant inlet temperature when the engine is being operated at low boost and hence low power, it also is very effective in: (a) avoiding corrosion and cracking of the exhaust pipe weldment; (b) Removing exhaust heat from the immediate vicinity of the engine for the comfort of the operator; (c) in avoiding seizure of the nuts and studs holding it to the cylinder head.

A recommended system, which has given a minimum of trouble and has been widely used, is one in which the exhaust gasses are cooled by a water spray, the resultant mixture passing through a section of rubber covered steam hose to the exhaust pipe. Such a system has the double advantage of cooling the exhaust pipe for operator comfort and preventing exhaust pipe leaks occurring from cracking of seams or welds due to excessive temperatures. The water spray nozzle is welded to a flange, the unit being held to the exhaust weldment by stainless steel bolts and nuts. The elbow faces in a downward direction away from the operator, the water-exhaust mixture going into a 10.2 cm (4 in) pipe that is led outside the building into a 10.2 cm (4 in) tee. Two pieces of pipe are screwed into this tee; one extending vertically above the building parapet on which a muffler may be placed for quieting purposes, the other extending vertically downward to an exhaust sump. The water drain in the sump is held at a level approximately 12.7 cm (5 in) above the bottom end of this lower section and serves both as a water seal and as a back pressure relief valve in the event the upper vertical stack becomes plugged.

A simple back pressure alarm may be made by inserting a wire into each leg of a U-tube that contains a solution of water and salt, one wire immersed in and the second wire located above the electrolyte. A simple electrical circuit is made by connecting a bell, a 6 V power supply, and the U-tube "switch" in series. When the back pressure increases to raise the electrolyte sufficiently to contact the second wire, the circuit is completed to ring the bell.

The remainder of the exhaust system for the engine may be left to the discretion of the test laboratory provided a few precautions are taken. In general, it is recommended that precautions be taken to avoid any resonant effect that may cause alternating high and low back pressures. Such a resonant effect may be easily overcome by any of a variety of damping methods, such as elbows, surge chambers, and so on. Back pressure in the system should be limited to avoid difficulty in cylinder exhaust scavenging due to valve overlap resulting in abnormal cylinder head temperatures. Any possible water trap in the exhaust system should be avoided. It is recommended to slant the exhaust down from the weldment to prevent collection of moisture when the engine is not in operation. This pipe may be water jacketed for additional heat removal from the test area.

Provisions should be made so that the exhaust pipe may readily be disconnected and plugged in the event that the engine is not to be run for a prolonged period to avoid exhaust pipe weldment corrosion from exhaust acids.

12. Crankcase Breather System

- 12.1 Standard System**—The 5750 engine has a casting attached to the left side cover plate. This casting is tapped for 12.7 mm (1/2 in) pipe. An elbow may be inserted here and a short length of pipe extended vertically or to an exhaust system. A baffle on the inside of the plate prevents splash leakage.