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AEROSPACE STANDARD

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REV. G

Submitted for recognition as an American National Standard

GENERAL PRACTICES FOR USE OF SAFETY WIRE, KEY WASHERS, AND COTTER PINS FOR PROPULSION SYSTEMS

1. SCOPE:

This standard covers those devices whose primary function is retaining and excludes those devices that have integral locking features incorporated into the item being retained.

1.1 The practices cover the types of retaining devices described in the following sections:

Section 3	Safety Wire (used to prevent disengagement)
Section 4	Key Washers
Section 5	Cotter Pins

1.2 Special applications involving conditions not covered by the basic principles described herein are shown on the drawings, and where contradiction occurs between a drawing and this instruction, the drawing shall prevail.

2. PURPOSE:

The purpose of this standard is to establish the requirements of good practices for retaining various fasteners and other parts which may require retaining in aerospace propulsion systems, and to ensure the safety of the product and its environs.

3. SAFETY WIRE:

3.1 Basic Rules for the Installation of Safety Wire:

3.1.1 Safety wiring is the securing together of two or more parts with safety wire which shall be installed in such a manner that any tendency for a part to loosen will be counteracted by an additional tightening of the wire.

3.1.2 For general purpose safety wiring, use the preferred sizes shown in Table 1. Use smaller diameter wire where parts are too small to permit a hole diameter to accommodate the preferred sizes, or where space limitations preclude the use of the preferred sizes. The larger sizes are used where stronger wire is required. The proper wire shall be specified on the drawing by part number.

TABLE 1 - Safety Wire and Safety Wire Hole Data

Wire diameter in (mm)	Twists per inch (25.4 mm)	Recommended hole diameter[1,2] in (mm)	Recommended chamfer diameter (90° ± 5 incl) in (mm)
0.015-0.017 (0.381-0.431)	11-14	0.037-0.057 (0.94-1.44)	0.070-0.090 (1.78-2.28)
0.019[3]-0.021 (0.483-0.533)	9-12	0.037-0.057 (0.94-1.44)	0.070-0.090 (1.78-2.28)
0.024-0.026 (0.610-0.660)	9-12	0.060-0.080 (1.53-2.03)	0.090-0.110 (2.29-2.79)
0.030[3]-0.034 (0.770-0.860)	7-10	0.060-0.080 (1.53-2.03)	0.090-0.110 (2.29-2.79)
0.038-0.042 (0.970-1.070)	7-10	0.060-0.080 (1.53-2.03)	0.090-0.110 (2.29-2.79)
0.049-0.053 (1.250-1.340)	5- 8	0.060-0.080 (1.53-2.03)	0.090-0.110 (2.29-2.79)
0.061-0.065 (1.550-1.650)	5- 8	0.070-0.090 (1.78-2.28)	0.100-0.120 (2.54-3.04)
0.089-0.093 (2.270-2.360)	4- 7	0.100-0.120 (2.54-3.04)	0.140-0.160 (3.56-4.06)

/1/ Where safety wire is used to secure a castellated nut on a threaded item, selection of safety wire hole diameter for the item shall be based on cotter pin requirements (see TABLE 4).
/2/ Where parts cannot accommodate the recommended hole size, it is permissible to use a smaller hole provided a minimum diametral clearance of 0.003 (0.08 mm) is maintained between the wire and the hole, except on the two largest wire sizes.
/3/ Preferred size

3.1.3 The safety wire material for use up to 1200°F (649°C) shall be corrosion-resistant steel such as AMS 5689, and for use up to 1800°F (982°C), a corrosion and heat-resistant alloy such as AMS 5687 shall be used. Where AMS or other material specifications are used, the specified diameter tolerances in Table 1 shall supersede those in the material specifications.

3.1.4 The common method of installing safety wire shall consist of two strands of wire twisted together (so called "Double-Twist" method) where one twist is defined as being produced by twisting the wires through an arc of 180° and is equivalent to half of a complete turn. The single strand method of safety wiring may be used, when so specified, such as in a closely spaced, closed geometrical pattern (triangle, square, rectangle, circle, etc.), or

3.1.4 (Continued):

parts in electrical systems, and in places that would make the single strand method more advisable. In such cases the single strand wire shall be limited to the pattern or group of similar parts.

3.1.5 The maximum span of safety wire between tension points shall be 6 in (152 mm) unless otherwise specified.

3.1.6 Where multiple groups are safety wired by either the double-twist or the single strand method the maximum number in a series shall be determined by the number of units that can be safety wired by a 24-in (609 mm) length of wire.

3.1.7 Wire shall be pulled taut while being twisted. See Table 1 for the number of twists per inch (25.4 mm).

3.1.8 Caution must be exercised during the twisting operation to keep the wire tight without overstressing. Abrasions caused by commercially available wire twisting pliers shall be acceptable but nicks, kinks, and other mutilations caused by improper tooling and wiring techniques are not acceptable. Gripping surfaces of pliers shall have edges sufficiently rounded to preclude wire damage.

3.1.9 Safety wire shall not be installed in such a manner as to cause the wire to be subjected to chafing, fatigue through vibration, or additional tension other than the tension imposed on the wire to prevent loosening.

3.1.10 In all cases wiring must be done through the holes provided. In the event that no wire hole is provided, wiring should be to a convenient neighboring part in a manner so as not to interfere with the function of the parts and in accordance with the basic principles described herein (see Figs. 15, 20, and 21).

3.1.11 Safety wire shall be new upon each application.

3.1.12 When drawing specifies a safety wiring seal, it shall be applied and crimped to the safety wire as shown in Figs. 13 or 14. Fig. 13 shows the seal application where all units in a series do not require sealing. Fig. 14 gives examples of sealing required at the end of a series, showing ends of safety wire beyond seal twisted and secured to safety wire between units (Fig. 14A) and to an unused safety wire hole in the last unit (Fig. 14B). When sealing is required for the single strand method, apply and crimp the seal to the twisted wire at the end of the series as represented by Fig. 14A except that twisted wire beyond seal is secured to single strand wire between units.

3.1.13 Hose and electrical coupling nuts shall be wired in the same manner as tube coupling nuts.

3.1.14 Various examples of safety wiring are shown in Figs. 1 through 29. Although not every possible combination is shown, any combination used must adhere to the basic rules outlined in this specification. Figure 12 shows the single-strand method, while the other figures show the two-strand or double-twist method.

3.2 Detail Instructions for the Installation of Safety Wire:

3.2.1 Check the units to be safety wired to make sure that they have been correctly torqued. Under-torquing or over-torquing to obtain proper alignment of the holes is not permitted. If it is impossible to obtain a proper alignment within the specified torque limits, back off the unit and try it again or select another unit.

3.2.2 In adjacent units, it is desirable that the holes be in approximately the same relationship to each other as shown in Figs. 1 through 4 for right-hand threads, and the safety wire shall be installed in such a manner that the strand through the hole will have a tendency to pull the unit clockwise. This should be reversed for left-hand threads.

3.2.3 Insert the safety wire through the first unit and bend around the head of the unit. The direction of wrap and twist of strands shall be such that the loop around the unit comes under the strand proturuding from the hole so that the loop will stay down and will not tend to slip up and leave a slack loop (see Fig. 1). See also paragraph 3.2.7.

3.2.4 Twist the strands while taut until the twisted part is just short of a hole in the next unit. The twisted portion should be within 1/8 in (3.17 mm) from the hole in either unit.

3.2.5 Insert the uppermost strand through the hole in the second unit and follow the rules in 3.2.3. (see center unit Fig. 1). If there are more than two units in the series, repeat the above procedure. See also paragraph 3.2.7.

3.2.6 After wiring the last unit, continue twisting the wire to form a pigtail, providing sufficient twist (four minimum) to assure that the pigtail will not unravel. Bend in toward the part to assure that the cut edges will not be exposed and cause a snag. Cut off the excess wire taking care to dispose of the excess wire so that it does not become a hazard. Short pigtails may be desirable because of vibration.

3.2.7 As an alternative to wrapping wire around the unit as in Fig. 1, wire may be crossed through the unit as in Fig. 6, 7, and 8. Wire passing over the top of a bolt, as in Figure 3 and 14A, is an acceptable alternative to the illustrated routing around the head.

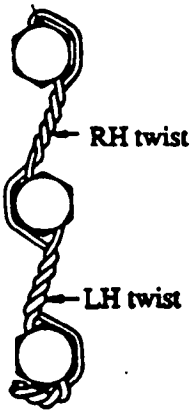


FIGURE 1

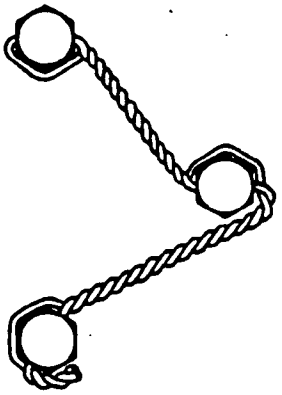


FIGURE 2

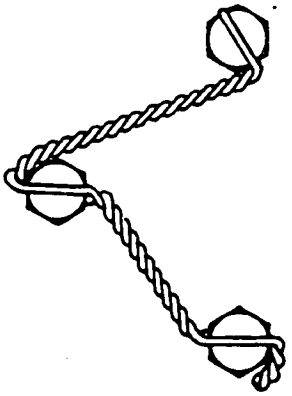


FIGURE 3

FIGURE 4

FIGURE 5

FIGURE 6

FIGURE 7

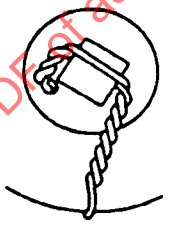


FIGURE 8

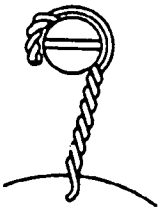


FIGURE 9

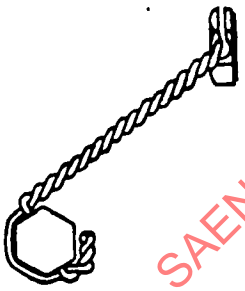


FIGURE 10 – Correct method for wiring bolts in different planes. Note that wire should always be applied so that tension is in the tightening direction.

FIGURE 11 – When practicable, hollow head plugs shall be wired as shown with the pigtail bent inside the hole to avoid snags and possible injury to personnel.

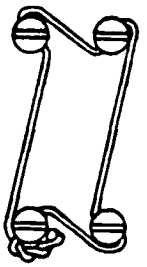


FIGURE 12

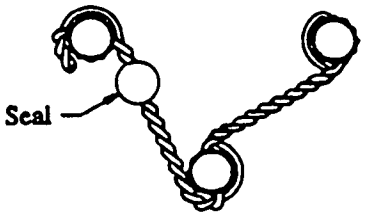


FIGURE 13 – Method for attaching seal to protect critical adjustments.

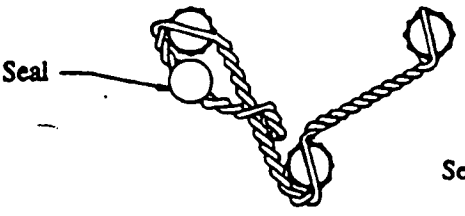


FIGURE 14A

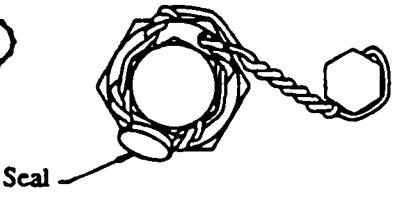


FIGURE 14B

FIGURE 14 – Methods for attaching seal to protect critical adjustments.

FIGURE 15 – Bolt wire to a right angle bracket with the wire wrapped around the bracket.

FIGURE 16 – Correct method for wiring adjustable connecting rod.

FIGURE 17 – Correct method for wiring the coupling nut on flexible line to the straight connector brazed on rigid tube.

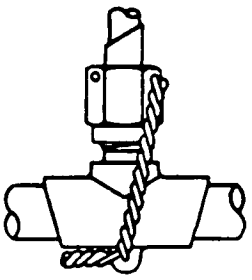


FIGURE 18 – Fittings incorporating wire lugs shall be wired as shown in Figs. 18 and 19.

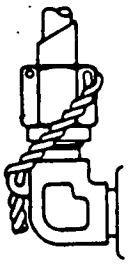


FIGURE 19 – See Fig. 18

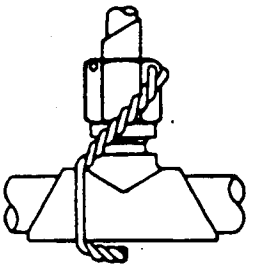


FIGURE 20 – When no lock wire lug is provided, wire should be applied as shown in Figs. 20 and 21 with caution being exercised to insure that wire is wrapped tightly around the fitting.

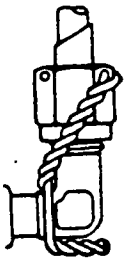
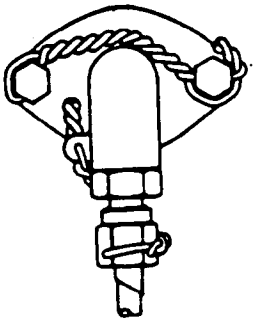


FIGURE 21 – See Figure 20.



END VIEW
(enlarged)

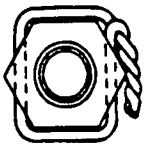


FIGURE 22 – Small coupling nuts or those made of soft material may be wired as shown to lessen possibility of wire breaking or tearing out.

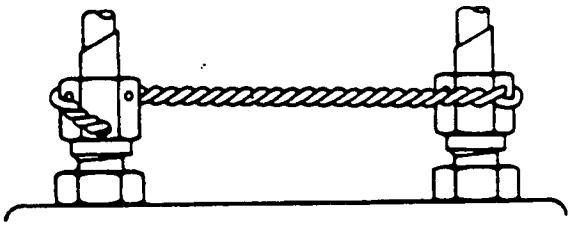


FIGURE 23 - Coupling nuts attached to straight connectors shall be wired as shown where unwired fitting is an integral part of the connector.

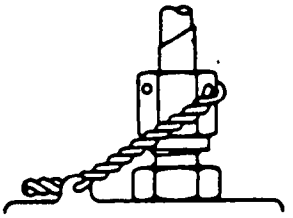


FIGURE 24 - See Figure 23.

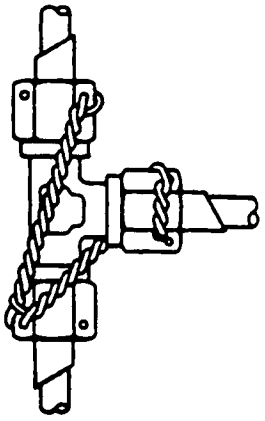


FIGURE 25 - Coupling nuts on a tee shall be wired as shown above so that tension is always in the tightening direction.

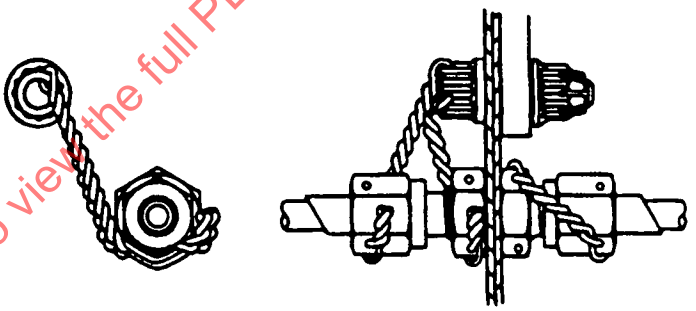


FIGURE 26 - Straight connector (bulkhead type)

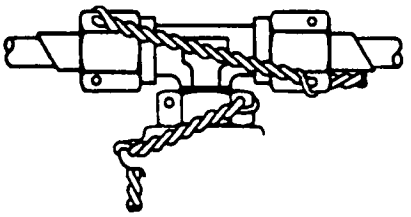


FIGURE 27

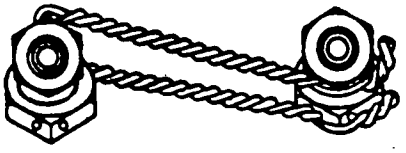


FIGURE 28 – The proper method for wiring a standard fitting with check nut wired independently so that it need not be disturbed when removing the coupling nut.

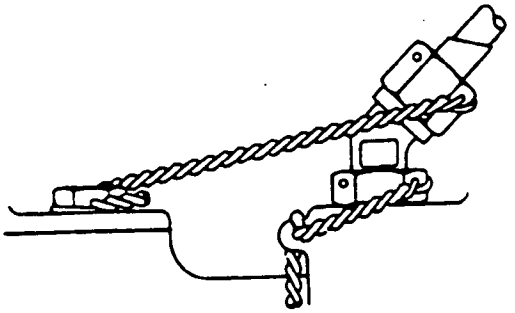


FIGURE 29 – See Figure 28.

4. KEY WASHERS:

4.1 Locking with Key Washers:

4.1.1 Key washers are used to restrain relative motion between two parts by fitting the keys in keyways in adjacent parts or by bending the keys over parts after application.

4.1.2 Key washers with bendable keys are not reusable and must be replaced with a new key washer after removal.

4.2 Locking Hex Nuts with Key Washers:

4.2.1 When single hole key washers are used, the key which is bent down against the stationary part shall be positioned as illustrated by key A in Fig. 30 so that it will maintain the gap in a tightening direction.

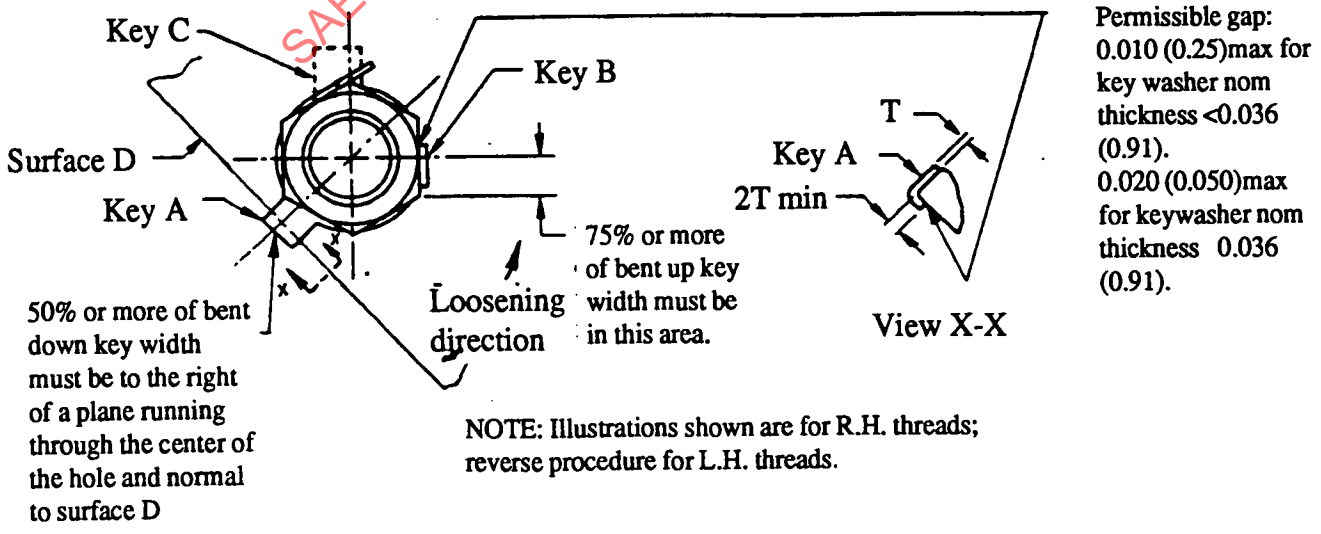


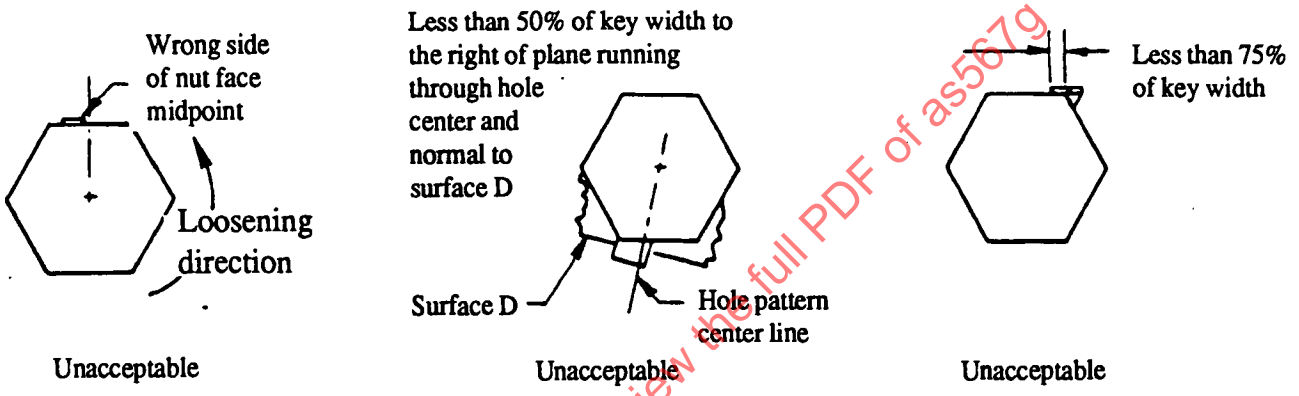
FIGURE 30 – Key Washer Stationary Surface Lock

4.2.2 Of the other keys, one that will provide the maximum contact with a single hex flat in the required area (key B in Fig. 30) shall be bent up against a hex flat.

4.2.2.1 Other keys which also happen to be aligned properly with a second hex flat (key C in Fig. 30) may also be bent up at the option of the assembler and may be bent around corner of nut if desired.

4.2.3 Any excess key protrusion above the hex flat shall be bent over the nut to avoid becoming a snag.

4.2.4 Fig. 31 shows keys located in unacceptable position for bending.



NOTE: Illustrations shown are for R.H. threads; reverse procedure for L.H. threads

FIGURE 31 - Unacceptable Bent Key Locations

4.3 Drilled Holes for Washer Keys:

4.3.1 If there is no stationary part against which to retain the key as illustrated in Fig. 30, a hole may be drilled to fulfill this function as shown in Fig. 32.

4.3.1.1 Key should not be allowed to move within the hole but should be braced against the side to prevent objectionable movement.

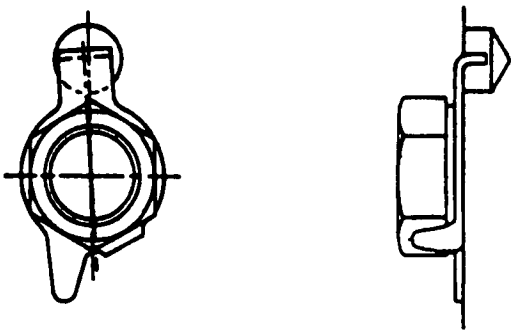


FIGURE 32 - See MS9276, MS9581, MS9582 for key washers of this type.

4.4 Use of Multiple Hole Key Washers:

4.4.1 When a multiple hole key washer is required, installation shall be as for the single hole key washer except key A provision of 4.2.1 does not apply (see Fig. 33). When rotating parts are involved and a choice of keys is available, the key shall be bent that will utilize centrifugal force to aid in maintaining its bent position.

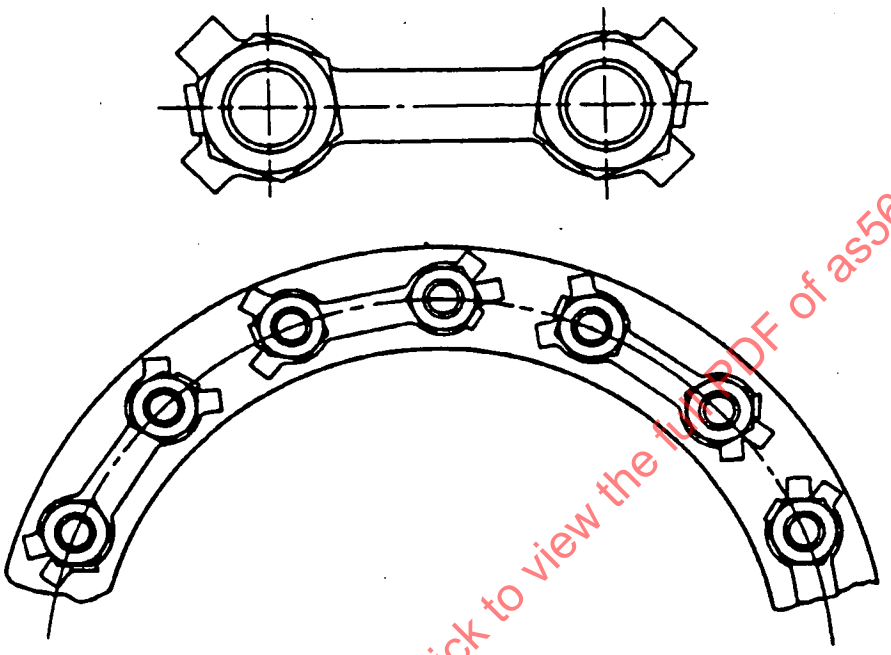
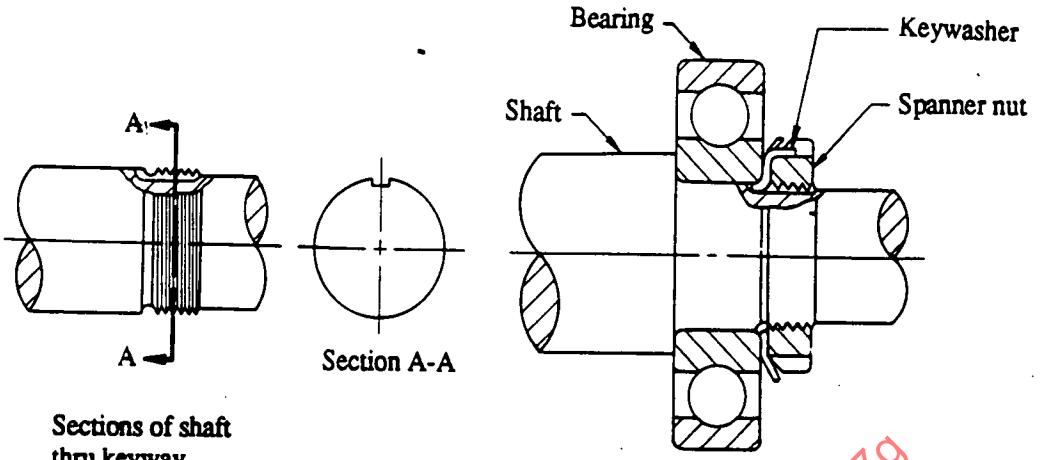


FIGURE 33 – View showing split line nuts locked with multiple key washers

4.5 Locking Spanner Nuts with Key Washers:

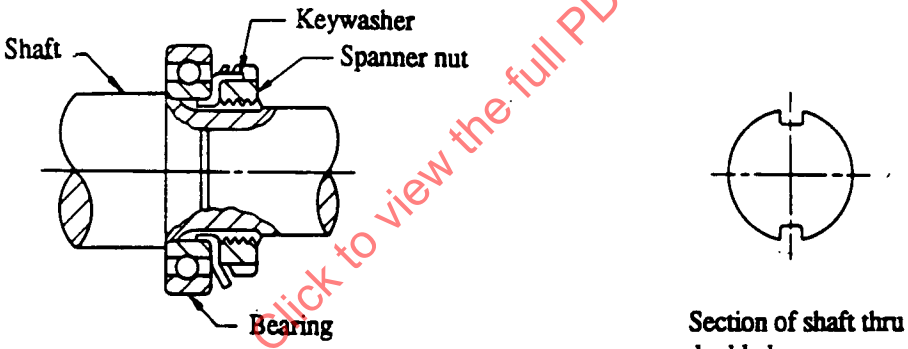
4.5.1 Assemble keywasher on shaft with washer key engaging keyway in shaft. When the nut has been torqued to the proper level, bend one of the tabs at the periphery of the washer into the corresponding slot in the nut. Use the tab and slot which are most favorably aligned. Only one tab need to be bent to secure the nut. It is not necessary to bend the tabs into additional slots which may also be favorably aligned. Figs. 34 and 35 show typical bearing retention applications. Note that the washer may engage shaft with a single key as in Fig. 34, or with a double key as in Fig. 35. The double key configuration provides better resistance to shear loads thru the key.



Sections of shaft thru keyway

Typical bearing retention application. Shaft engaged by single key.

FIGURE 34



Typical bearing retention application. Shaft engaged by double key.

Section of shaft thru double keyway

FIGURE 35

4.5.1.1 Table 2 references recommended MS standard key washers and spanner nuts. See AS462 and AS919 for dimensions of shaft features.

TABLE 2 – Recommended MS Key Washers and Spanner Nuts

Application	Key washer	Nut
Single keyway shaft		
Millimeter series bearings	MS172201 thru MS172235	MS172236 thru MS172270
Inch series bearings	MS172271 thru MS172320	MS172321 thru MS172370
Double keyway shaft		
Millimeter bearings	MS9081, MS9274	MS172236 thru MS172270

4.5.1.2 When clearance problems prohibit the use of spanner nuts with slots in the circumference, spanner nuts with the slots in the face may be used. Key washers for use with these spanner nuts are designed with keys on the ID. The keys are long enough to extend through the slot keyway and past the nut. The part of the key extending out of the keyway is bent up into the nut slot (see Fig. 36) thereby creating a locked condition.

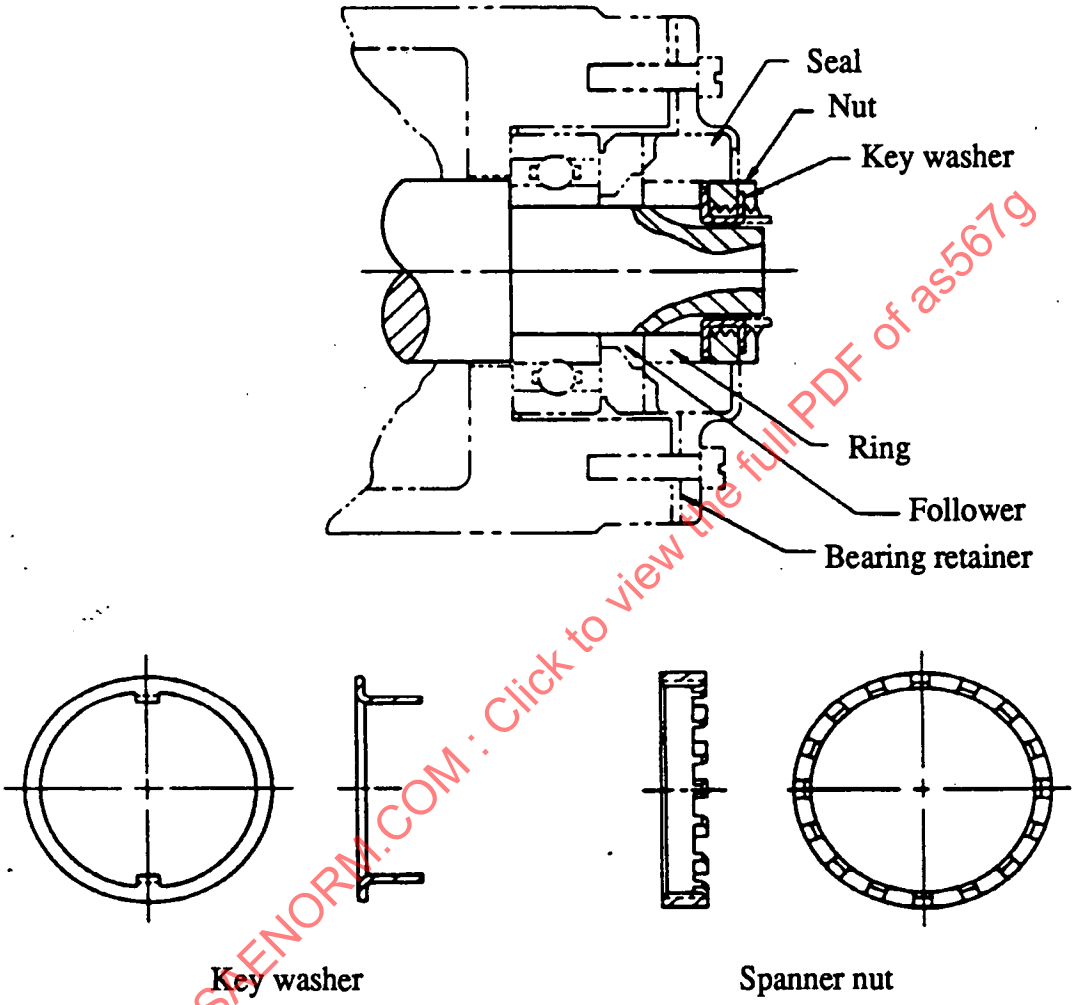


FIGURE 36

4.6 Elliptical Key Washers:

4.6.1 The installation of 180° ellipses shall be accomplished by bending up across one whole face of the hex as shown in Fig. 37.

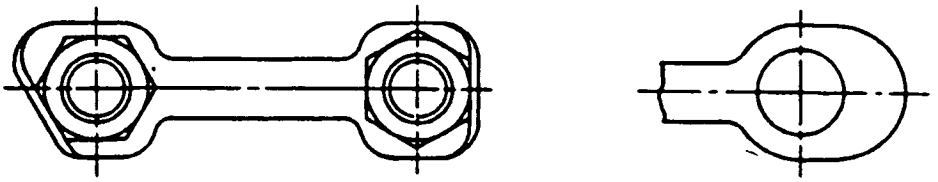


FIGURE 37

4.7 Cup-Type Keywasher:

4.7.1 Lock fastener by dimpling the washer as shown in Fig. 38. Two dimples, placed 180° apart, are required. Form dimples with a spherically tipped tool. Radius of sphere must be such that it forms smooth, well formed dimples that are free of cracks and that engage scallops of the fastener to the depth shown in View A.

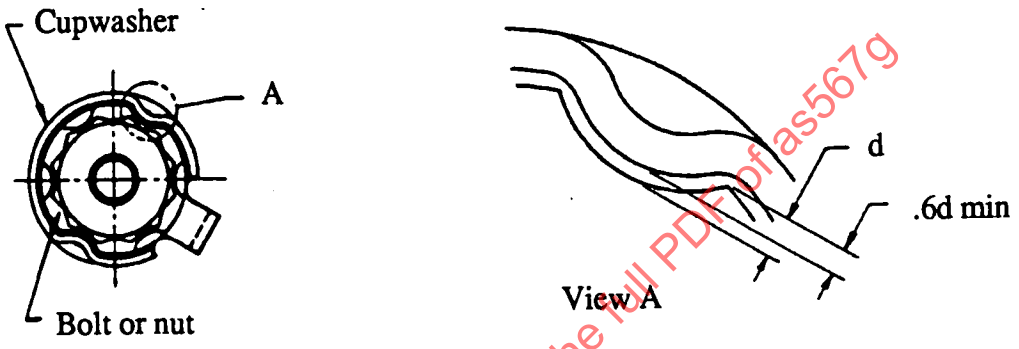


FIGURE 38

4.7.1.1 Table 3 gives dimple engagements for MS standard cupwashers and fasteners.

TABLE 3 - Recommended Dimple Engagement for MS Standard Cupwashers and Fasteners

Nom size in (mm)	Bolt	Nut	Cupwasher	Dimple engagement (0.6 d min)[1] in (mm)
0.190 (4.83)	MS9676 MS9680	MS9766-09	MS9684-09	0.026 (0.67)
0.250 (6.35)	MS9677 MS9681	MS9766-10	MS9684-10	0.025 (0.64)
0.3125 (7.94)	MS9678 MS9682	MS9766-11	MS9684-11	0.024 (0.61)
0.375 (9.52)	MS9679 MS9683	MS9766-12	MS9684-12	0.023 (0.59)

[1]See Fig. 37

4.7.2 To release fastener from lock, restrain the key and untorque fastener. As fastener turns, it will restore periphery of cup washer to virtually the predimpled state. This method of release is recommended in preference to prying out dimple with sharp tool because it is surer and less likely to produce burred surfaces.

5. COTTER PINS:

5.1 Locking with Cotter Pins:

5.1.1 Cotter pins are used to restrain relative motion between two parts by inserting the cotter pin through a hole in one part and slots in the other part and spreading the exposed ends.

5.1.2 Cotter pins are not reusable and must be replaced with a new cotter pin after removal.

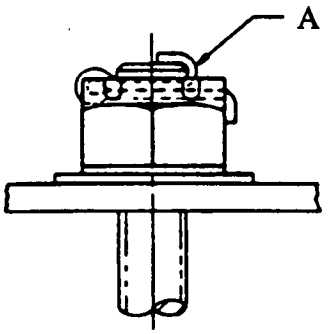
5.1.3 Cotter pin material shall be a corrosion resistant steel, such as AMS 7210, for use up to 700°F (371°C); and a corrosion and heat-resistant material, such as AMS 7211, for use up to 1200°F (649°C). See AS123751 through AS123850 and MS9245, respectively; these cotter pins range in size from 0.031 in (0.79 mm) to 0.188 in (4.78 mm) diameter.

5.2 Locking Nuts with Cotter Pins:

5.2.1 The preferred method of cotter pin installation is illustrated in Fig. 39. General rules for the installation of cotter pins are as follows:

5.2.1.1 Tighten the nut to the low side of the selected torque range, unless otherwise specified, and continue tightening until the slot aligns with the hole in the bolt shank (see Fig. 42). Maximum applicable torque should not be exceeded.

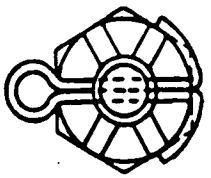
5.2.1.2 Install the cotter pin with the head seated firmly in the slot of the nut with the axis of the eye at right angles to the bolt shank as shown in Fig. 39. Bend prongs so that the head and upper prongs are firmly seated against the bolt. Upper prong may be cut off at "A", if necessary, to provide clearance.



Preferred installation

FIGURE 39

5.2.1.3 The alternative method of installation to be used in overcoming a clearance problem is shown in Fig. 40. This will require longer pins than those outlined in Table 4.

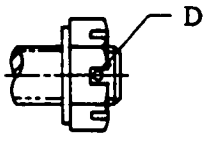


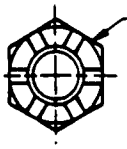
Alternative installation

FIGURE 40

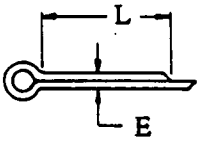
TABLE 4A – Inches
(U.S. Customary Units)

Cotter Pin and Cotter Pin Hole Data

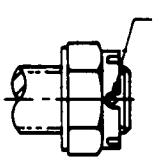




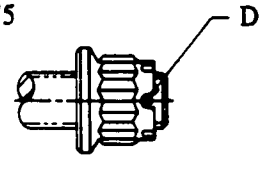
AN150426 thru AN150450
MS9363 and MS9364



Slotted nut-type 1



AN121551 thru AN121575
MS9358 and MS9359



Castellated nut-type 2

12 point nut-type 3

Fastener size	Cotter Pin Hole: D dia	Cotter Pin Hole: Chamfer dia (60° ± 2° incl)	Nut Type	Recommended Cotter Pin: L length	Recommended Cotter Pin: E dia	Recommended Cotter Pin: 800°F[1] AMS 7210 Ref P/N	Recommended Cotter Pin: 1200°F[1] AMS 7211 Ref P/N
0.190–32	0.065–0.072	0.090–0.110	1	0.312	0.0625	AS123770	MS9245–22
			2	0.375	0.0625	AS123771	MS9245–23
			3	0.312	0.0625	AS123770	MS9245–22
0.250–28	0.065–0.072	0.090–0.110	1	0.375	0.0625	AS123771	MS9245–23
			2	0.438	0.0625	AS123772	MS9245–24
			3	0.375	0.0625	AS123771	MS9245–23
0.3125–24	0.065–0.072	0.090–0.110	1	0.438	0.0625	AS123772	MS9245–24
			2	0.500	0.0625	AS123773	MS9245–25
			3	0.438	0.0625	AS123772	MS9245–24

TABLE 4A – Inches
(U.S. Customary Units) (Continued)

Fastener size	Cotter Pin Hole: D dia	Cotter Pin Hole: Chamfer dia (60° ± 2° incl)	Nut Type	Recommended Cotter Pin: L length	Recommended Cotter Pin: E dia	Recommended Cotter Pin: 800°F[1] AMS 7210 Ref P/N	Recommended Cotter Pin: 1200°F[1] AMS 7211 Ref P/N
0.375-24	0.094-0.101	0.140-0.160	1	0.500	0.0938	AS123788	MS9245-42
			2	0.562	0.0938	AS123789	MS9245-43
			3	0.500	0.0938	AS123788	MS9245-42
0.4375-20	0.094-0.101	0.140-0.160	1	0.562	0.0938	AS123789	MS9245-43
			2	0.625	0.0938	AS123790	MS9245-44
			3	0.562	0.0938	AS123789	MS9245-43
0.500-20	0.094-0.101	0.140-0.160	1	0.625	0.0938	AS123790	MS9245-44
			2	0.750	0.0938	AS123791	MS9245-45
			3	0.625	0.0938	AS123790	MS9245-44
0.5625-18	0.126-0.133	0.178-0.198	1	0.750	0.125	AS123805	MS9245-62
			2	0.875	0.125	AS123806	MS9245-63
			3	0.750	0.125	AS123805	MS9245-62
0.625-18	0.126-0.133	0.178-0.198	1	0.875	0.125	AS123806	MS9245-63
			2	1.000	0.125	AS123807	MS9245-64
			3	0.875	0.125	AS123806	MS9245-63
0.750-16	0.126-0.133	0.178-0.198	1	1.000	0.125	AS123807	MS9245-64
			2	1.125	0.125	AS123808	MS9245-65
0.875-14	0.126-0.133	0.178-0.198	1	1.125	0.125	AS123808	MS9245-65
			2	1.250	0.125	AS123809	MS9245-66
1.000-12	0.126-0.133	0.178-0.198	1	1.250	0.125	AS123809	MS9245-66
			2	1.500	0.125	AS123811	MS9245-68

[1]Maximum recommended temperature