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SERVICE INSTRUCTION

DATE: August 15, 1986

Service Instruction No. 1029D
(Supersedes Service Instruction No. 1029C)
Engineering Aspects are
FAA Approved

SUBJECT: Tightening Procedures for Crankcase Thru-Studs and Bolts

MODELS AFFECTED: All Avco Lycoming piston engines.

TIME OF COMPLIANCE: When assembling cylinder(s) to engines.

All Avco Lycoming aircraft engines incorporate bolts and long thru studs that extend through the crankcase halves primarily for holding them together. The studs also secure the cylinders to their mounting decks on the crankcase.

Two basic types of thru studs are used: anchored and free-thru.

The anchored-thru studs are threaded into one of the crankcase halves; the free-thru studs are not. Instead, the free-thru studs extend through both crankcase halves. Because of their interference fit in the main bearing webs, the free-thru studs also serve as dowels to align the crankcase halves.

To insure uniform loading on the main bearings, it is necessary to tighten these studs and bolts in a sequence beginning at the approximate center of the engine and progressing evenly to both front and rear of the engine as described in detail in the following procedures.

Two different procedures are shown. The first procedure, shown in PART I, is to be used when the engine has been completely disassembled, or when all the cylinders have been removed; the second procedure, shown in part II, is used when individual cylinders are replaced on an assembled engine. The procedure shown in PART II is simpler to undertake, because bearing loading is localized.

PART I: TIGHTENING PROCEDURE FOR CRANKCASE THRU-STUDS. (Disassembled engines, or engines on which all cylinders have been removed.)

NOTE

Before installing cylinder hold-down nuts, lubricate crankcase thru stud threads with any one of the following lubricants, or combination of lubricants.

1. 90% SAE 50W engine oil and 10% STP
2. Parker Thread Lube
3. SAE 30W engine oil
4. 60% SAE 30W engine oil and 40% Parker Thread Lube.

1. Before the cylinders are assembled on the crankcase, install torque plate P/N ST-222 over the 1/2 inch thru-studs to simulate the thickness of the cylinder base flange; then install nuts on the free ends of 1/2 inch thru-studs and tighten each to 300 in. lbs. (25 ft. lbs.) Use tightening sequences that follow Figures 1 through 11.

NOTE

On O-235 Series crankcases, install spacers or flat washers over the 3/8 in. or 7/16 in. thru-studs (since torque plate P/N ST-222 does not apply) and torque to 300 in. lb. (25 ft. lb.).

2. Using same sequence as specified in paragraph 1, retorque the 1/2 in. thru-studs to 600 in. lbs. torque (50 ft. lbs). On O-235 model engines using 7/16-inch thru studs, retorque to 420-in. lb. (35 ft. lb.). Where 3/8-inch nuts are used, do not tighten more than 300 in. lb. (25 ft. lb.).

NOTE

Before tightening free-thru studs, make sure that they extend equally from both sides of crankcase.

3. Using sequences shown in figures 1 thru 11, tighten the 3/8-inch and 1/4-inch nuts at the crankcase parting flange. Torque values are:

3/8-inch nuts, 300 in. lb. (25 ft. lb.);
1/4-inch nuts and capscrews, 96-108 in. lb.;
1/4-inch shear nuts, 55-60 in. lb.

NOTE

The tightening sequence procedures following the illustrations are numerically keyed to the legends in the illustrations. As for those crankcase fastenings not specifically covered, use any sequence and tighten to torque values listed in paragraph 3, Part I.

a. Four Cylinder Engines, Wide Cylinder Flange (See Figure 1).

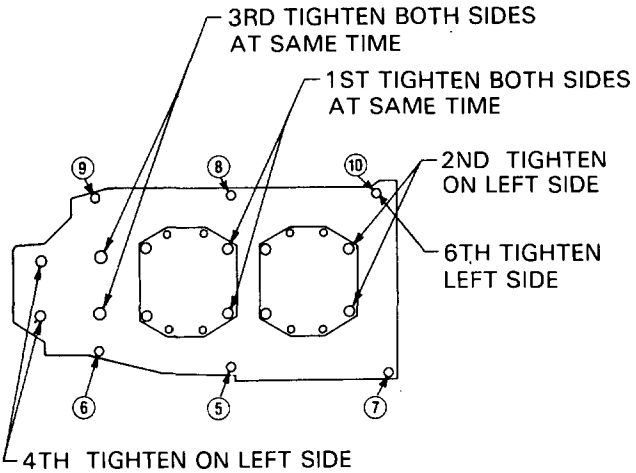

Figure 1. Left Side of Crankcase

1st - Tighten both ends of free-thru studs simultaneously at rear of No. 2 cylinder and at front of No. 3 cylinder.
2nd - Tighten thru studs at rear of No. 4 cylinder.
3rd - Tighten both ends of free-thru studs simultaneously in front of No. 2 cylinder and at front of No. 1 cylinder.
4th - Tighten 3/8-inch nuts at front main bearing (left side) to 300 in. lb. (25 ft. lb.).
5th - Tighten crankcase fastenings 5 thru 9 in sequence shown.
6th - Tighten 3/8-inch nut 10 at camshaft bearing location (left side) to 300 in. lb. (25 ft. lb.).

b. Four Cylinder Engines, Standard Cylinder Flange (See Figure 2).

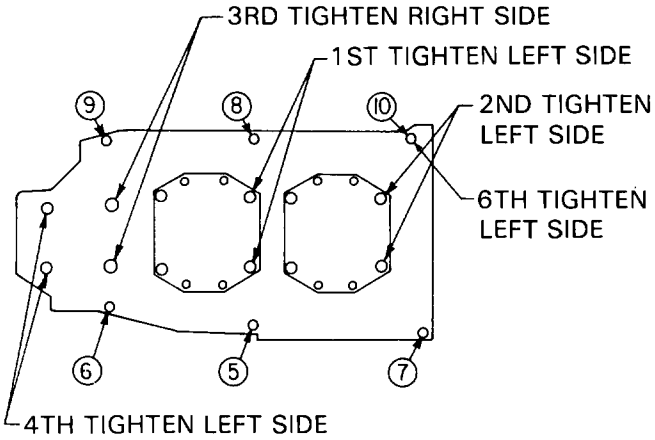

Figure 2. Left Side of Crankcase

1st - Tighten thru studs at rear of No. 2 cylinder.
2nd - Tighten thru studs at rear of No. 4 cylinder.
3rd - Tighten thru studs at front of No. 1 cylinder.
4th - Tighten 3/8 nuts at front main bearing (left side) to 300 in. lb. (25 ft. lb.).
5th - Tighten crankcase fastenings 5 thru 9 in sequence shown.
6th - Tighten 3/8-inch nut and bolt 10 at rear camshaft bearing location (left side) to 300 in. lb. (25 ft. lb.).

c. Four Cylinder Engines, Wide Cylinder Flange — "76" Series (See Figure 3).

NOTE

On 76 series engines, initially torque all 1/2-inch free-thru and anchored-thru studs to 300 in. lb. (25 ft. lb.). Then apply a final torque of 600 in.-lb. (50 ft. lb.). Tighten 3/8-inch nuts at front main bearings to 300 in.-lb. (25 ft. lb.).

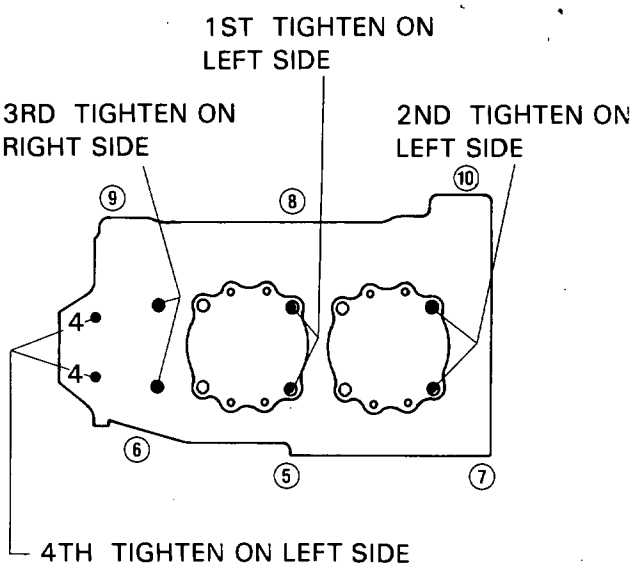

Figure 3. Left Side of Crankcase

1st - Tighten thru studs at rear of No. 2 cylinder.
2nd - Tighten thru studs at rear of No. 4 cylinder.
3rd - Tighten thru studs at front of No. 1 cylinder.
4th - Tighten 3/8-inch nuts at front main bearing (left side) to 300 in. lb. (25 ft. lb.).
5th - Tighten crankcase fastenings 5 thru 10 in sequence shown.

d. Six Cylinder Engines (O-540 Type), Wide Cylinder Flange (See Figure 4).

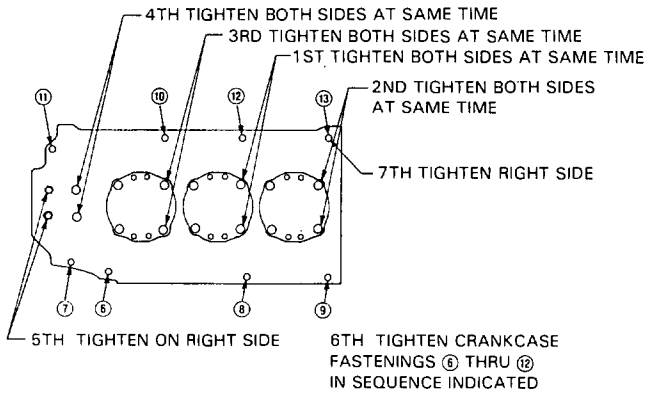

Figure 4. Left Side of Crankcase

1st - Tighten both ends of free-thru studs simultaneously at rear of No. 4 cylinder and at front of No. 5 cylinder.
2nd - Tighten both ends of free-thru studs simultaneously at rear of No. 6 cylinder and behind No. 5 cylinder.
3rd - Tighten both ends of free-thru studs simultaneously at rear of No. 2 cylinder and at front of No. 3 cylinder.
4th - Tighten both ends of free-thru studs simultaneously in front of No. 2 cylinder and at front of No. 1 cylinder.
5th - Tighten 3/8-inch nuts at front main bearing (right side) to 300 in. lb. (25 ft. lb.).
6th - Tighten crankcase fastenings 6 thru 12 in sequence shown.
7th - Tighten 3/8-inch nut 13 at rear camshaft bearing location (right side) to 300 in. lb. (25 ft. lb.).

e. Integral Accessory Drive Engines (TIO-541), Wide Cylinder Flange (See Figure 5).

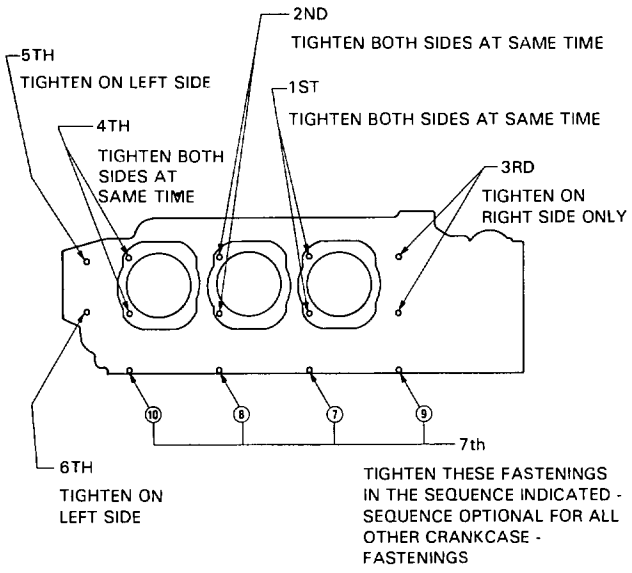

Figure 5. Left Side of Crankcase

1st - Tighten both ends of free-thru studs simultaneously at front of No. 5 cylinder and at rear of No. 4 cylinder.
2nd - Tighten both ends of free-thru studs simultaneously at front of No. 3 cylinder and at rear of No. 2 cylinder.
3rd - Tighten nuts on thru bolts at rear of No. 6 cylinder.
4th - Tighten both ends of free-thru studs simultaneously at front of No. 1 cylinder and in front of No. 2 cylinder.
5th - Tighten 1/2-inch bolt in front of No. 1 cylinder.
6th - Tighten 1/2-inch stud in front of No. 1 cylinder.
7th - Tighten 5/16-inch camshaft bearing nuts 7 thru 10 to 125-170 in. lb. (10-14 ft. lb.).

f. Integral Accessory Drive Engines (TIGO-541), Wide Cylinder Flange (See Figure 6).

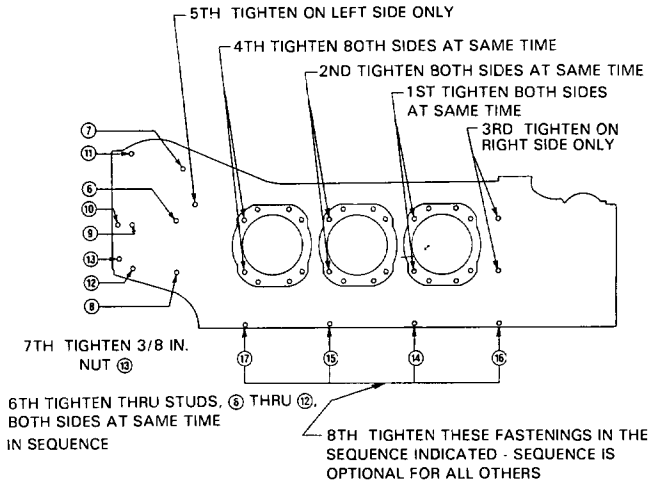

Figure 6. Left Side of Crankcase

1st - Tighten both ends of free-thru studs simultaneously at front of No. 5 cylinder and at rear of No. 4 cylinder.
2nd - Tighten both ends of free-thru studs simultaneously at front of No. 3 cylinder and at rear of No. 2 cylinder.
3rd - Tighten 1/2-inch thru bolts at rear of No. 6 cylinder.

4th - Tighten both ends of free-thru studs simultaneously at front of No. 1 cylinder and in front of No. 2 cylinder.
5th - Tighten 1/2-inch thru stud in front of No. 1 cylinder.
6th - In sequence, tighten both ends simultaneously of free-thru studs, 6 thru 12.
7th - Tighten 3/8-inch nut, 13, at front main bearing to 300-in. lb. (25 ft. lb.).
8th - Tighten 5/16-inch camshaft bearing nuts 14 thru 17 to 125-170 in. lb. (10-14 ft. lb.).

g. Six Cylinder Geared Engines (Wrap-Around Crankcase), Standard Cylinder Flange (See Figure 7).

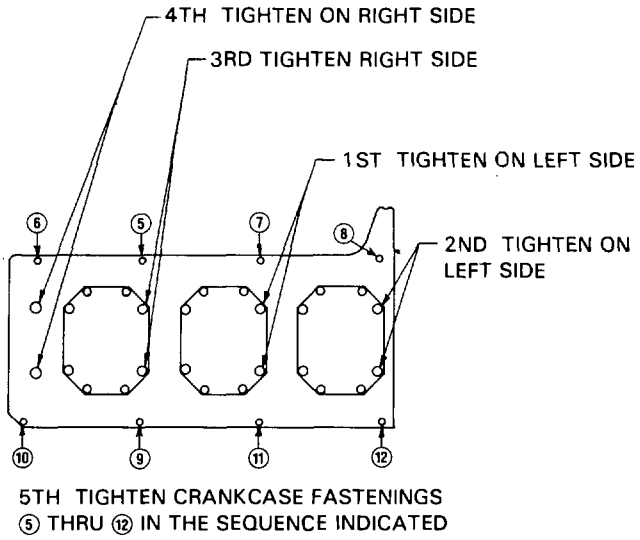

Figure 7. Left Side of Crankcase

1st - Tighten thru studs at rear of No. 4 cylinder.
2nd - Tighten thru studs at rear of No. 6 cylinder.
3rd - Tighten thru studs at front of No. 3 cylinder.
4th - Tighten thru studs at front of No. 1 cylinder.
5th - Tighten 3/8-inch nuts 5 thru 12 in sequence shown (left side) to 300 in. lb. (25 ft. lb.).

h. Six Cylinder Geared Engines (Open Bottom Crankcase), Standard Cylinder Flange (See Figure 8).

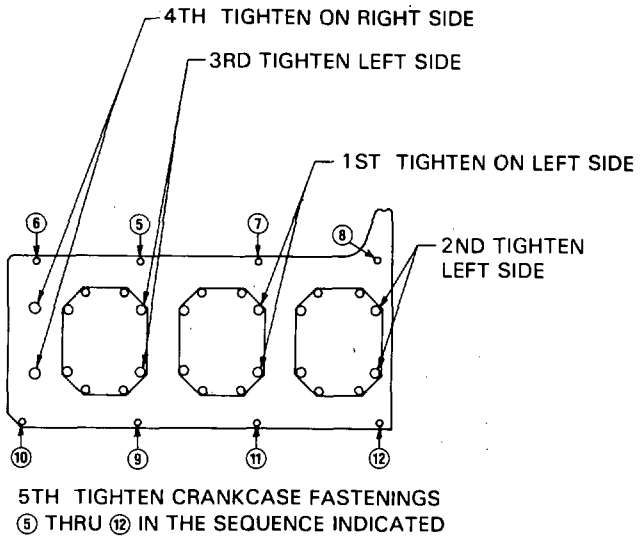

Figure 8. Left Side of Crankcase

1st - Tighten thru studs at rear of No. 4 cylinder.
2nd - Tighten thru studs at rear of No. 6 cylinder.
3rd - Tighten thru studs at rear of No. 2 cylinder.
4th - Tighten thru studs at front of No. 1 cylinder.
5th - Tighten 3/8-inch nuts 5 thru 12 in sequence shown (left side) to 300 in. lb. (25 ft. lb.).

i. Six Cylinder Direct Drive Engines, O-435A/O-540 type, Standard Cylinder Flange (See Figure 9).

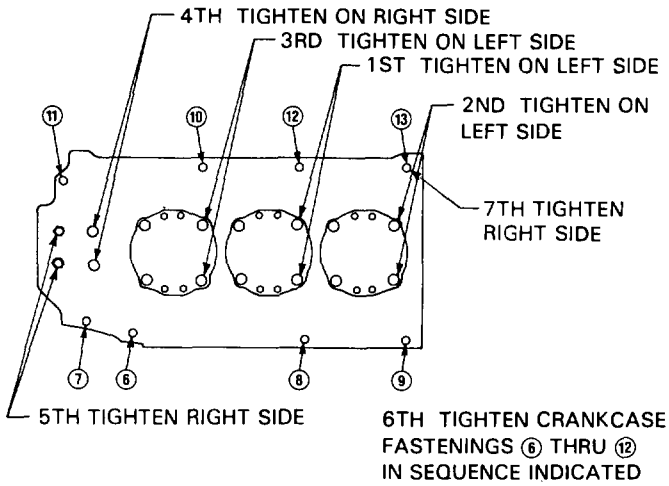

Figure 9. Left Side of Crankcase

1st - Tighten thru studs at rear of No. 4 cylinder.
2nd - Tighten thru studs at rear of No. 6 cylinder.
3rd - Tighten thru studs at rear of No. 2 cylinder.
4th - Tighten thru studs at front of No. 1 cylinder.
5th Tighten 3/8-inch nuts at front main bearing (right side) to 300 in. lb. (25 ft. lb.).
6th - Tighten crankcase fastenings 6 thru 12 in sequence shown.
7th - Tighten 3/8-inch nut 13 at rear camshaft bearing location (right side) to 300 in. lb. (25 ft. lb.).

j. Eight Cylinder Engines, Wide Cylinder Flange (See Figure 10).

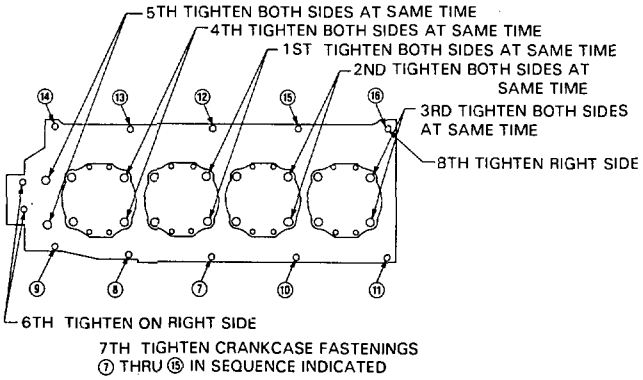

Figure 10. Left Side of Crankcase

1st - Tighten both ends of free-thru studs simultaneously at rear of No. 4 cylinder and at front of No. 5 cylinder.
2nd - Tighten both ends of free-thru studs simultaneously at rear of No. 6 cylinder and at front of No. 7 cylinder.
3rd - Tighten both ends of free-thru studs simultaneously at rear of No. 8 cylinder and in the crankcase behind No. 7 cylinder.
4th - Tighten both ends of free-thru studs simultaneously at rear of No. 2 cylinder and at front of No. 3 cylinder.
5th - Tighten both ends of free-thru studs simultaneously at front of No. 1 cylinder and in the crankcase in front of No. 2 cylinder.
6th - Tighten 3/8-inch nuts at front bearing location (right side) to 300 in. lb. (25 ft. lb.).
7th - Tighten crankcase fastenings 7 thru 15 in sequence shown.
8th - Tighten 3/8-inch nut 16 at right rear camshaft bearing location to 300 in. lb. (25 ft. lb.).

k. Eight Cylinder Engines, Standard Cylinder Flange (See Figure 11).

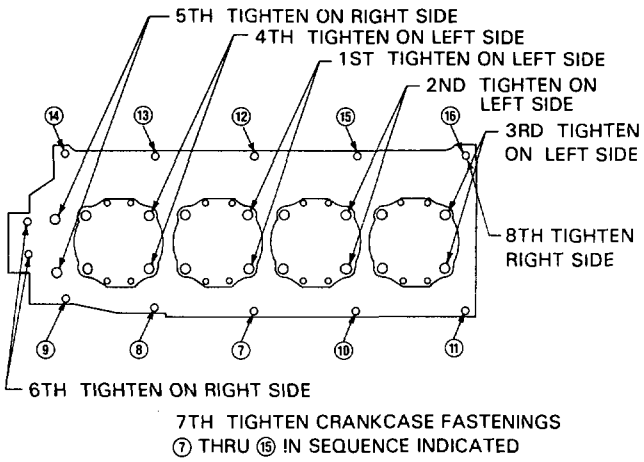

Figure 11. Left Side of Crankcase

1st - Tighten thru studs at rear of No. 4 cylinder.
2nd - Tighten thru studs at rear of No. 6 cylinder.
3rd - Tighten thru studs at rear of No. 8 cylinder.
4th - Tighten thru studs at rear of No. 2 cylinder.
5th - Tighten thru studs at front of No. 1 cylinder.
6th - Tighten 3/8-inch nuts at front main bearing (right side) to 300 in. lb. (25 ft. lb.).
7th - Tighten crankcase fastenings 7 thru 15 in sequence shown.
8th - Tighten 3/8-inch nut 16 at right rear camshaft bearing location to 300 in. lb. (25 ft. lb.).

4. Install sump, accessory housing, reduction gear unit and supercharger where applicable. Remove nuts and torque plate P/N ST-222 from the thru-studs on both rear cylinder mounting pads (cylinders 3 and 4 on four cylinder engines; 5 and 6 on six cylinder engines; and numbers 7 and 8 on eight cylinder engines).

5. Install cylinders on the pads from which the nuts were removed in the previous step. Initially tighten cylinder hold-down nuts, to a torque of 300 in. lb. (25 ft. lb.) in the sequence shown in Fig. 12. On engines with cylinder hold-down plates, follow instructions in Figure 13.

6. Proceed to install the remaining cylinders on the engine in pairs, proceeding toward the front, in the same manner as described in paragraphs 4 and 5.

7. Install 3/8 inch nuts on the remaining cylinder base studs and torque to 300 in. lbs. (25 ft. lbs.). The sequence for tightening these nuts is optional.

8. Using the same sequence as described in paragraphs 5 and 6, and shown in Figure 12, check all 1/2-inch nuts for tightness by bringing torque to 600 in. lb. (25 ft. lb.). Be sure shims are removed before final torquing engines using cylinder hold-down plates. On O-235 engines using 7/16-inch thru studs, retorque to 420-in. lb. (35 ft. lb.). Where 3/8-inch nuts are used, do not tighten more than 300 inches (25 ft. lb.).

9. Check 3/8-inch nuts for tightness on the remaining cylinder base studs by bringing torque up to 300 in. lb. (25 ft. lb.). Sequence is optional.

10. After all cylinder base nuts have been tightened, remove any nicks in cylinder fins by burring or filing.

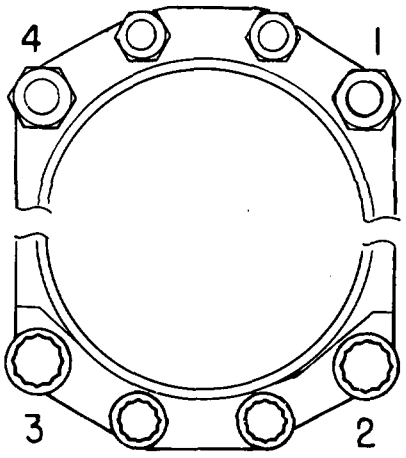

Figure 12. Sequence for Tightening Cylinder Basenuts

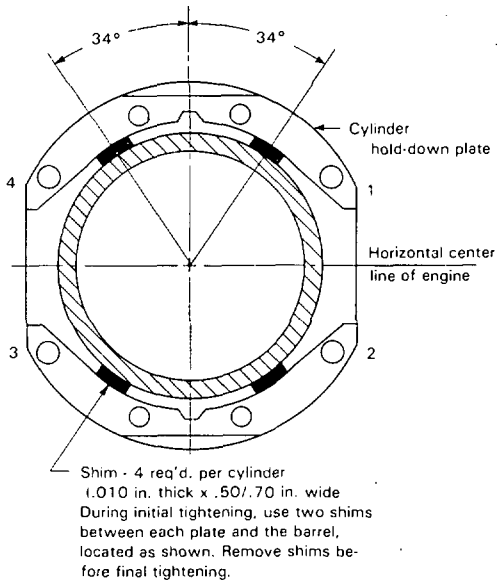

Figure 13. Location of Shims Between Cylinder Barrel and Hold-Down Plates

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PART II: TIGHTENING PROCEDURE FOR CYLINDER REPLACEMENT. (Assembled engines.)

NOTE

The tightening procedure for cylinder replacement on all wide cylinder flange engines is the same as the following procedure, except that both ends of free-thru studs must be tightened simultaneously. At any time one or more cylinders are replaced, it is necessary to retorque the thru-studs on the cylinder on the opposite side of the engine; the procedure is as follows:

1. Lubricate the threads of the thru-studs with any of the lubricants listed in the note preceding paragraph 1, Part I.

2. Install the cylinder on its mounting pad. If the engine employs hold-down plates, shim as shown in Figure 13. Initially torque the 1/2-inch thru studs to 300 in. lb. (25 ft. lb.) per sequence in Figure 12.

3. Then remove all shims from hold-down plates, if fitted, and retorque the 1/2-inch thru studs to 600 in. lb. (50 ft. lb.) per Figure 12.

NOTE

For those O-235 model engines using 3/8 inch thru studs, do not exceed torque of 300 in. lb. (25 ft. lb.). And if 7/16-inch studs are used, torque initially to 300 in. lb. (25 ft. lb.); then, following the same sequence in Figure 12, apply final torque of 420 in. lb. (35 ft. lb.).

4. Torque the thru-stud nuts on the opposite cylinder in the same manner as described above.

5. Install 3/8-inch nuts on remaining cylinder base studs and torque to 300 in. lb. (25 ft. lb.). The tightening sequence for these nuts is optional.

6. Recheck all thru studs and 3/8-inch cylinder basenuts on both the installed cylinder and its opposing cylinder by applying maximum torque values given.

NOTE

If thru studs and other cylinder basenuts are tightened properly, it is not necessary to use lockwire or Pal-Nuts for security purposes. However, this is the prerogative of the mechanic.

7. After all cylinder basenuts have been tightened, remove any nicks in cylinder fins by burring or filing.

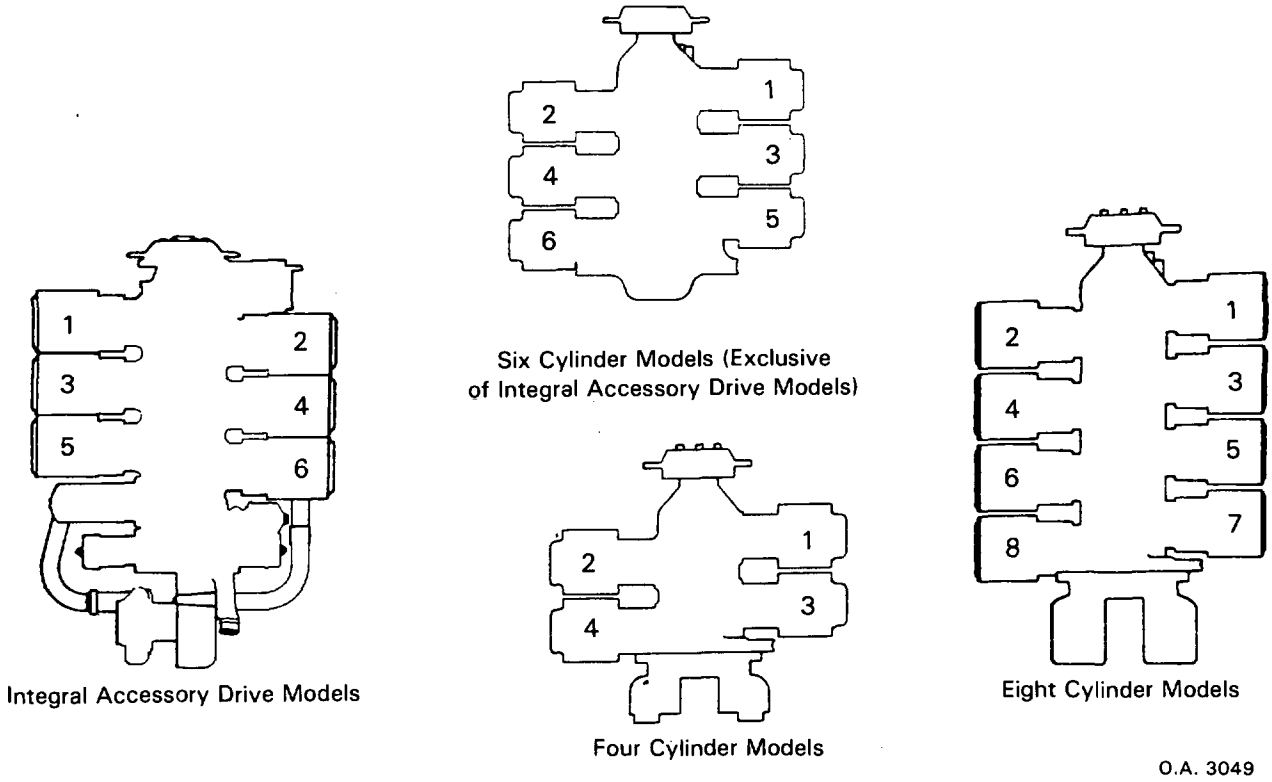

Figure 14. Cylinder Numbering System (Viewed from Top)

TOOL DATA:

CYLINDER BASE NUT PART NUMBER	TYPE	STUD SIZE	WRENCH PART NUMBER
71134	Allen head	3/8	64943 and ST-84 (3/8-inch Allen head)
71133	Allen head	1/2	64942 and ST-83 (1/2-inch Allen head)
383B	Hex head	3/8	ST-374 (9/16-inch Hex head)
STD-2090	Hex head	1/2	STD-375 (3/4-inch Hex head)
STD-2106	Hex head	7/16	ST-322 (5/8-inch Hex head)
68515	Spline head	3/8	64700 (9/16-inch spline head)
68514	Spline head	1/2	64701 (3/4-inch spline head)
Torque Hold Down Plate			ST-222

NOTE: Revision "D" revises text, artwork, format and part numbers; also adds wide cylinder flange 4-, 6-, and 8-cylinder engines.

6-118. (All Pistons.) Upon completion of assembly of the piston rings, check the side clearance of the rings in the grooves. Use feeler gage and straight edge as shown in figure 6-11.

NOTE

Under no circumstances should oversize piston rings be used in chrome plated barrels.

6-119. Assembly of Cylinder. See figure 6-5. Coat the valve guides and valves with a pre-lubricant as described in paragraph 3-39. Insert the intake and exhaust valve in their respective guides. The intake valve can be identified by the fact that it is slightly larger than the exhaust valve. Hold the ends of the valve stems and place the cylinder on the applicable cylinder holding block. Install on each valve a lower spring seat (5), outer and auxiliary valve spring (4 and 3), and outer valve spring seat (2).

NOTE

Assemble the dampener ends of springs (close wound coils marked with dye or lacquer) downward or next to lower spring seats.

6-120. Compress the valve springs with the valve spring compressor and assemble the valve retaining keys. If the valve is not seated properly the valve may be seated by using a wooden hammer handle against the tip of valve stem and hitting hammer with palm of hand. No other means should be used.

NOTE

Sodium-cooled exhaust valves are assembled with special keys and caps (32). Do not install caps until just before valve rockers are installed.

6-121. Installation of Pistons and Cylinders. See that all preservative oil accumulation on cylinder and piston assemblies is washed off with solvent and thoroughly dried with compressed air. Insert valve rocker shafts in their bores in the rocker box. Immediately prior to assembly of piston and cylinder to the engine, space the rings correctly and apply a generous coating of the oil mixture described in paragraph 3-39. Apply to the inside of the cylinder barrel and to piston and rings working the mixture well around the rings and into the grooves. Starting with No. 1 cylinder, proceed to install as follows:

6-122. Rotate crankshaft so that No. 1 piston, when installed, will be approximately at top dead center on the firing stroke; this is determined by both tappets of No. 1 cylinder being on the base circle of the cam lobes. Before any attempt is made to rotate the crankshaft support the connecting rods as shown in figure 6-2.

6-123. Assemble piston on connecting rod with piston number, which is stamped on bottom of piston head, toward the front of the engine. The piston pin should be palm or hand push fit. If the original piston pin is tighter than a palm push fit, it is porbably caused by

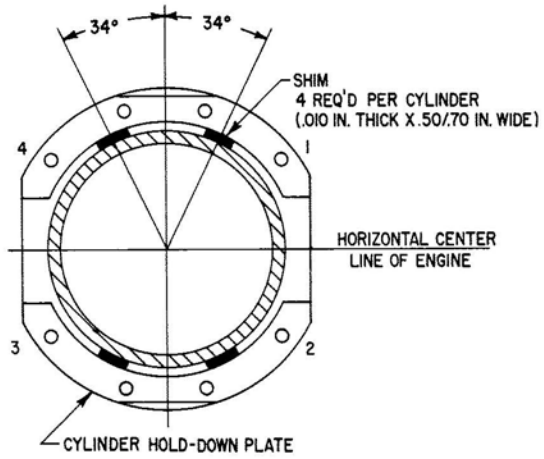

Figure 6-31. Location of Shims Between Cylinder Barrel and Hold-Down Plates

nicks or slight carbon in the piston pin bore of the piston. If a new piston pin or piston is to be installed, select the pin to give a palm push fit at room temperature of 15° to 20°C. (60° to 70°F.). After piston pin is in place and centrally located, insert a piston pin plug at each end of the piston pin.

6-124. Place a rubber cylinder base oil seal ring (27, figure 6-5) around the cylinder base, assemble the applicable piston ring compressor over the top piston rings and install the cylinder over the piston, pushing the piston ring compressor ahead with the cylinder barrel. This will encircle and compress the oil scrapper ring of O-235-C pistons at the piston skirt. As the cylinder barrel approaches the crankcase, catch the piston ring compressor as it drops off the piston skirt. When the base of cylinder is seated on crankcase pad, secure the cylinder with 3/8 inch and 1/2 inch cylinder base nuts, tightening the nuts finger tight only.

NOTE

Cylinder hold-down plates (10, figure 6-5) are not employed on all engines. Consult the applicable Parts Catalog for model application. When applicable, install the hold-down plates before assembling hold-down nuts. Also note that on o-235, O-290-D and -D2 series shroud tubes must be inserted prior to assembling cylinder to crankcase.

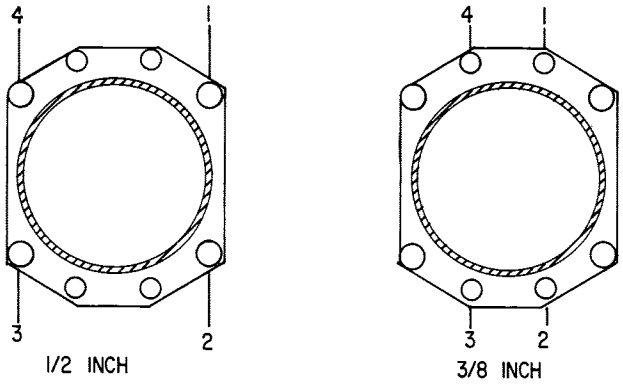

Figure 6-32. Sequence of Tightening Cylinder Base Nuts

6-126. When all cylinders have been initially installed on the crankcase as described in paragraph 6-124, begin tightening all cylinder base nuts as described below, using the proper cylinder base nut wrenches and handle in conjunction with a suitable torque indicator. Torque wrenches should employ the flexible beam design hydraulic principle or a dial indicator with rack and pinion.

NOTE

Before installing cylinder hold-down nuts, lubricate crankcase through stud threads with any one of the following lubricants, or combination of lubricants.

1. 90% SAE 50W engine oil and 10% STP.
2. Parker Thread Lube
3. 60% SAE 30 engine oil and 40% Parker Thread Lube.

a. Assemble hold down plates (where applicable) and cylinder base hold down nuts. Install shims between hold down plates and cylinder barrel as directed in figure 6-31.

b. Tighten 1/2 inch or 7/16 inch hold down nuts to 300 inch pounds (25 foot pounds) torque.

c. Remove shims and using the same sequence, tighten the 1/2 inch nuts to 600 inch pounds (50 foot pounds) torque or the 7/16 inch hold down nuts to 420 inch pounds (35 foot pounds) torque.

d. Tighten the 3/8 inch hold down nuts to 300 inch pounds (25 foot pounds) torque. Sequence is optional.

NOTE

All O-235 series engines, except the 125 HP series, employ only 3/8 inch hold down nuts. Tighten these nuts to 300 inch pounds (25 foot pounds) torque in the sequence shown for 1/2 inch hold down nuts in figure 6-32.

e. As a final check, hold the torque wrench on each nut for about five seconds. If the nut does not turn, it may be presumed to be tightened to correct torque.

f. Recheck clearance between hold-down plates and cylinder barrel. If .010 clearance is not obtained, loosen nuts and repeat steps b and c.

6-127. After all cylinder base nuts have been tightened, remove any nicks in the cylinder fins by filing or burring.

6-128. Install some type of vented plug in each spark plug hole after assembly of cylinder to prevent entrance of foreign matter and at the same time to permit the engine to be turned easily by hand.

6-129. (Except O-235, O-290-D). Install hydraulic tappet plunger and cylinder assemblies with spring end outward and sockets with concave end outward in the hydraulic tappet bodies.

CAUTION

Be sure that there is no oil inside tappet body and that the tappet plunger and cylinder assembly are thoroughly clean and dry. Wash any lubricating or preservative oil out of these parts, since tappet assemblies must be absolutely dry in order to check tappet clearance.

6-130. Assemble new shroud tube oil seals in both shroud tube oil seal retainers in crankcase and on outer end of the two push rod shroud tubes; then assemble a shroud tube seal sleeve over each of these seals, centering the sleeve on the seal.

6-131. Parallel Valve Cylinders. (Except O-235-C, O-290-D, -D2.) See figure 6-1. Install each shroud tube (1) through its hole in the rocker box and seat the end firmly in the crankcase. Place a spacer, two springs (2), a lockplate (3), and a plain 1/4-20 nut (4) over the stud provided in the rocker box. Tighten the nut to proper torque and secure by bending the lockplate over the nut and springs.

6-132. Angle Valve Cylinders. See figure 6-5. Assemble shroud tube spring (17) over the inner ends of the two shroud tubes (18) so that the detent notches in the spring are approximately 90° removed from detents on tubes. Place shroud tube washers (15), as many as necessary to bring minimum overlap between the spring and detent lugs to 1/8 inch, over end of each tube and insert tube ends through oil seals in crankcase. Hold both push rod shroud tubes with detent at inner end at unlocked position and insert the outer end of tubes in cylinder head rocker box. See that all rubber seals (14) are inserted squarely and then turn each shroud tube 90° thus locking the tubes by engaging the detents with the notches in the spring.

6-133. Select two push rods (13), dip in oil mixture described in paragraph 3-39 and insert full length through shroud tubes. Press tightly against outer ends and check for spring tension and free travel of unloaded or dry hydraulic tappet plungers.

6-134. Parallel Valve Cylinders. Pull rocker shaft out far enough to enable the rocker arm to be installed and push rocker shaft thru center hole, insert other rocker arm and secure with rocker shaft. Before installing exhaust rocker place special cap (39, figure 6-4) over the sodium cooled exhaust valve stem. Position rocker shaft until it protrudes equally from both outside bosses.