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SAE 17.6 Cubic Inch Spark Plug Rating Engine

RATIONALE

Information updated to reflect current industry practice related to the spark plug rating engine system including highlights noted below:

- Updated engine assembly pictures
- Deleted references to original engine manufacturer that is no longer in business (Labeco)
- Added Section 8.2 for alternative electronic fuel injection system
- Removed section 16 on test procedure and referred to SAE J549
- Updated Appendix B1 Table and added drawings for spark plug inserts
- Updated Appendix C1 Table

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 Inch[1] Spark Plug Rating Engine. The background of its design, development, and applications is contained in SAE publication SP-243.

[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.

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.

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.

This Edition of the manual includes only the 5750 / 16047 series engine since it is the newer design and in use at many of the spark plug companies. The older type 5000 series was covered thoroughly in a previous edition of the manual (publication date, July 1964). The 5750 / 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.

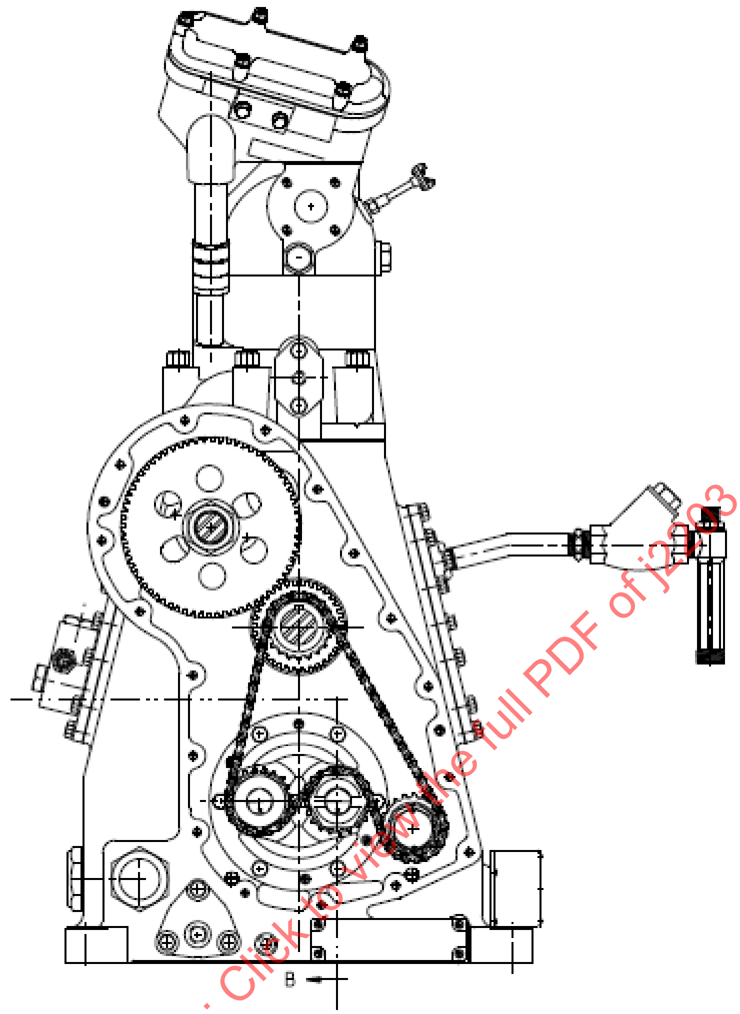

FIGURE 1A - THE 5750 / 16047 ENGINE

NOTE: Shown for illustrative purposes only.

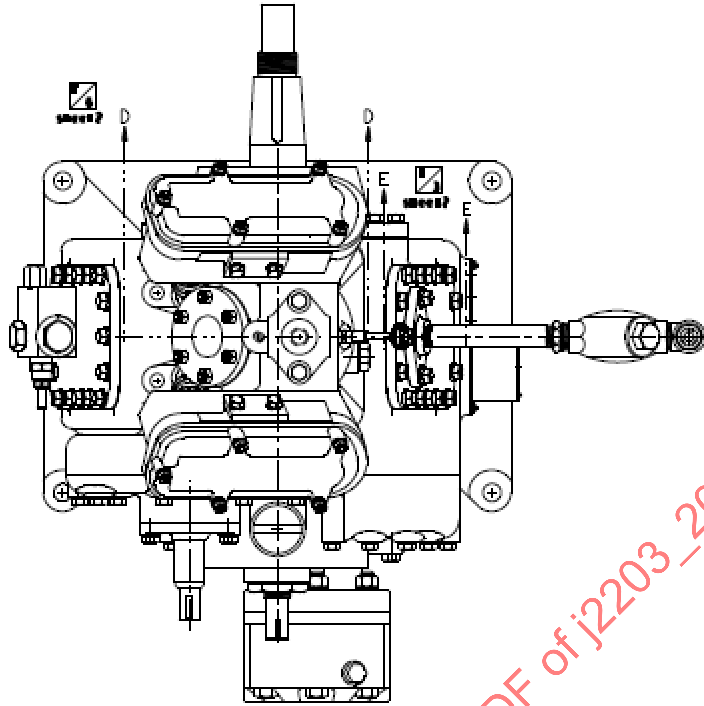

FIGURE 1B - THE 5750 / 16047 ENGINE

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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 Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J 549 Preignition Rating of Spark Plugs

SAE J973 Ignition System Measurements Procedure

SAE 630416 Automotive Fuels and Combustion Problems

SAE ARP890 Spark Plug Rating Calibration

ISO 15409 Road Vehicles - Heat Rating of Spark Plugs

AS840 Manual, July 1964

3. ABREVIATIONS

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
Btu	British thermal unit
Cal	calorie
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
g	gram
gal	gallons
HD	head
hex	hexagon
h	hours

Hg	mercury
HP	horsepower
Hz	hertz
/	per
ID	inside diameter
IMEP	indicated mean effective pressure
in	inches
kg	kilogram
K.O.	knock out
lb-ft	pound-feet
lb-in	pound-inches
m	meter
mm	millimeter
Mach.	machine
Mfg.	manufacturer
min	minimum or minute
misc	miscellaneous
mnt.	mounting
N-m	Newton-meter
No.	number
NPT	National pipe thread
NPTF	National pipe thread fuel
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	SAE International
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.

The cylinder head for both the older 5573 integral type (Figure 2) and the newer 16001 insert-type (Figure 4) will be described. On the 5573 type, 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 Table B1 in Appendix B.

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).

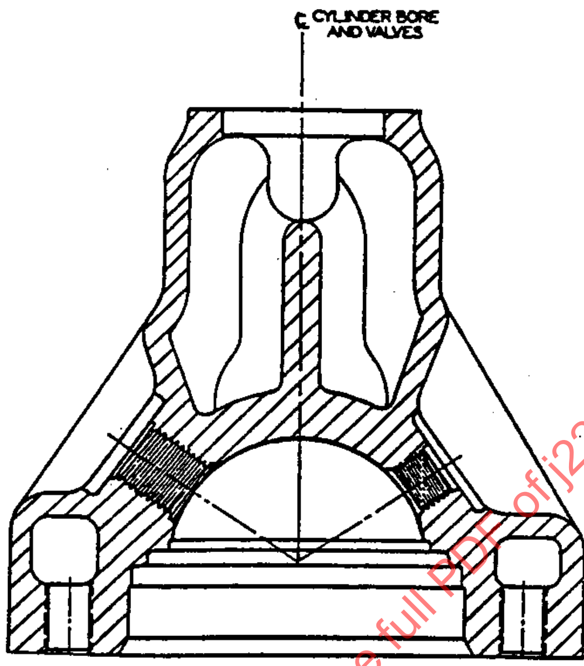


FIGURE 2 - INTEGRAL TYPE HEAD (PART # 5573)

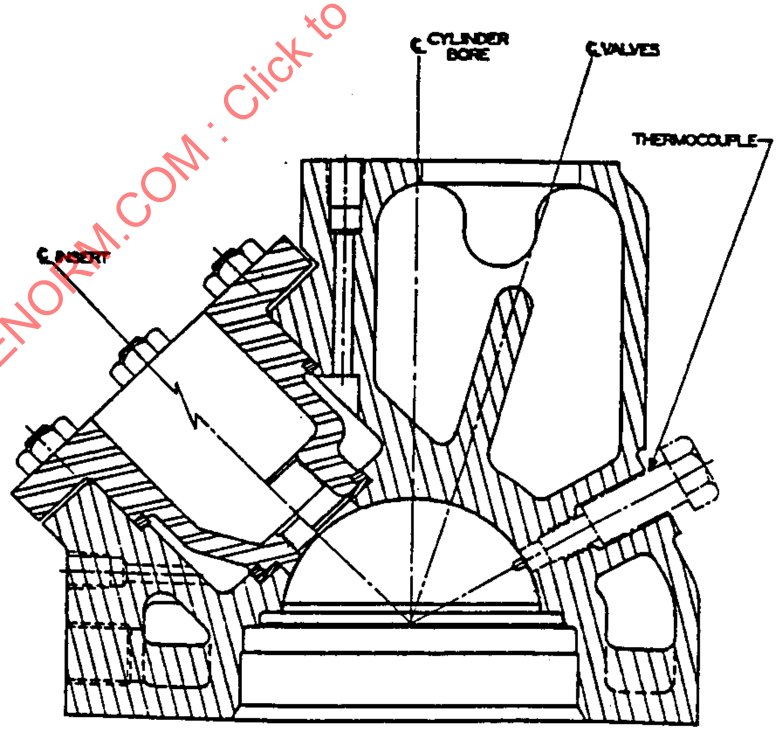


FIGURE 3 - INSERT TYPE HEAD (PART # 16001)

The 16001 head, which is now standard, incorporates spark plug boss inserts that are mounted into the cylinder head with six 8 mm (5/16 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 treated with Parco-Lubrite or other similar process to improve cylinder durability.

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, babbitt 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.

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. 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 °C ± 2.8 °C (225 °F ± 5 °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.

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 voltage magneto, one high voltage 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 voltage cables to the high voltage coil. The low voltage is transformed to high voltage by this coil and is conducted through a short length of high voltage 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 µs (maximum)

Arc Duration: 60 µs (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. Refer to section 16.1.1 for information on fuel type recommendation.

8.1 MECHANICAL FUEL INJECTION SYSTEM

The gear type, positive displacement fuel supply pump is driven at 600 rpm and has a capacity of 2.0 L/min ± 1.0 L/min (1/2 gal/min ± 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 µm filter before delivery to the fuel system.

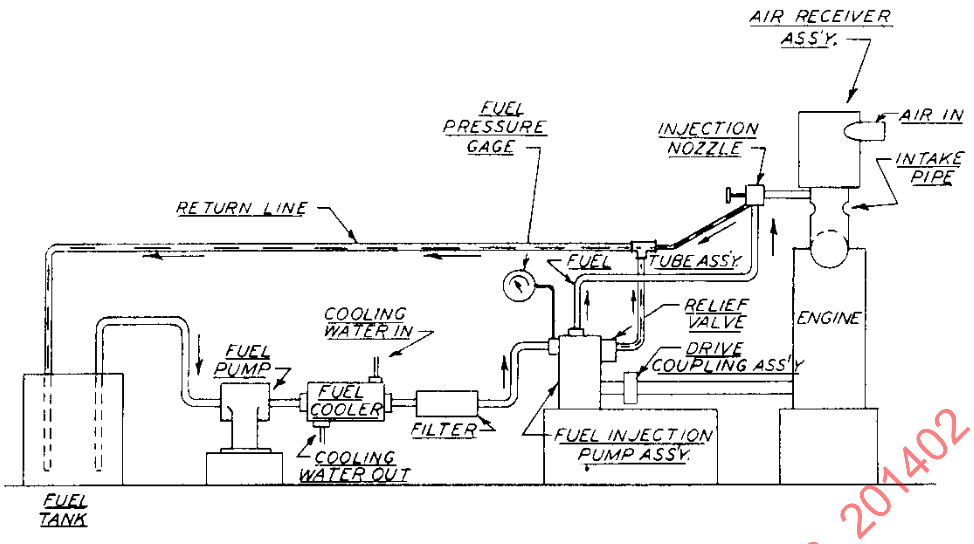


FIGURE 4 - SUGGESTED FUEL SYSTEM

The fuel injection pump assembly, a single cylinder Robert Bosch type PES1A80C 300/3RSX01 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 kPa ± 15 kPa (15 psi ± 2 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.

8.2 ALTERNATE ELECTRONIC FUEL INJECTION SYSTEM

Any commercially available electronic fuel injector and exhaust gas sensor closed loop control system will be satisfactory as long as it provides the fuel flow rate and pressure necessary to guarantee sufficient fuel delivery and atomization for engine operation.

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.

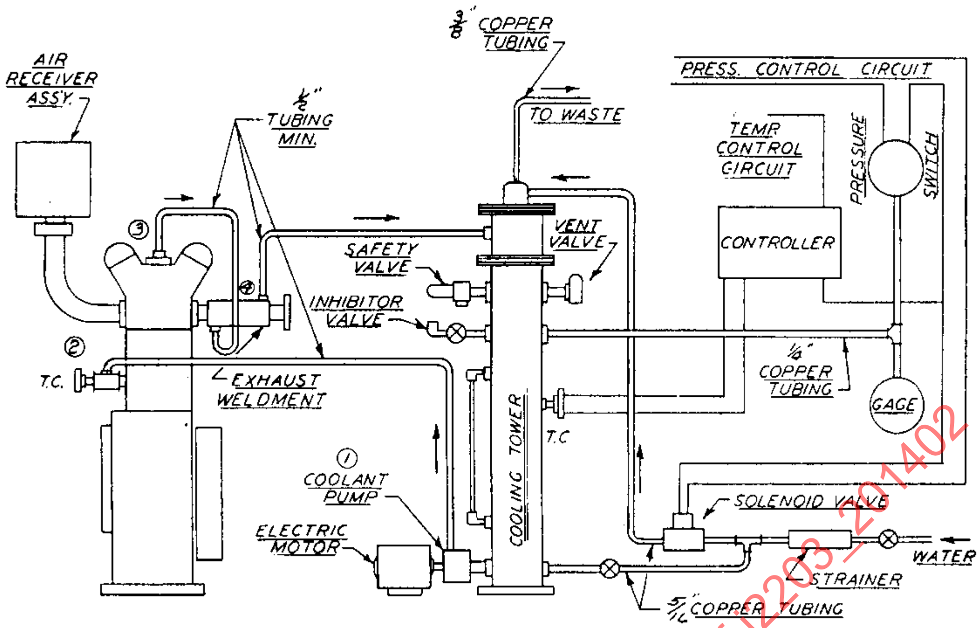


FIGURE 5 - SUGGESTED COOLING SYSTEM

The heat exchanger may be a commercial unit which has a rating of approximately 95 000 Btu/h (6650 g-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 / 16047 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 ± 35 kPa (100 psi ± 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.

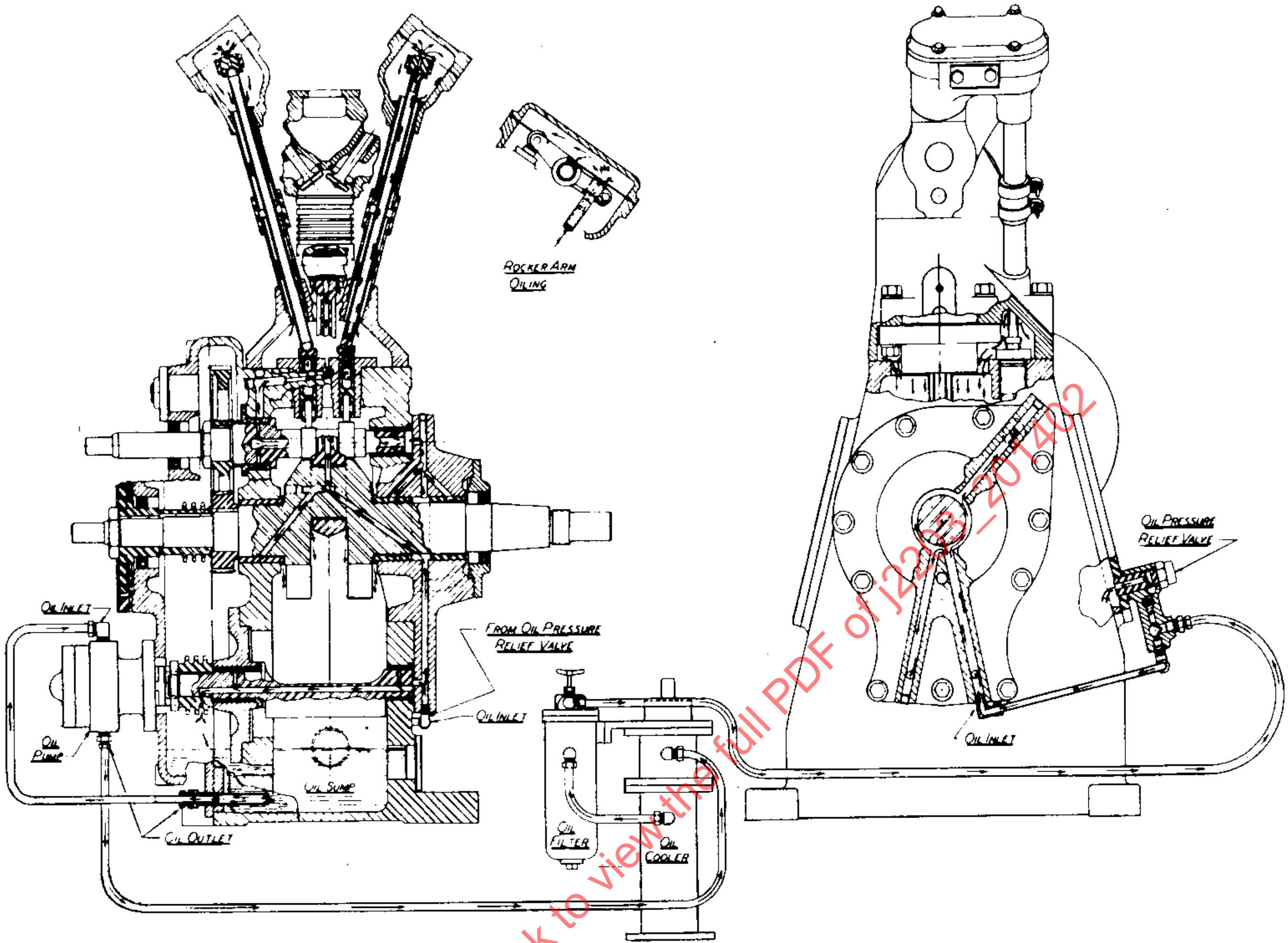


FIGURE 6 - #5750 / 16047 ENGINE LUBRICATION SYSTEM

10.1 Oil Filter

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 automotive high performance or 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 ideally 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 greater than 90% efficiency @ >45um when tested as shown in ISO 4548-12 at rated flow of the filter.

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. An additive for reducing varnish may be used if it is demonstrated to have no significant effect on engine pre-ignition or friction characteristics. 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.

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.

13. AIR SUPPLY SYSTEM

The air supply system consists of a compressor, an air/water separator tank, a float-operated valve, a water circulatory pump, a water level alarm, a normally closed solenoid valve, an air pressure regulator, two air heaters, an auto transformer, an air temperature controller, and miscellaneous electrical equipment.

The compressor used is of the centrifugal displacement type of pump (Nash MD574 or Nash 1251) and consists of a round, multiblade rotor that revolves freely in an elliptical casting partially filled with water. The rotor blades are curved and project radially from the hub and form, with the side shrouds, a series of pockets around the periphery. The rotor revolves at a speed high enough to throw the liquid out from the center by centrifugal force, resulting in a solid ring of liquid revolving in a casing at the same speed as the rotor, but following the elliptical shape of the casing. As the liquid follows the casing and withdraws from the rotor, the air is pulled in through two inlet ports located around the hub of the rotor and connected with the pump inlet. As the liquid is forced back into the rotor chamber by the casing, the air trapped in the chamber is compressed and forced out through two discharge ports located around the hub of the rotor and connected to the pump outlet. The water supplied to the pump takes up the heat of compression, the surplus water being discharged with the air.

The air/water separator consists of a tank that acts as a centrifugal separator by removing the sealing water from the air. As the mixture of air and water enters the separator tangentially, the water falls to the bottom and is dumped by a float-operated discharge valve located about one-third the way up the tank. Vertical baffles rise several inches above the water level and prevent the water in the base from spinning in a vortex and climbing the sides of the separator. Air is drawn off through a delivery pipe that projects some 3 in into the dome to prevent swirling water on the dome surface from creeping into the discharge air. The interior of the separator is galvanized as it is subjected to rather severe corrosive conditions due to being violently scrubbed with air-saturated water. Couplings are welded to the tank for drain, water level sight glass, thermocouples, and pressure taps.

The air delivered from the separator is in a saturated condition and may be cooled below its dew point and deposit water in the lines if the surrounding temperature conditions are suitable. In order to prevent such deposition of moisture, the air is discharged from the separator into a 3 kW line air heater. Current is supplied to an automatically-controlled heater to raise the temperature of the air a sufficient amount so that it will remain above the tank temperature to the next air heater located adjacent to the engine. Constant pressure is held at any predetermined value in the system by an air pressure regulator of the differential pressure diaphragm type, which bleeds off any excess air not used by the engine.

The air pressure delivered to the engine is controlled by a large valve 31.8 mm (1-1/4 in) gate and a small fine adjustment valve 3.18 to 12.7 mm (1/8 to 1/2 in) needle manually controlled. The throttle air passes through an inlet air heater into the engine air receiver assembly. With the equipment in this sequence, the expansion of the air at the throttle valves occurs before the heat is applied and regulation of manifold pressure and temperature is simplified. The inlet air heater consists of an enclosed 3 kW electric unit connected to the air receiver assembly by a flexible tube, preferably metallic, as rubber hose is likely to char. The inlet air heat is automatically controlled to 107.2 °C ± 2.8 °C (225 °F ± 5 °F) by suitable temperature control connected to a thermocouple located in the air receiver assembly. The across-the-line load of the heater is carried by a suitable normally open contactor, the holddown coil current being supplied by the controller.

The schematic layout of the air supply system is shown in Figure 7. As may be seen, the air is delivered to the compressor through a silencer and a check valve and fed together with the sealing water into the separator. The silencer is used to lower the noise level, the check valve to prevent the water from being blown back through the compressor when it is shut down. From the separator, the air goes through the line air heater to the engine throttle valves, through the inlet air heater into the engine. All the piping is 31.8 mm (1-1/4 in) galvanized and lagging is recommended for all long runs.

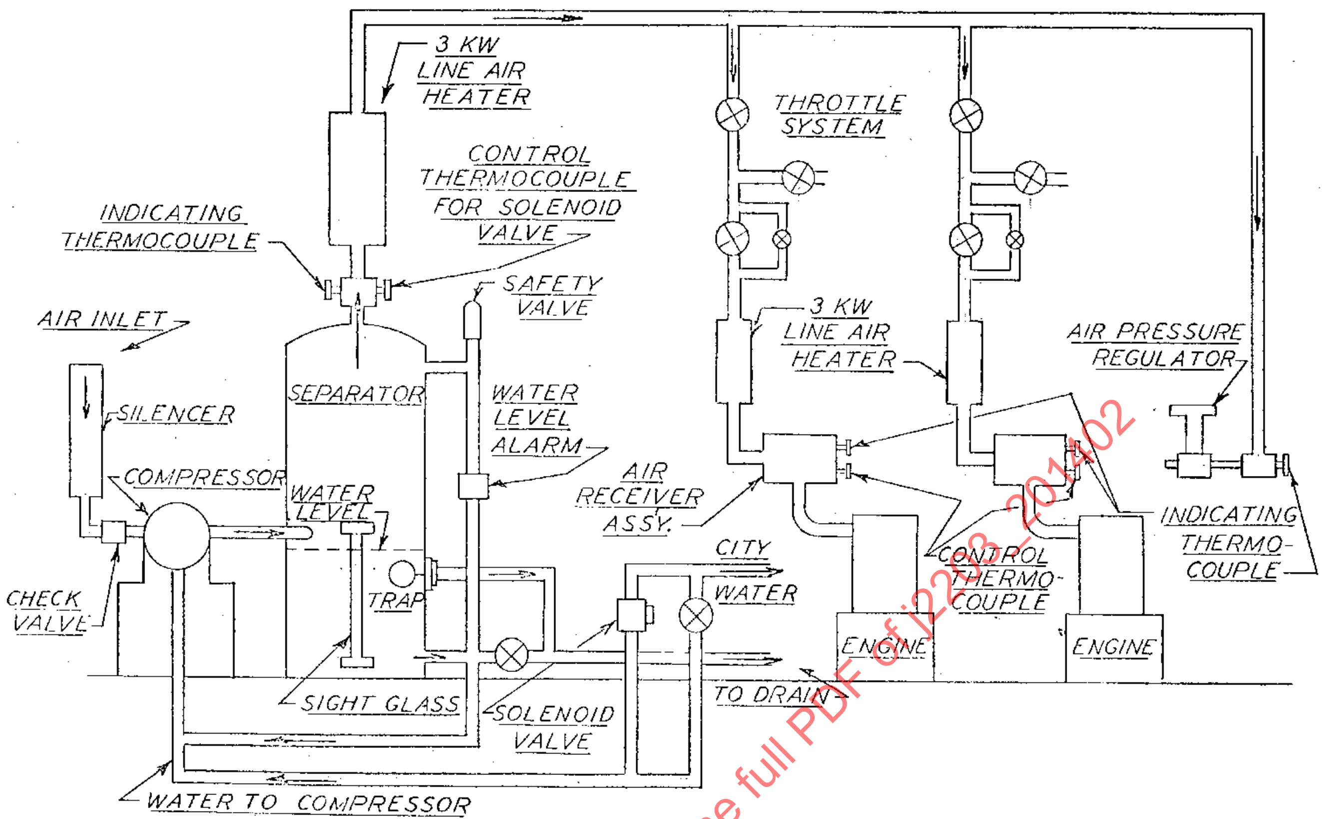


FIGURE 7 - AIR SUPPLY SYSTEM

To control the moisture content of the supercharging air at 75 grains ± 25 grains (4.85 g ± 1.62 g) of water per pound of dry air, the air pressure and air temperature in the tank must be held to essentially constant values. The temperature for various pressures to maintain this moisture content are as in Table 1:

TABLE 1 - TEMPERATURE FOR VARIOUS PRESSURES TO MAINTAIN MOISTURE CONTENT

System Pressure	Separator Tank Air Temperatures	Separator Tank Air Temperatures
	°C	°F
310 kPa (45 psi)	38.9	102
380 kPa (55 psi)	41.7	107
468 kPa (65 psi)	44.4	112

These temperatures are controlled by automatic regulation of the amount of water being admitted to the inlet of the water circulating pump, which in turn supplies the water under pressure to the compressor. This circulating pump must be started and pressure developed before the compressor is started. The sealing water is now in circulation through the system; it warms up due to heat of compression in the compressor. When the discharge air temperature reaches the specified separator tank air temperature, a normally closed solenoid valve is opened and cold water enters the system. The water supply must be at least 69 kPa (10 psi) higher than the compressed air pressure. The excess water goes out through the water float in the separator to the drain. When the discharge air temperature drops below the specified value, the solenoid closes and the water is again warmed by the compressor. A thermocouple mounted in the exit air line leading from the separator actuates the solenoid valve.

Two safety devices are incorporated in the installation. Mounted on the side of the separator is a water level alarm that rings a bell if the water rises in the tank and warns the operator that the water float valve has stuck. This can be connected to the compressor and/or the engine to automatically shut it off if desired.

To prevent the line air heater from burning up in the event the compressor fails, the line to the holding coil in the contactor for the heater is wired to the load side of the starter for the compressor motor. In this way, either seizure of the compressor or momentary power failure throws out the starter switch that has thermal overload protection and cuts the power to the heater.

WARNING: Extreme caution should be exercised in completely shutting off the throttle valves to the engine if the compressor is allowed to run while the engine is shut down for any length of time. If the throttle valve is just barely cracked to atmospheric pressure, the expansion of the humidified air results in the water falling out of the air in the pipe downstream from the valve and entering the air receiver assembly. Although this water may not be of sufficient depth to flow over the standpipe in the receiver and into the intake pipe with the engine stopped, there may readily be enough lying in the bottom of the receiver to climb its walls in a vortex as the airflow through the receiver increases due to its tangential air entry. As the engine is of such small displacement, sufficient water may collect in the inlet air heater or throttle valve assembly to wreck the engine if allowed to enter the cylinder. If there is the slightest doubt that water has collected in the system, first, drain the receiver by the plug provided at the bottom of the casting; second, remove the spark plug and motor the engine with gradually increasing air velocity into the intake pipe. Such a procedure will safely remove all water and bent connecting rods; caved-in pistons and broken cylinders will be avoided.

14. MAINTENANCE AND OVERHAUL PROCEDURE

14.1 General

It is strongly recommended that inspection of engine components be avoided unless there are obvious signs of trouble. Frequent teardown of the engine not only is unnecessary and time-consuming, but greatly increases the possibility of damage to the engine parts through careless handling.

With proper attention, the crankcase should run 5000 h before teardown inspection and overhaul are required. The need of an overhaul or replacement of any engine part or assembly in most instances is quite evident. A deep rumbling type of knock usually denotes main bearing failure; a high-pitched rattle, a loose wrist pin, and a high-pitched howl or whine indicates timing gear trouble. Oil seepage at the camshaft or crankshaft extensions through the crankcase denotes oil seal failures. Excessive clatter in the rocker boxes indicates either wear of the rocker roller pin, wear of the rocker arm thrust washer, valve spring interference, or excessive tappet clearance. Loss of oil pressure may denote wear in the pump, loosening of the pump body from the crankcase, a plugged inlet line, a relief valve stuck open, or bearing failure. Runaway coolant temperatures may mean either vapor locking in the coolant pump, seizure of the pump, or failure of the driving motor. Missing may be caused by spark plug failure, ignition cable failure, magneto trouble, injection pump plunger sticking, vapor locking of the fuel in the injection pump, fuel supply pump failure or perhaps by simply being too lean. Continued experience with the engine will make the operator familiar with the general noise level of the unit and more able to diagnose any symptoms accurately. In the event of any sign of distress, the fault should be found and repaired immediately, not allowed to continue until major damage has been done to the engine.

The need for having a valve job or reringing is not usually as evident and will be covered in some detail. Under normal routine operation, valve reconditioning periods of 150 h are sufficiently conservative, but engine performance is still the best indication for the need of an overhaul as service under conditions of severe preignition at high IMEP may bring the time period under 100 h. It is desirable to check the compression pressure periodically. Compression pressure should be approximately 790 kPa (115 psi) at 900 rpm. At any fixed set of engine conditions, there is a definite boost-IMEP relationship that is a straight line function as shown in Figure 8 and should be used to determine when the engine is in good condition. At high power levels, plotted points will fall below this curve if valves or rings are bad. A positive valve check may be made by removing the intake pipe and exhaust pipe weldment, turning the engine flywheel by hand until the piston is at bdc on the compression stroke, pouring gasoline into the valve ports covering the valve heads, and bringing the piston to tdc on the compression stroke by turning the flywheel with the hands. If valves or seats are in bad condition, the leakage of air past the valve through the gasoline is readily visible.

The most positive check of oil pumping is inspection of the piston head by means of a light (a medical diagnostic type is best) inserted through a spark plug hole. If the cylinder bore looks scuffed or scored and the piston head flooded with oil, it can readily be assured that the rings are also scuffed and possibly either stuck or broken. If the cylinder bore looks good and more than a film of oil is present on the piston head after shutting down the engine from 2700 rpm, reringing is generally indicated providing the rings are not new or have not just been cleaned. If the rings are either new or have been recently removed from the piston for cleaning, additional running is necessary to establish a good seal between the ring faces and the cylinder bore. Usually this can be accomplished by operating the engine at 2.415 MPa (350 psi) IMEP for 2 to 3 h.

The most common reason for high oil consumption is excessive ring side and end clearance. The compression rings have a minimum of 0.1 mm (0.004 in) of chrome plate and can readily accept 0.05 mm (0.002 in) average wear on the face without possible danger of wearing through the plate. Thus, an end clearance increase of 0.3 mm (0.012 in) could be tolerated. The limits of the end and side clearances are listed in Appendix A. Rings that show any signs of scuffing should be replaced. If one ring requires replacement, all rings should be replaced.

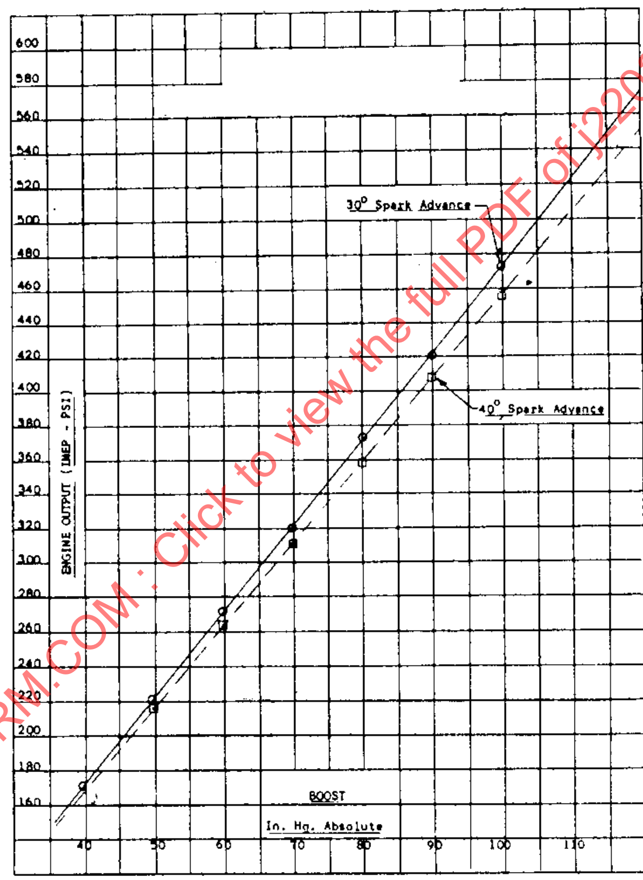


FIGURE 8 - ENGINE BOOST VERSUS OUTPUT POWER CURVES AT MAXIMUM THERMAL PLUG TEMPERATURE

14.2 Detailed Disassembly of 5750 Engine

14.2.1 Removal of Cylinder Assembly

a. Disconnect all accessories.

b. Remove intake pipe and exhaust pipe weldment.

c. Remove rocker box covers.

d. Fasten a wire clip, Part No. 5700, to each push rod and its respective rocker arm to prevent the push rods from falling out as the cylinder is lifted.

e. Remove the six nuts holding the assembly to the crankcase.

f. Bring the engine to bdc.

g. Lift the assembly from the crankcase, being sure not to allow the piston to fall against the crankcase.

h. Remove the push rods.

14.2.2 Removal of the Piston

a. Repeat 14.2.1.

b. Push out full floating piston pin and remove piston.

c. Remove the piston rings being careful not to spread the rings more than necessary for removal. A perfect circle ring expander may be used.

14.2.3 Removal of Cylinder Head Assembly

a. Repeat 14.2.1.

b. Loosen the clamps on the push rod housing hoses and push the hoses down onto the lower push rod housing.

c. Remove the ten bolts holding the head assembly to the cylinder.

d. Remove the head from the cylinder. These will pull apart easily once the gasket seals are broken loose.

14.2.4 Removal of the Cylinder Sleeve[2]

a. Repeat 14.2.3.

b. Remove the two 9.5 mm (3/8 in) socket head capscrews on the lower face of the sleeve flange.

c. Remove the sleeve from its housing.

[2]Not to be done unless replacement is necessary.

14.2.5 Removal of the Valve Gear

a. Repeat 14.2.3.

b. Remove the rocker shaft cover.

c. Push out the full floating rocker shaft with the fingers.

d. Lift out the rocker arms and thrust washers.

e. Compress the valve springs and remove the valve spring retaining keys. Use compressing tool, Part No. 5254.

f. Remove valve springs, retainers, spacer, and valves.

14.2.6 Removal of the Ignition Timing Disc

a. Remove the ignition timing disc quadrant support.

b. Bend back the ear of the lock washer that anchors the nut on the front end of the crankshaft.

c. Remove the front crankshaft nut and lock washer.

d. Remove the disc by pulling with the fingers.

14.2.7 Removal of the Timing Disc Space Sleeve from the Crankshaft (if present)

a. Remove with puller, Part No. 5702.

14.2.8 Removal of the Oil Pump

a. Remove four 9.5 mm (3/8 in) nuts and washers.

b. Remove oil pump and Oldham coupling.

14.2.9 Removal of Timing Gear Case Cover

a. Repeat 14.2.7.

b. Remove the cap screws holding the casting to crankcase.

c. Remove the cover. Use cap screws in the two tapped holes provided and jack the cover loose.

14.2.10 Removal of the Counterbalance Drive Chain

a. Remove socket head locking screw from idler sprocket bushing bolt.

b. Remove idler sprocket bushing bolt.

c. Remove idler sprocket and bushing.

d. Remove drive chain.

14.2.11 Removal of the Camshaft Assembly

a. Repeat 14.2.1.

b. Repeat 14.2.9.

c. Remove the valve lifter guides from the crankcase top deck.

d. Remove the valve lifters through the crankcase.

e. Remove the cap screws holding the front shaft bearing to the crankcase.

f. Remove the camshaft together with its driving gear and front camshaft bearing.

14.2.12 Removal of the Camshaft[3]

a. Repeat Steps a, b, c, and d of 14.2.11.

b. Bend back the ear of the lock washer that anchors the nut on the front of the camshaft.

c. Remove the camshaft nut and lock washer. Use socket wrench, Part No. 5703.

d. Repeat Steps e and f of 14.2.11.

e. Remove the timing gear from the camshaft. Use an arbor press to press the camshaft out of gear, taking care not to foul the front bearing.

14.2.13 Removal of the Crankshaft Sprocket and Timing Gear

a. Repeat 14.2.9.

b. Remove crankshaft sprocket with suitable puller.

c. Remove timing gear. Use the puller, Part No. 5704.

14.2.14 Removal of the Flywheel

a. Bend back the ear of the lock washer that anchors the flywheel nut.

b. Remove the flywheel nut and lock washer. Use the socket Part No. 5705.

c. Thread on the collar, Part No. 5706, over the crankshaft threads.

d. Remove the flywheel. Use a suitable puller and do use a chain fall or get help to lift it off the shaft.

[3] Only to be done if obviously damaged.

14.2.15 Removal of the Crankshaft Rear Oil Retainer

a. Remove the flywheel key.

b. Remove six cap screws and washers.

c. Remove crankshaft oil retainer. Use 9.5 mm (3/8 in) cap screws in the two holes tapped in the flange.

d. Remove gasket.

14.2.16 Removal of the Connecting Rod

a. Repeat 14.2.2

b. Remove the crankcase side cover assembly (breather side).

c. Remove the cotter keys in the connecting rod bolts and the nuts.

d. Remove the connecting rod cap. Use a composition hammer and tap the cap lightly, first on one side and then on the other.

e. Remove the connecting rod.

14.2.17 Removal of the Crankshaft Rear Bearing Adapter

a. Repeat 14.2.14.

b. Repeat 14.2.15.

14.2.18 Removal of the Counterbalance Assembly

a. Remove six cap screws and washers.

b. Remove assembly. Note locating dowel on top flange.

14.2.19 Removal of the Counterbalance Shafts

a. Mount the counterbalance assembly in a soft jaw vise, using the flats on the counterbalance shafts.

b. Bend back ear of the lock washer on right-hand shaft.

c. Remove both nuts with suitable wrench.

d. Remove sprockets and bearing adapter.

14.3 Detailed Inspection and Assembly of 5750 Engine

14.3.1 Counterbalance Assembly

a. Inspect the counterbalance shaft bearing journals for galling and wear. See Appendix A for dimensions.

b. Inspect front and rear counterbalance shaft bushings for wear. See Appendix A for dimensions. Replace if required. Bushings are a push fit.

c. Inspect sprockets for excessive wear and replace, if required.

d. Insert counterbalance shafts in bearing adapter. Clamp in a soft jaw vise. (The shafts are interchangeable.)

e. Replace sprockets. Dowel pin hole in adapter indicates top. Use vertical keyway on left-hand shaft and horizontal keyway on right-hand shaft. This is to align the chain oiling hole in the sprocket and the shaft.

f. Replace nuts using a lock washer on the right-hand shaft only. The nut on the left-hand shaft has a slot for an Oldham coupling.

g. Install assembly in crankcase. No gasket used.

14.3.2 Crankshaft

a. Inspect the crankshaft for galling and for wear of the bearing journals. See Appendix A for dimensions.

b. Inspect main bearings for any sign of failure and wear. See Appendix A for dimensions.

c. Insert crankshaft through the front main bearing, being careful not to nick bearing with threads or shoulders of crankshaft.

d. Clean mating surfaces of crankcase and rear main bearing adapter, removing any nicks or burrs.

e. Install gasket dry or with soft soap.

f. Install rear main bearing adapter, being careful not to nick bearings on shoulders of crankshaft. Alignment is assured by the piloted shoulder on the adapter.

14.3.3 Crankshaft Rear Oil Retainer

a. Clean mating surfaces of crankcase, rear bearing adapter and rear oil retainer. Inspect oil seal and replace if necessary.

b. Install gasket.

c. Install retainer on adapter.

14.3.4 Crankshaft Timing Gear

a. Inspect the gear teeth, bore and faces, and remove any nicks and burrs.

b. Insert the Woodruff drive key in the crankshaft.

c. Align the gear on the shaft with the side outward having an “X” on one tooth. Tap gently with a composition hammer to start.

d. Press the gear on the crankshaft. Push it on using the front crankshaft lock nut and the tool, Part No. 5708.

e. Install crankshaft chain sprocket.

14.3.5 Camshaft

a. Inspect cams and bearing journals for signs of galling or wear and replace if necessary.

b. Inspect camshaft bearings. See Appendix A for clearance.

c. Install the camshaft and its front bearing.

d. Check end play. See Appendix A for clearance.

14.3.6 Camshaft Drive Gear

a. Install Woodruff key in the camshaft.

b. Reinstall gear using original keyway. Use arbor press.

c. Install camshaft assembly with the “X” marks on the gears mating.

d. Install the camshaft gear lock nut and lock washer.

e. Bend a shoulder of the lock washer over a flat on the camshaft nut.

When new timing gears are to be installed, the assembly procedure is as follows: Install the crankshaft timing gear on the crankshaft so that the puller holes on the front face of the gear face outward. Normally select the center keyway of the camshaft gear for the initial timing check. The front of the camshaft gear may be identified by the 9.5 mm (3/8 in) hub extending from the web to the face of the gear; the rear has a 3.2 mm (1/8 in) hub extending to the face of the gear. Install the Woodruff key in the camshaft and press the gear on to the camshaft, using the center keyway in the gear and the front of the gear extending outward.

Set the crank angle and flywheel at 28 degrees atc on the flywheel indicator. Using the intake valve lifter and intake lobe of the camshaft for the initial setting, install the camshaft assembly mating with the crankshaft gear in such a position that the intake valve lifter is raised approximately 1.0 mm (0.040 in) on the ramp of the camshaft in the direction of engine rotation on the opening side of the intake cam lobe, with the camshaft bolted in the running position.

Then, using an indicator on the intake valve lifter, turn the flywheel toward tc or to a point before top center where there is no movement on the indicator needle. Then turn the flywheel in the direction of rotation and observe when you get 1.0 mm (0.040 in) lift on the intake valve lifter from the indicator and check flywheel degrees to see if the timing is within the limits listed in this section.

If the valve lifter rise does not fall within the limits, it will be necessary to shift the camshaft and gear assembly one or more teeth in the proper direction to bring the timing within the limits. If this operation does not bring the timing within the limits, then remove the camshaft gear and reinstall it on the camshaft, using one of the other two keyways of the gear; reassemble camshaft and gear assembly in the crankcase and repeat preceding procedure. Since this is a cut-and-try procedure, it may be necessary to try all three keyways of the cam gear before the timing will follow the timing data.

After the engine is timed correctly, set the engine on tdc of the firing stroke and make suitable markings on the teeth of the timing gears and camshaft gear keyway.

The camshaft timing, with the engine completely assembled and valve clearance set at 1.26 mm (0.050 in) is as follows (Figure 9):

Intake valve opens at 28 degrees atc ± 5 degrees atc

Intake valve closes at 22 degrees abc ± 5 degrees abc

Exhaust valve opens at 23 degrees bbc ± 5 degrees bbc

Exhaust valve closes at 1 degree btc ± 5 degrees btc

The valve clearance then must be reset to 0.46 mm (0.018 in) before running the engine.

NOTE: When checking the timing, some thought must be given that wear on the rocker arm rollers and pins, valve lifter rollers, hubs, and pins will cause some lag in the timing characteristics; so for a true check, all above parts should be within the recommended clearances. A 10-degree tolerance is allowed for a used cam before replacement is required.

14.3.7 Valve Lifter Assemblies and Guides

a. Inspect parts for galling or wear. Replace if necessary. See Appendix A for clearance.

b. Install assembly and guide as a unit holding fingers under valve lifter during installation to prevent dropping into crankcase.

14.3.8 Counterbalance Drive Chain

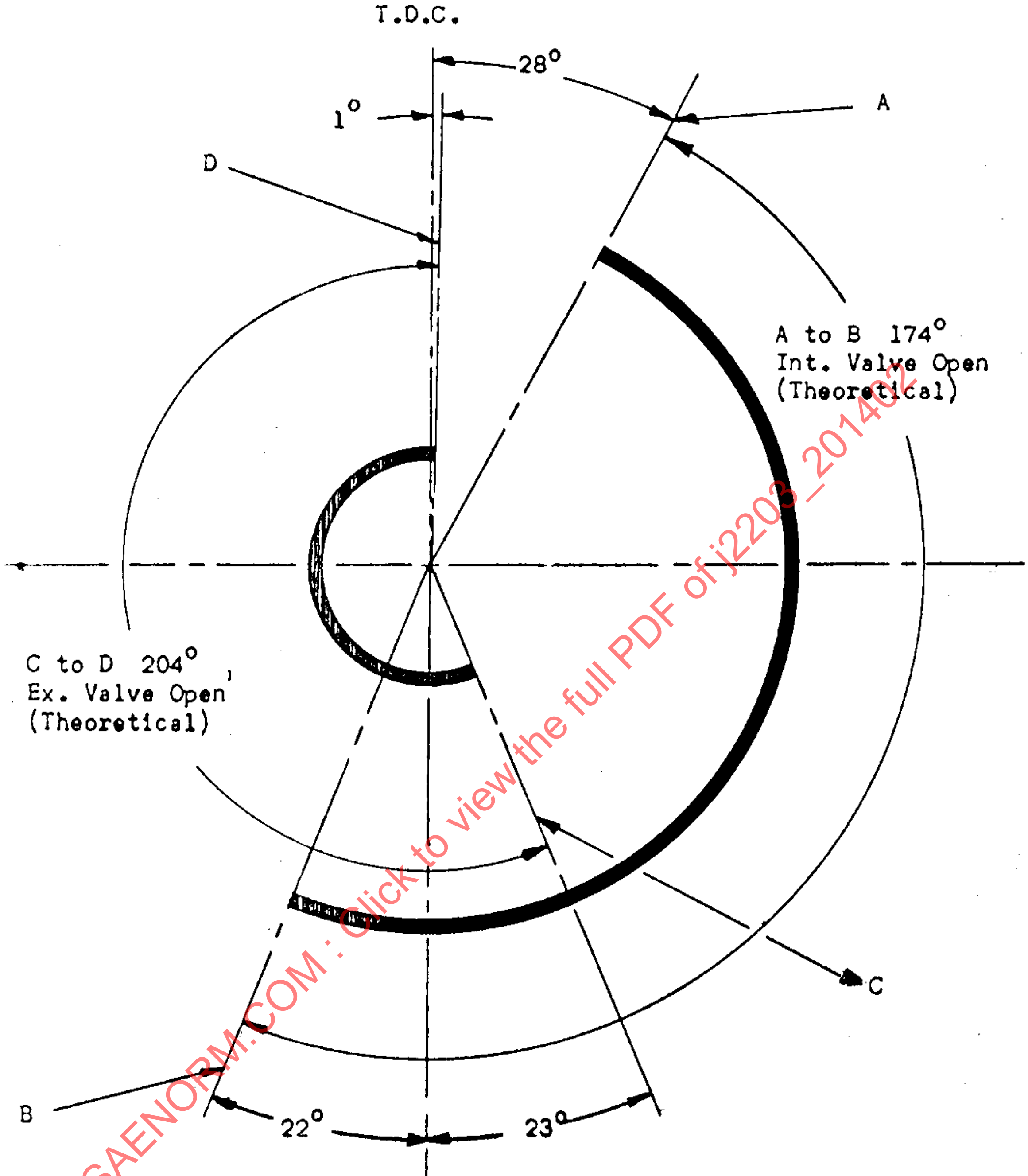
a. Place crankshaft at top dead center.

b. Install counterbalance drive chain over crankshaft sprocket, under left-hand counterbalance driveshaft sprocket and over right-hand counterbalance driveshaft sprocket. Arrows on counterbalance shafts should point down.

c. Install idler sprocket bushing into idler sprocket.

d. Insert bolt. Tighten chain by turning eccentric bushing until it has 6.35 mm (1/4 in) deflection measured midway between the idler and crankshaft sprockets.

e. Lock idler sprocket bolt to idler sprocket bushing with Allen set screw. With chain tight, the arrows on the counterbalance shafts may not be exactly parallel.



A Point .050″ Intake Tappet Lift
B Point .050″ Before End Intake Tappet Travel
C Point .050″ Exhaust Tappet Lift
D Point .050″ Before End Exhaust Tappet Travel
Maximum Cam Lift = Intake .274″, Exhaust .280″
Lift Angle Tolerances ±5°

FIGURE 9 - VALVE TIMING DIAGRAM 1.26 MM (0.050 IN) (VALVE CLEARANCE)
(COURTESY OF LABORATORY EQUIPMENT CORP.)

14.3.9 Timing Gear Case Cover

a. Inspect mating surfaces of crankcase and cover.

b. Inspect oil seals and replace if necessary.

c. Install gasket and timing gear case cover.

14.3.10 Install Timing Disc Spacer Sleeve

14.3.11 Oil Pump

a. Inspect pump for bushing wear and back lash. See Appendix A for clearances.

b. Insert Oldham coupling.

c. Inspect mating faces of pump and timing gear cover and install gasket.

d. Mount oil pump.

14.3.12 Flywheel

a. Lift the flywheel and slip it on the crankshaft over the flywheel key with dummy nut, Part No. 5706, on threads. Remove dummy nut after the flywheel is in place.

b. Install the flywheel nut and lock washer. Tighten until the flywheel is well driven onto the crankshaft taper. Bend one side of the washer over the nut as an anchor.

14.3.13 Connecting Rod

a. Inspect the big end bearing and replace if scored or cracked. See Appendix A for dimensions. Avoid scratching the bearing during measurement. Use a snap gage, not inside calipers.

b. Inspect the wrist pin bushing. See Appendix A for fit.

c. Install by lowering upper end together with its bearing onto crankshaft journal and raising the cap with its bearing into place.

d. Draw up the connecting rod belts, using a torque wrench and 61.0 to 67.8 N-m (45 to 50 lb-ft) torque. Use cotter pins to secure the nuts to the bolts.

14.3.14 Cylinder Head

a. Remove spark plug insert and spark plug insert gaskets.

b. Remove combustion chamber deposits.

c. Inspect the valve seat inserts for looseness. This may be determined by inserting a close fitting pilot in the valve guide and measuring seat concentricity before and after tapping the insert on its back shoulder. Replace inserts if found loose.

d. Inspect the valve guides. Replace if scuffed, if bell-mouthed more than 0.6 mm (0.0025 in) or if I.D. of the intake and exhaust is greater than 10.9 mm (0.438 in). If new guides are needed, do not hammer them in. Do press them in with the tool, Part No. 5709, and finish ream to 10.9 mm (0.4365 in) for both the intake and exhaust.

e. Install a close fitting pilot in the valve guide and measure the runout of the inserts with a suitable indicator. If the runout exceeds 0.5 mm (0.002 in) or if the insert is pitted, burned, or corroded, refacing is necessary. Using a suitable grinder and 45 degree stones with true faces, grind the insert, first using a coarse stone and finishing with a fine stone, removing as little metal as necessary. Runout of the ground face should not exceed 0.025 mm (0.001 in). See Figures 10 to 13 for refacing limits and method of checking. Care should be exercised that intake valves are not installed in exhaust seats. To assist in identification, a dimple has been machined in the intake valve heads, and a bump has been left on the exhaust valve heads. The previously mentioned drawings illustrate these identifying markings.

f. Inspect the valves. Replace if bent, galled, or burned. See Appendix A for clearance. If the stems are lightly scuffed, remove the marks by stoning and lapping. Clean the valve heads and stems with fine steel wool. Do not clean them with a hard scraper. Reface, removing as little material as possible to provide a clean face having a 45 degree angle. If the valve face is 5.6 mm (7/32 in) or wider, replace.

g. Lap the valve face to the seat, first using a coarse regrinding compound and following with a fine compound. Lapping should be continued until blueing shows the seats on both valve and insert to be concentric. The valves shall withstand 690 kPa (100 psi) air pressure without leakage.

h. Completely and thoroughly wash the head in kerosene to remove all ground metal and grinding compound.

i. Inspect the rocker arm thrust washers and replace if galled.

j. Inspect the rocker arm needle bearings and replace if necessary. Press them in, using the tool, Part No. 5710, always with the lettered side of the bearing out.

k. Inspect the rocker arm shafts and replace if any Brinelling is evident.

l. Inspect the rocker arm rollers and pins. Replace if worn or galled.

m. Check valve springs for fractures. See Appendix A for load limits.

n. Place the thrust washer and the lower retaining washer over the valve guide in each rocker box.

o. Compress the valve springs, slip in the valve, and place the retaining keys on the valve stem, release the valve springs. Use the tool, part No. 5245.

p. Push the rocker shaft from the lower side of the rocker box, through the rocker arm, the thrust washer, and the upper side of the rocker box. Use the drift, Part No. 5701.

q. Install rocker shaft covers, washers, and gaskets.

r. Check the thrust washer side clearance. If below 0.025 mm (0.001 in), lap the washer, if above 0.33 mm (0.013 in), replace it.

s. Check the mating surfaces between the head and cylinder housing and remove any nicks or burrs.

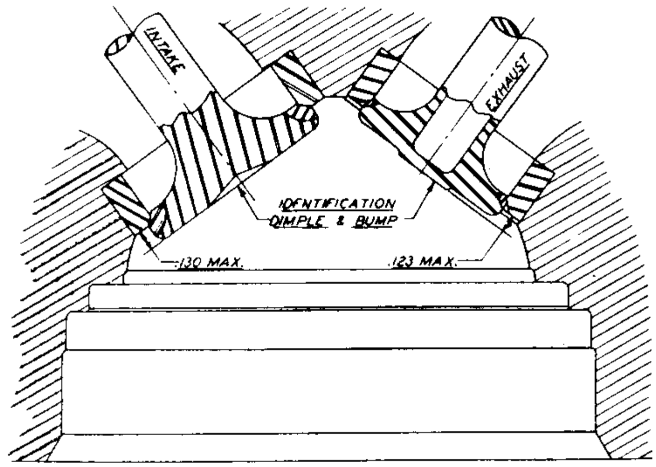


FIGURE 10 - PROPER VALVE SEATING IN NEW CYLINDER HEAD

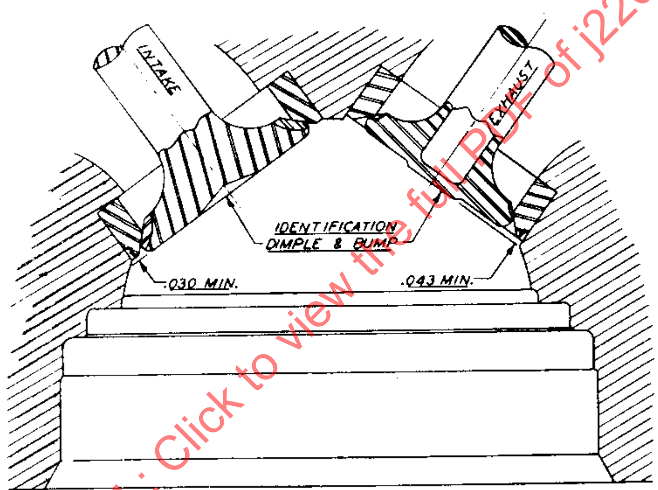


FIGURE 11 - PROPER VALVE SEATING WITH REFACED VALVES AND REGROUND SEATS

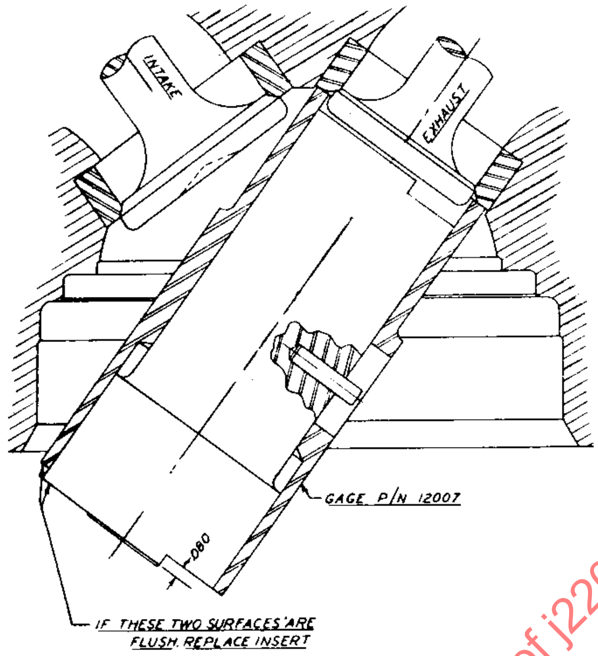


FIGURE 12 - METHOD FOR CHECKING EXHAUST VALVE SEATING LIMITS

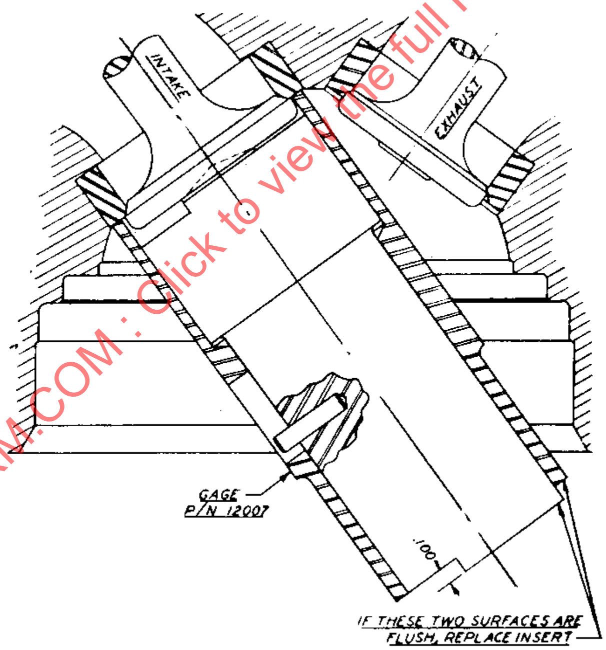


FIGURE 13 - METHOD FOR CHECKING INTAKE VALVE SEATING LIMITS

14.3.15 Cylinder Assembly

a. Remove deposits with steel wool.

b. Inspect. See Appendix A for dimensions.

c. Check mating surfaces between sleeve flange and cylinder housing, removing all burrs and nicks.

d. Install copper gasket on sleeve outer ring sealing surface and 0.2 mm (0.007 in) thick nonmetallic gasket on sleeve flange.

e. Assemble sleeve and housing, using the two 9.5 mm (3/8 in) socket head cap screws.

f. Check all mating surfaces between cylinder housing and cylinder head, removing any burrs or nicks.

g. Install 0.2 mm (0.007 in) thick nonmetallic gasket between cylinder housing and cylinder head, and dry copper gasket between sleeve and cylinder head.

h. Fasten cylinder barrel assembly to cylinder head, using bolts with solid copper gaskets under the bolt heads, tighten the bolts evenly, using a torque wrench and 81.4 to 101.7 N-m (60 to 75 lb-ft) torque. Tighten bolts in an accepted sequence. Use a socket wrench with a torque measuring device.

14.3.16 Piston Assembly

a. Remove deposits with a stiff brush, steel wool, or a scraper made by flattening the end of a copper tube. Do not use a wire brush or a buffing wheel.

b. Check piston for nicks and dents.

c. Check piston boss. Replace piston if scored or cracked.

d. Check for concentricity. Replace piston if skirt is more than 0.2 mm (0.007 in) out of round.

e. Inspect piston pin. Replace if worn or galled.

f. Remove ring deposits with steel wool.

g. See Appendix A for clearances.

h. If one ring is replaced, replace all rings.

i. Place the rings on the piston in the order removed. Install the compression rings with the inside bevel, if any, toward the piston head. Do not twist the rings and do not expand more than just enough to clear the piston. Do use a suitable expander and do expand them only enough to clear the piston.

j. Install the piston and its rings in the ring compressor, Part No. 5711.

k. Insert the piston pin through the piston bosses and connecting rod bushing. Do not drive it into position.

14.3.17 Cylinder Assembly to Crankcase

a. Examine mating surfaces of cylinder housing and crankcase deck.

b. Install the gasket on the crankcase deck.

c. Install the piston in the cylinder barrel by aligning the ring compressor I.D. with the bore of the cylinder and lowering the cylinder over the piston assembly. Remove ring compressor.

d. Insert the push rods and retain in position with wire clips.

e. Lower the assembly slowly, guiding all elements into proper alignment.

f. Tighten the assembly to the crankcase using a torque wrench and 61.0 to 67.8 N-m (45 to 50 lb-ft) torque on the hold-down nuts. Tighten bolts in an accepted sequence. Use a socket wrench with a torque measuring device.

g. Remove push rod wire clips and clamp the push rod housing hoses to the push rod housings.

h. Adjust the tappets to 0.45 to 0.50 mm (0.018 to 0.020 in) with engine hot and tighten the clamp screws.

i. Inspect mating surfaces on rocker boxes and covers.

j. Install rocker box cover gaskets.

k. Bolt covers to rocker boxes.

l. Install accessories.

15. ENGINE RUN-IN SCHEDULE

The run-in schedule for a new or rebuilt engine is dictated by the rapidity with which the rings and cylinder sleeve bore run-in, provided bearing clearances follow recommendations and lubrication is adequate.

The engine schedule recommended for a new or rebuilt engine is shown in Table 2.

If the power absorption equipment is such that the speed schedules in Table 2 cannot be followed, the best compromise available is acceptable.

TABLE 2 - ENGINE RUN-IN SCHEDULE FOR NEW OR REBUILT ENGINES PLUS USED CYLINDER AND NEW RINGS

Hr	RPM	Operating Conditions mm (in) Hg abs.	Operating Conditions Jacket Temp. °C (°F)	Operating Conditions Air Temp. °C (°F)
1	900 Firing	762 (30)	87.8 (190)	43.3 (110)
1	1800 Firing	762 (30)	87.8 (190)	43.3 (110)
2	2700 Firing	762 (30)	87.8 (190)	107.2 (225)
2	2700 Firing	1016 (40)	87.7 (190)	107.2 (225)
1	2700 Firing	1270 (50)	87.8 (190)	107.2 (225)
1	2700 Firing	1524 (60)	87.8 (190)	107.2 (225)
At this point, spark plugs may be rated at 200 IMEP or lower.				
1	2700 Firing	1778 (70)	87.8 (190)	107.2 (225)
1	2700 Firing	2032 (80)	87.8 (190)	107.2 (225)

NOTE: On installations equipped with pressure coolant control, jacket temperature should be maintained at 107.2 °C (225 °F).

The schedule shown in Table 2 is conservative for most cases as run-in can be accomplished in less time. It is recommended that the engine be shut down before each change of operating conditions and the cylinder inspected with a light through the spark plug hole for any signs of scratching or scuffing. Any indication of distress is considered to be sufficient reason to drop back on the run-in schedule and operate longer at less severe conditions. When the barrel has reached a proper run-in condition, the surface is free from grinding marks and scratches and presents a glazed or mirror-like appearance that is broken only by the knurling marks.

Such a schedule of run-in gives more than ample time to run-in any other bearing surfaces. Main bearings, connecting rod bearings, camshaft bearings, and gears require only 5 h running to be able to withstand severe duty and 1 h running is usually adequate for crankshaft oil seal rings, carriers, and races. One hour's running at 2700 rpm with 762 mm (30 in) Hg abs. boost and 1 h running at 2700 rpm with 1524 mm (60 in) Hg abs. boost is considered adequate for the run-in of valve gear after a carbon and valve job.

It is not considered advisable to operate the engine at high power levels with cold engine oil, as the viscosity of the oil will be too high at low temperatures to ensure proper lubrication of the bearing surfaces. The following warmup schedule is recommended:

900 rpm firing with no boost until oil temperature has reached 50 °C (120 °F).

1800 rpm firing with no boost until oil temperature has reached 60 °C (140 °F).

2700 rpm firing with no boost until oil temperature has reached 70 °C (160 °F).

If the proper absorption equipment prevents following the warmup schedule, any suitable compromise is acceptable as long as high power and/or high rpm operation are avoided until the oil temperature has reached 70 °C (160 °F).

16. OPERATING INSTRUCTIONS - REFER TO THE LATEST REVISION OF SAE J549

17. NOTES

17.1 Marginal Indicia

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE SAE IGNITION STANDARDS COMMITTEE

APPENDIX A
MANUFACTURING TOLERANCES AND REPLACEMENT LIMITS

A.1 SEE TABLE A1.

TABLE A1 - MANUFACTURING TOLERANCES AND REPLACEMENT LIMITS (CONTINUED)
ALL DIMENSIONS NOT OTHERWISE INDICATED ARE IN MILLIMETERS
(ALL DIMENSIONS IN PARENTHESES ARE IN INCHES)

		As Manufactured	Condemning
TAPPET SETTING (INTAKE VALVE)		0.457(0.018) Hot	
TAPPET SETTING (EXHAUST VALVE)		0.457(0.018) Hot	
VALVE STEM TO GUIDE (INTAKE) (HAND REAM GUIDE AT ASSEMBLY)			
5835 Intake Valve	11.05-11.07 (0.435-0.436)Dia.	0.0127-0.0381 (0.0005-0.0015)	0.08 (0.003)
5134 Intake Valve Guide	11.07-11.087 (0.436-0.4365) Bore		
VALVE STEM TO GUIDE (EXHAUST) (HAND REAM GUIDE AT ASSEMBLY)			
5836 Exhaust Valve	11.010-11.036 (0.4335-0.4345) Dia.	0.051-0.026 (0.002-0.003)	0.1143 (0.0045)
5135 Exhaust Value Guide	11.074-11.087 (0.436-0.4365) Bore		
VALVE GUIDES P.F. IN CYLINDER HEAD			
Cylinder Head	17.436-17.48 (0.6875-0.688)		
5134 Intake Valve Guide	17.488-17.495 (0.6885-0.6888)	0.0127-0.033 (0.0005-0.0013) P.F.	
5135 Exhaust Valve Guide			
VALVE SPRING LOAD			
5230 Inner Valve Spring	At 34.925 (1.375) Height	8.05-9.45 kg (115-135 lb)	Under 7.7 kg (110 lb)
	At 42.849 (1.687) Height	4.41-4.83 kg (63-69 lb)	Under 4.06 kg (58 lb)
5231 Outer Valve Spring	At 34.925 (1.375) Height	7.7-9.1 kg (110-130 lb)	Under 7.35 kg (105 lb)
	At 42.849 (1.687) Height	5.25-5.95 kg (75-85 lb)	Under 4.90 kg (70 lb)

VALVE ROCKER ARM SIDE CLEARANCE			
Cylinder Head	41.986-42.139 (1.653-1.659)		
Rocker Area	39.649-39.725 (1.561-1.564)	0.051-0.330 (0.002-0.013)	
5223 Thrust Washer	2.159-2.209 (0.085-0.087)		
VALVE ROCKER ARM SHAFT TO CYLINDER HEAD (5750 ENGINE)(HAND REAM AT ASSEMBLY)			
Cylinder Head	15.875-15.808 (0.625-0.6255) Bore	0.0127-0.0254 (0.0005-0.001)	
Rocker Arm Shaft	15.862-15.875 (0.6245-0.625) dia.		
VALVE PUSHROD HOUSING TO CYLINDER HEAD			
Cylinder Head	25.095-25.146 (0.988-0.990) Bore	0.000-0.076 (0.000-0.003) P.F.	
Intake, Upper Push Rod Housing	25.146-25.171 (0.990-0.991)		
Exhaust, Upper Push Rod Housing	25.146-25.171 (0.990-0.991)		
VALVE PUSHROD HOUSING TO CYLINDER HOUSING			
5544 Cylinder Housing	25.349-25.146 (0.998-0.990) Bore	0.000-0.076 (0.000-0.003) P.F.	
5164 Lower Push Rod Housing	25.146-25.171 (0.990-0.991) dia.	0.000-0.076 (0.000-0.003) P.F.	
VALVE LIFTER ASSEMBLY TO GUIDE			
5501 Valve Lifter Guide	17.462-17.475 (0.6875-0.600) Bore	0.043-0.071 (0.0017-0.0028)	
5502 Tappet, Valve	17.404-17.419 (0.6852-0.6858) Dia.	0.043-0.071 (0.0017-0.0028)	
5740 CYLINDER SLEEVE		66.662-66.700 (2.6245-2.626) Bore	0.050 (0.002) Out of Round 0.127 (0.005) Variation
PISTON TOP LAND			
5474 Piston (Top Land)		66.395-66.421 (2.614-2.615) Dia.	66.015 (2.599) Dia.

PISTON SKIRT AND OTHER LANDS			66.269 (2.609) Dia.
5474 Piston (Skirt and Other Lands)	66.523-66.548 (2.619-2.620) Dia.	66.523-66.548 (2.619-2.620) Dia.	0.178 (0.007) Out of Round
PISTON RING END CLEARANCE			
3296 Oil Control Ring	End Clearance at 66.675 (2.625)	0.178-0.181 (0.007-0.15)	0.686 (0.027) or
5863 Compression Ring	Gage Dia.		0.305 (0.012)
3387 Optional Compression Ring			Actual Increase
PISTON RING SIDE CLEARANCE NO. 1 (TOP)			
5474 Piston (Groove Width)	2.476-2.502 (0.0975-0.985)	0.102-0.1397 (0.004-0.0055)	
5863 Ring	2.362-2.375 (0.093-0.0935)	0.102-0.1397 (0.004-0.0055)	
3387 Ring (Optional)(Tungsten)	2.362-2.375 (0.093-0.0935)	0.102-0.1397 (0.004-0.0055)	
PISTON RING SIDE CLEARANCE NOS. 2, 3, AND 4			
5474 Piston (Groove Width)	2.451-2.477 (0.0965-0.0975)	0.076-0.1143 (0.003-0.0045)	0.1397 (0.0055)
5863 Ring	2.362-2.375 (0.093-0.0935)	0.076-0.1143 (0.003-0.0045)	
PISTON RING SIDE CLEARANCE NO. 5 (BOTTOM)			
5474 Piston (Groove Width)	4.788-4.813 (0.1885-0.1895)	0.050-0.089 (0.002-0.0035)	
3296 Ring	4.724-4.737 (0.186-0.1865)	0.050-0.089 (0.002-0.0035)	0.127 (0.005)
PISTON PIN TO PISTON CLEARANCE			
5474 Piston	25.4025-25.4152 (1.0001-1.0006) Bore	0.0025-0.0203 (0.0001-0.0008)	
5120 Piston Pin	25.0000-25.3949 (1.0000-0.9998) Dia.	0.0025-0.0203 (0.0001-0.0008)	0.0381 (0.0015)
PISTON PIN TO CONNECTING ROD BUSHING CLEARANCE			
5120 Piston Rod	25.4000-25.3949 (1.0000-.09998)	0.00635-0.0305 (0.00025-0.0012)	
5487 Connecting Rod Assembly	25.40635-25.4254 (1.00025-1.001) Bore	0.00635-0.0305 (0.00025-0.0012)	0.1143 (0.0045)

CRANKSHAFT TO CONNECTING ROD BEARING CLEARANCE			
5641 Crankshaft Connecting Rod Journal	57.1373-57.1500 (2.2495-2.250) Dia.		
200072-1 Connecting Rod Bearings		0.076 (0.003)	0.127 (0.005)
CRANKSHAFT TO MAIN BEARINGS CLEARANCE			
5641 Crankshaft Main Bearing Journal	57.1373-57.1500 (2.2495-2.250) Dia.	0.76-0.1143 (0.003-0.0045)	
200071-1 Front Main Bearing	57.2262-57.2389 (2.253-2.2535) Bore	0.76-0.1143 (0.003-0.0045)	
200071-1 Rear Main Bearing	57.2262-57.2389 (2.253-2.2535) Bore	0.76-0.1143 (0.003-0.0045)	0.1397 (0.0055)
200071-1 Rear Main (Front) Bearing	(at assembly)	0.76-0.1143 (0.003-0.0045)	
CRANKSHAFT END CLEARANCE			
5641 Crankshaft (Between Surfaces)	101.041-101.092 (3.978-3.900)		
5681 Rear (Front) Main Bearing			
(Flange Thickness)			
5642 Front Main Bearing (Flange Thickness)	(Fitted at Assembly)	0.254-0.356 (0.010-0.014)	0.635 (0.025)
CRANKSHAFT BEARINGS P.F. IN CRANKCASE AND REAR ADAPTER			
5601 Crankcase	69.8627-69.8754 (2.7505-2.751) Bore		
5605 Rear Bearing Adapter	69.8627-69.8754 (2.7505-2.751) Bore		
5642 Front Main Bearing	Grind OD to Fit at Assembly		
5677 Rear Main Bearing	Grind OD to Fit at Assembly	0.0005-0.001 (0.0127-0.254) P.F.	
5681 Rear (Front) Main Bearing	Grind OD to Fit at Assembly		

CAMSHAFT TO BEARINGS			
5641 Camshaft - Front Journal	45.2120-45.2245 (1.780-1.7805) Dia.	0.0254-0.0635 (0.001-0.0025)	
Rear Journal	25.3746-25.3873 (0.999-0.9995) Dia.	0.0254-0.0635 (0.001-0.0025)	
5051 Front Bearing	45.2501-45.2755 (1.7815-1.7825) Bore	0.0254-0.0635 (0.001-0.0025)	0.102 (0.004)
5646 Rear Bearing	25.4127-25.4381 (1.0005-1.0015) Bore	0.0254-0.0635 (0.001-0.0025)	
CAMSHAFT END PLAY			
5640 Camshaft (Journal Length)	42.799-42.849 (1.685-1.687)	0.102-0.203 (0.004-0.008)	0.254 (0.010)
5051 Front Bearing (O.A.L.)	42.646-42.697 (1.679-1.681)	0.102-0.203 (0.004-0.008)	
CAMSHAFT FRONT BEARING TO CRANKCASE			
5601 Crankcase	57.150-57.175 (2.250-2.251) Bore	0.0127-0.508 (0.0005-0.002)	
5051 Front Bearing	57.124-57.137 (2.249-2.2495)	0.0127-0.508 (0.0005-0.002)	
CAMSHAFT REAR BEARING TO CRANKCASE (5750 ENGINE)			
5601 Crankcase	31.750-31.775 (1.250-1.251) Bore	0.0127-0.0508 (0.0005-0.002)	
5646 Rear Bearing	31.725-31.7373 (1.249-1.2495) Dia.	0.0127-0.0508 (0.0005-0.002)	
MAGNETO BREAKER POINT GAP		0.355-0.559 (0.014-0.022)	
MAGNETO CAM FOLLOWER PRESSURE (WITH CAM ON DWELL)		0.83-2.2 N (3-8 oz)	
MAGNETO-PRESSURE BETWEEN POINTS WITH FOLLOWER ON DWELL OF CAM		5.0-7.0 N (18-25 oz)	
COUNTERBALANCE SHAFTS TO BUSHINGS			
5608 Counterbalance Shafts (Bushing Journal)	31.699-31.711 (1.248-1.2485) Dia.	0.051-0.0889 (0.002-0.0035)	
5610 Rear Bushings	31.763-31.788 (1.2505-1.2515) Bore	0.051-0.0889 (0.002-0.0035)	0.1143 (0.0045)
5647 Front Bushings	31.763-31.788 (1.2505-1.2515) Bore		

COUNTERBALANCE SHAFT BUSHINGS TO CRANKCASE AND BEARING ADAPTER			
5601 Crankcase	38.0873-38.1127 (1.4995-1.5005) Bore	0.000-0.0889 (0.000-0.0035)	
5609 Bearing Adapter	38.0873-38.1127 (1.4995-1.5005) Bore	0.000-0.0889 (0.000-0.0035)	
5610 Rear Bushings	38.075-38.0873 (1.499-1.4995) OD	0.000-0.0889 (0.000-0.0035)	
5647 Front Bearings	38.075-38.0873 (1.499-1.4995) OD	0.000-0.0889 (0.000-0.0035)	
COUNTERBALANCE SHAFT END PLAY			
5608 Counterbalance Shaft (Shoulder Length)	55.093-55.219 (2.169-2.174)	0.076-0.279 (0.003-0.011)	
5609 Bearing Adapter (Length Through Bore)	50.800-50.749 (2.000-1.998)	0.076-0.279 (0.003-0.011)	0.508 (0.020)
5647 Front Bushing (Flange Thickness)	4.191-4.216 (0.165-0.166)	0.076-0.279 (0.003-0.011)	
5656 OIL PUMP ASSEMBLY (5650 ENGINE)			
Driveshaft to Bushing in Body at Drive End			
5651 Shaft	12.725-12.7381 (0.501-0.5015) Dia.	0.038-0.076 (0.0015-0.003)	0.127 (0.005)
5002 Bushing	12.776-12.802 (0.503-0.504) Dia.	0.038-0.076 (0.0015-0.003)	
Driveshaft to Bushing in Cover			
5651 Shaft	12.6619-12.6746 (0.4985-0.499) Dia.	0.051-0.076 (0.002-0.003)	0.127 (0.005)
5662 Bushing	12.725-12.738 (0.501-0.5015) Bore	0.051-0.076 (0.002-0.003)	
Idler Shaft to Bushings			
5782 Shaft	12.6619-12.6746 (0.4985-0.499) Dia.	0.051-0.076 (0.002-0.003)	
5652 Bushings	12.725-12.7381 (0.501-0.5015) Bore	0.051-0.076 (0.002-0.003)	
Bushings P.F. Into Body and Cover			
Housing Bores	15.8623-15.8877 (0.6245-0.6255) Bore	0.0381-0.0889 (0.0015-0.0035) P.F.	
Bushing OD	15.925-15.951 (0.627-0628) OD	0.031-0.0889 (0.0015-0.0035) P.F.	
Pump Gears Backlash		0.076-0.127 (0.003-0.005)	0.178 (0.007)

APPENDIX B
STANDARD SPARK PLUG INSERTS

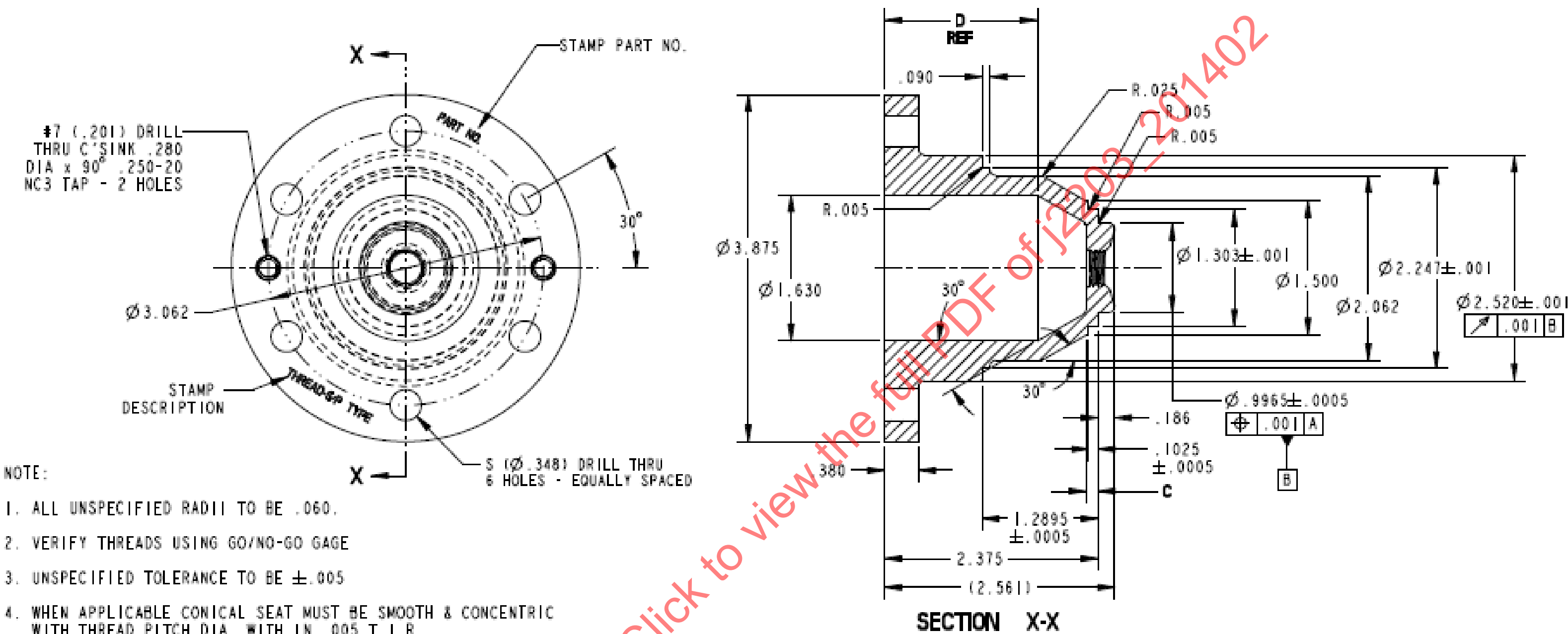
B.1 SEE TABLE B1.

TABLE B1 - STANDARD SPARK PLUG INSERTS

Spark Plug Thread Size	Reach mm (in)	Type	Part Number Meehanite
8 mm	12.497 (0.492)	1	200001
10 mm	6.35 (0.250)	1	16200
10 mm	11.90 (0.469) (conical seat)	1	16246
10 mm	12.70 (0.500)	1	16201
10 mm	19.00 (0.748)	1-L	16202
10 mm	19.00 (0.748)	1-EL	16235
10 mm	26.50 (1.043)	1-XL	16236
10 mm	26.50 (1.043)	1-EXL	16237
12 mm	12.70 (0.500)	1	16204
12 mm	19.00 (0.748)	1-L	16205
12 mm	19.00 (0.748) (conical seat)	1-L	16247
12 mm	19.00 (0.748)	1-EL	16238
12 mm	26.50 (1.043)	1-XL	16239
12 mm	26.50 (1.043) (conical seat)	1-XL	16248
12 mm	26.50 (1.043)	1-EXL	16240
14 mm	9.53 (0.375)	1	16206
14 mm	9.53 (0.375) (conical seat)	1	16223
14 mm	11.10 (0.437)	1	16207
14 mm	11.20 (0.441) (conical seat)	1	16209
14 mm	12.70 (0.500)	1	16208
14 mm	17.27 (0.680)	1	16221
14 mm	17.50 (.689) (conical)	1	16219
14 mm	17.50 (.689) (conical) 1/2 Thread	1	16232
14 mm	19.00 (0.748)	1-L	16210
14 mm	19.00 (0.748) 1/2 Thread	1-L	16211
14 mm	19.00 (0.748)	1-EL	16241
16 mm	22.00 (.866) (conical)	HT	16242
14 mm	25.00 (0.984) (conical)	1	16243
14 mm	25.00 (0.984) (conical), 1/2 Thread	1	16233
14 mm	26.50 (1.043)	1-XL	16244
14 mm	26.50 (1.043)	1-EXL	16245
18 mm	10.90 (.429) (conical)	1	16214
18 mm	11.30 (0.445)	1	16212
18 mm	12.70 (0.500)	1	16213
18 mm	20.63 (0 .812)	2	16215
18 mm	29.72 (1.125) (3/16 thread relief)	2	16220
18 mm	29.72 (1.125) 3/4 Thread	2	16222
18 mm	38.10 (1.500) (conical) 1/2 Thread	2	16231
.875"-18	15.90 (.625)	3	16216
.875"-18	20.625 (.812)	3	16217
.875"-18	20.625 (.812) (Special)	3	16218

B.2 APPENDIX B

TYPE 1 STANDARD SPARK PLUG INSERT DRAWINGS (INCH) SEE TABLE B1.

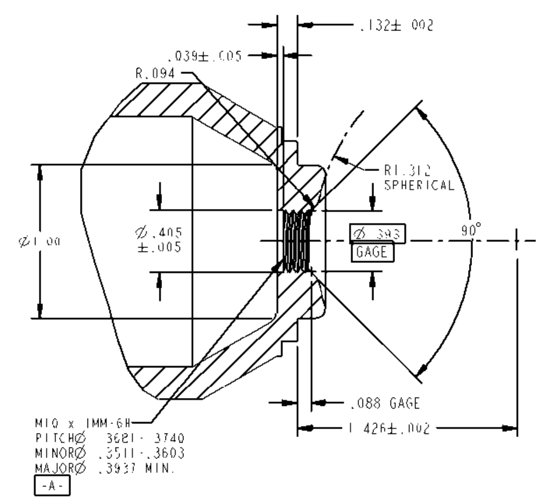


NOTE:

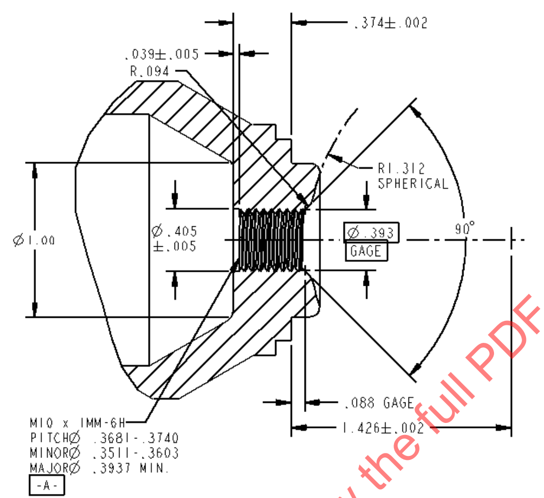
1. ALL UNSPECIFIED RADII TO BE .060.
2. VERIFY THREADS USING GO/NO-GO GAGE
3. UNSPECIFIED TOLERANCE TO BE ±.005
4. WHEN APPLICABLE CONICAL SEAT MUST BE SMOOTH & CONCENTRIC WITH THREAD PITCH DIA. WITH IN .005 T.I.R.
5. MATERIAL: MEEHANITE, TYPE GC

	Part No.	C	D	Part No.	C	D	Part No.	C	D	Part No.	C	D	Part No.	C	D
TYPE 1	16200	0.137	1.700	16208	0.250	1.480	16219	0.530	1.240	16237	0.630	0.796	16245	0.646	0.778
	16201	0.250	1.460	16209	0.250	1.480	16221	0.500	1.300	16238	0.637	1.060	16246	0.250	1.455
	16202	0.430	1.250	16210	0.500	1.230	16223	0.250	1.610	16239	0.637	0.924	16247	0.530	1.230
	16204	0.190	1.480	16211	0.500	1.230	16232	0.530	1.240	16240	0.637	0.767	16248	0.644	0.935
	16205	0.430	1.220	16212	0.200	1.630	16233	0.530	1.184	16241	0.646	1.070	200001	0.250	1.460
	16206	0.250	1.610	16213	0.170	1.580	16235	0.590	1.090	16243	0.644	0.935			
	16207	0.250	1.550	16214	0.190	1.560	16236	0.630	0.953	16244	0.646	0.935			

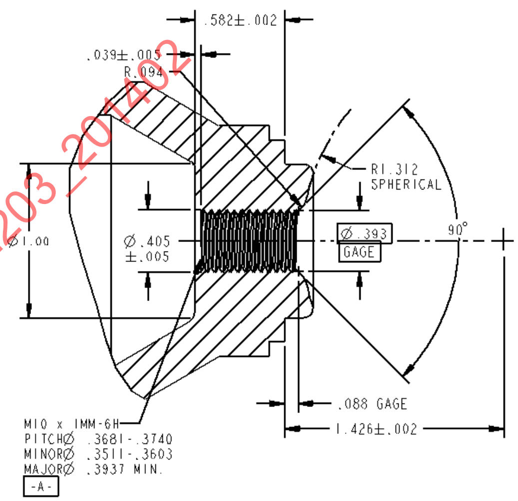
Type 1 STANDARD SPARK PLUG INSERT DRAWINGS - Spark Plug Hole Detail (Inch)



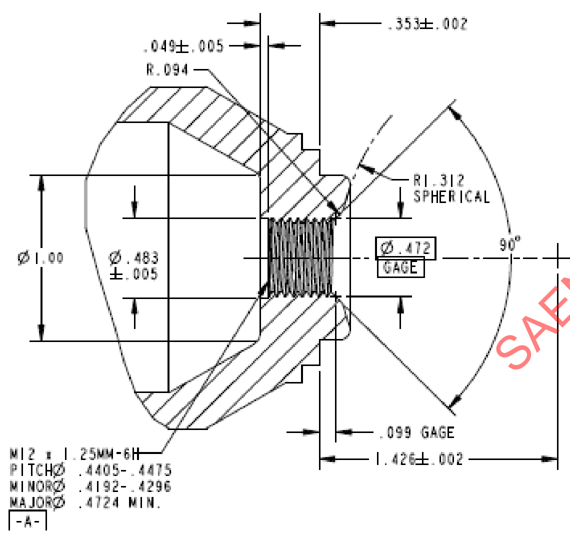
Part Number 16200



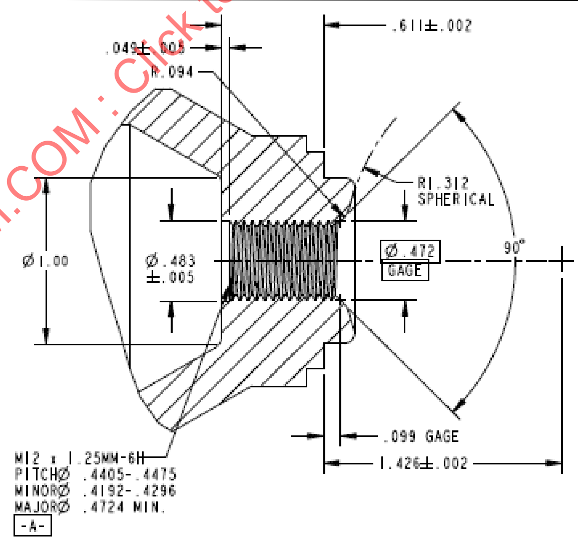
Part Number 16201



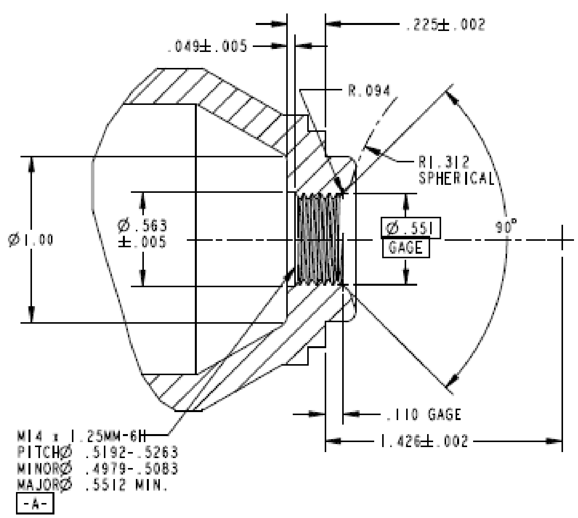
Part Number 16202



Part Number 16204

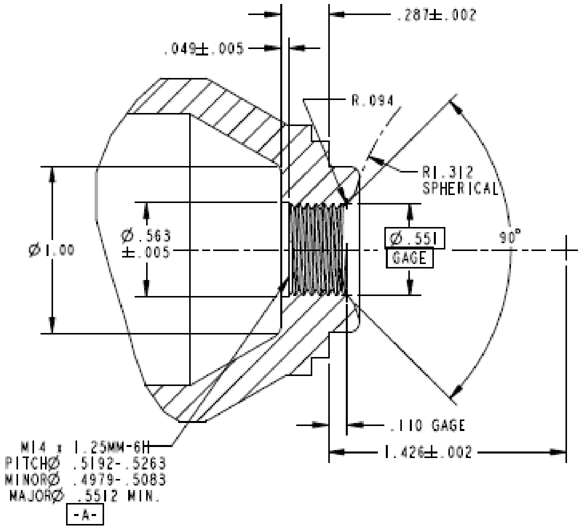


Part Number 16205

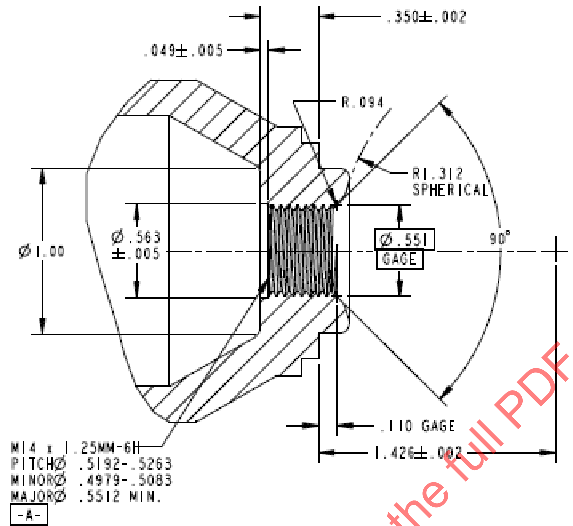


Part Number 16206

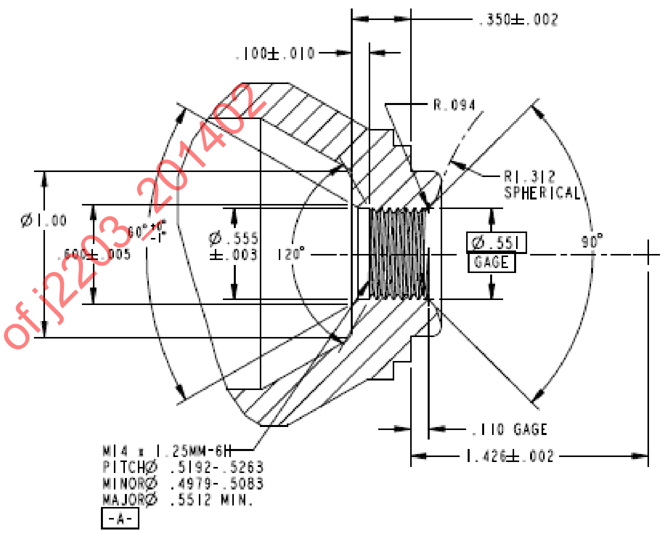
Type 1 STANDARD SPARK PLUG INSERT DRAWINGS - Spark Plug Hole Detail (Inch)



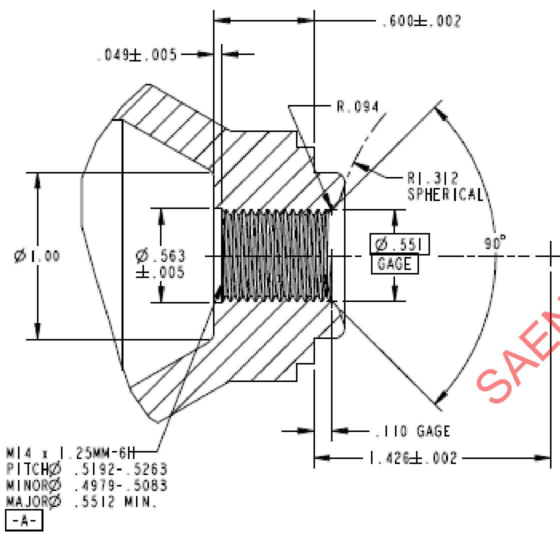
Part Number 16207



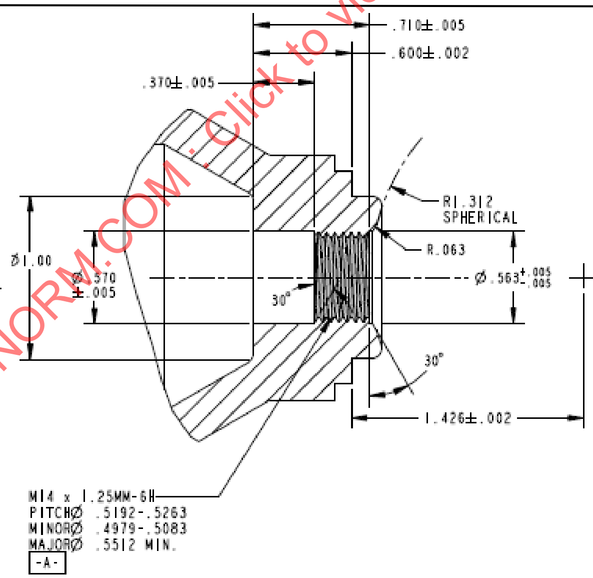
Part Number 16208



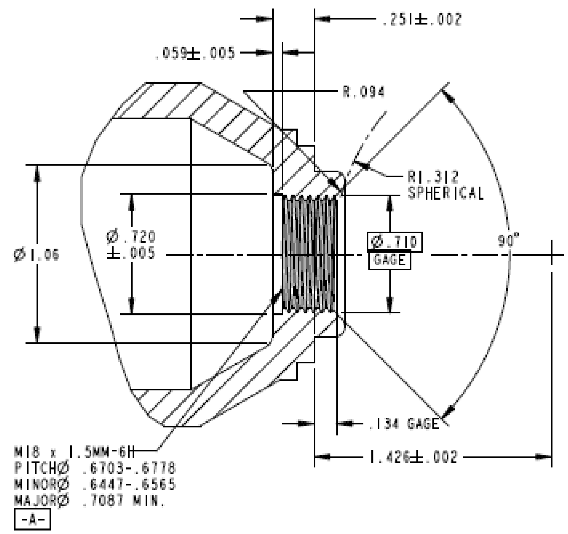
Part Number 16209



Part Number 16210

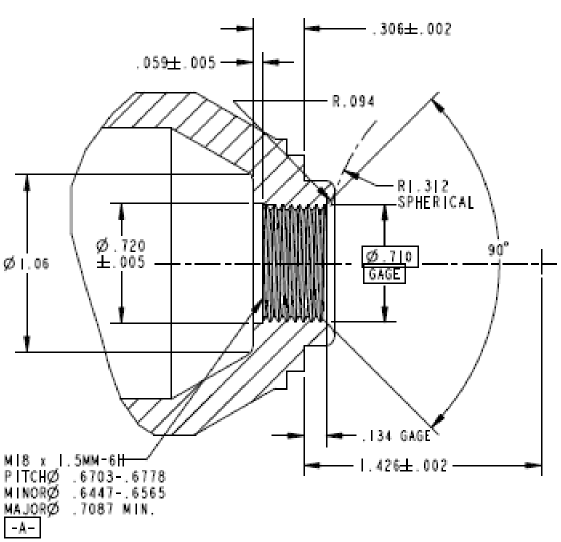


Part Number 16211

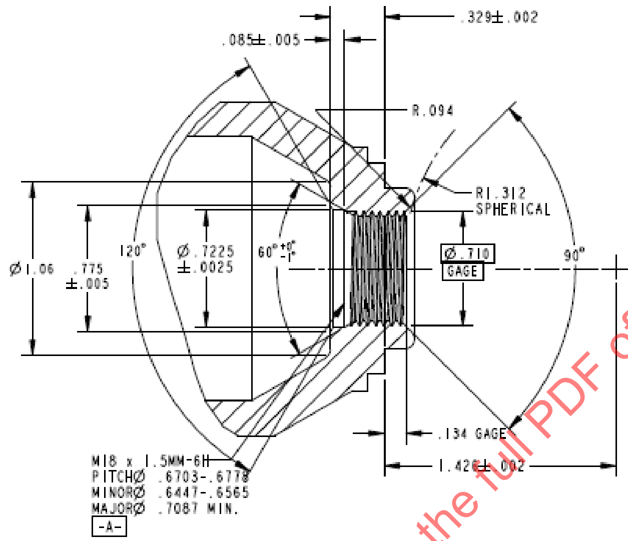


Part Number 16212

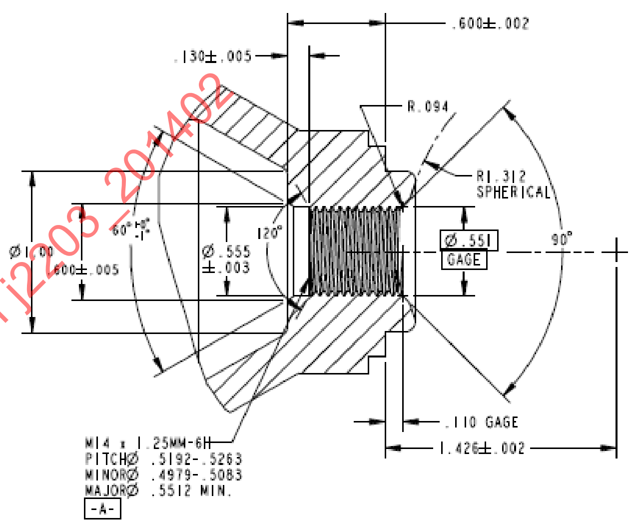
Type 1 STANDARD SPARK PLUG INSERT DRAWINGS - Spark Plug Hole Detail (Inch)



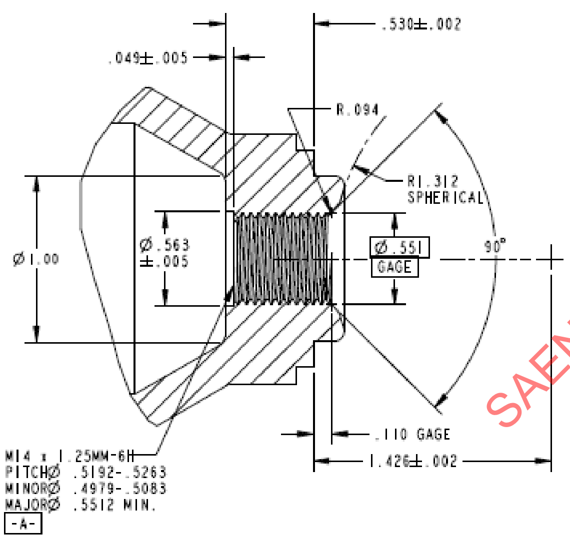
Part Number 16213



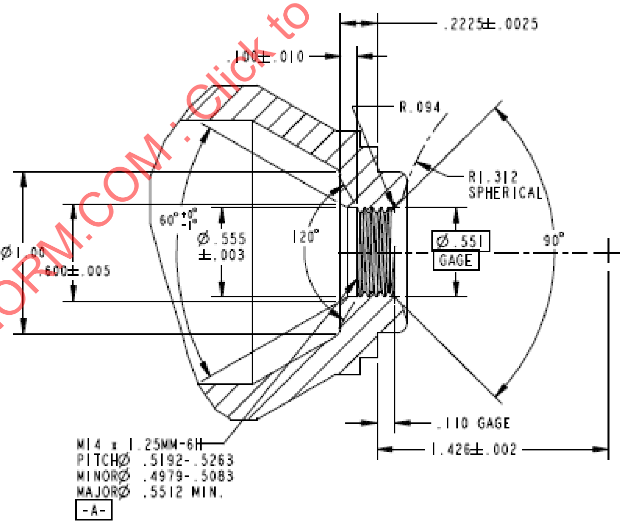
Part Number 16214



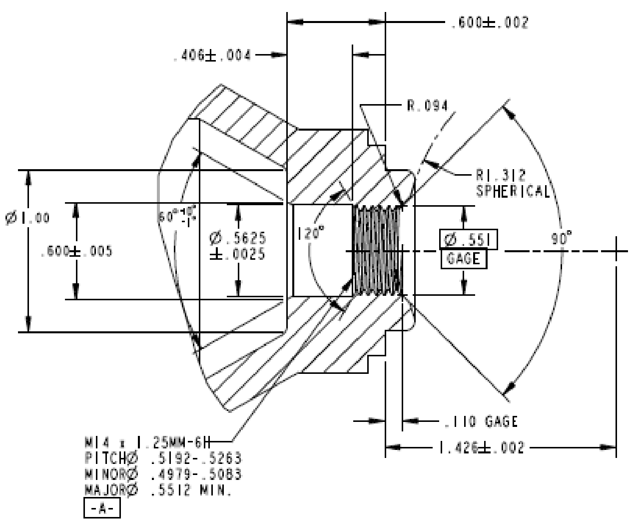
Part Number 16219



Part Number 16221

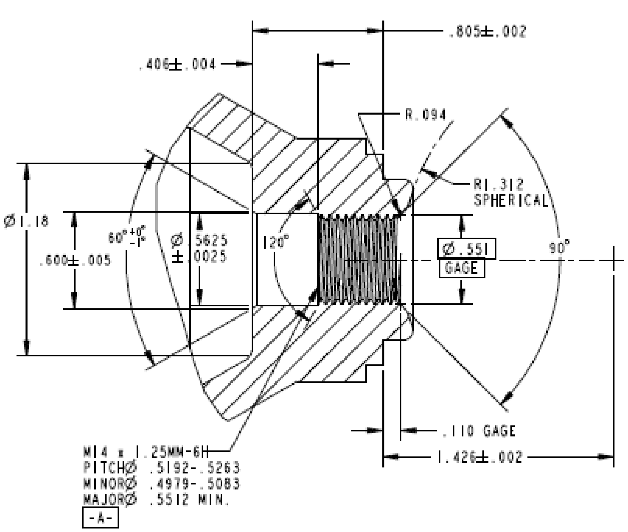


Part Number 16223

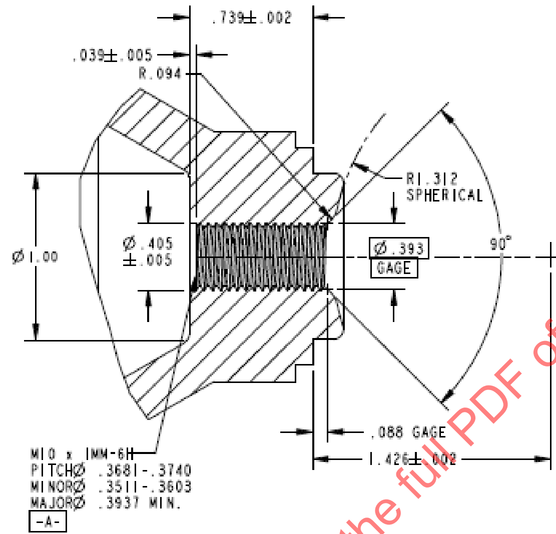


Part Number 16232

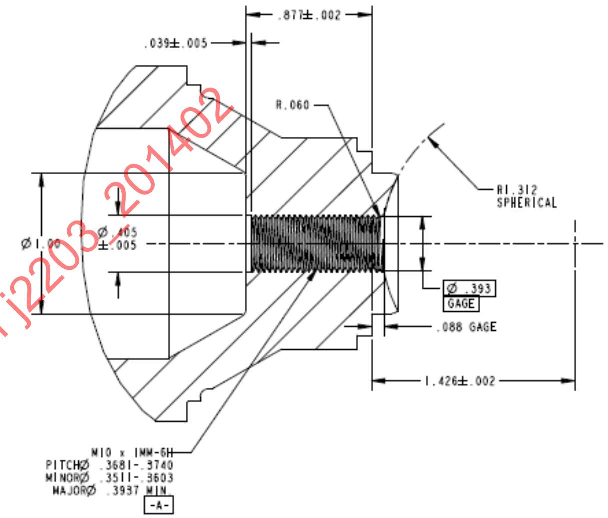
Type 1 STANDARD SPARK PLUG INSERT DRAWINGS - Spark Plug Hole Detail (Inch)



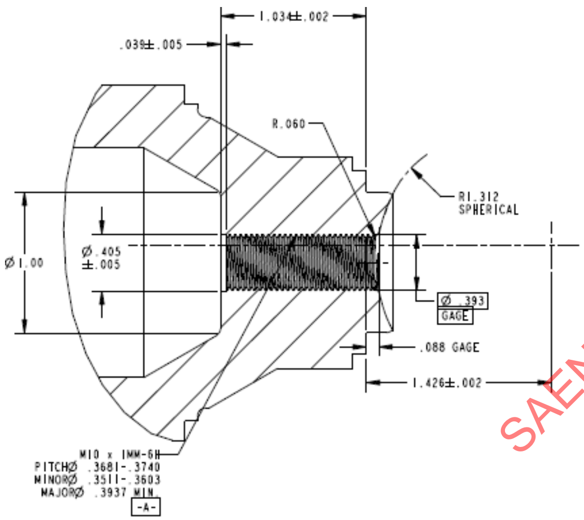
Part Number 16233



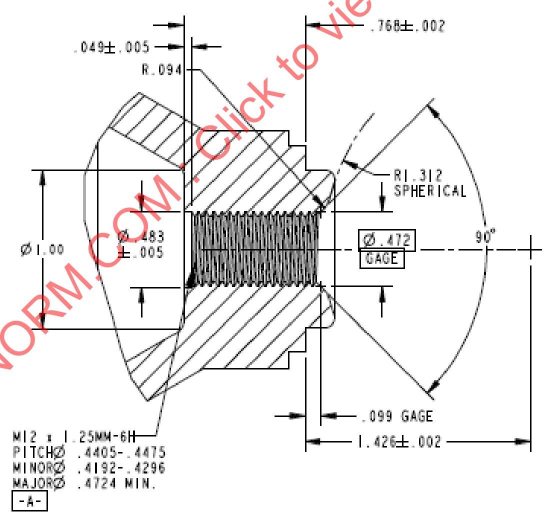
Part Number 16235



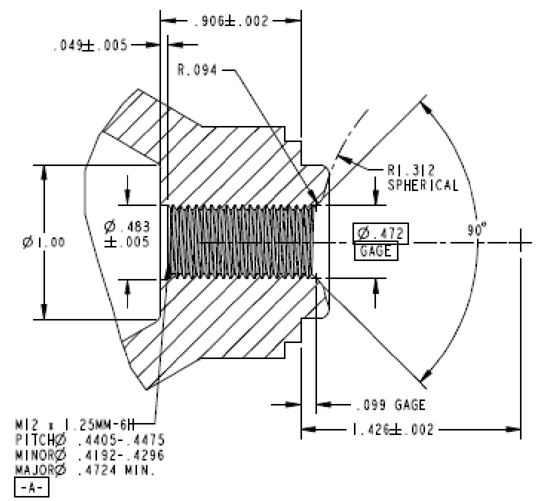
Part Number 16236



Part Number 16237

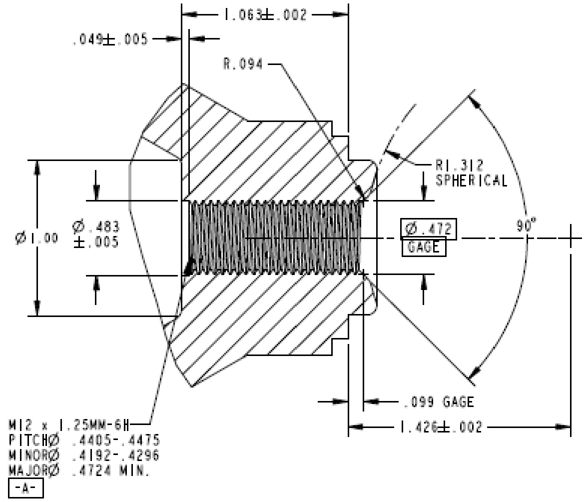


Part Number 16238

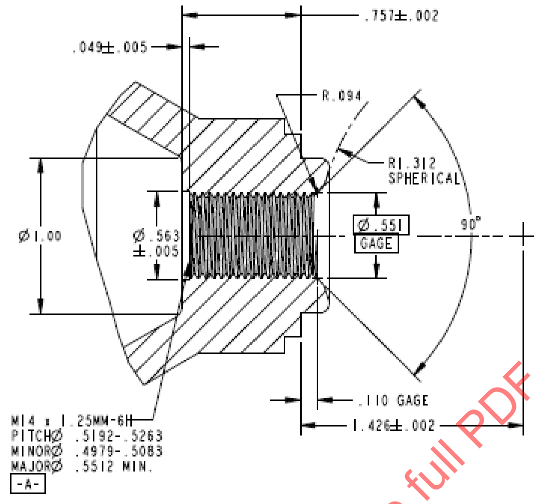


Part Number 16239

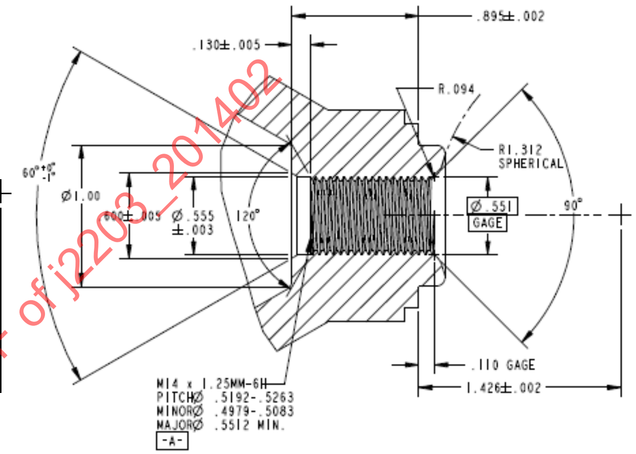
Type 1 STANDARD SPARK PLUG INSERT DRAWINGS - Spark Plug Hole Detail (Inch)



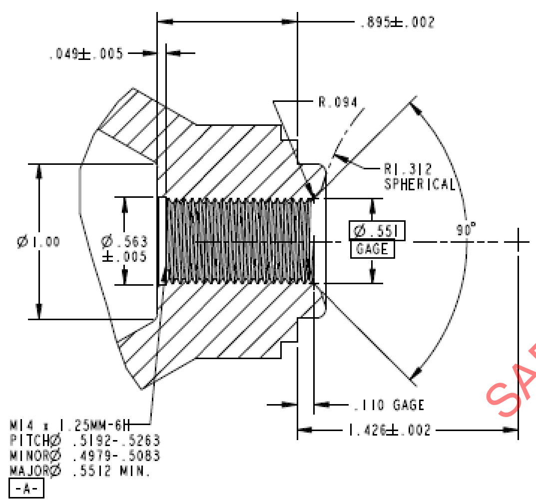
Part Number 16240



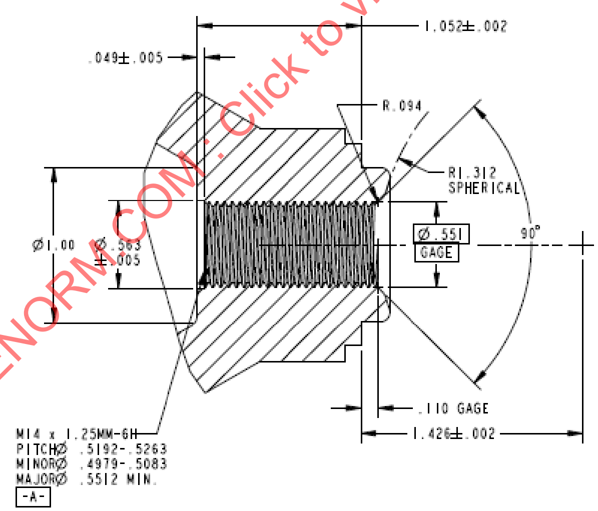
Part Number 16241



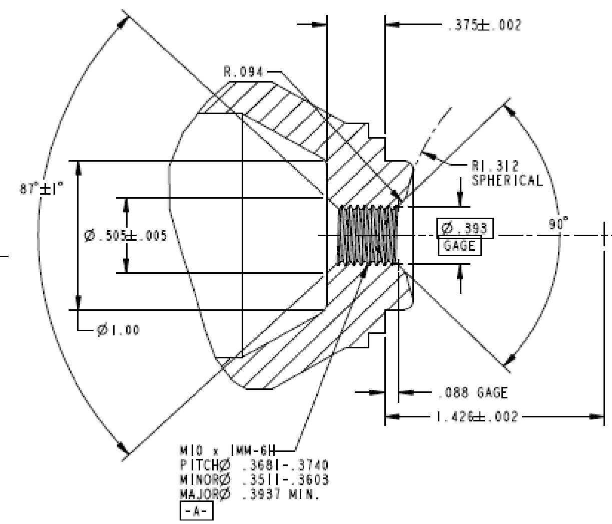
Part Number 16243



Part Number 16244

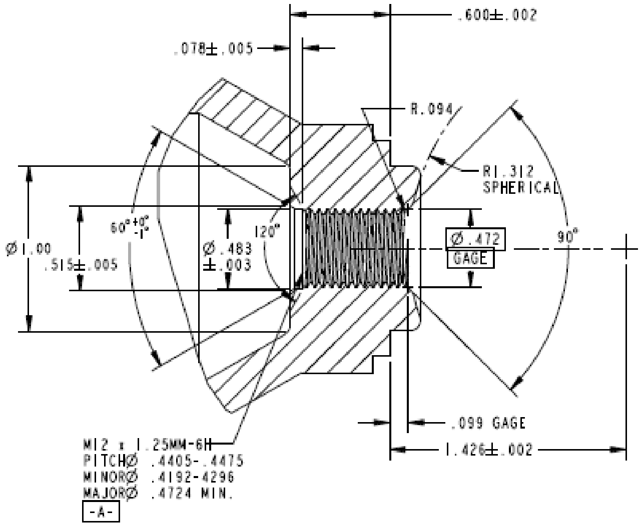


Part Number 16245

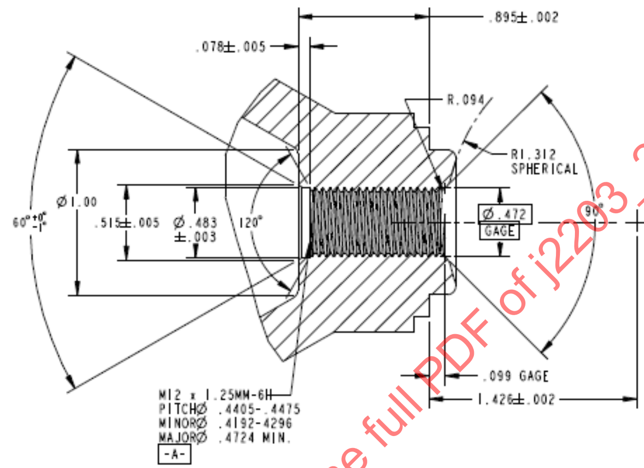


Part Number 16246

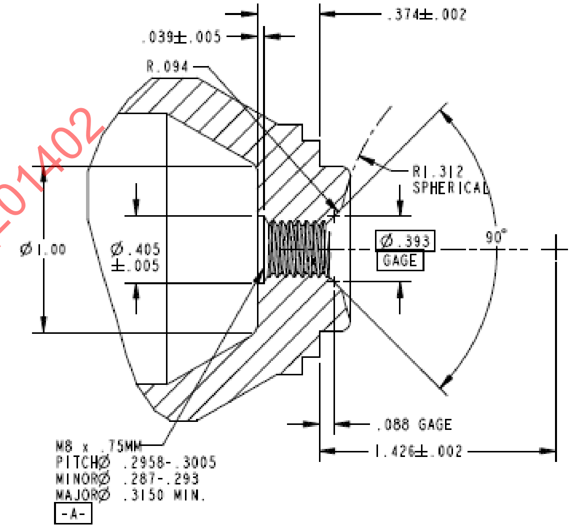
Type 1 STANDARD SPARK PLUG INSERT DRAWINGS - Spark Plug Hole Detail (Inch)



Part Number 16247

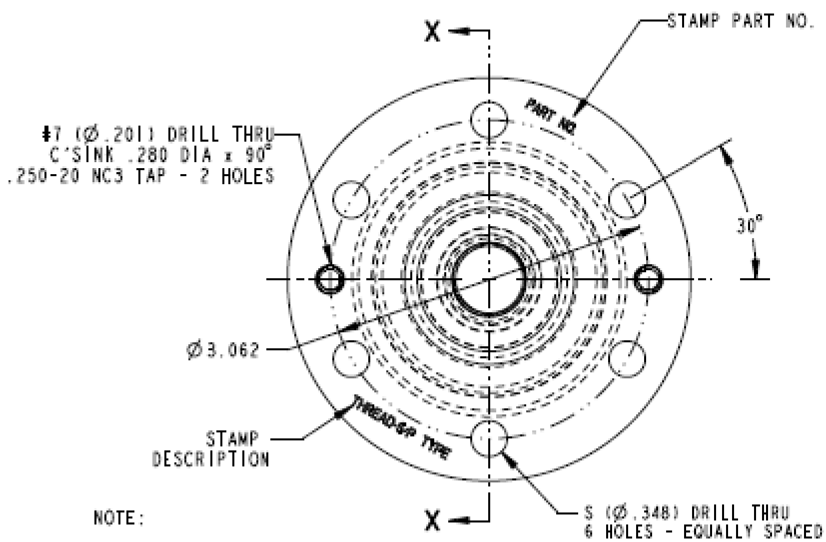


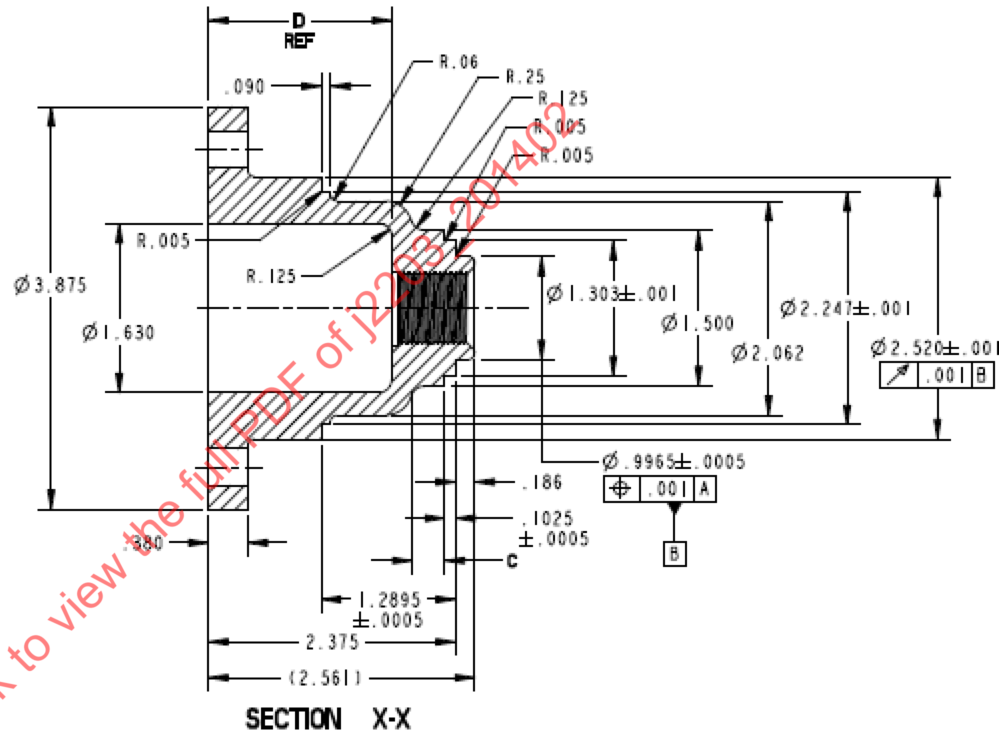
Part Number 16248



Part Number 200001

Type 2 STANDARD SPARK PLUG INSERT DRAWINGS (INCH) See Table B1.



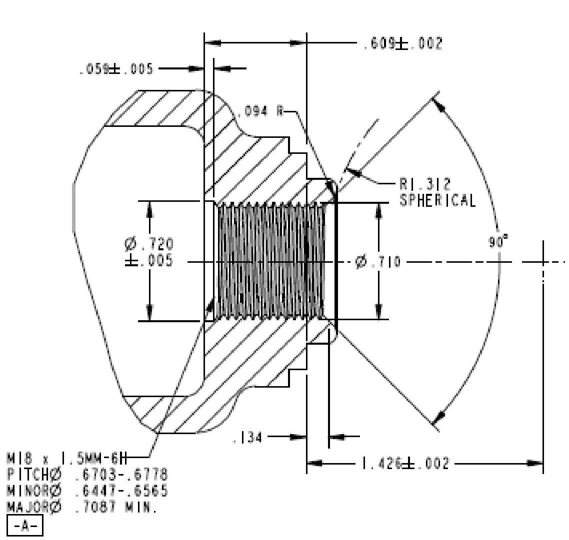


NOTE:

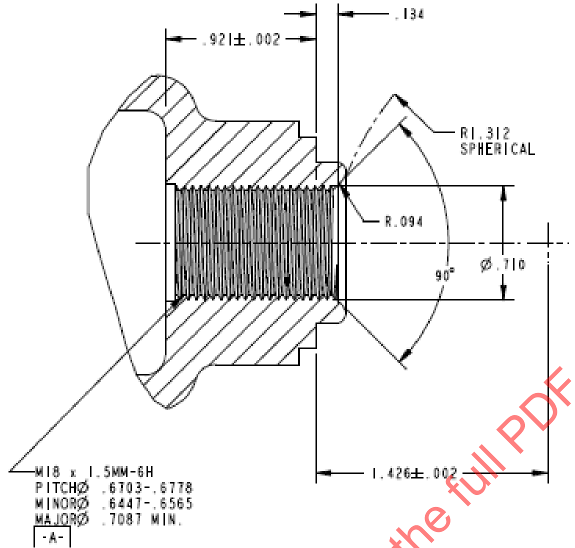
1. ALL UNSPECIFIED RADII TO BE .060.
2. VERIFY THREADS USING GO/NO-GO GAGE
3. UNSPECIFIED TOLERANCE TO BE ±.005
4. WHEN APPLICABLE CONICAL SEAT MUST BE SMOOTH & CONCENTRIC WITH THREAD PITCH DIA. WITH IN .005 T.I.R.
5. MATERIAL: MEEHANITE, TYPE GC

	Part No.	C	D
TYPE 2	16215	0.312	1.767
	16220	0.625	1.455
	16222	0.625	1.455
	16231	0.531	1.515

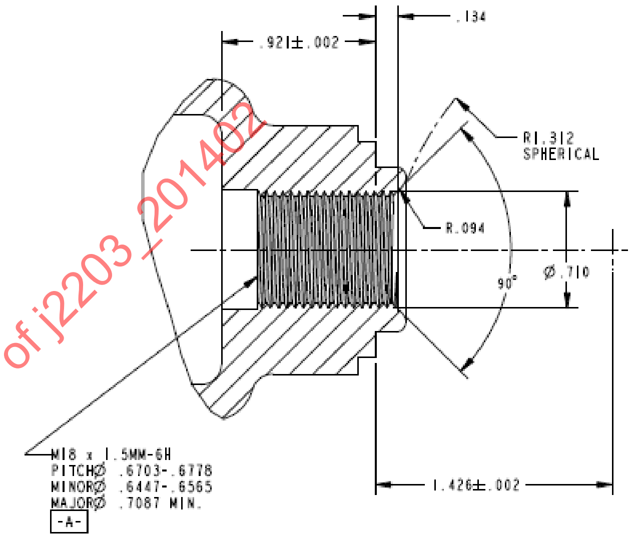
Type 2 STANDARD SPARK PLUG INSERT DRAWINGS - Spark Plug Hole Detail (Inch)



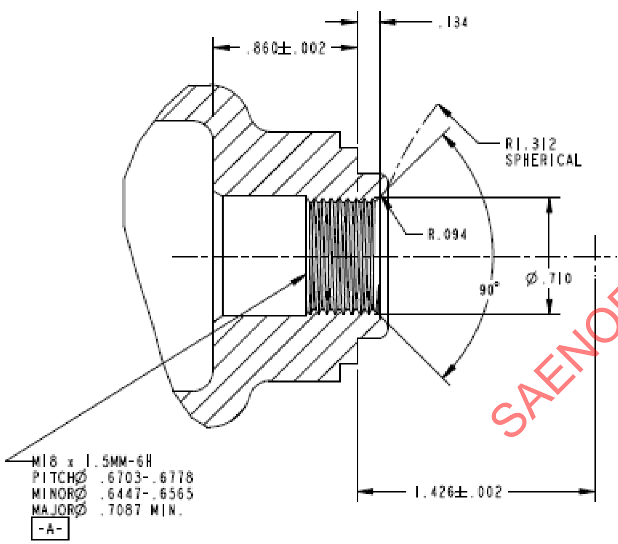
Part Number 16215



Part Number 16220

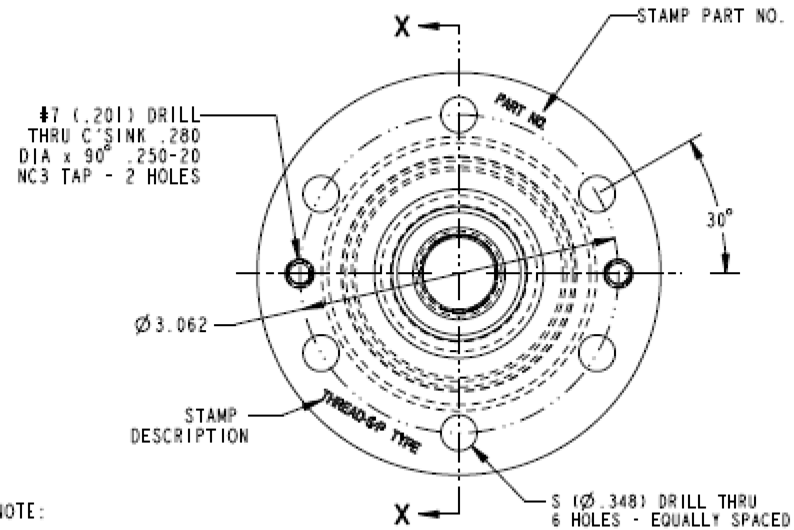


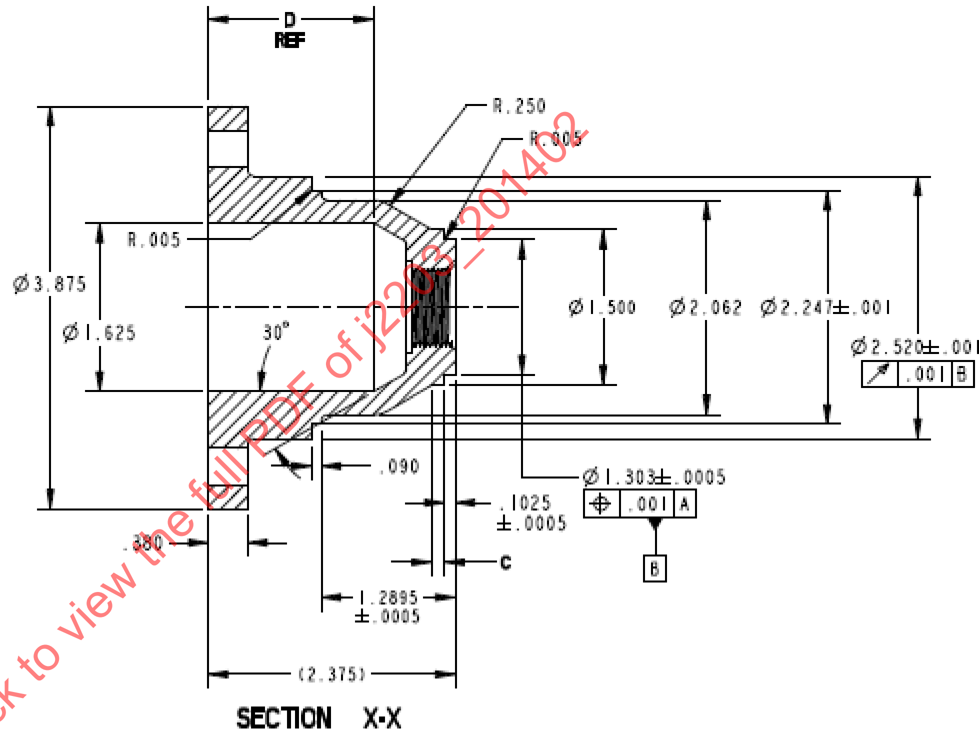
Part Number 16222



Part Number 16231

Type 3 STANDARD SPARK PLUG INSERT DRAWINGS (Inch)



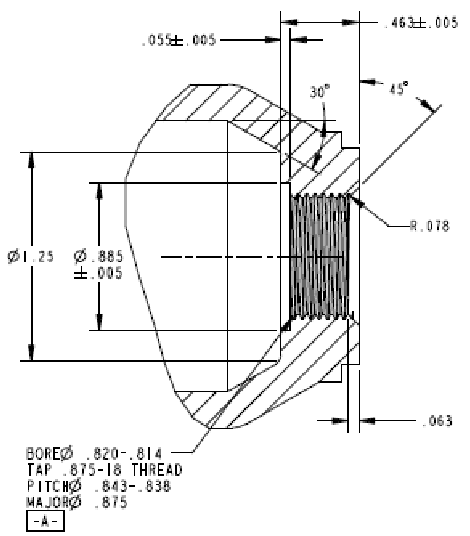


NOTE:

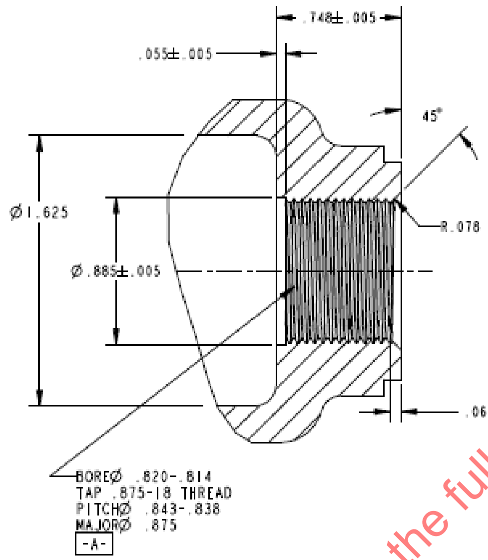
1. ALL UNSPECIFIED RADII TO BE .060.
2. VERIFY THREADS USING GO/NO-GO GAGE
3. UNSPECIFIED TOLERANCE TO BE ±.005
4. WHEN APPLICABLE CONICAL SEAT MUST BE SMOOTH & CONCENTRIC WITH THREAD PITCH DIA. WITH IN .005 T.I.R.
5. MATERIAL: MEEHANITE, TYPE GC

	Part No.	C	D
TYPE 3	16216	0.125	1.357
	16217	0.375	1.627
	16218	0.438	1.689
	16226	0.440	1.567

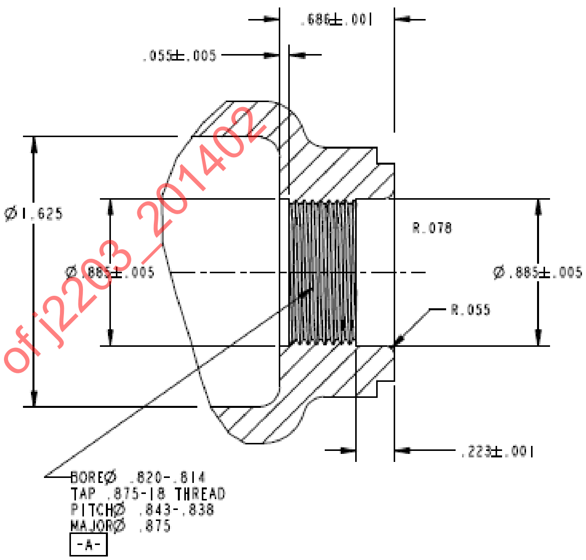
Type 3 STANDARD SPARK PLUG INSERT DRAWINGS - Spark Plug Hole Detail (Inch)



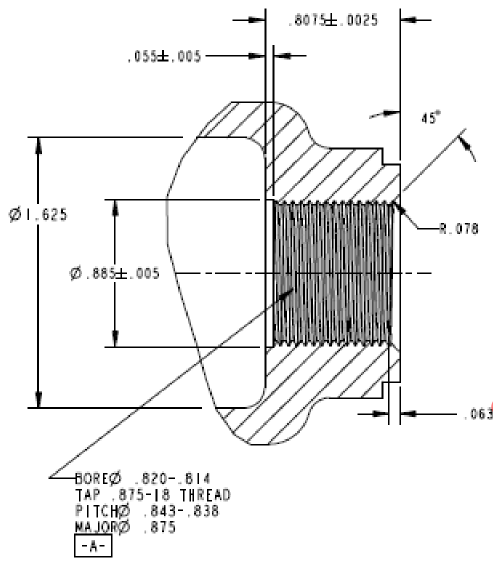
Part Number 16216



Part Number 16217

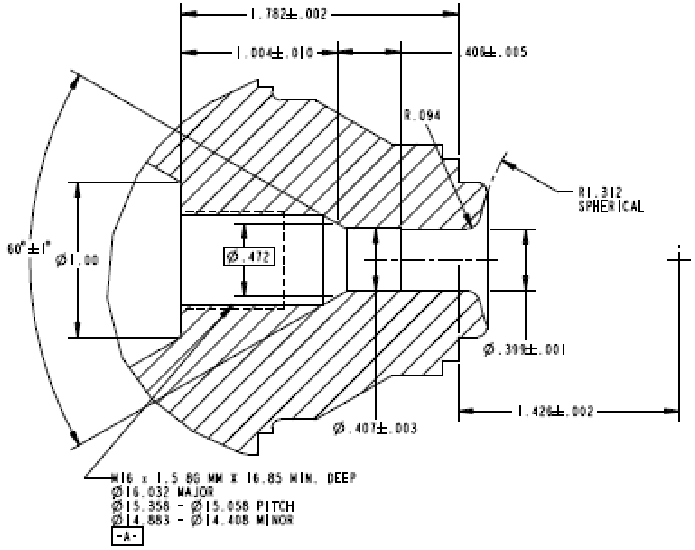


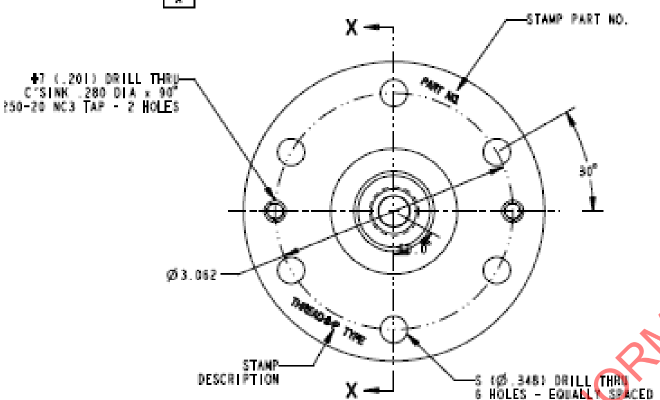
Part Number 16218

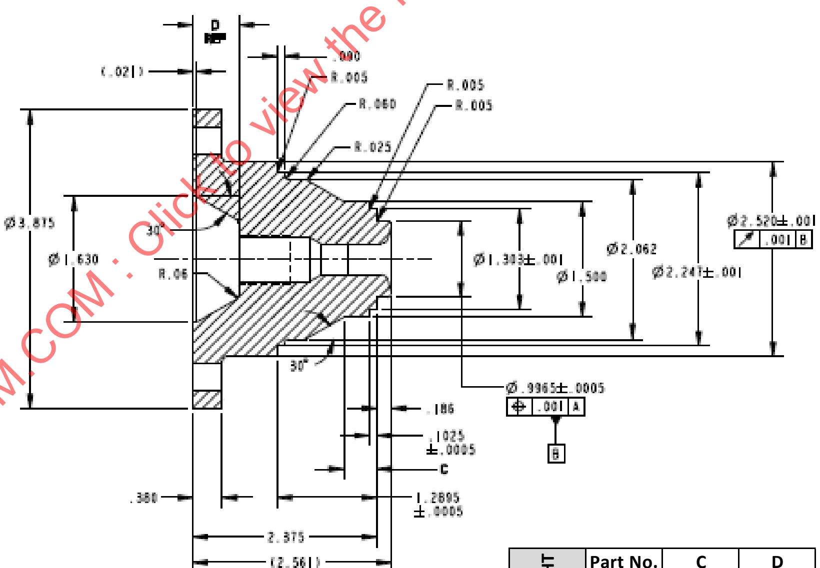


Part Number 16226

Type HT STANDARD SPARK PLUG INSERT DRAWINGS (Inch)







SECTION X-X

NOTE:

1. ALL UNSPECIFIED RADII TO BE .060.
2. VERIFY THREADS USING GO/NO-GO GAGE
3. UNSPECIFIED TOLERANCE TO BE ±.005
4. WHEN APPLICABLE CONICAL SEAT MUST BE SMOOTH & CONCENTRIC WITH THREAD PITCH DIA. WITH IN .005 T.I.R.
5. MATERIAL: MEEHANITE, TYPE GC

TYPE HT	Part No.	C	D
	16242	0.430	0.593

SPARK PLUG INSTALLATION TORQUE

B.3 SEE TABLE C1.

TABLE C1 - SPARK PLUG INSTALLATION TORQUE

Plug Size	Torque N-m (lb-ft)
10 mm	10-15 (7-11)
12 mm	15-25 (11-18)
12 mm (conical seat)	15-20 (11-15)
14 mm	35-40 (26-30)
14 mm (conical seat)	9-20 (7-15)
16 mm (conical seat)	30-38 (22-28)
18 mm	43-52 (32-38)
18 mm (conical seat)	20-27 (15-20)
0.875 in x 18	47-58 (35-43)

APPENDIX C
BILL OF MATERIAL FOR
5750 / 16047 ENGINE ASSEMBLY, SAE SPARK PLUG
RATING W/ INSERT TYPE HEAD

C.1 CONTROL ITEMS

REQUIRED

*SAE Control Item

1 5600 CRANKCASE ASSEMBLY, COUNTERBALANCED

1 5660 RETAINER, CRANKSHAFT OIL (REAR)
ASSEMBLY (REAR) N. D.

1 5653 RETAINER, CRANKSHAFT OIL (REAR)

1 5661 SEAL OIL

1 5630 BEARING ADAPTER ASSEMBLY
COUNTERBALANCE SHAFTS

1 5609 BEARING ADAPTER FOR COUNTERBALANCED SHAFT

2 5647 BUSHING, FRONT C-B SHAFT

2 4243 SCREW, SET, HEX SOCKET HEAD
0.375-16 UNC X 0.500 LONG CUP POINT

2 4260 PIN, DOWEL 0.1251/0.1253 DIA. X 0.375 LONG

1 5654 CAMSHAFT ASSEMBLY

1 5640 CAMSHAFT

1 5052 GEAR TIMING CAMSHAFT

1 5051 BEARING BUSHING CAMSHAFT FRONT

1 5053 NUT CAMSHAFT FRONT GEAR TO CAMSHAFT

1 4051 KEY, WOODRUFF 0.156 X 0.750 SAE #8, ANSI (506),

1 5054 WASHER, LOCK, GEAR TO CAMSHAFT

1 4076 KEY, WOODRUFF 0.250 X 0.875 SAE #A, ANSI (807)

REQUIRED		
1	5631	COVER, GEAR CASE ASSEMBLY
1	5602	COVER, GEAR CASE
1	5457	SEAL, OIL, FRONT CAMSHAFT
1	5111	FILLER CAP, WING TYPE
1	5112	GASKET FOR FILLER CAP
1	5661	SEAL OIL
4	5634	STUD, OIL PUMP TO CASE
1	4246	SCREW, SET, HEX SOCKET HEAD 0.375-16 UNC X 2.625 LONG CUP POINT
1	4247	SCREW, SET, HEX SOCKET HEAD 0.375-16 UNC X 1.000 LONG CUP POINT
1	5635	CRANKCASE SUB-ASSEMBLY
1	5601	CRANKCASE
1	5605	BEARING ADAPTER CRANKSHAFT REAR
1	5642	BEARING FRONT MAIN
1	5677	BEARING, CRANKSHAFT, REAR ADAPTER
1	5681	BEARING, CRANKSHAFT, FRONT ADAPTER
3	4329	PIN, TAPER, #3 X 2.500 LONG
15	35105	SCREW, CAP, HEX HEAD, 0.375-16 UNC X 1.250 LONG, GRADE 5 CADMIUM PLATED
15	4111	WASHER, PLAIN 0.375 0.391 I. D. X 0.625 O. D. X 0.062 THICK, CADMIUM PLATED AN960-616
2	4243	SCREW, SET, HEX SOCKET HEAD 0.375-16 UNC X 0.500 LONG CUP POINT
1	4060	FITTING, TUBE, INV FLARE, MALE 90 ELBOW 0.250 NPT X 0.375 TUBE BRASS WEATHERHEAD #402X6

REQUIRED

1	5621	CRANKSHAFT ASSEMBLY
1	5641	CRANKSHAFT
2	5639	COUNTERWEIGHT - CRANKSHAFT
4	5019	CAPSCREW COUNTERWEIGHT TO CRANKSHAFT
1	4000	PIPE PLUG, SOCKET HEAD, STEEL 0.125 PT BLACK OXIDE FINISH
2'	S11205	WIRE, SAFETY, 0.032 DIAMETER STAINLESS STEEL, MS20995C32
1	5673	OIL OUTLET FLANGE ASSEMBLY
1	5664	HEATER TERMINAL PLATE ASSEMBLY
1	5665	PLATE HEATER TERMINAL
1	5685	COVER HEATER TERMINAL PLATE (REAR)
4	4038	SCREW, MACHINE, FLAT HEAD #10-32 UNF X 0.750 LONG, PLATED
4	4030	WASHER, PLAIN #10 0.219 I. D. X 0.500 O. D. X 0.049 THICK, ZINC PLATED
8	4031	NUT, HEX, MACHINE SCREW #10-32 UNF, ZINC PLATED
1	5697	CONNECTOR TERMINAL
15	37729	TERMINAL, SOLDERLESS, RING, 16-14 AWG X #10 STUD
1	5696	COVER, HEATER TERMINAL PLATE FRONT
2	4179	SCREW, MACHINE, FLAT HEAD #6-32 UNC X 0.500 LONG 18-8 STAINLESS STEEL
2	5698	SEPARATOR, WIRE
1	200003-1	CONTROL ASSEMBLY, OIL SUMP HEATER
1	200005-1	ENCLOSURE, SWITCH, OIL SUMP HEATER
1	200006-1	COVER, SWITCH ENCLOSURE, OIL SUMP HEATER

REQUIRED	
1	200007-1 NAMEPLATE, SWITCH, OIL SUMP HEATER
1	37547 SWITCH, SELECTOR
1	37548 JUMPER, SELECTOR SWITCH
2	30741 SCREW, MACHINE, ROUND HEAD #10-32 UNF X 0.250 LONG, PLATED
1	5549 RECEPTACLE SUMP HEATER
4	35602 SCREW, CAP, HEX SOCKET HEAD #4-40 UNC X 0.313 LONG
1	5656 OIL PUMP ASSEMBLY
1	5649 BODY, OIL PUMP
1	5650 COVER, OIL PUMP
1	5651 SHAFT, OIL PUMP DRIVE
1	5782 SHAFT IDLER, OIL PUMP
1	5761 GEAR, OIL PUMP DRIVER
1	5762 GEAR, OIL PUMP DRIVEN
1	5643 COUPLING FLANGE
3	5652 BUSHING OIL PUMP COVER
1	5082 BUSHING OIL PUMP MAIN SHAFT
6	35105 SCREW, CAP, HEX HEAD 0.375-16 UNC X 1.250 LONG, GRADE 5 CADMIUM PLATED
6	4111 WASHER, PLAIN 0.375 0.391 I. D. X 0.625 O. D. X 0.062 THICK, CADMIUM PLATED AN960-616
2	4026 KEY, WOODRUFF 0.094 X 0.500 SAE #2 ANSI (304)
2	4054 PIN, DOWEL 0.2501/0.2503 DIA. X 0.625 LONG
1	5519 OIL PRESSURE REGULATOR ASSEMBLY A. C. SPEC
1	5923 HOUSING, RELIEF VALVE PRESSURE REGULATOR

REQUIRED		
1	5924	VALVE, RELIEF VALVE PRESSURE REGULATOR
1	5925	BOLT - RELIEF VALVE PRESSURE REGULATOR
1	5726	SCREW, OIL PRESSURE ADJUSTING
1	5938	SPRING - RELIEF VALVE, PRESSURE REGULATOR-SAE 17.6 3-7-62
2	4956	GASKET COPPER 0.750 I. D. 0.062 THICK SAME AS 5103 (“MCCORD” #511-A)
1	4339	NUT, HEX, LOCK, ELASTIC STOP
1	4340	GASKET 5/8 I. D. 7/8 O. D. COPPER CLAD ASBESTOS
1	5926	PLUG, RELIEF VALVE PRESSURE REGULATOR
8	35651	SCREW, CAP, HEX HEAD 0.313-18 UNC X 1.250 LONG GRADE 5 PLATED
6	35105	SCREW, CAP, HEX HEAD 0.375-16 UNC X 1.250 LONG GRADE 5 CADMIUM PLATED
3	4022	KEY, WOODRUFF 0.250 X 1.125 SAE #18, ANSI (809)
4	4030	WASHER, PLAIN #10 0.219 I. D. X 0.500 O. D. X 0.049 THICK, ZINC PLATED
4	4037	NUT, HEX 0.375-24 UNF ZINC PLATED
2	35066	SCREW, CAP, HEX HEAD 0.375-16 UNC X 0.750 LONG GRADE 5 CADMIUM PLATE
39	35024	SCREW, CAP, HEX HEAD 0.375-16 UNC X 0.875 LONG GRADE 5 CADMIUM PLATED
2	4047	WASHER, PLAIN 0.313 0.328 I. D. X 0.562 O. D. X 0.062 THICK, CADMIUM PLATED AN960-516
3	4051	KEY, WOODRUFF 0.156 X 0.750 SAE #8, ANSI (506)
8	35610	SCREW, CAP, HEX HEAD 0.250-20 UNC X 0.875 LONG GRADE 5 PLATED
74	4111	WASHER, PLAIN 0.375 0.391 I. D. X 0.625 O. D. X 0.062 THICK CADMIUM PLATED AN960-616