AN AMERICAN NATIONAL STANDARD

LAND SEA AIR SPACE

# AEROSPACE STANDARD

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## GENERAL PRACTICES FOR USE OF LOCK WIRE, KEY WASHERS, AND COTTER PINS

1. PURPOSE: To establish the requirements of good practices for locking various fasteners and other parts which may require locking in critical applications such as aerospace propulsion systems.

2. SCOPE: This standard covers those devices whose primary function is locking, and excludes those devices which have integral locking features incorporated into the item being locked.

ϕ 2.1 The practices cover the types of locking devices described in the following sections:

Section I Lock Wire (Safety wire used for locking purposes)
Section II Key Washers
Section III Cotter Pins

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

### SECTION I LOCK WIRE

I-1. BASIC RULES FOR THE INSTALLATION OF LOCK WIRE:

ϕ I-1.1 Lock 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.

I-1.2 For general purpose lock wiring, use the preferred sizes shown in Table I-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.

ϕ I-1.3 The lock wire material for use up to 1200°F (649°C) shall be a 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 I-1 shall supersede those in the material specifications.

I-1.4 The common method of installing lock 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 degrees and is equivalent to half of a complete turn. The single strand method of lock wiring may be used, when so specified, such as in a closely spaced, closed geometrical pattern (triangle, square, rectangle, circle, etc.), or 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.

ϕ I-1.5 The maximum span of lock wire between tension points shall be six inches (152 mm) unless otherwise specified.

ϕ I-1.6 Where multiple groups are lock 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 lock wired by a twenty-four inch (609 mm) length of wire.

ϕ I-1.7 Wire shall be pulled taut while being twisted. The number of twists per inch (25.4 mm), as recorded in Table I-1, represents general practice and is given as guidance information only.

I-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.

I-1.9 Lock 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.

I-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 Figures I-15, I-20, and I-21).

I-1.11 Lock wire shall be new upon each application.







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I-1.12 When drawing specifies a lock wiring seal, it shall be applied and crimped to the lock wire as shown in Figure I-13 or I-14. Figure I-13 shows the seal application where all units in a series do not require sealing. Figure I-14 gives examples of sealing required at the end of a series, showing ends of lock wire beyond seal twisted and secured to lock wire between units (Figure I-14a) and to an unused lock wire hole in the last unit (Figure I-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 Figure I-14a except that twisted wire beyond seal is secured to single strand wire between units.

I-1.13 Hose and electrical coupling nuts shall be wired in the same manner as tube coupling nuts.

I-1.14 Various examples of lock wiring are shown in Figures I-1 through I-29. Although every possible combination is not shown, any combination used must adhere to the basic rules outlined in this specification. Figure I-12 shows the single-strand method, while the other figures show the two-strand or double-twist method.

ϕ TABLE I-1

Lockwire and lockwire hole data

| Wire diameter | | Twists per inch (25.4 mm) | θ # Recommended hole diameter | | Recommended chamfer dia (90°±5° incl) | |
|---|---|---|---|---|---|---|
| IN | (mm) | | IN | (mm) | IN | (mm) |
| .015-.017 | 0.381-0.431 | 11-14 | .037-.057 | 0.94-1.44 | .070-.090 | 1.78-2.28 |
| * .019-.021 | 0.483-0.593 | 9-12 | .037-.057 | 0.94-1.44 | .070-.090 | 1.78-2.28 |
| .024-.026 | 0.610-0.660 | 9-12 | .060-.080 | 1.53-2.03 | .090-.110 | 2.29-2.79 |
| * .030-.034 | 0.77-0.86 | 7-10 | .060-.080 | 1.53-2.03 | .090-.110 | 2.29-2.79 |
| .038-.042 | 0.97-1.07 | 7-10 | .060-.080 | 1.53-2.03 | .090-.110 | 2.29-2.79 |
| .049-.053 | 1.25-1.34 | 5-8 | .060-.080 | 1.53-2.03 | .090-.110 | 2.29-2.79 |
| .061-.065 | 1.55-1.65 | 5-8 | .070-.090 | 1.78-2.28 | .100-.120 | 2.54-3.04 |
| .089-.093 | 2.27-2.36 | 4-7 | .100-.120 | 2.54-3.04 | .140-.160 | 3.56-4.06 |

* PREFERRED SIZE.

θ Where lock wire is used to secure a castellated nut on a threaded item, selection of locking hole diameter for the item shall be based on cotter pin requirements (see Table III-1).

# Where parts cannot accommodate the recommended hole size, it is permissible to use a smaller hole provided a minimum diametral clearance of .003 (.08 mm) is maintained between the wire and the hole, except on the two largest wire sizes.



I-2. DETAIL INSTRUCTIONS FOR THE INSTALLATION OF LOCK WIRE:

I-2.1 Check the units to be lock 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.

I-2.2 In adjacent units, it is desirable that the holes be in approximately the same relationship to each other as shown in Figures I-1 through I-4 for right-hand threads, and the lock 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.

I-2.3 Insert the lock 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 protruding from the hole so that the loop will stay down and will not tend to slip up and leave a slack loop (see Figure I-1). See also paragraph I-2.7.

I-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 one-eighth inch (3.17 mm) from the hole in either unit.

I-2.5 Insert the uppermost strand through the hole in the second unit and follow the rules in Para. I-2.3 (see center unit Figure I-1). If there are more than two units in the series, repeat the above procedure. See also paragraph I-2.7.

ϕ I-2.6 After wiring the last unit, continue twisting the wire to form a pigtail, providing sufficient twists (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.

As an alternative to wrapping wire around unit as in Figure I-1, wire may be crossed through unit as in Figure I-5; also in the case of castellated nuts or taper head bolts, wire may be wrapped over the unit as in Figure I-6, I-7, and I-8. Wire passing over the top of a bolt, as in Figure I-3 and I-14a, is an acceptable alternative to the illustrated routing around the head.

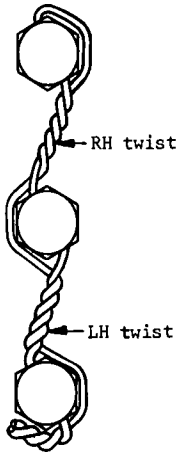



FIGURE I-1

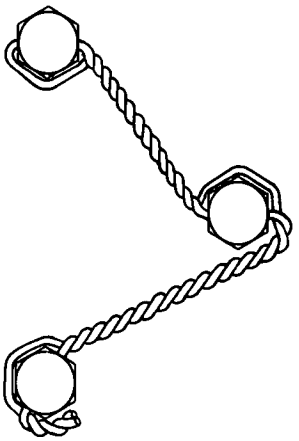


FIGURE I-2

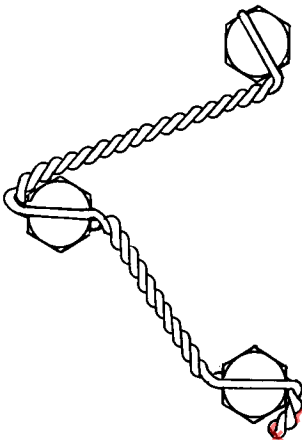


FIGURE I-3

FIGURE I-4

FIGURE I-5

FIGURE I-6



FIGURE I-7

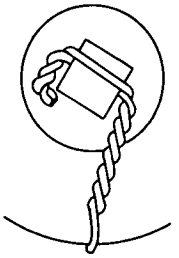


FIGURE I-8

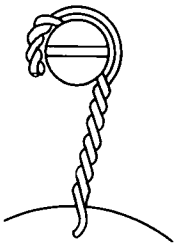


FIGURE I-9

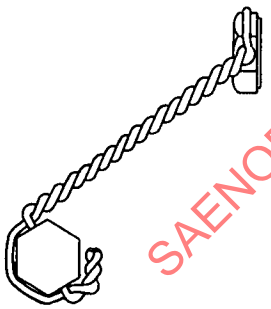


FIGURE I-10

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

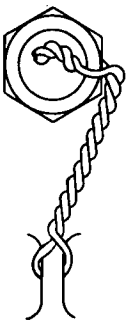


FIGURE I-11

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.

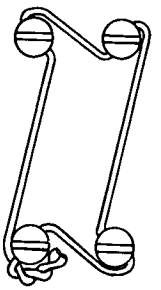


FIGURE I-12

Correct application of single wire to closely spaced multiple group.

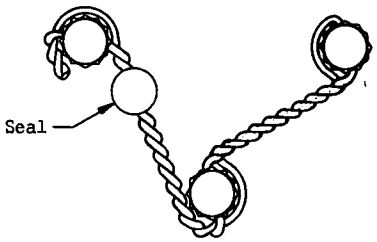



FIGURE I-13

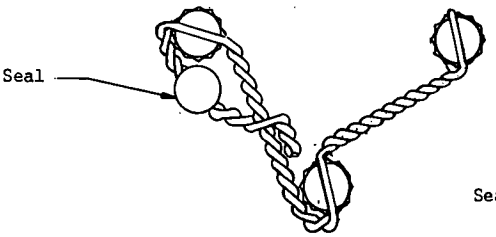



FIGURE I-14a

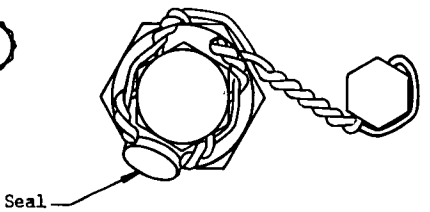



FIGURE I-14b

Methods for attaching seal to protect critical adjustments.

FIGURE I-15

Bolt wired to a right angle bracket with the wire wrapped around the bracket.

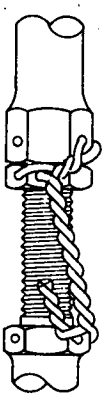


Figure at left shows correct method for wiring adjustable connecting rod.

FIGURE I-16

FIGURE I-17

Correct method for wiring the coupling nut on flexible line to the straignt connector brazed on rigid tube.

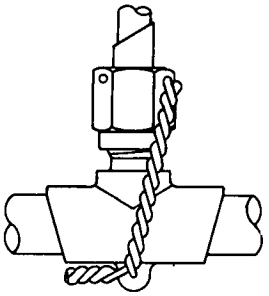


FIGURE I-18

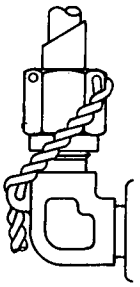
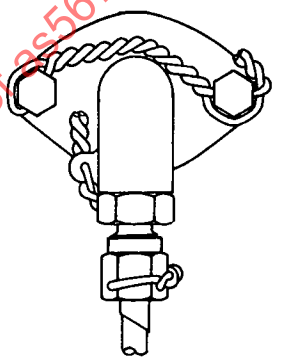


FIGURE I-19



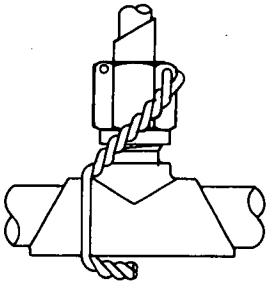


FIGURE I-20

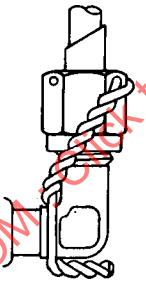
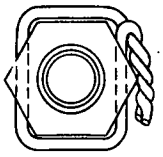


FIGURE I-21



END VIEW
(enlarged)

FIGURE I-22

Fittings incorporating wire lugs shall be wired as shown in Figures I-18 & I-19. When no lock wire lug is provided, wire should be applied as shown in Figures I-20 & I-21 with caution being exercised to insure that wire is wrapped tightly around the fitting.

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

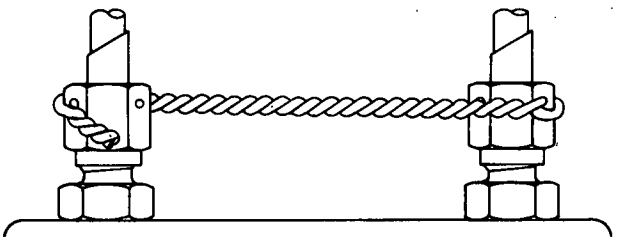


FIGURE I-23

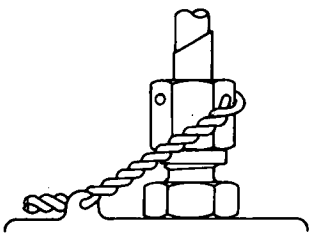


FIGURE I-24

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

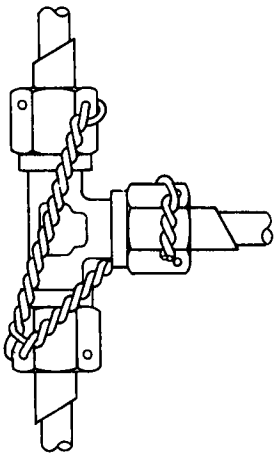


FIGURE I-25

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

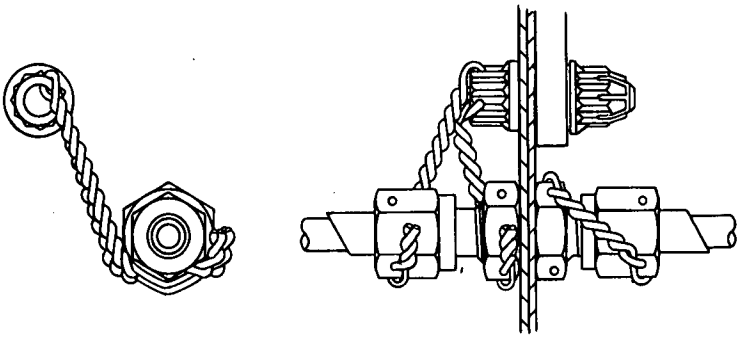


FIGURE I-26

Straight connector (bulkhead type)



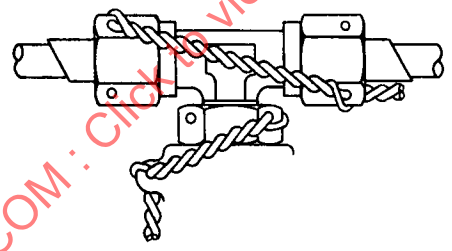


FIGURE I-27

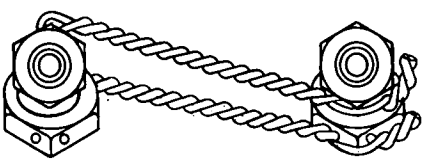


FIGURE I-28

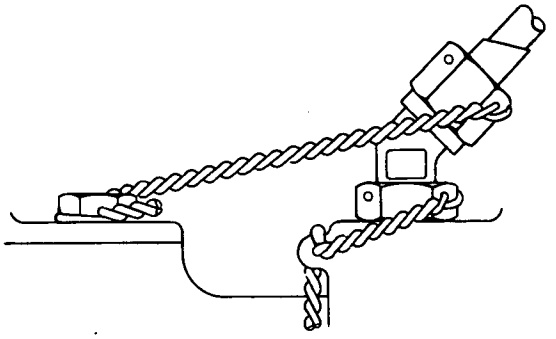


FIGURE I-29

Above figures show the proper method for wiring various standard fittings with check nut wired independently so that it need not be disturbed when removing the coupling nut.

## SECTION II KEY WASHERS

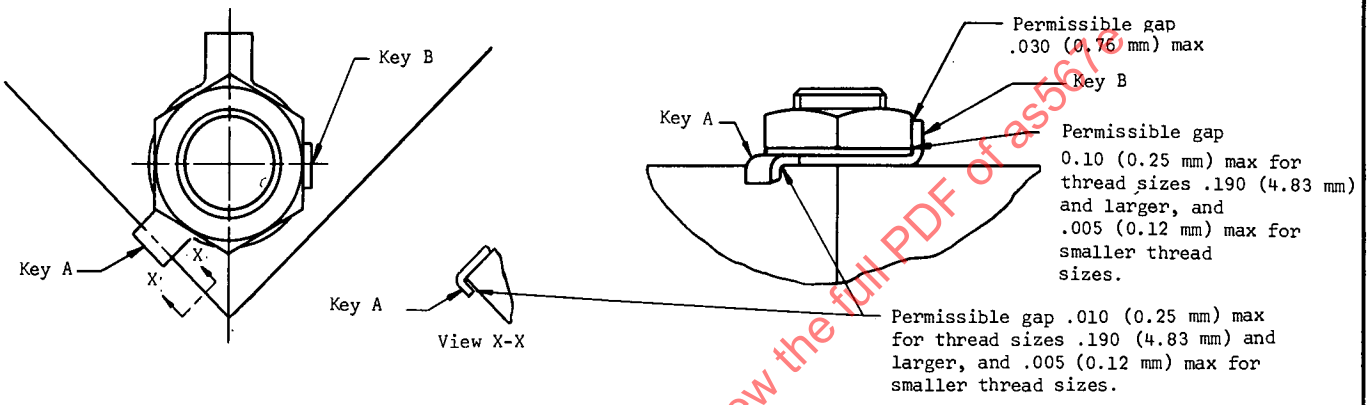
II-1. LOCKING WITH KEY WASHERS:

II-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.

II-1.2 Key washers with bendable keys are not reusable and must be replaced with a new key washer after removal.

II-2. LOCKING HEX NUTS WITH KEY WASHERS:

II-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 Figure II-1.




ϕ FIGURE II-1

II-2.1.1 Key B shall be bent up across the bottom of only one face of the hex until flat against the face. Figure II-2 shows acceptable and unacceptable bends.

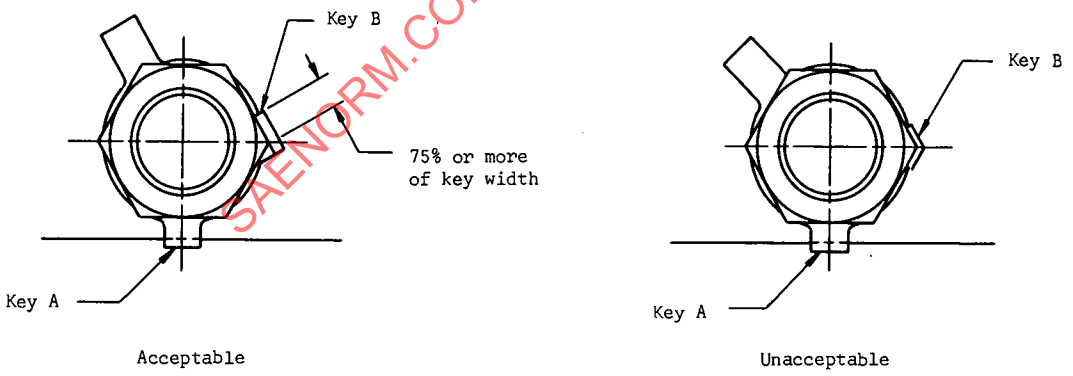



FIGURE II-2

II-2.1.2 The key shall be bent up against the hex face with which its junction line is 75% or more of the key width.

II-2.1.3 In cases of two or more keys, the key most favorably aligned shall be bent as described. It is not mandatory to bend up other keys which may also be aligned.

ϕ II-2.1.4 The gap between the hex flat and the bent up key shall not exceed the values given in Figure II-1. Any excess key protruding above the nut shall be bent over the nut to avoid becoming a snag.

II-3. DRILLED HOLES FOR WASHER KEYS:

II-3.1 If there is no stationary part against which to retain the key as illustrated in Figure II-1, a hole may be drilled to fulfill this function as shown in Figure II-3.

II-3.1.1 Key should not be allowed to move within the hole but should be braced against the side to prevent objectionable movement.

II-3.1.2 See MS9276, MS9581, MS9582 for key washers of the type shown in Figure II-3.

FIGURE II-3

II-4. USE OF MULTIPLE HOLE KEY WASHERS:

II-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 paragraph II-2.1 does not apply (see Figure II-4). 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.

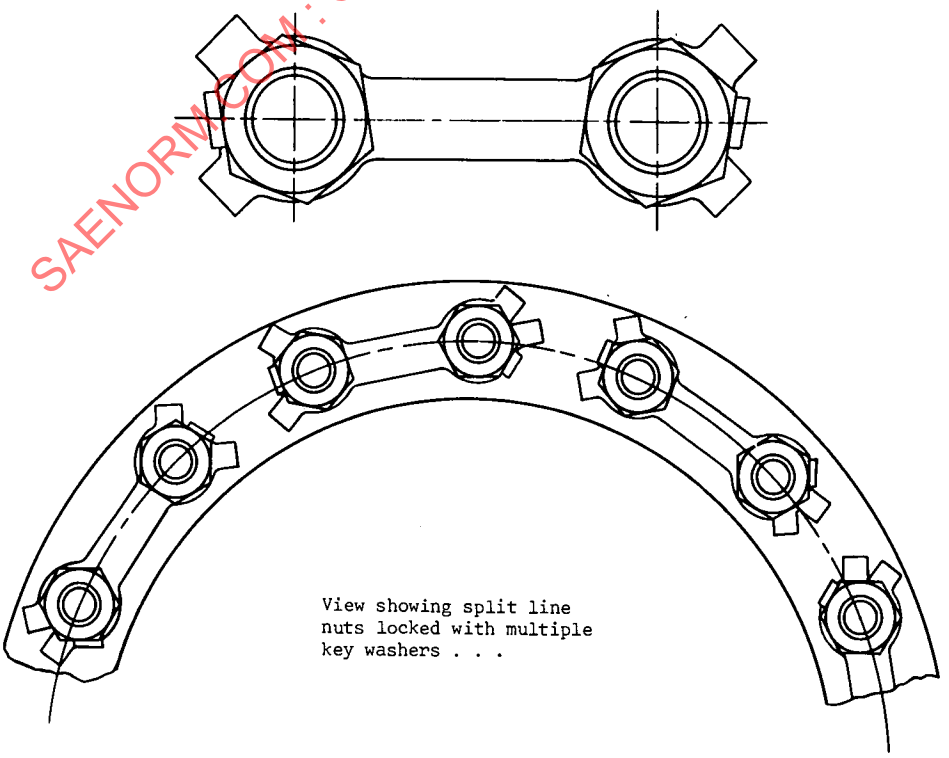
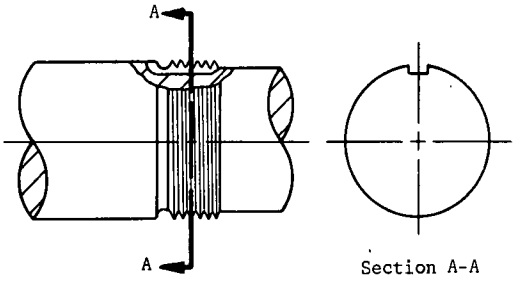


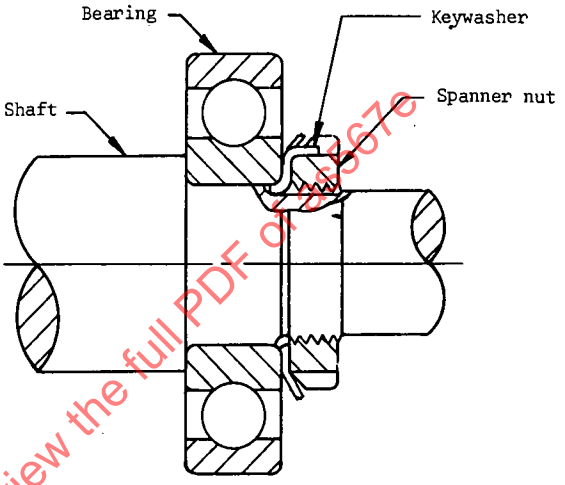

FIGURE II-4

II-5. LOCKING SPANNER NUTS WITH KEY WASHERS:

II-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 be bent to secure the nut. It is not necessary to bend the tabs into additional slots which may also be favorably aligned. Figures II-5 and II-6 show typical bearing retention applications. Note that the washer may engage shaft with a single key as in Figure II-5, or with a double key as in Figure II-6. The double key configuration provides better resistance to shear loads thru the key.

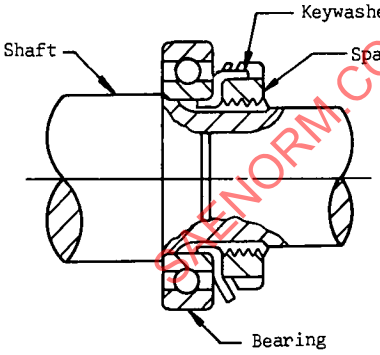



Sections of shaft thru single keyway

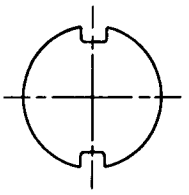



Typical bearing retention application. Shaft engaged by single key.

FIGURE II-5




Typical bearing retention application. Shaft engaged by double key.



Section of shaft thru double keyway

FIGURE II-6

Φ II-5.1.1 Table II-1 references recommended MS standard key washers and spanner nuts. See AS 462 and AS 919 for dimensions of shaft features.

TABLE II-1

| Recommended MS key washers and spanner nuts | | |
|---|---|---|
| Application | Key washer | Nut |
| Single keyway shaft | | |
| Millimetre series bearings | MS172201 thru MS172235 | MS172236 thru MS172270 |
| Inch series bearings | MS172271 thru MS172320 | MS172321 thru MS172370 |
| Double keyway shaft | | |
| Millimetre bearings | MS9081, MS9274 | MS172236 thru MS172270 |

II-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 Figure II-7) thereby creating a locked condition.

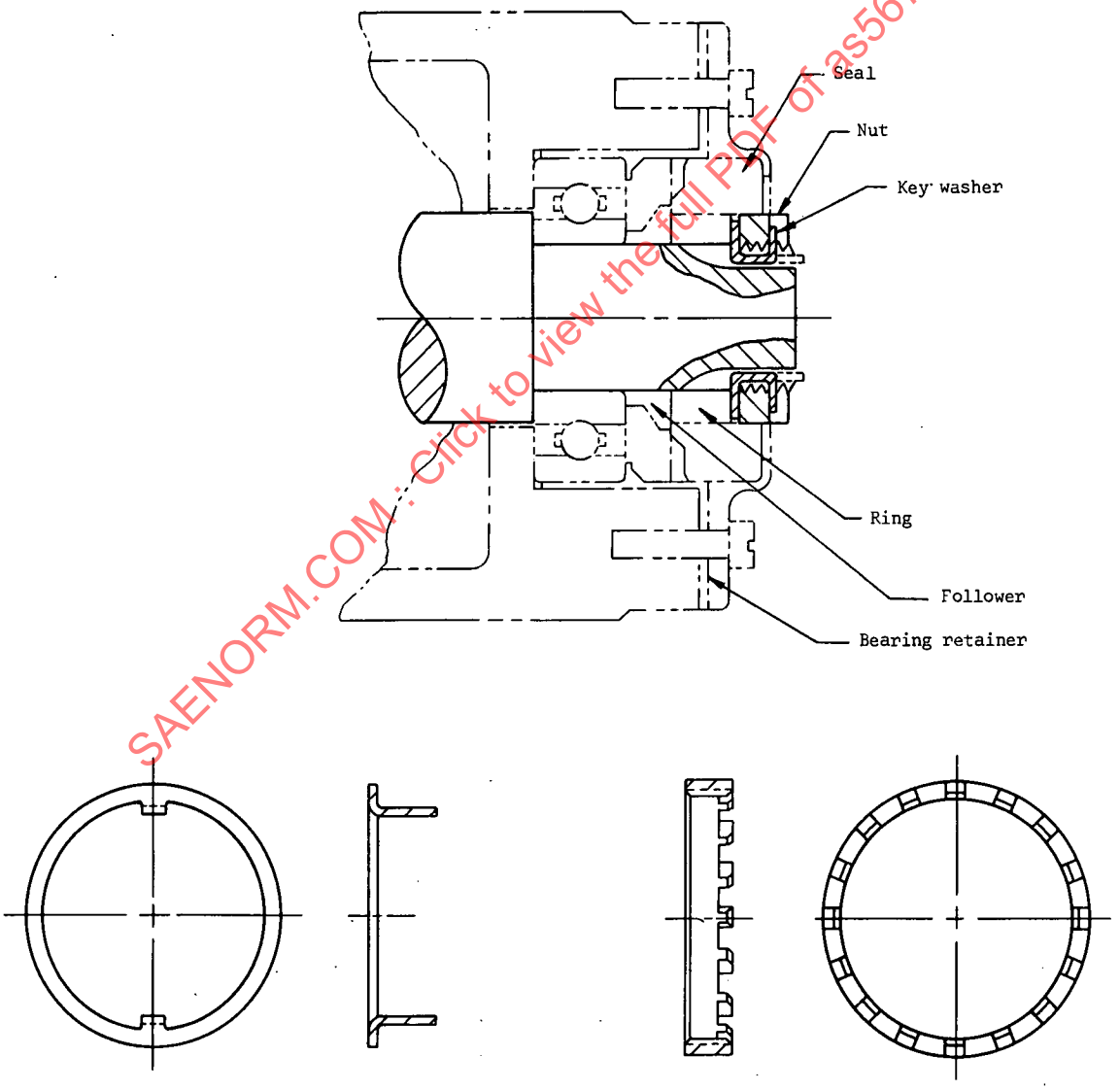





FIGURE II-7

II-6 ELLIPTICAL KEY WASHERS:

II-6.1 The installation of 180° ellipses shall be accomplished by bending up across one whole face of the hex as shown in Figure II-8.

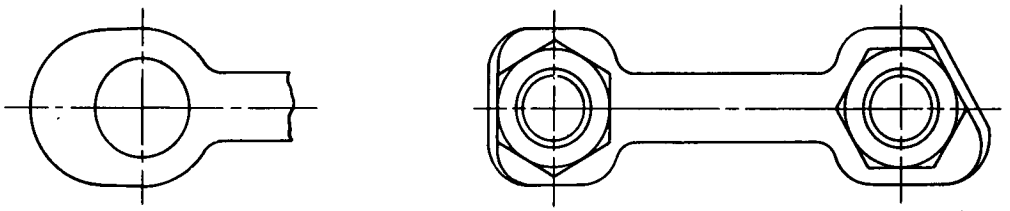


FIGURE II-8

II-7 CUP-TYPE KEYWASHER:

II-7.1 Lock fastener by dimpling the washer as shown in Figure II-9. Two dimples, placed 180 degrees 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.

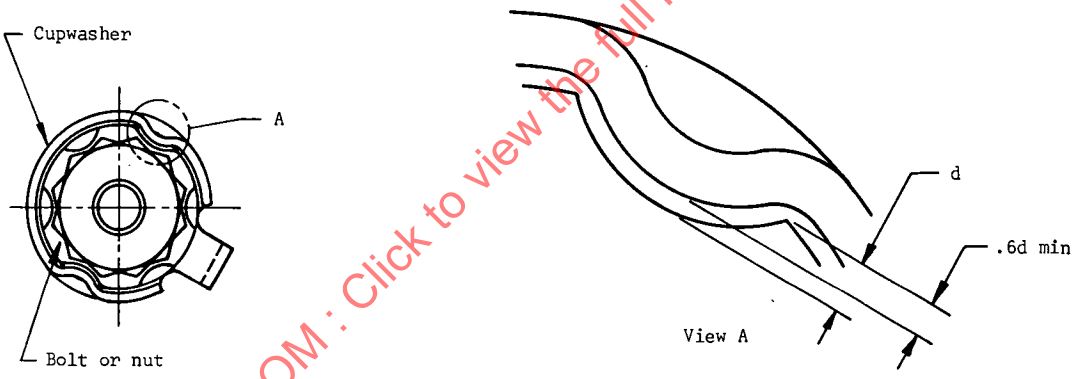



FIGURE II-9

II.7.1.1 Table II-2 gives dimple engagements for MS standard cupwashers and fasteners.

TABLE II-2

| Recommended dimple engagement for MS standard cupwashers and fasteners | | | | | | |
|---|---|---|---|---|---|---|
| Nom Size | | Bolt | Nut | Cupwasher | Dimple engagement (.6d min)* | |
| IN | mm | | | | IN | mm |
| .190 | 4.83 | MS9676 MS9680 | MS9766-09 | MS9684-09 | .026 | 0.67 |
| .250 | 6.35 | MS9677 MS9681 | MS9766-10 | MS9684-10 | .025 | 0.64 |
| .3125 | 7.94 | MS9678 MS9682 | MS9766-11 | MS9684-11 | .024 | 0.61 |
| .375 | 9.52 | MS9679 MS9683 | MS9766-12 | MS9684-12 | .023 | 0.59 |
| *See Figure II-9 | | | | | | |

II-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 pre-dimpled 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.

SECTION III COTTER PINS

III-1. LOCKING WITH COTTER PINS:

ϕ III-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.

III-1.2 Cotter pins are not reusable and must be replaced with a new cotter pin after removal.

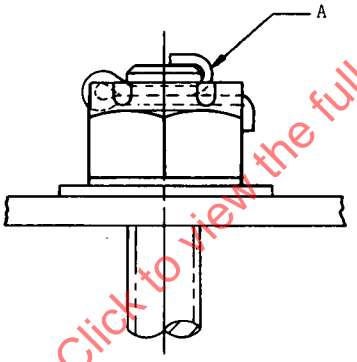
III-1.3 Cotter pin material shall be a corrosion resistant steel, such as AMS 7210, for use up to 700°F (371°C); and a corrosion and heat-resistant material, such as AMS 7211, for use up to 1200°F (649°C). See AS123751 thru AS123850 and MS9245, respectively; these cotter pins range in size from .031 (0.79 mm) to .188 (4.78 mm) diameter.

III-2 LOCKING NUTS WITH COTTER PINS:

III-2.1 The preferred method of cotter pin installation is illustrated in Figure III-1. General rules for the installation of cotter pins are as follows:

III-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 Figure III-4). Maximum applicable torque should not be exceeded.

III-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 Figure III-1. Bend prongs so that the head and upper prong are firmly seated against the bolt. Upper prong may be cut off at "A", if necessary, to provide clearance.

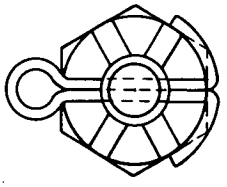



Preferred installation

FIGURE III-1

III-2.1.3 The alternative method of installation to be used in overcoming a clearance problem is shown in Figure III-2. This will require longer pins than those outlined in Table III-1.





Alternative installation

FIGURE III-2