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STANDARD PRACTICES - MAINTENANCE PRACTICES

1. General

A. During disassembly, tag and mark all parts, clips, and brackets as to their location and position to prevent incorrect installation.

B. During removal of tubes or engine parts look for indications of scoring, burning or other undesirable conditions. Tag unserviceable parts and units for investigation and possible repair.

C. Extreme care shall be taken to prevent dust, dirt, lockwire, nuts, washers or other foreign matter from entering the engine. It cannot be overemphasized that this precaution applies whenever work is done on the engine either on the wing or off the wing. Suitable plugs, caps, and other covering shall be used to protect all openings as they are exposed. Dust caps used to protect open tubes against contamination shall always be installed over tube ends and not in the tube. Flow through the lines may be blocked if lines are inadvertently installed with dust caps in the tube ends.

D. If at any time items are dropped into the engine, the assembly process must stop until the dropped articles are located, even though this may require a considerable amount of time and labor. Before assembling or installing any part, be sure it is thoroughly clean.

E. Lockwire, lockwashers, tablocks, tabwashers, or cotterpins must never be reused. All lockwire and cotterpins must fit snugly in holes drilled in studs and bolts for locking purposes. Install a cotterpin so that the head fits into the castellation of the nut, and unless otherwise specified, bend one end of the pin back over the stud or bolt and the other end down flat against the nut. Only lockwire and cotterpins made of corrosion resistant steel shall be used. Bushing plugs shall be lockwired to the assembly boss or case; do not lockwire the plug to the bushing.

F. Replace all gaskets, packings, and rubber parts at reassembly. Make sure that new nonmetallic parts to be installed (such as an oil seal) show no sign of having deteriorated in storage.

G. To protect critical areas of engine parts (such as compressor and turbine disks) against scratches and nicks, tool surfaces contacting these areas must be covered with protective material.

H. During replacement of components, note condition of any removed preformed packings. Pieces accidentally torn or cut from packings must be retrieved, regardless of size, even if this entails a systematic disassembly and cleaning of the system. Make sure that new packings are free of cuts, flashings and deformities which may be sheared off at installation.

I. When installing engine parts that require the use of a hammer to facilitate assembly or installation, use only a plastic or rawhide hammer.

J. Whenever pressure sensitive tape has been applied to any part, the tape must be removed and the part thoroughly cleaned of all tape residue prior to being subjected to high temperature during engine run. Test results indicate that all tapes are capable of causing surface attack and/or reduction in tensile ductility as temperature increases. Do not leave tape or tape residue on engine parts.

K. If any part has been coated with corrosion preventive compounds, all traces of the compound and accumulated foreign matter must be removed.

2. Standard Torques

A. General

(1) Torque values given in the manual are to be interpreted:

(a) Pound-inches at room temperature.

(b) Angle of turn, in degrees.

(c) Stretch values in inches.

(2) Unless otherwise specified, thread lubricant shall be engine oil and shall be applied to parts which are to be tightened.

(3) If the part to be tightened is hot, allow sufficient time for the part to reach temperature equilibrium with the surrounding area before final torquing.

(4) Flange bolts shall be drawn up evenly. This can be achieved by having two mechanics working simultaneously 180 degrees apart.

(5) Tightening applications should be done slowly and evenly for consistency and the best possible accuracy. Check for adequate torque of self-locking fasteners before reuse. Discard fastener if locking capability is impaired. Do not repair self-locking fasteners.

(6) Self-locking nuts, self-locking bolts, and self-locking helical coil inserts shall be capable of meeting the torque requirements in Table 201.

TABLE 201, Torque Check for Reuse of Self-Locking Nuts, Bolts and Helical Coil Inserts (Pound-inches at Room Temperature and Lubricated With Engine Oil)

Mating Bolt Thread Size	Max Locking Torque	Min Breakaway Torque	Mating Bolt Thread Size	Max Locking Torque	Min Breakaway Torque
0.112-48NF-2A	3	0.5	0.112-40NC-2A	3	0.5
0.138-40NF-2A	6	1.0	0.125-40NC-2A	4	1.0
0.164-36NF-2A	9	1.5	0.138-32NC-2A	6	1.0
0.190-32UNF-3A	13	2.0	0.164-32NC-2A	9	1.5
0.250-28UNF-3A	30	3.5	0.190-24UNC-3A	13	2.0

TABLE 201, Torque Check for Reuse of Self-Locking Nuts, Bolts and Helical Coil Inserts (Pound-inches at Room Temperature and Lubricated With Engine Oil) (Cont'd)

Mating Bolt Thread Size	Max Locking Torque	Min Breakaway Torque	Mating Bolt Thread Size	Max Locking Torque	Min Breakaway Torque
0.3125-24UNF-3A	60	6.5	0.250-20UNC-3A	30	4.5
0.375-24UNF-3A	80	9.5	0.3125-18UNC-3A	60	7.5
0.4375-20UNF-3A	100	14.0	0.375-16UNC-3A	80	12.0
0.500-20UNF-3A	150	18.0	0.4375-14UNC-3A	100	16.5
0.5625-18UNF-3A	200	24.0	0.500-14UNC-3A	150	24.0
0.625-18UNF-3A	300	32.0	0.5625-12UNC-3A	200	30.0
0.750-16UNF-3A	400	50.0	0.625-11UNC-3A	300	40.0
0.875-14UNF-3A	600	70.0	0.750-10UNC-3A	400	60.0

NOTE: The breakaway torque specified is the minimum torque required to overcome static friction, and applies at installation or removal. The locking torque specified is the maximum torque required to overcome kinetic friction and applies at installation or removal.

NOTE: Use the listed bolt sizes for torque testing cadmium plated nuts, carbon steel nuts, alloy steel nuts, and aluminum nuts.

3. Torque Indicating Devices

A. General

(1) Check torque indicating devices before using, and calibrate them by means of weights and a measured lever arm to make sure that there are no inaccuracies. Checking one torque wrench against another is not sufficient. Some wrenches are quite sensitive to the way they are supported during a tightening operation, and every effort must be made to adhere to the instructions furnished by the respective manufacturers.

B. Torque Wrench and Extensions

(1) Occasionally, it is necessary to use a special extension, or adapter wrench together with a standard torque wrench (Ref. Fig. 201). In order to arrive at the resultant required torque limits, the following formula shall be used:

T - Desired torque on the part.

E - Effective length of special extension or adapter.

L - Effective length of torque wrench.

A - Distance through which force is applied to part.

R - Reading on scale or dial of torque wrench.

$$R = \frac{LT}{A} = \frac{LT}{L + E}$$

Example:

A torque of 1440 lb.in. is desired on a part, using special extension having a length of three inches from center to center of its holes, and a torque wrench measuring 15 inches from center of handle or handle swivel pin to center of its square adapter. Then:

$$R = \frac{LT}{L + E} = \frac{15 \times 1440}{15 + 3} = 1200 \text{ lb.in.}$$

(2) With the axis of the extension or adapter and the torque wrench in a straight line, tightening to a wrench reading of 1200 lb.in. will provide the desired torque of 1440 lb.in. on the part.

4. Torque Recommendations

A. Lubricated Parts

(1) All nut, bolt and screw torques should be obtained using a thread lubricant. The lubricant should be engine oil, or equivalent, unless otherwise specified. Torque requirements for interference fit application, such as studs and pipe plugs, may be obtained with or without lubrication, unless otherwise specified.

(2) Antigalling compound should be applied to all loose-fit spline drives which are external to the engine and have no other means of lubrication. For certain assembly procedures, molybdenum disulfide in either paste or powder form mixed with engine oil or grease may be used. Particular applications of molybdenum disulfide are indicated in the individual text portions of this manual. Make sure antiseize and antigalling compounds are applied in a thin even coat, and that excess is completely removed to avoid contamination of adjacent parts, passages or surfaces where the compound may cause malfunctioning, or failure, of engine.

(3) The torque values given within the text apply to nuts where the height of the nut is approximately equal to the major diameter of the thread. For jam nuts refer to REMOVAL/INSTALLATION. Torque values do not apply to hollow bolts and screws.

B. Nuts, Bolts and Screws

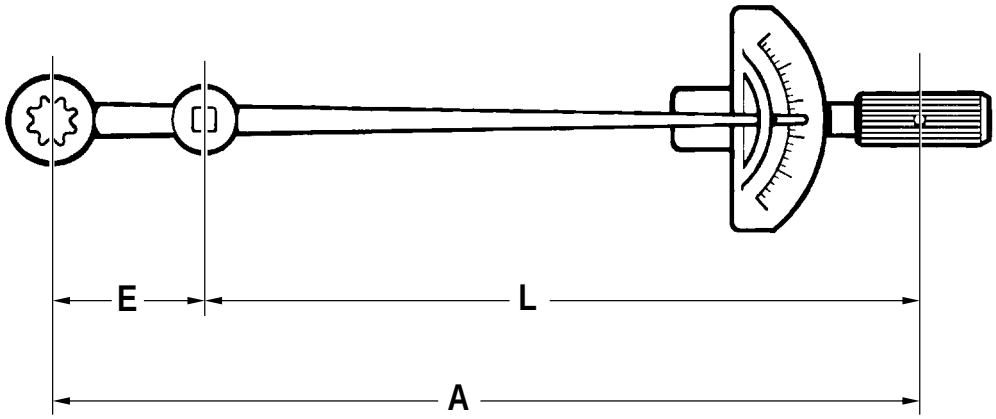
(1) Bolts and nuts on flanges with metal tubular gaskets must be initially torqued to the required torque and then retorqued until the torque value given in the relevant assembly instruction remains constant.

C. Self-locking Nuts

(1) The locking torque for self-locking nuts and helical coil inserts must be checked at assembly. The locking torque must not be less than the values shown (Ref. Table 202) unless otherwise specified.

(2) When checking self-locking torque, care must be taken to ensure the fastener is not seated. This ensures that only the torque necessary to overcome the friction holding the thread is measured.

NOTE: Self-locking nuts should be checked for effectivity of self-locking feature before reinstallation. Reject suspect nuts as necessary.



C192A

Torque Wrench and Extension
Figure 201

(3) For each item, note the torque necessary to turn nut on bolt before seating the nut.

(4) Add this torque to the value detailed in the assembly instructions for the application. Use this new value as the total applied torque.

TABLE 202, Locking Torque for Self-locking Nuts and Helical Coil Inserts

Thread Size	Torque lb.in. Min
0.112-40	0.5
0.112-48	0.5
0.138-32	1.0
0.164-32	1.5
0.164-36	1.5
0.190-24	2.0
0.190-32	2.0
0.2500-20	4.5
0.2500-28	3.5
0.3125-18	7.5
0.3125-24	6.5
0.3750-16	12.0
0.3750-24	9.5
0.4375-14	16.5
0.4375-20	14.0
0.5000-13	24.0
0.5000-20	18.0
0.5625-12	30.0
0.5625-18	24.0
0.6250-11	40.0
0.6250-18	32.0
0.750-10	60.0
0.750-16	50.0
0.875-9	82.0
0.875-14	70.0
1.000-8	110.0
1.000-12	90.0

D. Power Torque Wrench

(1) The retaining nut for the power turbines is removed and installed with a power torque wrench and appropriate adapter, supplied with the engine overhaul kit.

(2) The power torque wrench employs a high ratio geartrain operated by a handcrank (supplied with the tool) or a pneumatic ratchet drive tool. A ¾-inch square drive bar (also supplied with the tool) transmits the output torque of the geartrain to the socket wrench on the nut being turned. Two ½-inch diameter pins on each space adapter transmit the counteracting load. Input and output shafts of the wrench rotate in the same direction.

(3) It must be emphasized that when using a countertorque adapter attached to the nut, the direction of the input drive is opposite to that normally required on the nut being turned, i.e., when tightening a nut, the input drive must be turned counterclockwise; when loosening, the reverse rotation applies.

(4) To tighten a nut, using the power torque wrench and appropriate countertorque adapter:

(a) Install socket wrench on nut.

(b) Install appropriate countertorque adapter on part being assembled.

NOTE: Observe instructions marked on adapter denoting direction of rotation required when torquing and untorquing.

(c) Install power torque wrench on adapter, and engage both pins.

(d) Insert 3/4-inch output drive bar into wrench output shaft, and turn until bar engages socket wrench.

(e) Turn ratchet (located on front face of power wrench) in same direction as that required to turn output driveshaft.

(f) Insert input drive source (handle or power-operated wrench) in input shaft, and turn in same direction as that required for output shaft.

(g) Continue turning until torque indicator reaches required reading on scale.

NOTE: Since the torque indicator is calibrated in pounds-feet, the appropriate conversion must be made when torquing to values specified in pounds-inches.

(h) To remove power wrench, reverse direction of rotation of input drive until indicator returns to zero (green band); this removes the holding pressure on the wrench, allowing it to be withdrawn from the adapter.

(i) Remove power wrench, adapter and socket wrench.

(5) To untorque, repeat the preceding steps (a) through (i), except for rotational direction of ratchet and input shaft, which must be reversed.

E. Lockwire and Cotterpin Requirements

(1) When tightening a castellated nut, alignment of the slot must be obtained without exceeding the maximum torque. If this is not possible, replace the nut with another one. After tightening the nut to the recommended torque, the nut must not be loosened to permit insertion of lockwire or cotterpin. If the slot in the nut or the lockwire hole in the bolt or screw is not correctly aligned at the minimum torque value given, the nut, screw or bolt should be further tightened to the next alignment position, but the maximum torque value given must not be exceeded. Should the alignment still be impossible without exceeding the maximum torque, back off the nut, screw or bolt one-half turn and retorque.

F. Slotted, Steel Locknuts (Prevailing Torque Type)

(1) Effective locking of slotted, steel locknuts on bolts or studs requires full engagement of all locknut threads. The chamfered section of the locknut ID does not exert force on the bolt or stud; therefore, it is not necessary that the bolt or stud be flush with, or protrude from, the outer face of the locknut.

G. Standard and Stepped Studs

(1) When the torque required to drive a stud to the correct protrusion does not reach the minimum value given, or exceeds the maximum value given, a new stud must be selected.

H. Hose, Tubing and Threaded Couplings

(1) If leakage occurs at a coupling, do not attempt to correct by overtorquing. Disassemble the fitting and check for nicks, burrs and/or foreign matter. Use new parts, as required, to rectify fault.

5. Locking Devices

A. Keywashers (Tab and Cup Type) (Ref. Fig. 202)

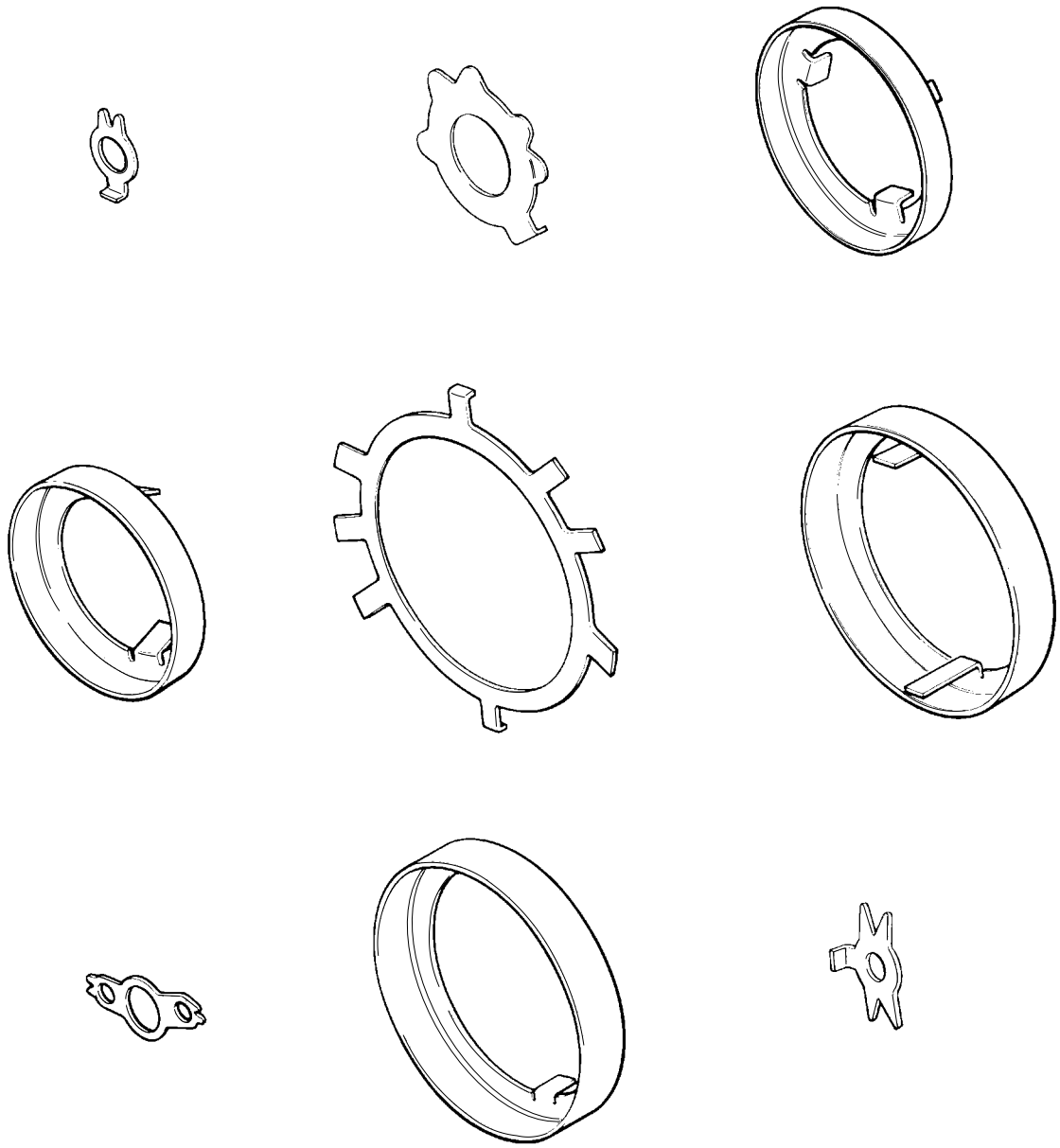
CAUTION: KEYWASHERS ARE TO BE USED ONCE ONLY. INSTALL NEW KEYWASHER(S) AT EACH ASSEMBLY.

CAUTION: DO NOT USE SHARP EDGED TOOLS TO BEND OR SET KEYWASHER TABS. TAB DETACHMENT MAY OCCUR WITH SUBSEQUENT DAMAGE TO THE ENGINE.

(1) The terms keywasher, tabwasher and cupwasher are interchangeable, as used in this manual.

(2) When bending or setting the tabs on these washers, do not use sharp-pointed tools. Use of such tools can lead to subsequent failure of the locking tabs which, on becoming detached, can pass through the engine causing extensive damage.

(3) Assembly requirements for cupwashers:



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Examples of Lockwashers
Figure 202

(a) Examine the cupwasher for freedom from deep drawing score marks (especially in undercut adjacent to tangs) and for freedom from prior assembly/handling damage, i.e. bent tangs or prior stake marks.

(b) Examine contact surfaces for excessive roughness, burrs, or scores that may cause the washer to bend on the nut.

(c) Examine the nut for burrs, nicks or scratches on the face adjacent to the cupwasher that could cause the nut to pick up on the washer.

(d) The cupwasher must be lubricated on the nut side only, the opposite face must be clean and dry.

(e) With the cupwasher placed against the shaft slots opposite to direction of nut tightening, screw the nut fingertight.

(f) With an approved silver pencil, make an alignment mark on the cupwasher outside diameter and the component immediately adjacent to cupwasher.

(g) Tighten the nut in the normal manner.

(h) If the alignment mark has moved, remove and discard the cupwasher.

(i) Repeat the procedure with a new cupwasher.

(j) Stake the cupwasher.

B. Retaining Rings

CAUTION: THOROUGHLY INSPECT ALL RETAINING RINGS, INCLUDING SPIROLOX, FOR CONDITION. DISTORTED RINGS ARE NOT ACCEPTABLE AND MUST BE REPLACED.

(1) Retaining rings must be installed using approved retaining ring pliers. Internal type rings must not be compressed beyond the point where the ends of the ring meet. External type rings must be expanded just enough to allow installation without becoming bent. After installation, make sure that each ring is completely seated, without looseness or distortion in its groove.

C. Lockwire

(1) Except where otherwise specified, the wire is made of heat and corrosion resistant steel wire 0.025 inch diameter.

(2) Lockwire must be tight after installation to prevent failure due to rubbing or vibration.

(3) Lockwire must be installed in a manner that tends to tighten and keep a part locked in place thus counteracting the natural tendency of the part to loosen.

(4) Lockwire must never be overstressed. It will break under vibration if twisted too tightly. The lockwire shall be pulled taut when being twisted, but shall have minimum tension, if any when secured.

(5) Lockwire ends must be bent toward the engine, or part, to avoid sharp or projecting ends which might present a safety hazard or vibrate in the air stream.

(6) Internal wiring must not cross over or obstruct a flow passage when an alternate method can be used.

(7) Check the units to be lockwired to make sure they have been correctly torqued and that the wiring holes are properly positioned in relation to each other. When there are two or more units, it is desirable that the holes in the units be in the same relationship to each other. Never overtorque or loosen units to obtain proper alignment of the holes. It should be possible to align the wiring holes when the units are torqued within the specified limits. However, if it is impossible to obtain a proper alignment of the holes without either over or under torquing, select another unit which will permit proper alignment within the specified torque limits.

(8) To prevent mutilations of the twisted section of the wire when using pliers, grasp the wire at the ends or at a point that will not be twisted. Lockwire must not be nicked, kinked, or mutilated. Never twist the wire ends off with the pliers and when cutting off ends, leave at least three complete turns after the loop, exercising extreme care to prevent the wire ends from falling into the engine. The strength of the lockwire holes is marginal; never twist the wire off with pliers. Cut the lockwire close to the hole, exercising extreme care.

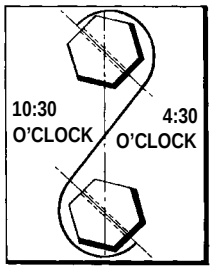
(9) Figure 203 illustrates a typical lockwiring procedure. Although there are numerous lockwiring operations performed on these engines, practically all are derived from the basic examples shown in Figure 204.

6. Identification of Hardware Material, Particularly Nuts and Bolts

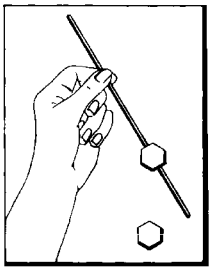
A. A permanent type of material code designation has been adopted for use in these engines. Correct engine reassembly procedures require that particular attention be paid to the material requirements for nuts and bolts used in the hot section of the engine. In these areas, where parts must be of material which is resistant to high operating temperatures, special heat resistant alloys are employed. It is imperative, that at reassembly of the engine or its components, the properly coded part be reassembled in its original location, if serviceable.

B. The code system employs the use of a letter ‘‘C’’ for corrosion resistant steel for normal application and ‘‘H’’ for heat resistant alloys in hot section application. The stamped or embossed letter will be followed by a number of one or more digits, such as C1, C8, H3, and H12. Bolt code identification will usually appear on the top of the head and nut identification on one side of the hex (Ref. Fig. 205). When the application is an AN or MS six digit part number, the code identification ‘‘C’’ or ‘‘H’’ will be preceded by the letter ‘‘E’’ as in EC3 or EH10.

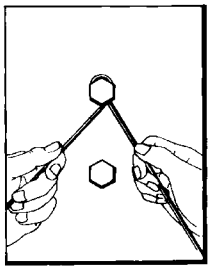
NOTE: All AN or MS six digit part numbers, when manufactured of material in the common temperature range (such as cadmium plated, low alloy steel parts), are also coded ‘‘E’’ to indicate, in part, close material quality control.



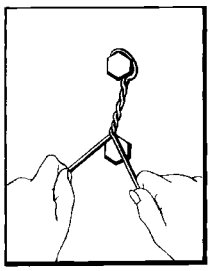
POSITION THE HOLES



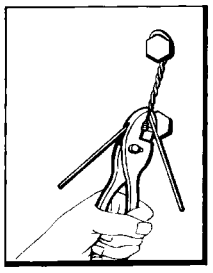
INSERT PROPER GAGE WIRE



GRASP UPPER END OF THE WIRE AND BEND IT AROUND THE HEAD OF THE BOLT, THEN UNDER THE OTHER END OF THE WIRE. BE SURE WIRE IS TIGHT AROUND HEAD.

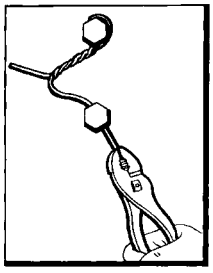


TWIST WIRE UNTIL WIRE IS JUST SHORT OF HOLE IN THE SECOND BOLT.

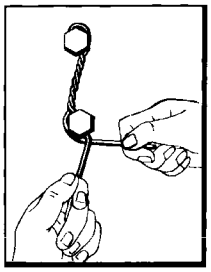


KEEPING WIRE UNDER TENSION, TWIST IN A CLOCKWISE DIRECTION UNTIL THE WIRE IS TIGHT. WHEN TIGHTENED THE WIRE SHALL HAVE APPROXIMATELY 7 TO 10 TWISTS PER INCH.

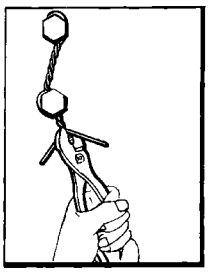
INSERT THE UPPERMOST WIRE, WHICH POINTS TOWARDS THE SECOND BOLT, THROUGH THE HOLE WHICH LIES BETWEEN THE NINE AND TWELVE O'CLOCK POSITIONS. GRASP THE END OF THE WIRE WITH A PAIR OF PLIERS AND PULL THE WIRE TIGHT.



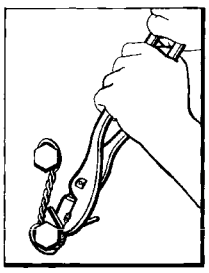
BRING THE FREE END OF THE WIRE AROUND THE BOLT HEAD IN A COUNTERCLOCKWISE DIRECTION AND UNDER THE END PROTRUDING FROM THE BOLT HOLE. TWIST THE WIRE IN A COUNTERCLOCK–WISE DIRECTION.



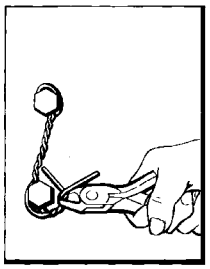
GRASP THE WIRE BEYOND THE TWISTED PORTION AND TWIST THE WIRE ENDS COUNTER–CLOCKWISE UNTIL TIGHT.



DURING THE FINAL TWISTING MOTION OF THE PLIERS, BEND THE WIRE DOWN AND UNDER THE HEAD OF THE BOLT.



CUT OFF EXCESS WIRE WITH DIAGNOL CUTTERS.



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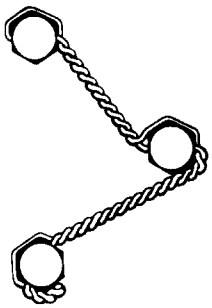
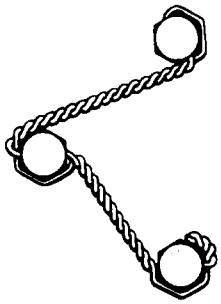
Lockwiring Procedure
Figure 203

EXAMPLE 1



EXAMPLE 2



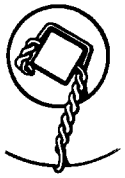
EXAMPLE 3

EXAMPLE 4

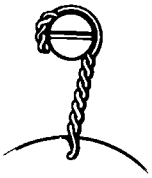
EXAMPLES 1,2,3 AND 4 APPLY TO ALL TYPES OF BOLTS, FILLISTER HEAD SCREWS, SQUARE HEAD PLUGS, AND OTHER SIMILAR PARTS WHICH ARE WIRED SO THAT THE LOOSENING TENDENCY OF EITHER PART IS COUNTERACTED BY TIGHTENING OF THE OTHER PART. THE DIRECTION OF TWIST, FROM THE SECOND TO THE THIRD UNIT, IS COUNTER–CLOCKWISE TO KEEP THE LOOP IN POSITION AGAINST THE HEAD OF THE BOLT. THE WIRE ENTERING THE HOLE IN THE THIRD UNIT WILL BE THE LOWER WIRE AND BY MAKING A COUNTER–CLOCKWISE TWIST AFTER IT LEAVES THE HOLE, THE LOOP WILL BE SECURED IN PLACE AROUND THE HEAD OF THAT BOLT.

EXAMPLE 5

EXAMPLE 6

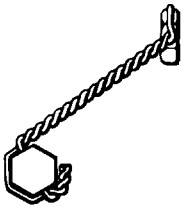


EXAMPLE 7



EXAMPLE 8

EXAMPLES 5,6,7 AND 8 SHOW METHODS FOR WIRING VARIOUS STANDARD ITEMS. WIRE MAY BE WRAPPED OVER THE UNIT RATHER THAN AROUND IT WHEN WIRING CASTELLATED NUTS OR ON OTHER ITEMS WHEN THERE IS A CLEARANCE PROBLEM.



EXAMPLE 9

EXAMPLE 9 SHOWS THE METHOD FOR WIRING BOLTS IN DIFFERENT PLANES. NOTE THAT WIRE SHOULD ALWAYS BE APPLIED SO THAT TENSION IS IN THE TIGHTENING DIRECTION.

EXAMPLE 10

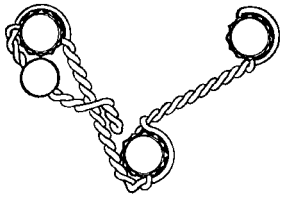
EXAMPLE 10 SHOWS HOLLOW HEAD PLUGS WIRED WITH THE TAB BENT INSIDE THE HOLE TO AVOID SNAGS AND POSSIBLE INJURY TO PERSONNEL WORKING ON THE ENGINE.

EXAMPLE 11

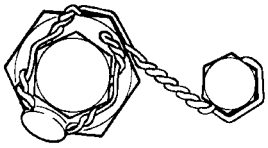
EXAMPLE 11 SHOWS CORRECT APPLICATION OF SINGLE WIRE TO CLOSELY SPACED MULTIPLE GROUP.

C195_1

Lockwiring Examples
Figure 204 (Sheet 1 of 3)



EXAMPLE 12



EXAMPLE 13

EXAMPLES 12 AND 13 SHOW METHODS FOR ATTACHING LEAD SEAL TO PROTECT CRITICAL ADJUSTMENTS.

EXAMPLE 14

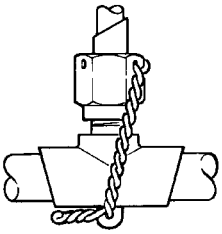
EXAMPLE 14 SHOWS BOLT WIRED TO A RIGHT ANGLE BRACKET WITH THE WIRE WRAPPED AROUND THE BRACKET.

EXAMPLE 15

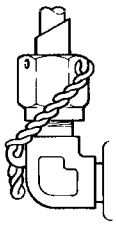
EXAMPLE 15 SHOWS CORRECT METHOD FOR WIRING ADJUSTABLE CONNECTING ROD.

EXAMPLE 16

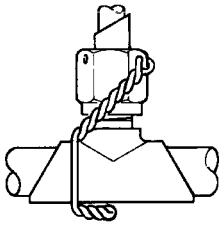
EXAMPLE 16 SHOWS CORRECT METHOD FOR WIRING THE COUPLING NUT ON FLEXIBLE LINE TO THE STRAIGHT CONNECTOR BRAZED ON RIGIDTUBE.



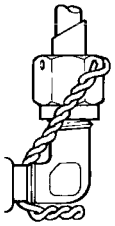
EXAMPLE 17



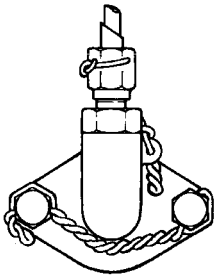
EXAMPLE 18



EXAMPLE 19



EXAMPLE 20



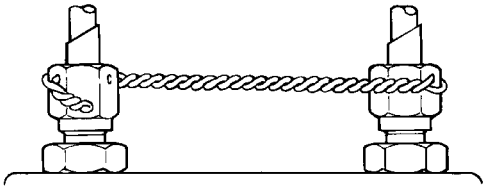
EXAMPLE 21

FITTINGS INCORPORATING WIRE LUGS SHALL BE WIRED AS SHOWN IN EXAMPLES 17 AND 18. WHERE NO LOCKWIRE LUG IS PROVIDED, WIRE SHOULD BE APPLIED AS SHOWN IN EXAMPLES 19 AND 20 WITH CAUTION BEING EXERTED TO ENSURE THAT WIRE IS WRAPPED TIGHTLY AROUND THE FITTING.

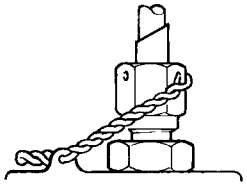
SMALL SIZE COUPLING NUTS SHALL BE WIRED BY WRAPPING THE WIRE AROUND THE NUT AND INSERTING IT THROUGH THE HOLES AS SHOWN.

C195_2

Lockwiring Examples
Figure 204 (Sheet 2)

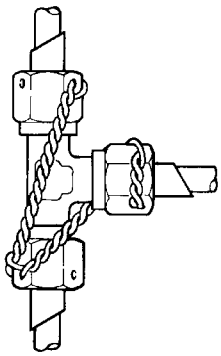


EXAMPLE 22



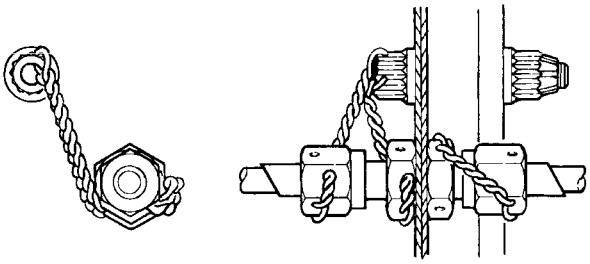
EXAMPLE 23

COUPLING NUTS ATTACHED TO STRAIGHT CONNECTORS SHALL BE WIRED AS SHOWN WHEN HEX IS AN INTEGRAL PART OF THE CONNECTOR.



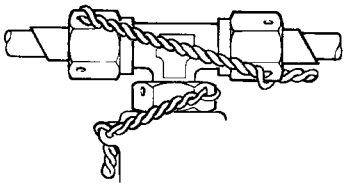
EXAMPLE 24

COUPLING NUTS ON A TEE SHALL BE WIRED AS SHOWN ABOVE SO THAT TENSION IS ALWAYS IN THE TIGHTENING DIRECTION.

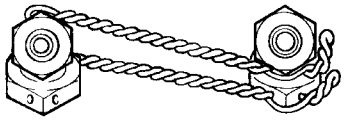


EXAMPLE 25

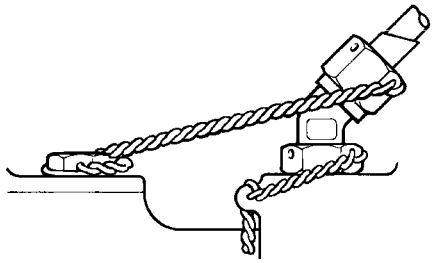
STRAIGHT CONNECTOR
(BULKHEAD TYPE)



EXAMPLE 26



EXAMPLE 27

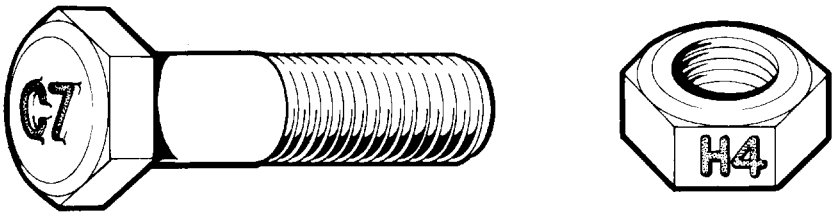


EXAMPLE 28

EXAMPLES 26, 27 AND 28 SHOW THE VARIOUS STANDARD FITTINGS WITH CHECK NUT WIRED SO THAT IT NEED NOT BE DISTURBED WHEN REMOVING THE COUPLING NUT.

C195_3

Lockwiring Examples
Figure 204 (Sheet 3)



C196

Hardware Code Identification
Figure 205

CAUTION: NEVER ASSEMBLE A MATERIAL CODED PART WITH A "C" IDENTIFICATION IN A LOCATION WHICH REQUIRES AN "H" CODED PART AND VICE-VERSA. NEVER USE CADMIUM PLATED NUTS, BOLTS OR ANY OTHER CADMIUM PLATED PART IN THE HOT SECTION OF THE ENGINE.

C. The adoption of this program will make it possible for service activities to avoid the assembly of parts, with similar physical appearance, in locations which require high heat resistant parts. In this regard, it is required, at time of disassembly (removal), that all similarly coded parts be segregated so that two, or more, physically similar parts with different code numbers will not be scrambled; and so that, at subsequent reassembly (installation), the properly coded parts are replaced in their proper locations.

D. Parts from several engines should not be scrambled at disassembly (removal) and cleaning, because, at the time of engine manufacture, production requirements may necessitate one or more material substitutions in a block of engines. Subsequent engine reassembly with indiscriminate scrambling of hardware, may result in unnecessary confusion in sorting these parts for proper reassembly.

CAUTION: IT IS IMPORTANT THAT "J" THREADED HARDWARE BE CAREFULLY SEGREGATED AND MARKED AT DISASSEMBLY (REMOVAL) TO PREVENT MIXING WITH NON "J" THREADED PARTS.

E. Unified Controlled Radius Root "J" Threaded Bolts feature full root radius for external threads with increased minor internal threaded diameter. "J" threads ensure greater fatigue life, improved stress relaxation characteristics and show improvement in tensile strength over previous designs. This thread form is used extensively throughout engines. Engine bolts having "J" threads appear just like items threaded with conventional threads.

7. Stainless Steel Bolts with Reduced Pitch Diameters

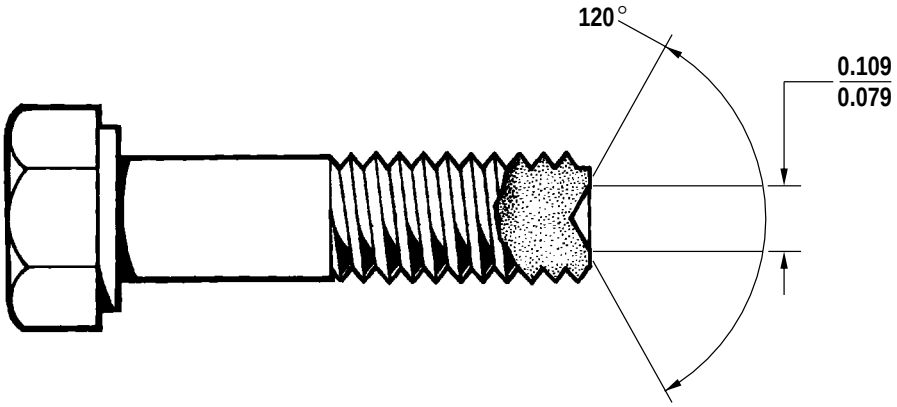
At engine manufacture, it is the practice to provide bolts with reduced pitch diameter for use in the hot sections of engines. This will minimize the possibility of bolt and nut seizure and is standard practice for locations where the parts are subjected to elevated temperatures (Ref. Fig. 206).

8. Debris Analysis and Material Specifications

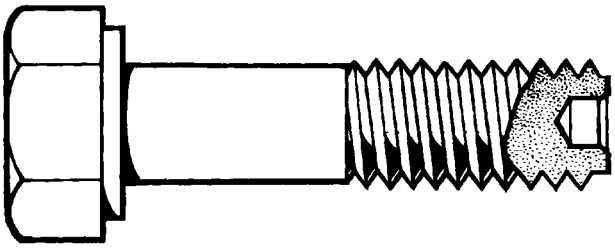
A. General

(1) Debris analysis monitors wear of oil-wetted engine parts. This procedure improves aircraft serviceability and dispatch reliability and reduces engine repair costs. This is achieved by identifying potential engine problems at the earliest possible stage, thus minimizing the possibility of in-flight shutdowns, away-from-base engine changes and secondary damage.

(2) Rapid wear or surface fatigue (e.g. on gear teeth contact surfaces, bearing raceways, rolling elements, housing bearing bores, etc.) or interference between rotating and fixed components (e.g. oil pump pinions, associated housings and labyrinth seals, etc.) produces debris. Magnetic debris over 100 microns in diameter is usually captured by the chip detectors. Magnetic and non-magnetic debris over 10 microns in diameter is usually captured by the oil system filters.



REDUCED PITCH DIAMETER BOLT



STANDARD BOLT

C197B

Reduced Pitch Diameter Bolt Identification
Figure 206

(3) Analysis (form, appearance, dimensions, quantity and material) of the debris captured by the filters and chip detectors is necessary to provide the information needed to facilitate locating the source of the debris and determining any preventive maintenance action required.

B. Filter Patch Check Debris Inspection/Analysis

(1) The analysis should be done by a qualified laboratory (Ref. Para . F.). Operators may send the contaminated filter or the debris to the laboratory for the filter patch check and/or analysis and provide the following information:

(a) Engine model and serial number.

(b) Engine time since new (TSN) or time since overhaul or refurbishment (TSO or TSR).

(c) Time since last filter inspection.

(d) Filter location.

(e) Reason for filter removal, inspection and debris analysis.

(2) Reports supplied by the laboratory to the operator containing the results of the analysis must include:

(a) Information provided by the operator with the filter or debris.

(b) Total weight of debris.

(c) Material and amount of non-magnetic debris when classified as major (Ref. NOTE).

(d) Material, appearance, shape and amount of non-magnetic metallic debris.

(e) Material, appearance, shape and amount of metallic debris.

NOTE: The amount of individual constituents in the debris should be classified as:

- Major - when the weight of the constituent is more than 50% of the total debris weight.
- Minor - when the weight of the constituent is less than 50% of the total debris weight.
- Traces - when the weight of the constituent is less than 5% of the total debris weight.

(3) If bearing material (Ref. Table 203) is found, the operator must be advised as soon as possible by telephone and provided with a detailed written report.

C. Chip and Flake Analysis

(1) The analysis should be done by a qualified laboratory (Ref. Para . F.).

(2) The operator must provide the laboratory with the following information:

(a) Engine model and serial number.

(b) Engine time since new (TSN) or time since overhaul or refurbishment (TSO or TSR).

(c) Chip detector position (Reduction Gearbox or Accessory Gearbox).

(d) Reason for chip detector inspection (scheduled or unscheduled).

(3) Reports supplied by the laboratory to the operator containing the results of the analysis must include:

(a) Information provided by the operator when submitting the material for analysis.

(b) Type(s) of material found.

(c) Shape and appearance of the material.

(d) If bearing material (Ref. Table 203) is found, the operator must be advised as soon as possible by telephone and provided with a detailed written report.

D. Identification of Metal Particles

(1) General

(a) When unidentified particles of metal are found, they may be either steel, tin, aluminum, magnesium, silver, bronze, titanium, or cadmium. In some cases the type of metal may be determined by the color and hardness of the pieces. However, when the particles cannot be positively identified by visual inspection and knowledge of the exact character of the metal is desired as an aid to troubleshooting, a few simple tests will determine the kind of metal present.

WARNING: USE EXTREME CARE IN HANDLING ACIDS.

(b) The following equipment and chemicals are required to make these tests:

a source of open flame

permanent magnet

two ounces of solution containing ten percent ammonium nitrate(PWC05-011) and water

electrical soldering iron

two ounces each of 50 percent by volume hydrochloric acid (PWC05-196) or (PWC05-196A) and concentrated nitric acid (PWC05-195)

sodium hydroxide pellets (PWC05-056)

watch glass

white porcelain spot plate

ammonium biflouride crystals (PWC05-009)

5 to 10 percent hydrofluoric acid (PWC05-004) or concentrated sulfuric acid (PWC05-074)

3 to 10 percent hydrogen peroxide (PWC05-038)

concentrated phosphoric acid (PWC05-006)

(2) Procedure

NOTE: The following test procedure is recommended for determining the character of unknown metal particles. For best results, follow the steps as outlined:

(a) Steel - the particles of many steels can be isolated by means of the permanent magnet. Magnetic steel or iron is attracted by the magnet.

(b) Titanium:

WARNING: THE FOLLOWING CHEMICALS ARE HAZARDOUS AND REQUIRE SPECIAL HANDLING. IT IS RECOMMENDED THE FOLLOWING TESTS BE DONE BY QUALIFIED LABORATORY PERSONNEL.

1 Place a piece, or pieces of the metal to be identified, on a white porcelain spot plate. A piece of titanium or titanium-bearing metal should be placed on another spot plate to observe and verify the results obtained.

2 Add several crystals of ammonium bifluoride (PWC05-009) and 5 to 10 drops of water to the metal particles. (Two or three drops of a 5 to 10 percent hydrofluoric acid solution PWC05-004 can be used instead).

NOTE: Solid ammonium bifluoride is crystalline and can be conveniently stored in a dry area and used as required.

3 Let stand 20 to 30 minutes, or until the solution becomes slightly discolored.

4 Add two or three drops of 1:1 sulfuric acid (one part demineralized water PWC05-073 to one part concentrated acid PWC05-074).

5 Let stand 20 to 30 minutes, or until solution becomes more discolored.

6 Add three to four drops of 3 to 10 percent hydrogen peroxide (PWC05-038). Solution must not be too old.

7 If titanium is present, a yellowish color will develop. This yellow color will become progressively darker with time, if allowed to set.

8 Add two to three drops of concentrated phosphoric acid (PWC05-006), and stir to discharge any yellow color due to the possible presence of iron.

9 Any light yellow to orange coloration indicates the presence of titanium.

WARNING: NEVER TRY TO BURN MORE THAN A FEW PARTICLES OF METAL SUSPECTED TO BE MAGNESIUM. DUST IS EXPLOSIVE.

(c) Magnesium - a simple test for these particles is burning. Magnesium will burn with a bright white flash.

(d) Cadmium - place the remaining particles in the solution of water and ammonium nitrate(PWC05-011). If all or any of the particles dissolve in this solution, they are cadmium. After this test, rinse and dry any remaining particles.

(e) Tin - the tin particles can be distinguished by their low melting point. With a clean soldering iron, heated to 260°C (500°F) and tinned with 50-50 solder (50 percent tin - 50 percent lead), a tin particle dropped on the iron will melt and fuse with the solder.

(f) Aluminum - when a particle of aluminum is placed in hydrochloric acid (PWC05-196), 50 percent by volume, it will fizz with rapid emission of gas bubbles and gradually disintegrate and form a black residue (aluminum chloride). Silver and bronze do not noticeably react with hydrochloric acid.

(g) Aluminum Paint - use this procedure to determine whether or not the material is aluminum silicone paint, aluminum chips, or silver particles.

1 Make a solution by adding one pellet of sodium hydroxide (PWC05-056) to three ccs of water.

2 Place several drops of this solution on a watch glass and drop in the suspected particles.

3 If the particles are aluminum silicone paint, there will be a mild reaction in the form of gas bubbles and some visible gas as the particles change to sodium aluminate.

4 If the particles are aluminum chips, the reaction will be much more active with many more gas bubbles forming and more visible gas.

5 If the particles are silver, there will be no reaction.

(h) Silver - when a silver particle is placed in nitric acid, it reacts rather slowly, producing a whitish fog in the acid.

(i) Bronze - when a bronze (or copper) particle is placed in nitric acid, a bright green cloud is produced.

E. Material Specifications

(1) To facilitate the identification of components which are the source of debris found in the oil system, the material specifications are listed in Table 203 . The common contaminants found in the oil system are listed in Tables 204 and 205.

TABLE 203, Material Specification (Engine Components)

Specification	Material	Nomenclature	Engine Location
AMS 2412	Silver Plating	Cage, No. 1 Brg	GG
		Cage, No. 2 Brg	GG
		Cage, No. 3 Brg	PT
		Cage, No. 4 Brig	PT
		Cage, No. 5 Brg	RGB
		Cage, No. 6 Brg	RGB
		Cage, No. 7 Brg	RGB
		Cage, FCU Drive Brg	AGB
		Cage, Start-Gen Drive Brg	AGB
AMS 4082, 4150	Alum (AA6061)	Sleeve, First-stage, Carrier	RGB
AMS 4117, 4127, 4150	Alum (AA6061)	Stator, No. 1 Brg Air Seal	GG
AMS 4214	Alum (Alloy 355)	Breather, Impeller	AGB
		Body, Main Scavenge Oil Pump	AGB
		Housing, Main Scavenge Oil Pump	AGB
		Cover, Main Scavenge Oil Pump	AGB
		Housing , External Scavenge Oil Pump	AGB
		Spacer, External Scavenge Oil Pump	AGB
		Cover Housing, Scavenge Oil Pump	AGB
AMS 4260	Alum. (Alloy 356)	Cover, Main Oil Pressure Pump	AGB
AMS 4275	Alum. (Alloy 750)	Brgs, Main Oil Pump Gear	AGB
		Sleeve, Accessory Drive Gears	RGB
AMS 4439	Magnesium (ZE41E)	Housing, Front	RGB
		Housing, Rear	RGB
		Housing, Main Oil Pressure Pump	RGB
		Compressor Inlet Case	GG
		Diaphragm	AGB
		Housing	AGB
AMS 4616	Bronze	Cage, FCU Drive Brgs	AGB

TABLE 203, Material Specification (Engine Components) (Cont'd)

Specification	Material	Nomenclature	Engine Location
		Cage, Start- Gen Drive Brg	AGB
		Cage, Vacuum Pump Drive Brg	AGB
		Cage, External Scavenge Oil Pump Drive Brg	AGB
		Cage, Coupling Shaft Brg	RGB
AMS 5315	Steel	Sleeve, Propeller, Oil Transfer	RGB
AMS 5613	SST (X51410)	No. 1 Brg Front Air Seal	GG
		No. 2 Brg Front Stator, Air Stator	GG
		No. 2 Brg Front Rotor Air Seal	GG
		No. 2 Brg Rear Stator Air Seal	GG
		No. 2 Brg Rear Rotor Air Seal	GG
		No. 3 Brg Stator Air Seal ,	PT
AMS 5645, 5646	SST (30321)	Sleeve, AGB Coupling Shaft Brg	AGB
AMS 5671	SST (Inconel X750)	Seal, No. 3 Brg, Front Labyrinth, Air	PT
AMS 5732	SST (A286)	Housing, No. 1 Brg, Outer	GG
AMS 6260	Steel (9310)	Gear, Main Oil Scavenge Pump	AGB
AMS 6265	Steel (9310)	Gear, Accessory Drive, Front	RGB
		Gear, Second-stage Planet	RGB
		Carrier, Second-stage Planet Gear	RGB
		Shaft, Second-stage Planet Gear	RGB
		Gear, Ng Tacho Drive	RGB
		Gear, Propeller and O/S Governor Drive	RGB
		Coupling, Propeller Governor Drive	RGB
		Gear, Second-stage, Ring	RGB
		Gear, First-stage, Ring	RGB
		Gear, Second-stage, Sun	RGB
		Coupling, Second-stage Sun Gear	RGB

TABLE 203, Material Specification (Engine Components) (Cont'd)

Specification	Material	Nomenclature	Engine Location
		Adapter, Second-stage Sun Gear	RGB
		Carrier, First-stage Planet Gear	RGB
		Gear, First-stage, Planet	RGB
		Gear, First-stage, Sun	RGB
		Coupling, AGB Drive	GG
		Coupling, First-stage Sun Gear	PT
		Shaft, AGB Coupling	AGB
		Gear, FCU, Drive	AGB
		Gear, Start- Gen Drive	AGB
		Gear, Vacuum Pump Drive	AGB
		Gear, Hydraulic Pump Drive	AGB
		Gear, Main Oil Pump Drive	AGB
		Gear, External Scavenge Pump Drive	AGB
		Gear, Oil Pressure Pump	AGB
		Gear, External Oil Scavenge Pump	AGB
		Gear, Scavenge Oil Pump	AGB
		Shaft, Vacuum Pump Drive	AGB
		Shaft, External Scavenge Pump Drive,	AGB
		Coupling, Oil Pump Drive	AGB
AMS 6322	Steel (8740)	Sleeve, Second-stage Sun Gear	RGB
		Shaft, First-stage Planet Gear	RGB
AMS 6414	Steel (4340)	Cage, No. 7 Roller Brg	RGB
		Torque Piston	RGB
		Inner Housing No. 1 Brg	GG
		Cage, No. 1 Brg	GG
		Cage, No. 2 Brg	GG
		Cage, No. 3 Brg	PT
		Cage, No. 4 Brg	PT
		Coupling, Main Oil Pump Drive Gear	AGB
AMS 6415	Steel (4340)	Shaft, Propeller	RGB

TABLE 203, Material Specification (Engine Components) (Cont'd)

Specification	Material	Nomenclature	Engine Location
		Cage, No. 6 Brg	RGB
		Cage, No. 5 Brg	RGB
		Locating Pin, Second-stage Planet Gear Carrier,	RGB
		Torque Cylinder,	RGB
		Shaft, Impeller	GG
AMS 6440/ 6444	Steel (52100)	Roller, AGB Coupling Shaft Brg	AGB
		Roller, Start-Gen Drive Brg	AGB
		Roller, Hydraulic Pump Drive Brg	AGB
		Roller, Vacuum Pump Drive Brg	AGB
		Roller, External Scavenge Pump Drive Brg	AGB
		No. 7 Brg, Roller and Rings	RGB
		No. 6 Brg, Ball and Rings	RGB
		No. 5 Brg, Roller and Rings	RGB
		First-stage Planet Gearshaft	RGB
		Rings, AGB Coupling Shaft Brg	AGB
		Rings, FCU Drive Brg	AGB
		Rings, Start-Gen Drive Brg	AGB
		Rings, Hydraulic Pump Drive Brg	AGB
		Rings, Vacuum Pump Drive Brg	AGB
		Rings, External Scavenge Pump Drive Brg	AGB
AMS 6490	Steel (M50)	No. 2 Brg, Rings and Rollers	GG
		No. 3 Brg Rings and Rollers	PT
AMS 6491	Steel (M50)	No. 1 Brg Rings and Balls,	GG
		PT Shaft	PT
		PT Shaft Coupling	PT
		No. 4 Brg Rings and Balls,	PT
AMS6265/ 6444	Steel	Shaft, Second-stage Planet Gear	RGB

TABLE 203, Material Specification (Engine Components) (Cont'd)

Specification	Material	Nomenclature	Engine Location
		Shaft, First-stage Planet Gear	RGB
AMS 4928	Titanium Alloy	Compressor, First-stage	GG
		Stubshaft, First-stage Compressor	GG
	Molybdenum	Coating, No. 2 Brg, Labyrinth, Seals, Air	GG

TABLE 204, Common Contaminants - Non-organic Material

Contaminant Detected	Main Elements	Cause of Contaminants
Alumina	Al_20_3	Manufacturing
Black Magnetic	Fe_30_4	Anaerobic decomposition of shaft material, can look like carbon is a corrosive product.
Calcium Oxide	CaO	Environment
Rust, Non-magnetic	Fe_2O_3	Rust
Sand	SiO_2	Manufacturing/Environment
Silicon Carbide (Black, Shiny, Angular)	SiC	Manufacturing/Blasting
Zirconia	$ZrSiO_4$	Manufacturing
	$Mo5_2$	Common as a trace, could combine with Fe (Iron) to indicate bearing alloy. Usually found in new or overhauled engines.
Calcium Chloride (Salt)	$CaCl_2$	Environment
Sodium Chloride (Salt)	NaCl	Environment
Calcium Sulphate (Salt)	$CaSO_4$	Environment

TABLE 205, Common Contaminants - Organic Material

Contaminant Detected	Source
Black Fluorocarbon Rubber, Red Silicon Rubber, Blue Fluorosilicon Rubber	Preformed Packings, Seal Gaskets
Chloroprene Nitrile Rubber	Gaskets

TABLE 205, Common Contaminants - Organic Material (Cont'd)

Contaminant Detected	Source
Carbon Fibers Plastics Paint Flakes	Decomposed Oil, Carbon Seals

F. Laboratories

(1) Chip and flake analysis should be done by a qualified laboratory; some of which are listed below.

Air Alliance (M-50, bearing alloy ONLY)
Engine Shop Supervisor
611, 6ieme Ave.
Saint-Foy, Quebec
Canada G2E 5W1

TEL: (418) 877-7622
FAX: (418) 872-8337

Alfa Romeo Avio Laboratory
80038 Pomigliano D'Arco
Napoli
Italy

TEL: 39-81-8430493
FAX: 39-81-8846522

Skywatch
Service of Analysts, Inc.
3075 Cornors North Court NW
Norcross, GA 30071
USA

TEL: (800) 241-6315
FAX: (404) 448-5918

Areco Canada Inc.
40 Camelot Drive
Napean, Ontario K2G-5W6
Canada

TEL: (613) 228-1145
FAX: (613) 228-1148

Aviation Laboratories Inc.
12911 South Bublong Ave.
Gardena, CA 90247
USA

TEL: (213) 217-9369

Aviation Laboratories Inc.
New Orleans International Airport
918 Maria Street
Kenner, LA 70062
USA

TEL: (504) 469-6751
FAX: (504) 469-6886

Chemical Analyst Laboratory
Department of Biochemistry
Trinity Collage
Dublin 2
Ireland

TEL: 772941, Ext: 1574
FAX: 772400

Deutsche Lufthansa AG
POSTFACH 300
2000 Hamburg 63
Germany

Jet-Care International Inc.
3 Saddle Road
Cedar Knolls, New Jersey 07927-902
USA

TEL: (201) 292-9597
FAX: (201) 292-3030

Martel Laboratory Services Inc.
1025 Cromwell Bridge Road
Baltimore, MD 21204-3309
USA

TEL: (301) 825-7790
FAX: (301) 821-1054

Martel Laboratory Services Inc.
Aero Services Building
Capital Airport
Spring field, IL 62707
USA

TEL: (217) 522-0009
FAX: (217) 544-2034

Martel Laboratory Services Inc.
250 Meadowfern
Suite 102
Houston, TX 77067
USA

TEL: (713) 872-9100
FAX: (713) 872-7916

Materials Research Laboratories
Industrial Technology Research Institute
Building 77, 195 Chung Hsing Road
Section 4, Chutung, Hsinchu 31015
Taiwan

Metro Tech Systems Ltd.
Bay 112
5621-11th Street N.E.
Calgary, Alberta T2E 7G9
Canada

TEL: (403) 295-8803
FAX: (403) 295-3848

PCAS (Produits Chimiques Auxiliaires et Syntheses)
Zone Industrielle de la Vigne aux Loups
23 Rue Bosselet
91-161 Long-Jumeau
France

FAX: (1) 64-482319

Predictive Maintenance Corporation
400 Sauve Street West, Suite 101
Montreal, Quebec H3L 1Z8
Canada

TEL: (514) 383-6330
FAX: (514) 383-5631
or

Predictive Maintenance Corporation
206, 2723-37 Avenue NE
Calgary, Alberta T1Y 5R8
Canada

TEL: (403) 250-8378
FAX: (403) 286-8287

Spectro Oil Analysis Company Ltd.
Palace Gate
High Street
Odiham, Hampshire RG29 1NP
United Kingdom

TEL: 44-0-1256 704000
FAX: 44-0-1256 704006

Vernolab
Zone Industrielle des Cents Sillone
27-130 Verneuil
Eure
France

FAX: 16-32601646

Wear Check Canada Inc.
4161 Sladeview Crescent
Unit 11
Mississauga, Ontario L5L 5R3
Canada

TEL: (905) 569-8600
(905) 268-2131
FAX: (905) 569-8605

9. Marking of Parts

A. General

(1) Marking of engine parts, assemblies, or weldments shall be applied so as to ensure maximum legibility and durability of mark but in a manner that will not affect function or serviceability of part. Only applicable Pratt & Whitney Canada marking methods shall be used.

(2) Except where otherwise specified, reidentification of parts shall be accomplished adjacent to, or in a location similar to that of, original marking.

(3) All marking characters, unless otherwise specified, shall be 0.060 to 1.160 inch high. In special cases, when marking area is governed by size or configuration of part, characters not less than 0.016 inch nor more than 0.250 inch in height are permitted.

(4) Electric-arc scribing, particularly hand arc scribing, whereby characters are produced by the action of an electric arc between the surface and an electrode (scriber), has been found unsuitable for jet engine parts and must not be used.

(5) Acid etching, whereby characters are formed by action of an acid on the surface of the part, is not recommended because of its possible corrosive effect.

(6) Soapstone shall not be used to mark engine parts.

B. Permanent Marking

(1) General

(a) Marking should be done as close to original marking as possible. Permanent methods of marking are those in which marking is legible during entire service life of part.

(b) Permanent markings shall not extend onto any radius, chamfer, sharp edge, or fillet adjoining designated marking surface.

(2) Methods

CAUTION: DO NOT ELECTROLYTICALLY ETCH ANODIZED SURFACES.

(a) Electrolytic Etch - Characters are produced by electrolysis confined to area of characters by a stencil. This technique is sometimes used as a temporary method. Do not confuse it with electric-arc scribing.

(b) Vibration Peening - Characters are produced by a vibrating, radius-tipped, conical tool.

Manual - tool is hand-guided and has a single tip.

Mechanical - tool is mechanically guided and has a single tip, or has multiple tips producing one or more complete characters simultaneously. This method is not usually permitted if hardness of part at time of marking is higher than Rockwell C45 or equivalent. It may be used on parts harder than Rockwell C45 when specifically permitted.

NOTE: Vibration peening marking method can be substituted for marking parts originally marked by diamond drag or roll marking.

C. Temporary Marking

(1) General

(a) Temporary methods of marking are those in which the marking will identify parts during ordinary handling, and storage, and final assembly.

CAUTION: LEAD AND/OR METALLIC PENCILS, OR ANY TEMPORARY MARKING METHOD LEAVING A DETRIMENTAL DEPOSIT OF CARBON, ZINC, COPPER, LEAD, OR SIMILAR RESIDUE WHICH MAY CAUSE A REDUCTION IN FATIGUE STRENGTH AS A RESULT OF CARBONIZATION OR INTERGRANULAR ATTACK WHEN THE PART IS SUBJECTED TO INTENSE HEAT, SHALL NOT BE USED. IN THE EVENT THAT AN UNAUTHORIZED MARKING MATERIAL IS USED, THE MARK MUST BE THOROUGHLY REMOVED BY A PROCEDURE DICTATED BY THE MARKING METHOD AND THE PART MATERIAL.

(b) When using a marking pencil, marks shall not be applied to carbon seal plate surfaces or to mating surfaces of finished machined parts. Heavy deposits of marking material could adversely affect clearance and runout.

(2) Methods

CAUTION: ANODIZED SURFACES MUST NOT BE ELECTROLYTICALLY ETCHED.

(a) Electrolytic Etch - Characters are produced by electrolysis confined to area by a stencil. This is primarily a permanent marking method. However, where specified, it may also be used for temporary marking.

(b) Ink Marking

1 Characters are produced by applying, by any means, an ink which does not injure the surface. Inks used in marking may have a light etching action, providing etching does not injure the surface.

NOTE: Ordinarily, ink stamping and electrolytic etching, when used as a temporary marking method, may be applied to any surface which, after assembly, does not move relative to a contacting surface.

(3) Marking Materials, Hot and Cold Section Engine Parts

(a) Felt Wick Pen (PWC05-048A) and Instant Dry Ink (PWC05-046).

(b) Marks-A-Lot Marker (PWC05-048B).

(c) Brushpen No. 57 (PWC05-048) and Fast Drying Ink (PWC05-046A), black, red, and purple.

(d) Micro Supreme Dye, Purple No. 142 (PWC05-002)

(e) Berol Verithin Pencil, Red No. 750 (PWC05-018F). May be used on parts which are not directly exposed to the gas path. This type of mark is easily obliterated and, therefore, less durable.

(f) Design Spectracolor Pencil, Silver No. 1428, (PWC05-018) or Verithin Pencil, Silver No. 753 (PWC05-018A).

(4) Marking Materials, Cold Section Engine Parts Only

Dykem Ink (PWC05-046C) KX425 (Black) or KXX122 (White).
Carters Ink (PWC05-027) No. 451 (Black).

(5) Marking Materials, Hot Section Engine Parts Only. Use layout dye (PWC05-041) (lightly applied) to mark parts which are directly exposed to engine gas path such as turbine blades and disks, turbine vanes, and combustion chamber liner.

10. Lubrication of Preformed Packings

A. General

CAUTION: APPLICATION OF LUBRICANT PLUS PROPER ASSEMBLY, WILL PREVENT DAMAGE TO PREFORMED PACKINGS. DAMAGED PREFORMED PACKINGS CAN CAUSE ENGINE MALFUNCTION.

(1) Prior to installation, it is recommended that all preformed packings be coated with lubricant to the following specifications:

(a) Preformed packings used in the fuel and/or oil system, use engine oil (PWC03-001).

(b) DELETED

11. Touch-up Solution

WARNING: REFER TO THE MATERIAL SAFETY DATA SHEETS BEFORE YOU USE THESE MATERIALS FOR INFORMATION SUCH AS HAZARDOUS INGREDIENTS, PHYSICAL/CHEMICAL CHARACTERISTICS, FIRE, EXPLOSION, REACTIVITY, HEALTH HAZARD DATA, PRECAUTIONS FOR SAFE HANDLING, USE AND CONTROL MEASURES. SOME OF THESE MATERIALS CAN BE DANGEROUS. YOU CAN GET THE DATA SHEETS FROM THE MANUFACTURERS OR THE SUPPLIERS OF THESE MATERIALS.

A. Chrome Pickle Solution (Magnesium RGB and AGB Housings) (Ref. Table 206)

(1) Fill a suitable container with tap water to no more than ½ of the volume of the solution required.

(2) Slowly and carefully add the required amount of sodium dichromate. Stir to dissolve the sodium dichromate.

(3) Slowly and carefully add the required amount of nitric acid. Stir to mix the solution.

(4) Fill the remainder of the container with tap water to the specified volume required.

TABLE 206, Chrome Pickle Solution

MATERIAL	PROPORTION	PROPORTIONAL LIMITS
Sodium Dichromate (PWC05-055)	1.5 lbs.	1.0 to 1.5 lbs.
Nitric Acid (PWC05-195)	1.5 pints	1.0 to 1.5 pints
NOTE: The figures that are given are per gallon of solution required.		

STANDARD PRACTICES - REMOVAL/INSTALLATION

1. General

   A. To ensure proper reinstallation, tag and mark all parts, clips, and brackets as to their location.

   B. During removal of tubes or engine parts look for indications of scoring, burning or other undesirable conditions. To facilitate reinstallation, observe the location of each part during removal. Tag unserviceable parts and units for investigation and possible repair.

   C. Extreme care shall be taken to prevent dust, dirt, lockwire, nuts, washers or other foreign matter from entering the engine. It cannot be overemphasized that this precaution applies whenever work is done on the engine either on the wing or off the wing. Suitable plugs, caps, and other covering shall be used to protect all openings as they are exposed.

   CAUTION: DUST CAPS USED TO PROTECT OPEN TUBES AGAINST CONTAMINATION SHALL ALWAYS BE INSTALLED OVER THE TUBE ENDS AND NOT IN THE TUBE ENDS. FLOW THROUGH THE LINES MAY BE BLOCKED OFF IF LINES ARE INADVERTENTLY INSTALLED WITH DUST CAPS IN THE TUBE ENDS.

   D. If at any time items are dropped into the engine, the assembly process must stop until the dropped articles are located, even though this may require a considerable amount of time and labor. Before assembling or installing any part, be sure it is thoroughly clean.

   E. Lockwire, lockwashers, tablocks, tabwashers, or cotterpins must never be reused. All lockwire and cotterpins must fit snugly in holes drilled in studs and bolts for locking purposes. Install a cotterpin so that the head fits into the castellation of the nut, and unless otherwise specified, bend one end of the pin back over the stud or bolt and the other end down flat against the nut. Only lockwire and cotterpins made of corrosion resistant steel shall be used. Bushing plugs shall be lockwired to the assembly boss or case. Do not lockwire the plug to the bushing.

   F. Replace all gaskets, packings, and rubber parts at reassembly. Make sure that new nonmetallic parts to be installed (such as an oil seal) show no sign of having deteriorated in storage.

   CAUTION: TOOL SURFACES WHICH MAY CONTACT ENGINE CRITICAL AREAS MUST BE ADEQUATELY COVERED WITH A PROTECTIVE MATERIAL.

   G. To protect critical areas of engine parts (such as compressor and turbine disks) against scratches and nicks, tool surfaces contacting these areas must be covered with protective material.

   H. During replacement of components, note condition of any removed preformed packings. Pieces accidentally torn or cut from packings must be retrieved, regardless of size, even if this entails a systematic disassembly and cleaning of the system. Ensure that new packings are free of cuts, flashings and deformities which may be sheared off at installation.

I. When installing engine parts that require the use of a hammer to facilitate assembly or installation, use only a plastic or rawhide hammer.

J. Whenever adhesive tape has been applied to any part, the tape must be removed and the part thoroughly cleaned of all tape residue with petroleum solvent prior to being subjected to high temperature during engine run. Test results indicate that all tapes are capable of causing surface attack and/or reduction in tensile ductility as temperature increases. Do not leave tape or tape residue on engine parts.

K. If any part has been coated with corrosion preventive compounds, all traces of this compound and accumulated foreign matter must be removed.

2. Consumable Materials

The consumable materials listed below are used in the following procedures.

Item No.	Name
PWC03-001	Oil, Engine Lubricating
PWC06-002	Petrolatum, White

3. Special Tools

Not Applicable

4. Fixtures, Equipment and Supplier Tools

Not Applicable

5. Removal/Installation

CAUTION: DO NOT BEND, TWIST OR FORCE HYDRAULIC AND PNEUMATIC TUBES, WHETHER RIGID OR FLEXIBLE, TO ACHIEVE ALIGNMENT WITH MATING FITTING. ADJUST FITTING TO ALIGN WITH TUBE. CLAMP AND SECURE TUBE ONLY WHEN IT IS INSTALLED IN POSITION WITH NO NOTICEABLE TENSION OR LOAD.

A. Removal of Straight Nipples, Straight Adapters, Bulkhead Couplings and Tube Connector Nipples

(1) Remove fittings from engine lines or accessory units.

(2) Remove preformed packings from fittings and discard.

B. Removal of Tube-to-Boss Elbows, Elbow Adapters and Elbow Assemblies

(1) Remove fittings from engine lines or accessory units.

NOTE: Before removal, mark angular position of fitting on engine or unit.

(2) Remove preformed packings, packing retainers (back-up rings) and discard. Discard jam nuts from fittings.

C. Installation of Straight Nipples, Straight Adapters, Bulkhead Couplings and Tube Connector Nipples

(1) Lubricate new preformed packing with light film of engine oil (PWC03-001) or fluid to be used in line.

(2) Install preformed packing on fitting and screw fitting in boss or flange, as applicable.

CAUTION: EXCESSIVE TIGHTENING WILL RESULT IN DAMAGE TO THREADS OF MATING PARTS.

(3) Tighten fitting in boss and torque to value detailed in relevant assembly instruction.

(4) Install jam nut on flange mounted fittings and torque jam nut to recommended value (Ref. Table 401).

TABLE 401, Torque Values for Jam Nuts

THREAD SIZE	TORQUE (lb.in.)
0.250 -28	14 to 16
0.3125-24	22 to 24
0.375 -24	28 to 32
0.4375-20	38 to 42
0.500 -20	58 to 62
0.5625-18	70 to 80
0.625 -18	95 to 105
0.750 -16	145 to 155
0.8125-16	165 to 185

D. Installation of Tube-to-Boss Elbows, Elbow Adapters and Elbow Assemblies (Ref. Fig. 401)

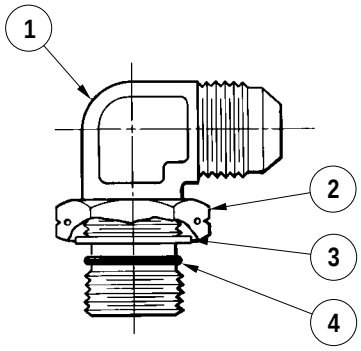
(1) Lubricate new preformed packings, packing retainer (back-up ring) and thread of elbow fitting with light film of petrolatum (PWC06-002) or fluid to be used in the line.

(2) Assemble jam nut, new packing retainer and preformed packing on elbow fitting, pressing packing retainer into counterbore of jam nut.

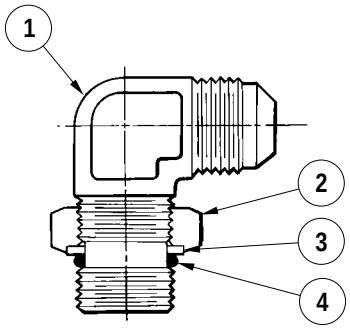
(3) Turn jam nut down elbow fitting until preformed packing is seated in non-threaded annulus of fitting.

(4) Turn jam nut outward until preformed packing is pushed firmly against first lower thread of fitting.

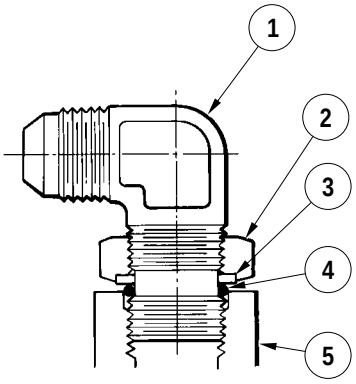
(5) Install elbow fitting into boss on unit, allowing jam nut to turn with fitting until preformed packing contacts boss mating face. This point will be recognized by increase in torque.



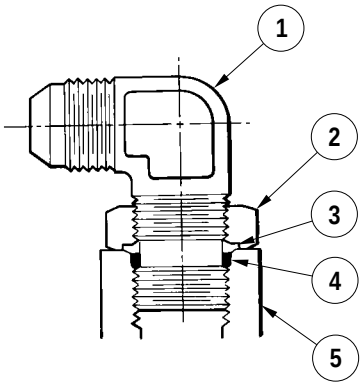
STEP 1



STEP 2



STEP 3



STEP 4

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Installation of Typical Elbow Fitting
Figure 401

Key to Figure 401

1. Elbow Fitting
2. Jam Nut
3. Back-up Ring
4. Preformed Packing
5. Boss

(6) With fitting in this position, hold jam nut stationary and turn elbow fitting into boss a further 1 1/2 turns.

NOTE: From this position the elbow fitting may be further turned inward to a maximum of one turn to facilitate alignment of fitting (Ref. Para. 1.B). Should the fitting tighten in the jam nut before completion of initial 1 1/2 turns or during final alignment, the jam nut may be allowed to turn with the fitting for the remainder of the distance.

(7) With elbow fitting in correct alignment position, tighten jam nut and torque to recommended torque (Ref. Table 401).

NOTE: Metal-to-metal contact between jam nut and boss must be obtained without exceeding recommended torque and there must be no extrusion of preformed packing or packing retainer.

E. Installation/Removal of Hydraulic, Oil and Pneumatic Lines

CAUTION: DO NOT USE FORCE TO POSITION LINE ON TO COUPLING ADAPTERS.

NOTE: Refer to specific chapter for assembly instructions; Chapter 73 for fuel and pneumatic lines, Chapter 79 for oil lines.

(1) When installing hydraulic, oil or pneumatic lines, whether dolid tubes or flexible hoses, ensure lines engage on to respective coupling adapters without tension or load.

(2) Alignment must be obtained by adjusting the position of the adapters. Refer to paragraphs C and D preceeding, for instructions pertaining to the installation of adapters.

STANDARD PRACTICES - INSPECTION

1. General

A close and complete inspection is important to prolong engine life and give maximum performance. Check for loose or missing parts and inspect any engine part or component that has been worn or damaged. Damage to engine parts may result from improper clearance, lack of lubrication, undesired movement of parts which are bolted or pressed together, overloaded, uneven load distribution, heat, shock, extension of minor damage such as scratches, tool marks, grinding cracks, nicks, etc. Damage to engine parts may also result from presence of foreign matter such as grit, chips, moisture, chemicals, etc., or from incorrect techniques during removal and installation.

All inspection procedures should be done in a well lighted, clean and dust-free area. Benches should be clean to keep previously cleaned parts free of dirt and dust. All parts shall be suitably tagged to indicate necessary repair or replacement. Although most parts will require only a visual inspection, a certain number will require use of gages and other measuring equipment. Some damage may only be detected by magnetic particle or fluorescent penetrant inspection methods. Methods of inspection for specific parts and components are detailed in relevant sections of this manual.

2. Inspection

A. General

(1) Examine parts for alignment, distortion, foreign matter, looseness, out-of-roundness, sharp edges, scratches, taper, warping and wear. Additionally, check the following:

(a) Holes in cases, manifolds, pipes and tubes for obstructions.

(b) Gear teeth and splines for contact patterns.

(c) Magnesium parts for corrosion.

(d) Mounting pads, parting and seating surfaces, for smoothness and flatness. Use pencil carbon paper whenever a smear-type indication of surface smoothness is required.

(e) Plugs for tightness.

(f) Studs, dowels, and similar protruding parts for alignment and projection length.

(g) Protective surface coatings for completeness.

(h) Threads for condition.

B. Inspection Terms

(1) For definitions of the inspection terms used throughout this manual, refer to Table 601.

TABLE 601, Inspection Terms

Term	Definition
Abrasion	Wearing away of small amounts of metal as a result of friction between parts.
Blister	The raised portion of surfaces caused by separation of layers of material.
Buckling	Large deformation from original shape. Usually caused by pressure or impact of a foreign object, unusual structural stresses, excessive heat, or any combination of these conditions.
Burning	Loss of material from excessive heat.
Burr	A sharp projection or rough edge.
Chafing	Wear caused by friction.
Corrosion	A surface chemical action resulting in surface discoloration, a layer of oxide, or, in advanced stages, the removal of surface material.
Crack	Pressure break in material
Dent	A smooth, round-bottomed depression.
Distortion	Change from the original shape.
Flaking	Loose particles of surface material.
Frosting	An initial stage of scoring caused by irregularities or high points of metal welding together with minute particles of metal transferring to the mating surface, giving a frosted appearance.
Galling	Fretting, and wearing away by friction.
Gouging	Removal of surface material, typified by rough and deep depressions.
Grooving	Smooth, rounded indentations caused by concentrated wear.
Inclusion	Foreign material enclosed in metal.
Metallization	Coating by molten metal particles sprayed through the engine.
Nick	Sharp bottomed depression with rough outer edges.
Peening	Flattening or displacing of material by repeated blows. A surface may be peened by continuous impact of foreign objects, or loose parts.

TABLE 601, Inspection Terms (Cont'd)

Term	Definition
Pitting	Surface condition characterized by minute holes or cavities which occur on overstressed areas. The pits may occur in such profusion as to resemble spalling.
Scoring	Form of wear characterized by a scratched, scuffed, or dragged appearance, with markings in the direction of sliding.
Scratches	Narrow shallow marks or lines resulting from the movement of a metallic particle or pointed object across a surface.
Scuff	Dull or moderate wear of a surface resulting from slight rubbing.
Seizure	Welding or binding of two adjacent surfaces, preventing further movement.
Spalling	Surface or sub-surface damage characterized by chips of parent metal that spall or flake out of material leaving cavities of varying sizes and depths.
Stress-failure	Metal failure due to compression forces, tension, shear, torsion, or shock.
Tear	Parent metal torn by excessive vibration or other stresses.
Unbalance	Condition created in a rotating body by an unequal distribution of weight about its axis. Will result in vibration.
Wear	Condition resulting from a relatively slow removal of parent material. Frequently not visible to the unaided eye.

C. Inspection Gages

NOTE: When an inspection procedure requires a very accurate measurement, a micrometer, vernier caliper or a dial indicator must be used.

(1) If a micrometer or vernier is to be used, check gage for accuracy before making measurement. Be sure that contacting surfaces are clean and contacting faces of part to be measured are free of dirt and burrs. When using depth gages, ensure anvil is held tight and square against part to be measured.

(2) If a dial indicator is used, ensure indicator base is anchored firmly and that any swivel connections are tightened securely.

(3) When taking measurements with feeler gages, ensure final size of feeler is a reasonably snug fit.

D. Magnetic Particle Inspection

(1) The magnetic particle inspection is a nondestructive test procedure which detects cracks, voids, pits, subsurface holes and other imperfections. This method is applicable to ferromagnetic steel and has no effect on nonferrous materials.

E. Fluorescent Penetrant Inspection

(1) Fluorescent penetrant inspection is a nondestructive means of inspecting nonferrous or nonmagnetic materials for cracks, cold shuts, porosity and other defects having surface openings. This method may be used on ferromagnetic parts of complex structure which could give false indications when checked by the magnetic particle inspection methods.

F. Inspection of Fuel, Oil and Air Tubes

NOTE: The following inspection criteria are a standard instruction. Specific instructions for tubing inspection, where applicable, will be described in the appropriate chapter within the manual.

(1) Circumferential scratches in tubes are acceptable, provided they do not exceed a 45 degree segment on circumference. Any number of scratches is permissible; these may be blended out, provided depth of blend does not exceed 0.005 inch.

(2) Longitudinal scratches in tubes must not exceed one-half inch in length. Any number of scratches is permissible.

(3) Nicks and chafing marks in tubes are acceptable and may be blended provided they do not exceed 0.005 inch in depth. Each blended area must not exceed one-half square inch.

(4) Dents in tubes are of limited acceptability, provided there are no restrictions to flow caused by sharp edges or corners. Dents are unacceptable within one inch of ferrule scarf-welds, or in a blended area.

(5) Minor isolated pitting is acceptable if not greater than 0.003 inch in depth. Clusters of pits should be blended out to a maximum depth of 0.005 inch.

(6) Rust and stains on tubes are acceptable if they can be removed by light polishing with very mild abrasive.

(7) Examine tubes for cracks, especially at brazed joints.

(8) Examine coupling and threaded fittings for cracks or damaged threads.

(9) Check tube bores for obstructions.

G. Inspection of Welded Repairs

(1) Inspect weld repair for quality, uniformity, undercutting, cracking and flux removal. Welds must be blended into adjacent metal in gradual, smooth curves. Welds must be sound, clean, free from foreign material, and from internal and external defects which would adversely affect strength of weld.

(2) Nominal welds (those not requiring finishing) must exhibit bead conditions as shown in Figure 601, detail A. Finished welds must exhibit bead conditions as shown in detail B.

H. Inspection of Rotating Components

(1) Life limited (critical) rotating components exhibiting cracks are unserviceable and shall not be repaired.

(2) Handle rotating components with extreme care to prevent damage or contamination of the material.

(3) Wear lint free gloves when touching rotating components.

(4) Make sure close attention is paid to areas such as counterweight holes and blade slots where imperfections are difficult to find.

(5) Use suitable clean, protective containers for storing and transporting components

(6) Inspect components in accordance with the criteria specified in the relevant Chapter/Section/Subject.

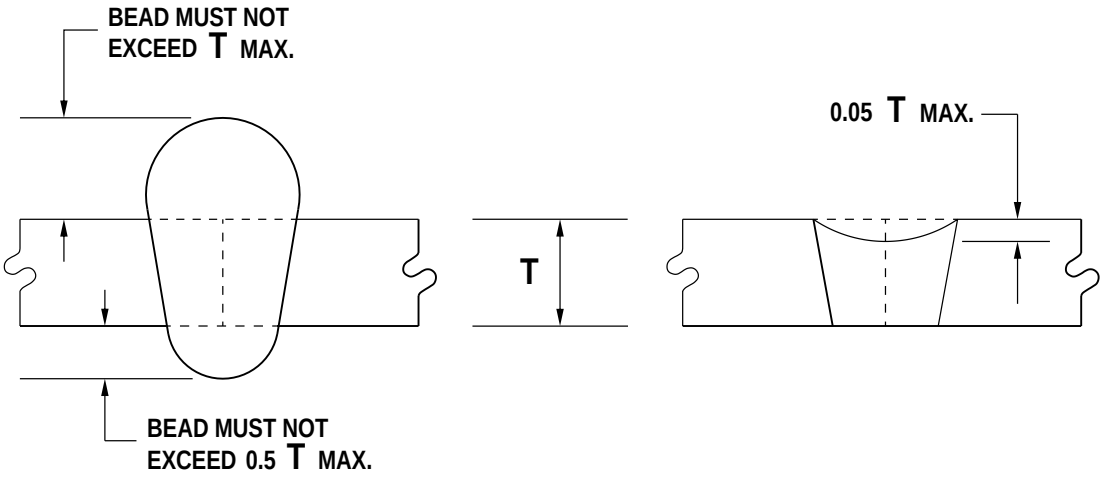
(7) Any observed conditions not defined in this manual are not acceptable for repair.

(8) Evaluation of the surface should take into consideration the need for repairs and the limits to which repairs may be made to determine the suitability for continued use of the component.

(9) Unrepairable components shall be quarantined to prevent further use.

(10) It is important to have suitable lighting. The minimum recommended illumination for close and difficult inspection is 100 foot-candles measured at the inspection table top.

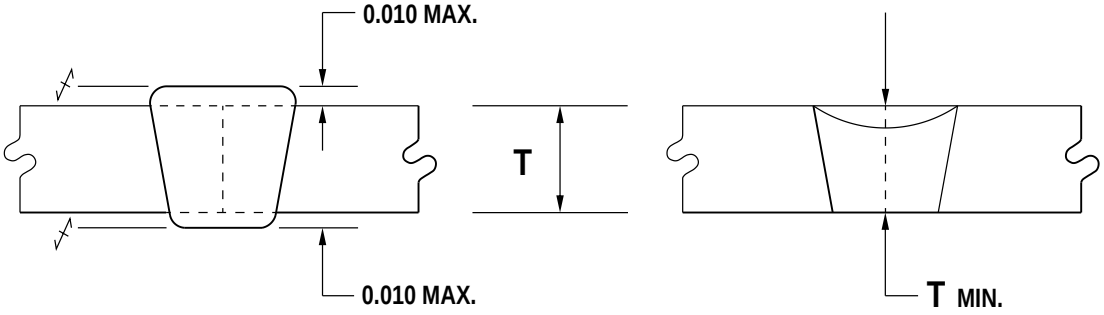
(11) Unless otherwise specified, magnification shall not be used. A magnification of 3X to 4X may be used as an aid to evaluate and confirm an observed condition in detail.



MAXIMUM MATERIAL CONDITION

MINIMUM MATERIAL CONDITION

A − NOMINAL WELD − NO FINISHING REQUIRED



MAXIMUM MATERIAL CONDITION

MINIMUM MATERIAL CONDITION

B − FINISHED WELD − DIMENSIONS AFTER DRESSING

C2589

Weld Repair - Inspection
Figure 601

STANDARD PRACTICES - CLEANING

1. General

   A. Gas turbine cleaning can be categorized into two broad areas, namely specific parts cleaning and field cleaning (i.e., compressor washing).

   B. Specific parts cleaning is primarily to remove contaminants which might conceal minor cracks and other defects which, if not detected, could eventually lead to failure of a component or part. Engine components or parts should be cleaned only as necessary to perform required inspection and repair. Overcleaning of components or parts is unnecessary and should be avoided. The cleaning methods given in the following text are adequate for all maintenance levels. For compressor washing methods, refer to Chapter 71-00-00, CLEANING.

2. Cleaning

   A. General

      (1) Prior to engine disassembly, ensure that the work area is clean.

      (2) Benches on which engine parts are placed must be clean and free from grit, metal filings, etc., which may contaminate engine oil systems, fuel systems or hardware.

      (3) Clean plastic bags should be available in which oil system and fuel system parts may be stored until ready for reassembly.

      (4) Clean plastic caps or covers should be used to protect exposed tubes or bearing areas.

      (5) At reassembly make sure that all parts are clean and new packings installed.

   B. Precautions

      NOTE: The choice of cleaning agents should be limited to the consumables listed in CONSUMABLE MATERIALS section. The toxicity of cleansing agent will, however, depend on the type of contamination encountered on part to be cleaned.

      CAUTION: TAKE PARTICULAR CARE IN SELECTING CLEANING METHOD TO MAKE SURE THAT ANODIZING AND OTHER PROTECTIVE COATINGS ARE NOT REMOVED FROM PARENT METAL. DO NOT USE ALKALIES ON ALUMINUM, MAGNESIUM, ALUMINIZED AND PAINTED AREAS.

      (1) Wear rubber gloves, apron or coveralls and face shield or goggles, when working with solvents.

      (2) Use the least toxic of available cleaning materials which will satisfactorily accomplish work.

      (3) Do all cleaning operations in a well ventilated work area.

(4) Make sure that adequate and usable fire fighting and safety equipment is conveniently located and available to all personnel.

(5) Do not smoke or expose a flame within 50 feet of cleaning area.

(6) Make sure that all degreasing agents are thoroughly removed from all parts after cleaning.

(7) Do not use steel brushes for any cleaning operation except when specifically detailed within this manual. Use a stiff bristle fiber brush.

C. Cleaning Before Welding

(1) Surface to be welded must be free from protective coatings, dirt, grease, oil and other contaminants, and as free as practicable from oxide formation. Wire brushes and abrasives may be used to remove protective coatings and oxides, except that the final step in removing oxides from aluminum alloys preferably should consist of chemical treatment immediately prior to welding. Wire brushes, when used for cleaning corrosion-resistant alloy, must have bristles of austenitic, corrosion-resistant steel. No undesirable deposit or residue must remain on surface to be welded after cleaning operation.

STANDARD PRACTICES - REPAIR

1. General

   A. The primary purpose of repair is to enable a component or engine part to be reworked to a condition which will provide safe operation. Approved repair schemes are detailed in the relevant sections of this manual using the various consumables listed in CONSUMABLE MATERIALS section.

2. Consumable Materials

   The consumable materials listed below are used in the following procedures.

Item No.	Name
PWC03-001	Oil, Engine Lubricating
PWC05-061	Cloth, Abrasive
PWC05-147	Electrode, Welding
PWC05-161	Solution, Touch-up
PWC05-197	Acid, Chromic
PWC11-016	Perchloethylene

3. Special Tools

   The special tools listed below are used in the following procedures.

Tool No.	Name
PWC30271-100	Spreader

4. Fixtures, Equipment and Supplier Tools

   The fixtures, equipment and supplier tools listed below are used in the following procedures.

Name	Remarks
Welder	AC/DC with high frequency controls
Torch	Linde HW-10 or equivalent with recirculating water
Regulator	Argon gas
Flowmeters	(2 off)

5. Welding

CAUTION: WELDING MUST BE DONE BY QUALIFIED PERSONNEL ONLY, USING SAFE WELDING PRACTICES, ADEQUATE VENTILATION, AND PROTECTIVE EQUIPMENT. DO NOT WELD IN CONFINED AREAS WITHOUT PROPER VENTILATION.

A. General

The following procedures apply to components that have been removed from the engine. Weld repair of components still installed on the engine, is not permitted under any circumstance.

A tungsten inert gas fusion welding process must be used when repairing cracks in engine parts. Argon or helium gas may be used in inert gas welding; however, argon is preferred by Pratt & Whitney Canada because its greater density reduces its rate of diffusion with the atmosphere.

Inert gas welding is a gas arc welding process which uses inert gas to protect the weld area from the surrounding atmosphere. The heat necessary for welding is provided by a very intense electric arc which is struck between a non-consumable thoriated tungsten (tungsten and thorium alloy) electrode and the metal part. On repairs where a filler material is required, a welding rod, of appropriate material, is fed into the weld area and melted with the base metal in the same manner as in conventional gas welding.

B. Cleaning Before Welding

(1) Refer to CLEANING.

C. Welding Procedures

WARNING: IF AN OXYGEN REGULATOR IS USED WITH ARGON GAS, DO NOT REINSTALL REGULATOR ON AN OXYGEN CYLINDER. ARGON GAS CONTAINS OIL AND THE POSSIBILITY EXISTS OF AN EXPLOSION DUE TO THE PRESENCE OF OIL IN THE REGULATOR. USE SAFE WELDING PRACTICES, ADEQUATE VENTILATION AND PROTECTIVE EQUIPMENT. DO NOT WELD IN CONFINED AREAS WITHOUT EXHAUST VENTILATION.

NOTE: The following procedures apply to components that are dispositioned for repair by welding and are removed from the engine. Weld repair of components still installed on an engine is not permitted.

(1) Welding must be done only by certified personnel.

(a) Connect one argon gas flowmeter to torch and connect other flowmeter, if necessary, behind crack as a backup when ready to weld.

(b) Connect torch to arc welder for straight polarity.

(c) Insert a 1/16 inch diameter thoriated tungsten electrode (PWC05-147) into torch, allowing approximately 5/16 inch of electrode to protrude from ceramic cup. The ceramic cup used must not be smaller than a No. 6 for the HW-10 torch, in order to provide a sufficient amount of inert gas to the weld area where cleanliness of the surface beader is important.

NOTE: A plain tungsten electrode may be used, but a needle point must be maintained on the electrode for more positive starting of arc. Where possible, the electrode must be kept clean of material pickup.

(d) If it is necessary to protect underside of weld from contamination, possible weld porosity, or poor surface finish, attach argon gas line behind crack to be welded. This may be accomplished by fabrication of small box-like fixtures having edges shaped to fit contours of part to be welded and using a suitable connection to secure gas line. Seal fixture to part in order to conserve gas leakage to minimum.

NOTE: The amount of gas pressure to provide sufficient backup must be determined. This pressure should not allow the gas to stir the weld puddle. Do not use flux when welding in an inert atmosphere.

(e) When high frequency controls are used, it is not necessary to strike an arc. Hold torch vertically to work so that the shielding gas (argon) forms a protective envelope around the weld. It is preferable to have area to be welded in a horizontal position.

(f) When high frequency controls are not used, strike arc and hold electrode tip approximately 1/8 to 1/4 inch above surface to be welded until a puddle is formed. Add welding rod, as applicable, and proceed as in conventional gas welding.

NOTE: Test welds, using corresponding material of same thickness and joint design, should be made to determine correct gas pressure and arc welding settings.

(g) Because a high percentage of steel parts used in the engine are fabricated from 12 percent chromium corrosion-resistant steels, which are characterized by their susceptibility to air hardening, field repair of cracks by fusion welding is a special problem. The high temperature at which fusion weld repairs are made and the subsequent air cooling of the part, or parts, from these temperatures usually results in an increase in material hardness and a loss in ductility. Parts on which fusion weld repairs have been made have a tendency to crack because the steel structure becomes unstable, brittle and highly stressed. The structure of the material can be improved by reheating the parts and controlling the cooling rate.

D. Cleaning After Welding

(1) Refer to CLEANING.

E. Local Stress Relief

(1) Components which are not highly stressed may be repaired by fusion welding. It is possible to partially restore the original properties of such welded parts through use of local heat treatment. The localized heat may be applied by neutral flame of an oxyacetylene torch. Extend the stress relief one inch minimum beyond the welded area. After the desired heat has been applied to the part for the correct length of time, reduce temperature of part gradually.

F. Inspection of Welding

(1) Inspect repair area (Ref. INSPECTION).

6. Blend Repairs

A. Repair Procedure

(1) Blend repair using carborundum stone.

CAUTION: DO NOT POLISH WITH POWER TOOLS.

(2) Polish blended area using crocus cloth (PWC05-061).

(3) Blend all repairs and finish smoothly.

(4) Lines, scratches or sharp edges which may cause a concentration of stress are not permitted.

B. Definitions

BLENDING	An operation that removes an irregularity or imperfection from a surface and results in restoring the surface to a smooth acceptable condition.
GRINDING	An operation that removes material by the use of an abrasive material to produce a predetermined size.
POLISHING	A finishing operation which produces a smooth surface finish.

C. General

Repairs are defined as freehand blending, deburring and/or polishing. It does not include machining or machine grinding.

Repair only defined damage within the limits specified in the relevant Chapter/Section/Unit. Undefined damage shall render the component unserviceable.

Do repairs in a direction so that the finishing marks follow the lay of the original manufacturing machining marks.

Restore surface finish of repaired area to the original manufacturing finish.

Make sure repaired area conforms to the original manufacturing shapes, profiles, contours and radii.

Make sure local repairs extend over an area 10 times the depth of damage.

Maintain a smooth transition between repaired areas and adjacent areas.

Make sure repaired area is 1/3 deeper than the damage to ensure removal of damage.

Examine all repaired components.

D. Air Gun

The air gun is hand held, with an adjustable spindle speed and drives a suitable mandrel.

Use a piece of abrasive cloth, rotary file, abrasive disk or wheel of appropriate shape, dimensions and grit size for hand grinding rotating components.

Adjust the rotation of the hand blending wheel to obtain the required surface finish.

Do not allow the wheel to exceed 2000 RPM to prevent local overheating of the material.

Adjust the applied pressure of the wheel to produce a maximum of 0.0005 inch of material removal in each pass.

A light, equal pressure on the wheel gives the best results as it permits the abrasive to cut easily without loading up and overheating.

7. Threaded Inserts

A. Replacement of Threaded Inserts

CAUTION: BEFORE USING INSERTS, IN ANY PART OF ENGINE, REFER TO ILLUSTRATED PARTS CATALOG FOR APPROVED LOCATIONS AND PART NUMBER OF INSERT.

(1) Remove unserviceable insert using an approved extraction tool.

(2) Clean out hole and make sure swarf and other foreign matter is removed.

(3) Install new threaded insert into threaded hole using installation tool. Insert outer thread must be between one and one-half threads below surface of hole or counterbore, whichever applies.

(4) Cut off driving tang at notch using approved tang removal tool and remove tang from holes.

(5) Inspect repaired hole.

8. Studs

A. Replacement of Studs

CAUTION: BEFORE INSTALLING NEW STUDS, REFER TO ILLUSTRATED PARTS CATALOG FOR APPROVED LOCATIONS AND PART NUMBERS.

When necessary, oversize studs are to be installed in place of those which are broken, stretched, loose or have damaged external threads. Whenever a stud which is already oversize requires replacement, install the next oversize stud. Use correct stud drivers to install new studs and torque to appropriate value (Ref. Tables 801 or 802, as applicable).

Before installing new studs, refer to associated Illustrated Parts Catalog, for approved locations and part numbers. When threads of a stud hole are damaged beyond dimensions suitable for fitting a maximum oversize stud, it is usually possible to do repairs by the installation of a helical coil (Ref. Subpara. A.) or key-type insert. Consideration should, however, be given to reduction of thickness of walls of parent metal around insert and the required strength. Specific problems should be referred to P&WC Service Department (Ref. INTRODUCTION).

B. Replacement of Studs

(1) Remove damaged stud using an approved method.

CAUTION: BEFORE INSTALLING NEW STUDS, REFER TO ILLUSTRATED PARTS CATALOG FOR APPROVED LOCATIONS AND PART NUMBERS.

(2) Examine stud hole for condition; on worn stud holes use oversize studs.

(3) Install stud using an approved stud driver to correct protrusion height; make sure torque limits (Ref. Tables 801 or 802, as applicable) are not exceeded.

TABLE 801, Standard Stud Torque Limits

Stud Thread Size (Drive End)	Minimum	Maximum Necked Down $	Maximum Plain #
0.112-40	4	-	8
0.138-32	8	-	14
0.164-32	10	30	30
0.190-24	15	40	45
0.216-24	20	65	70
0.250-20	40	95	105
0.3125-18	85	210	230
0.375-16	160	375	425
0.4375-14	200	600	675

TABLE 801, Standard Stud Torque Limits (Cont'd)

Stud Thread Size (Drive End)	Minimum	Maximum Necked Down $	Maximum Plain #
0.500-13	250	950	1050

NOTE: 1. Symbol $: These limits apply where the unthreaded diameter of the stud is less than the minimum minor diameter of the coarse pitch thread (drive end).

NOTE: 2. Symbol #: These limits apply where the unthreaded diameter of the stud is equal to or greater than the minimum minor diameter of the coarse pitch thread (drive end).

TABLE 802, Stepped Stud Torque Limits

Stud Thread Size (Nut End)	Minimum	Maximum Necked Down $	Maximum Plain #
0.138-40	8	-	18
0.164-36	10	30	30
0.190-32	15	45	50
0.216-28	20	65	75
0.250-28	40	115	125
0.3125-24	85	240	260
0.375-24	160	450	500
0.4375-20	200	700	800
0.500-20	250	1150	1300

NOTE: 1. Symbol $: These limits apply where the unthreaded diameter of the stud is less than the minimum minor diameter of the fine pitch thread (nut end).

NOTE: 2. Symbol #: These limits apply where the unthreaded diameter of the stud is equal to or greater than the minimum minor diameter of the fine pitch thread (nut end).

C. Repair of Damaged Stud Hole

(1) Make sure damaged hole is suitable for repair (Ref. Subpara. B. preceding).

(2) Measure core depth of existing hole.

(3) Select relevant size drill and drill hole to measured depth (Ref. Step (2), preceding).

(4) Using relevant special tap, thread hole one thread deeper than insert to be fitted.

(5) Where applicable, counterbore hole to required angle and depth.

(6) Clean out hole and ensure freedom from metal chippings and other foreign matter.

(7) If part being repaired is magnesium, treat tapped hole with chrome pickle touch-up solution (PWC05-161):

(a) Clean area to be treated with abrasive cloth (PWC05-061) and/or cloth impregnated with solvent (PWC11-016).

(b) On rough surfaces, remove corrosion using wire brush or abrasive paper.

(c) On finished surfaces, remove corrosion using swab or brush impregnated with solution (PWC05-197) at 85° to 93°C (180° to 200°F).

(d) Rinse with clean, cold water.

(e) Rinse with clean, hot water.

(f) Dry using clean, dry compressed air.

(g) Apply solution (PWC05-197) to area to be treated using a clean cloth. Repeat swabbing at frequent intervals to make sure treated area is maintained wet with solution during treatment.

(h) Thoroughly rinse touched up area by swabbing several times with clean cloth moistened with water.

(i) Dry using clean, dry compressed air.

(8) Using appropriate size threaded insert, install insert into repaired stud hole (Ref. Para. B.).

9. Shanknuts

A. Replacement of Shanknuts (Ref. Fig. 801)

CAUTION: AVOID DAMAGE TO FLANGE.

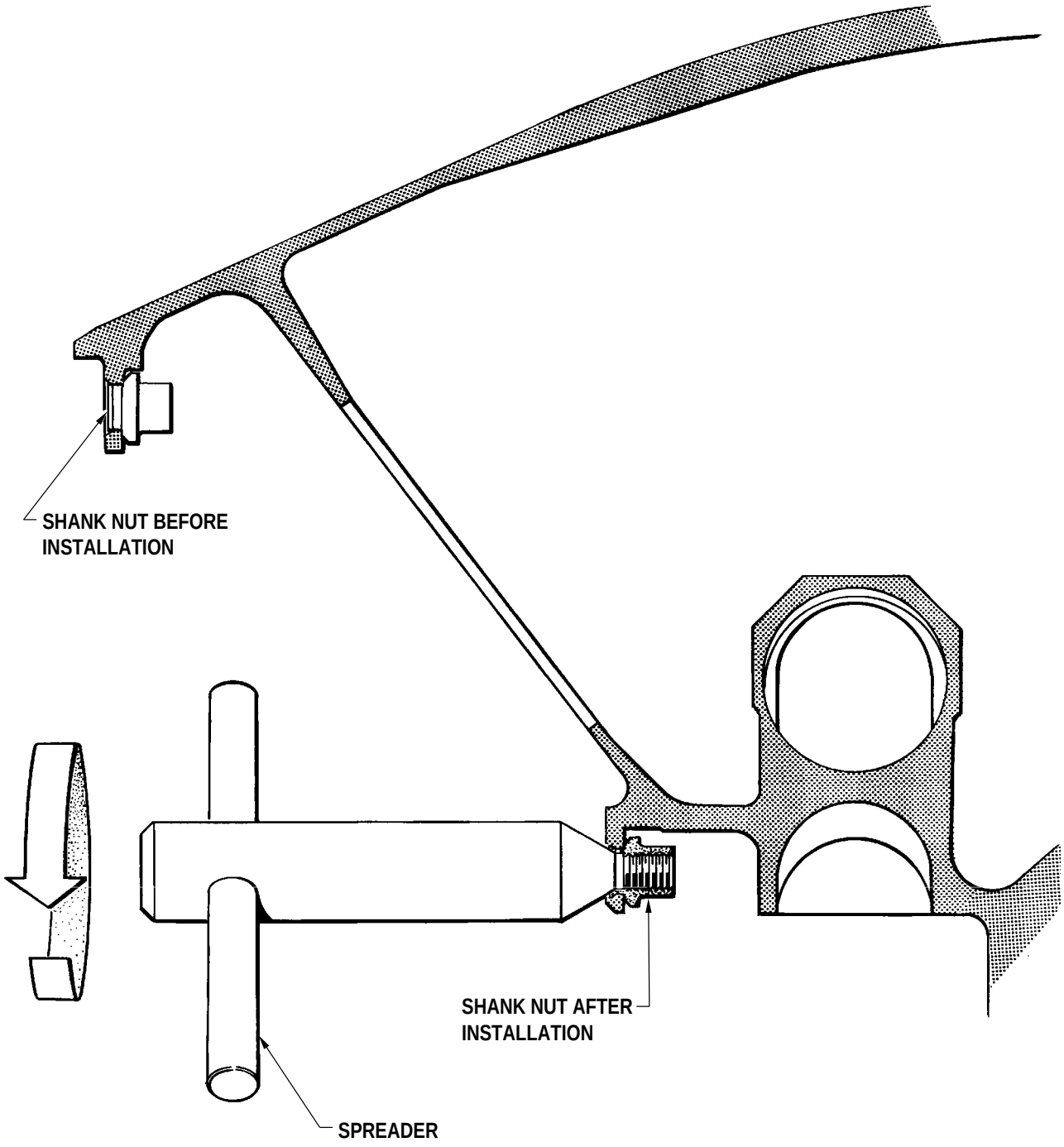
(1) Using a suitable drill, partially remove the flared end of shanknut.

(2) Remove shanknut body using a parallel pin punch at drilled end to shear weakened flare, and retrieve the shanknut case.

(3) Install new shanknut (Ref. IPC) and hold against flange.

(4) Lightly lubricate tapered portion of spreader (PWC30271-100) with oil (PWC03-001) and screw into shanknut until shank end is flared against flange.

(5) Remove spreader and examine flared end of shanknut for correct forming with no evidence of deformation or cracks.



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Shanknut Replacement
Figure 801