AEROSPACE STANDARD

AS567	REV. K

Issued 1959-02
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Revised 2015-04

Superseding AS467J

(R) Safety Cable, Safety Wire, Key Washers, and Cotter Pins for Propulsion Systems, General Practices for Use of

RATIONALE

Add installation requirements and practices for safety cable (removed from AS453), update references and general editorial update.

1. SCOPE

This SAE Aerospace Standard (AS) covers devices whose primary function is the retention of fasteners, except for such devices that are integral with the item being retained.

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

a. Section 3: Safety Cable and Safety Wire

b. Section 4: Key Washers

c. Section 5: Cotter Pins

1.2 Purpose

The purpose of this document is to establish the requirements and basic principles for retaining fasteners and other parts in aerospace propulsion systems.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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http://www.sae.org/technical/standards/AS567K

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS5687	Nickel Alloy, Corrosion and Heat-Resistant, Wire, 74Ni - 15.5Cr - 8.0Fe, Annealed
AMS5689	Steel, Corrosion and Heat Resistant, Wire, 18Cr - 10.5Ni - 0.40Ti (SAE 30321), Solution Heat Treated
AS462	Shafts for Ball Bearing Retaining Spanner Nuts and Key Washers
AS919	Shallow Groove Shafts and Locking Devices for Bearing Retaining Spanner Nuts
AS3618	Cable, Safety, Ferrule, Elongated, Corrosion Resistant Steel, UNS S32100
AS3619	Cable, Safety, Ferrule, Elongated, Nickel Alloy, UNS N06600
AS4536	Safety Cable Kit Procurement Specification and Requirement for Use
AS7210	Pins, Cotter, Steel, Corrosion Resistant, UNS S30200, Procurement Specification for
AS7211	Pins, Cotter, Steel, Corrosion and Heat Resistant UNS S32100 Procurement Specification for
AS9245	Pin, Cotter - CRES, AMS2711
AS9276	Washer, Key - 180°, Locking, Cres, UNS S32100
AS9581	Washer, Key-CRES, AMS 5510, 90°, Locking
AS9582	Washer, Key - 270°, Locking, Cres, Uns S32100
AS9676	Bolt, Machine - Double Hexagon Extended Washer Head, PD Shank, Cup Washer Locked, Cres, UNS S66286, 130 ksi min, .1900-32 UNJF-3A
AS9677	Bolt, Machine - Double Hexagon Extended Washer Head, PD Shank, Cup Washer Locked, Cres, UNS S66286, 130 ksi min, .2500-28 UNJF-3A
AS9678	Bolt, Machine - Double Hexagon Extended Washer Head, PD Shank, Cup Washer Locked, Cres, UNS S66286, 130 ksi min, .3125-24 UNJF-3A
AS9679	Bolt, Machine - Double Hexagon Extended Washer Head, PD Shank, Cup Washer Locked, Cres, UNS S66286, 130 ksi min, .3750-24 UNJF-3A
AS123751-AS123850	Pin, Cotter - CRES, UNS S30200, AS7210
AS172201-AS172235	Washer, Key-Single, Bearing Retaining, AMS8350
AS172236-AS172270	Nut, Spanner, Bearing Retaining, Aeronautical, UNS G41400
AS172271-AS172320	Washer, Key-Single, AMS6350
AS172321-AS172370	Nut, Spanner, Aeronautical, UNS G41400

2.1.2 U.S. Government Publications

Copies of these documents are available online at http://quicksearch.dla.mil.

MS9081 Washer, Key-Double, Bearing Retaining, AMS6350

MS9274 Washer, Key-Double, Bearing Retaining, AMS5510

MS9684 Washer, Cup, Lock - CRES AMS 5510

MS9766 Nut, Double Hexagon, Cupwasher Locked, AMS5737, CRES

2.2 Definitions

2.2.1 SAFETY WIRE

Safety wiring is the securing together of two or more parts with a wire. The wire shall be installed so that any tendency for a part to loosen will cause an additional tightening of the safety wire. Safety wire is not a means of obtaining or maintaining torque, but a safety device used to prevent disengagement of the part. See Figure 1 for standard configurations and terms.

2.2.2 SAFETY CABLE

Safety cabling is the securing together of two or more parts with a cable and crimped ferrule which shall be installed so that any tendency for a part to loosen will cause an additional tightening of the safety cable. Safety cable is not a means of maintaining torque but a safety device used to prevent disengagement of the part. See AS4536 for definitions and terms for safety cable.

2.2.3 ABRASION

Material worn, ground, or rubbed away from surface by frictional means. There is no sharp notch present; however, surface finish may be smooth or rough, raised material may or may not be visible.

2.2.4 KINK

Permanent deformation in the wire having a sharp radius less than or equal to the wire diameter and locally forming an angle less than 160 degrees. See Figure 2.

2.2.5 NICK

A surface impression that is greater than 0.003 inch in depth having a sharp notch at bottom.

2.2.6 PART

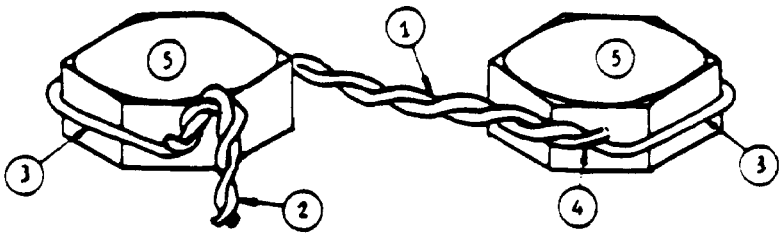
Parts or units that are bound by the safety cable or wire.

2.2.7 SCRATCH

A surface impression that is less than 0.003 inch in depth.

2.2.8 PIGTAIL

Termination point of safety wire. See Figure 3.



1 Double Twist Method - Common method where two strands of one continuous wire are twisted together over the installed length.

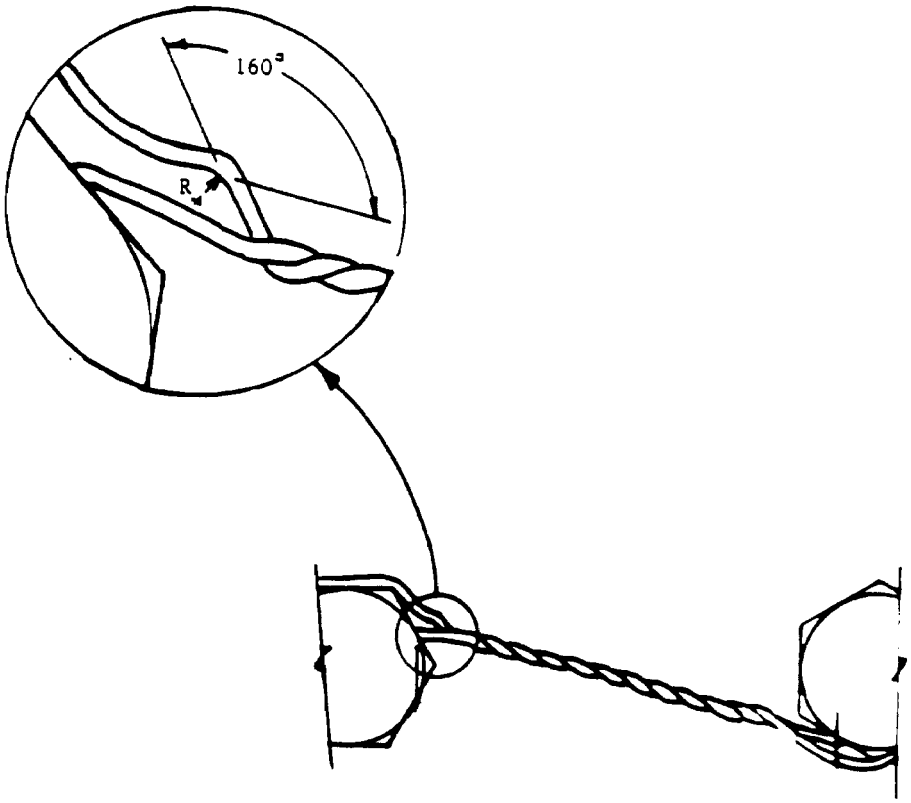
2 Pigtail - Termination point of safety wire.

3 Lower Loop or Strand - Portion of safety wire that extends around outside of fastener.

4 Uppermost Loop or Strand - Portion of safety wire that extends through the hole(s) in the fastener.

5 Fastener - There are multiple combinations of fasteners; shown is a hex head bolt with right hand threads (tightens clockwise). Safety wire is installed to apply tension in the wire should the fastener(s) loosen.

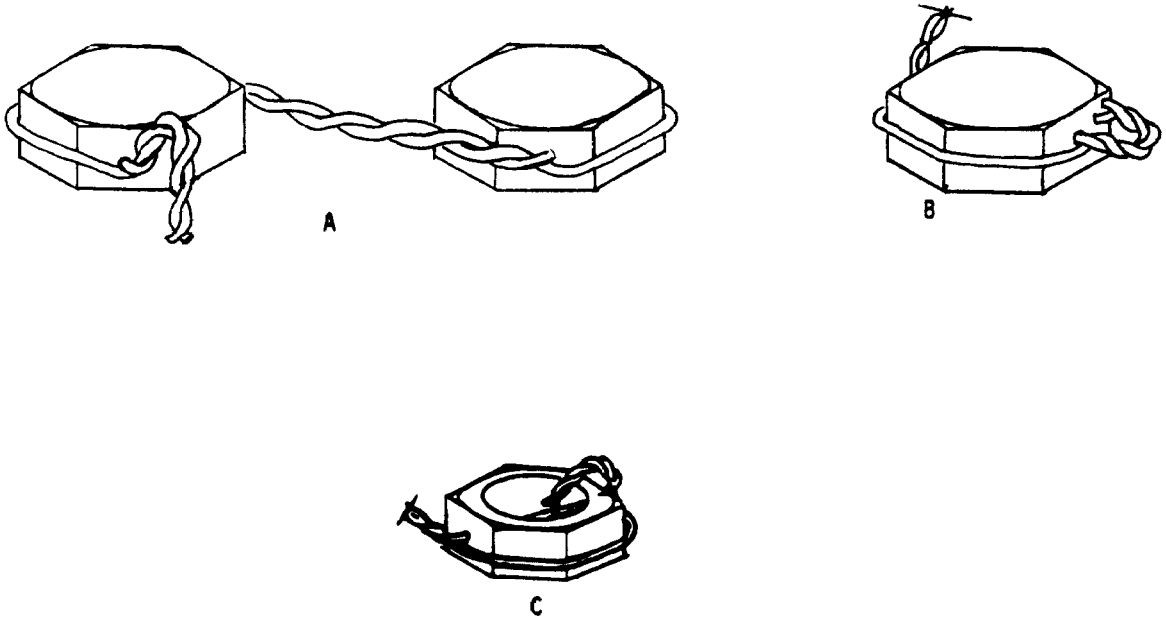
Figure 1 - Basic safety wire configuration



1 Radius at deformation "R" to be equal-to or less-than wire radius.

2 Angle at deformation to be less-than 60°.

Figure 2 - Kink



1 Cut ends of pigtail shall be positioned toward any adjacent surface as Views A or B.

2 Pigtail may be horizontal, vertical, in any plane or combination within area(s) shown. Views A through C.

3 Cut end of pigtail may be turned in toward middle on hollow center fasteners, preferably below the top surface. View C.

Figure 3 - Pigtail termination and orientation

3. SAFETY WIRE AND SAFETY CABLE

3.1 Basic Requirements for Installation of Safety Wire (for Safety Cable see 3.4)

3.1.1 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. Wire size shall be specified on the assembly drawing or parts list by part number.

Table 1 - Safety wire hole data

Wire Diameter in	Wire Diameter mm	Preferred Twists per inch (25.4 mm)	Preferred Hole Diameter in /1/ /2/	Preferred Hole Diameter in /1/ /2/	Preferred Chamfer Diameter (90° ± 5° incl.) in /3/	Preferred Chamfer Diameter (90° ± 5° incl.) mm /3/
0.015 - 0.017	0.381 - 0.431	10 - 15	0.037 - 0.057	0.94 - 1.44	0.070 - 0.090	1.78 - 2.28
0.019 - 0.021	0.483 - 0.533	8 - 14	0.037 - 0.057	0.94 - 1.44	0.070 - 0.090	1.78 - 2.28
0.024 - 0.026	0.610 - 0.660	8 - 14	0.060 - 0.080	1.53 - 2.03	0.090 - 0.110	2.29 - 2.79
0.030 - 0.034	0.770 - 0.860	6 - 11	0.060 - 0.080	1.53 - 2.03	0.090 - 0.110	2.29 - 2.79
0.038 - 0.042	0.970 - 1.070	6 - 11	0.060 - 0.080	1.53 - 2.03	0.090 - 0.110	2.29 - 2.79
0.049 - 0.053	1.250 - 1.340	4 - 9	0.060 - 0.080	1.53 - 2.03	0.090 - 0.110	2.29 - 2.79
0.061 - 0.065	1.550 - 1.650	4 - 9	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 - 8	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 hole diameter for the item shall be based on cotter pin requirements.
/2/ Where parts cannot accommodate the recommended hole size, it is permissible to use a smaller hole provided a minimum diameter clearance of 0.003 inch (0.08 mm) is maintained between the wire and the hole (except on the two largest wire sizes).
/3/ 0.005 inch (0.13 mm) maximum edge break on chamfer.

3.1.2 The safety wire material for use up to 1200 °F (649 °C) shall be corrosion resistant steel such as AMS5689, and for use up to 1800 °F (982 °C), a corrosion and heat resistant alloy such as AMS5687 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.

3.1.3 The common method of installing safety wire shall consist of two strands of wire twisted together (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 safety wiring may be used, when specified on the drawing, 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.

3.1.4 The maximum span of safety wire (between tension points) shall be 6 inches (152 mm). The wire shall be taut within the requirements of 3.3.1.5.

3.1.5 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 inch (609 mm) length of wire.

3.1.6 Caution must be exercised during the twisting operation to keep the wire taut. Gripping surfaces of pliers shall have edges sufficiently rounded to preclude nicks. Abrasions and scratches are allowed; however, nicks are not allowed.

3.1.7 Exercise caution when installing safety wire on parts subject to relative movement such that the wire itself is not chafed, fatigued through vibration, installed over radii less than 0.005 inch (0.13 mm) or given additional tension other than tension imposed on the wire to prevent loosening.

3.1.8 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 20 and 24).

3.1.9 Safety wire shall not be reused.

3.1.10 Examples of safety wiring are shown in Figures 5 through 32. Although not every possible combination is shown, any combination used must adhere to the basic rules outlined in this specification. Figure 16 shows the single strand method, while the other figures show the double twist method. Figures are for reference only.

3.1.11 When drawing specifies a safety wiring seal, it may be applied to the load bearing or pigtail portion of the wire and crimped to the safety wire as shown in Figures 17, 18, or 19. Figures 18 and 19 show the seal application at the end of a series, where the safety wire beyond seal is twisted and secured to safety wire between units and to an unused safety wire hole in the last unit. 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 18 except that twisted wire beyond seal is secured to single strand wire between units. Safety wire must go through and be twisted on both sides of a seal, the twisted wire direction shall be the same on both sides, so the seal cannot be turned in a manner to loosen the wire. The safety wire after the seal shall comply with the requirements of a pigtail.

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

3.2 Installation of Safety Wire (see 3.4 for Safety Cable)

3.2.1 Installation

3.2.1.1 Prior to installation assure the units to be safety wired have been tightened to the correct torque. Undertorquing or overtorquing 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, select another unit, or try another wire method.

3.2.1.2 For installation where the loop is not captured from movement and movement of the loop itself could cause the wire to loosen, the portion of the wire that exits the hole in the unit shall be twisted over the top of the wire that extends around the unit (see Figure 4).

3.2.1.3 In adjacent units, it is desirable that the holes be in approximately the same relationship to each other as shown in Figures 5 through 8 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 should the unit loosen. This should be reversed for left-hand threads.

3.2.1.4 For double twist method, twist the strands while taut (see Table 1) until one of the strands is just short of a hole.

3.2.1.5 Insert the uppermost strand through the hole in the second unit and follow the rules in 3.2.1.3 (see center unit Figure 5). If there are more than two units in the series, repeat the above procedure. See also 3.2.1.7. Pigtail shall be regarded as a continuation of the safety wire and is subject to all requirements defined herein.

3.2.1.6 After wiring the last unit, continue twisting the wire to form a pigtail. Bend in toward any adjacent surface or place inside part to assure that the cut edges will not cause personal injury. Cut off the excess wire taking care to dispose of the excess wire so that it does not become a hazard (see Figure 3).

3.2.1.7 As an alternative to wrapping wire around the unit, wire may be crossed through the unit as in Figures 9 through 12. Wire passing over the top of a bolt, as in Figures 7 and 18, is an acceptable alternative to the illustrated routing around the part.

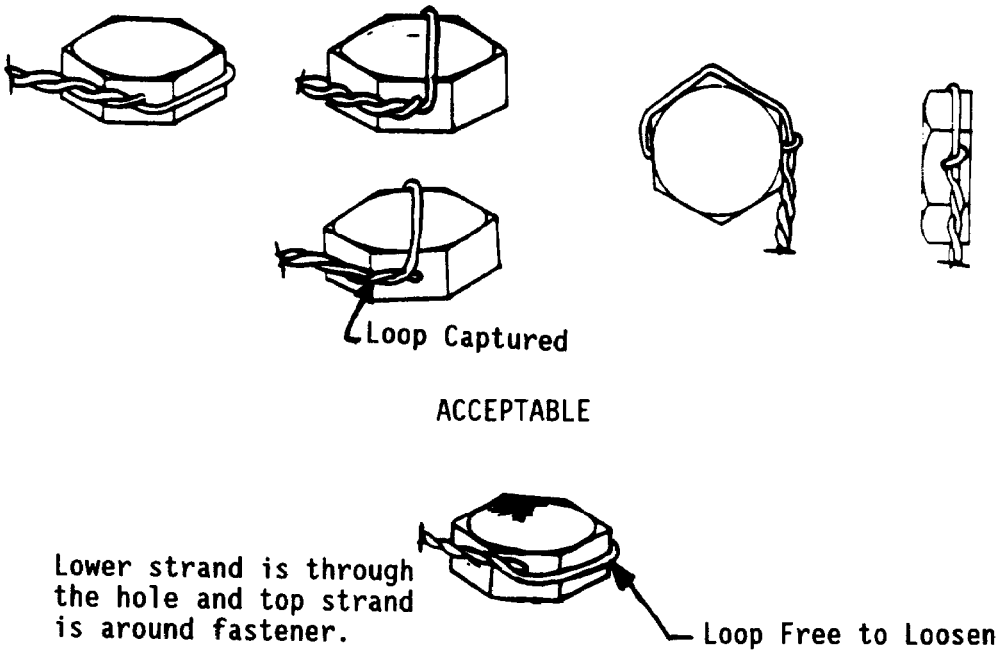


Figure 4 - Upper and lower strand orientation

FIGURE 5

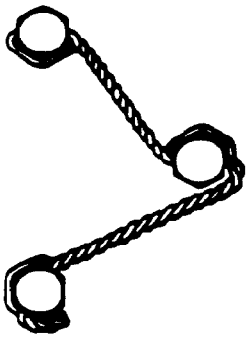


FIGURE 6

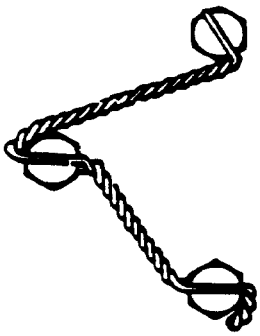


FIGURE 7

FIGURE 8

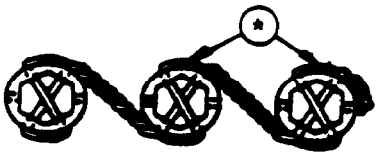


FIGURE 9

FIGURE 10

FIGURE 11

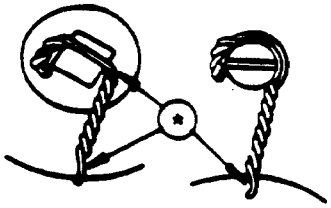


FIGURE 12

FIGURE 13

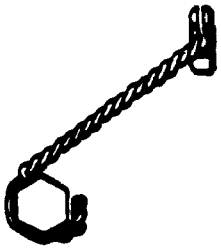


FIGURE 14 - Correct method for wiring bolts in different planes. Note that wire should always be applied so that tension is in the tightening direction.

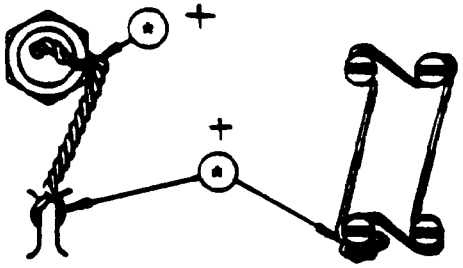


FIGURE 15 - When practicable, hollow head plugs shall be wired as shown with the pigtail bent inside the hole to avoid snags and possible injury to personnel.

FIGURE 16

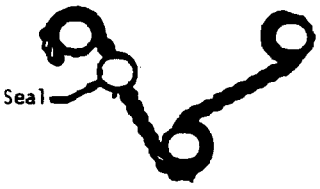


FIGURE 17

FIGURE 18

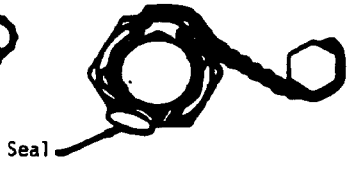


FIGURE 19

METHODS FOR ATTACHING SEAL TO PROTECT CRITICAL ADJUSTMENT

+ (*) See 3.3.1.3 and 3.3.1.5. Portions of these paragraphs do not apply with regard to upper and lowr strand orientation.

FIGURE 20 - Bolt wire to a right angle bracket with the wire wrapped around the bracket.

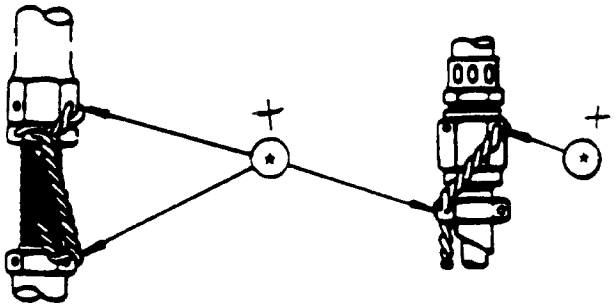


FIGURE 21 - Correct method for wiring adjustable connecting rod.

FIGURE 22 - Correct method for wiring the coupling nut on flexible line to the straight connector brazed on rigid tube.

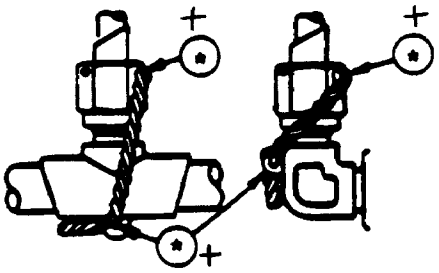


FIGURE 23 - Fittings incorporating wire lugs shall be wired as shown.

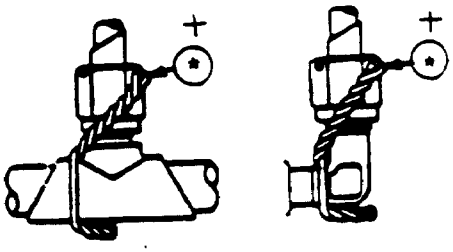


FIGURE 24 - When no safety wire lug is provided, wire should be applied as shown with caution being exercised to insure that wire is wrapped tightly around the fitting.

See 3.3.1.3 and 3.3.1.5. Portions of these paragraphs do not apply with regard to upper and lower strand orientation.

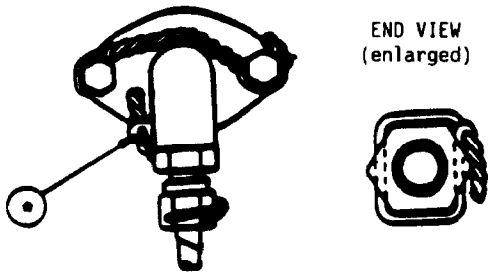


FIGURE 25 - Small coupling nuts or those made of soft material may be wired as shown to lessen possibility of wire breaking or tearing out.

3.2.1.8 The seal shall be installed around the wire per 3.1.11 and not positioned within one twist of the retaining part. Drawing shall specify seal requirement.

3.3 Details for Inspection for Safety Wire

3.3.1 Points of Inspection

3.3.1.1 All external safety wire shall be inspected visually for drawing conformity prior to shipment. Specific areas of inspection are as follows:

a. Broken wire

b. Direction of strand

c. Total flex

d. Pigtail length

e. Pigtail position

f. Loose part(s) on or within safety wire

3.3.1.2 Strands of twisted or single wire between parts shall not be broken or violate the kink and nick criteria of 2.2.4, 2.2.5, and Figure 2.

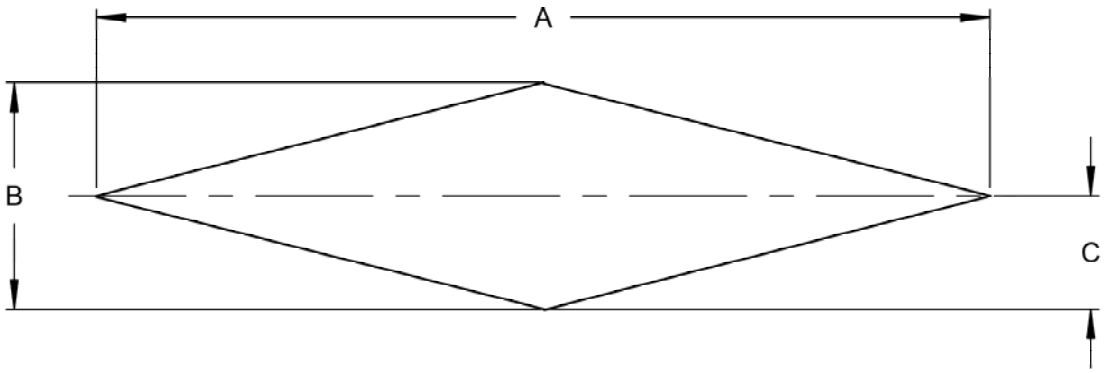
3.3.1.3 Twist per inch shall conform to the requirements of Table 1. Untwisted voids or inconsistent twists within the wire are acceptable provided they do not violate tabulated criteria.

3.3.1.4 For right-hand threads, clockwise twist must retain part by rotating retained part clockwise. For left-hand threads, counterclockwise twist must retain part by rotating retained part counterclockwise.

3.3.1.5 Total flex for twisted wire may not exceed the limits of Table 2 when light finger pressure (approximately 2 lbf) is applied at mid-span.

Table 2 - Safety wire flex limits

A Minimum Assembly Length in (mm)	B Maximum Flex at Center in (mm)	C Maximum Half Flex at Center in (mm)
0.5 (12.70)	0.125 (3.16)	0.063 (1.60)
1.0 (25.40)	0.250 (6.32)	0.125 (3.16)
2.0 (50.80)	0.375 (9.53)	0.188 (4.78)
3.0 (72.20)	0.500 (12.70)	0.250 (6.35)
4.0 (101.60)	0.500 (12.70)	0.250 (6.35)
5.0 (127.00)	0.625 (15.86)	0.313 (7.95)
6.0 (152.40)	0.625 (15.86)	0.313 (7.95)



3.3.1.6 Pigtail length shall be equal to or less than 0.75 inch and a minimum of four turns. Twist requirement of Table 1 apply to pigtail. It shall be turned toward or placed inside the part. Likewise, pigtails with seals shall be wrapped or twisted around load bearing safety wire or fastened to a nearby part within constraints of 3.2.1.8. Open pigtails are allowed provided their termination is positioned so as not to cause injury or interfere with the operation of the part (reference Figure 3).

3.3.1.7 Relative movement of seals on the wire greater than 0.125 inch is cause for rejection. Loose parts within the wire are also causes for rejection.

3.4 Basic Requirements for Safety Cable

3.4.1 Safety cable may be used as an alternate to safety wire only when permitted by the design activity, original equipment manufacturer (OEM), applicable drawing, maintenance or assembly documentation or other controlling process documentation.

3.4.1.1 Safety cable and ferrules shall meet the requirements of AS4536. Mixing of materials between ferrules and cable is prohibited. The material shall be the same for ferrule and cable for all installations of safety cable.

3.4.1.2 The diameter of safety cable shall be selected on the basis of safety cable hole diameter per Table 3.

3.4.2 Maximum Span

The maximum span of 0.022, 0.032, and 0.040 diameter safety cable between two termination points shall be 6 inches (152.40 mm) unless otherwise specified. The maximum span of 0.062 diameter safety cable between two points is 12 inches (304.80 mm) unless otherwise specified.

3.4.3 Installation Defects

Any cable defect (nick, fray, kink, or any other mutilation of the safety cable) found prior to, during, or subsequent to installation, at or between termination points, is not acceptable.

3.4.4 Installation Holes

Safety cable shall be installed through the holes intended for this purpose. Recommended hole sizes are shown in Table 3.

Table 3 - Safety cable installation hole diameter

Safety Cable Diameter (in)	Safety Cable Diameter (mm)	Recommended Hole Diameter (in) /1/ /2/ /3/	Recommended Hole Diameter (mm) /1/ /2/ /3/
0.022 - 0.026	0.56 - 0.66	0.037 - 0.060	0.94 - 1.53
0.032 - 0.038	0.81 - 0.97	0.060 - 0.080	1.53 - 2.03
0.040 - 0.046	1.02 - 1.17	0.070 - 0.090	1.70 - 2.28
0.062 - 0.072	1.57 - 1.83	0.080 - 0.120	2.03 - 3.04

/1/ Where safety cable is used to secure a castellated nut on a threaded item; section of safety cable diameter for the item shall be based on cotter pin size requirements.
/2/ Where parts cannot accommodate the recommended hole size, it is permissible to use a smaller hole provided the minimum diametrical clearance of 0.003 inch (0.076 mm) is maintained between the safety cable and the hole.
/3/ Fasteners with chamfer or smooth transition on edge of safety wire hole is required for installation of safety cable.

3.4.5 Safety Cable and Ferrule Reuse

Safety cable and ferrules shall be new upon each installation. Reuse of safety cable or ferrules is not acceptable.

3.4.6 Hose and Electrical Requirements

Hose and electrical coupling nuts shall have safety cable installed in the same manner as tube coupling nuts (see Figure 34).

3.4.7 Crimp Requirements (Pull-Off Load)

The safety cable assembly must be capable of meeting the minimum pull-off load requirements in Table 4 when installed with the manufacturer's recommended installation tool (see 3.4.9).

Table 4 - Safety cable minimum crimp requirements (pull-off load)

Nominal Cable Diameter in (mm)	Safety Cable Construction	Minimum Pull-Off Load lbf (N)
0.022 (0.51)	1 X 7	30 (133.4)
0.032 (0.81)	3 X 7	70 (311.4)
0.040 (1.02)	7 X 7	110 (489.3)
0.062 (1.57)	7 X 19	280 (1245.5)

3.4.8 Calibrated Installation Tool Required

Safety cable shall be installed with a calibrated tool designed specifically for that purpose, and supplied or recommended by a manufacturer that supplies safety cable which meets all the requirements of AS4536. The tool shall have a repeatable mechanism which applies a predetermined tension to the cable, crimps the ferrule, and cuts the excess cable without allowing tension to be lost or exceeding the excess cable requirements of 3.4.15.

3.4.9 Installation

Examples of safety cable installation are shown in Figures 33, 34, and 35. All possible combinations are not shown. Unless otherwise specified in the application engineering drawing, safety cable shall be installed in two or three bolt patterns, with two bolt patterns being the preferred method when safety cable is applied to an even number of fasteners. Although every possible combination is not shown, any combination must adhere to the basic rules outlined in this specification.

3.4.10 Hole Alignment

Under-torquing or over-torquing to obtain proper alignment of the holes is not permitted.

3.4.11 Adjacent Units

Safety-cable is to be installed in such a manner that any tendency for a fastener to loosen will be counteracted by an additional tension on the cable. The recommended practice for installation is to avoid sharp turns (in excess of 135 degrees), as the cable is threaded through the fasteners. This will produce installed safety cable with either positive or neutral pull.

3.4.12 Excess Cable

After installing the safety cable, excess cable from the crimped ferrule shall be cut off. The maximum allowable length of cable extending beyond the ferrule shall be 0.031 inch (0.79 mm).

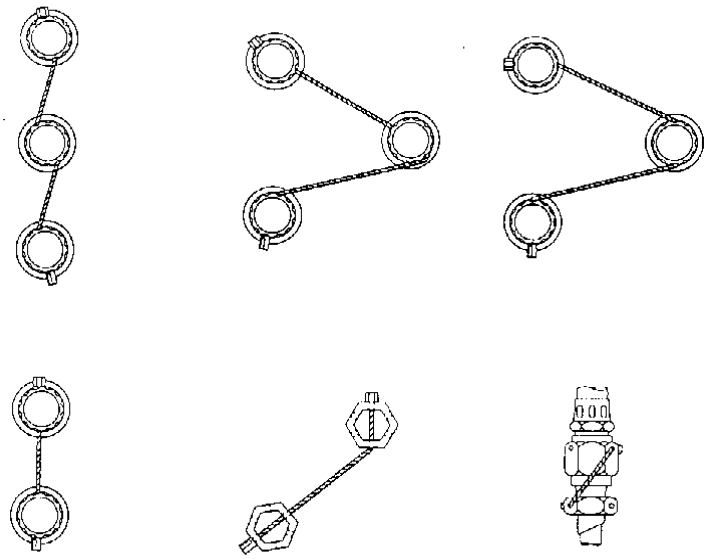


Figure 33 - Safety-cable, typical installation (standard hardware)

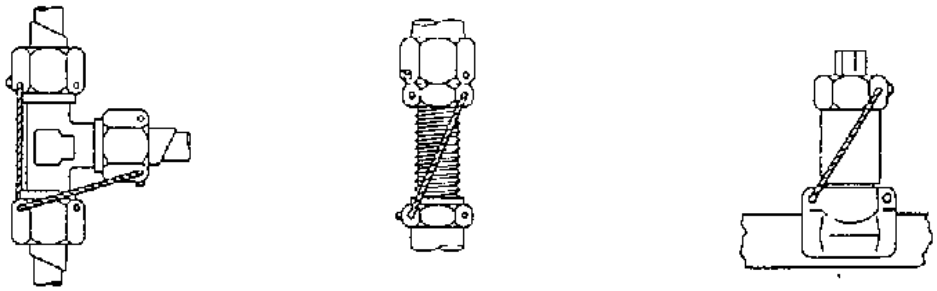


Figure 34 - Safety-cable, typical installation (tube couplings)

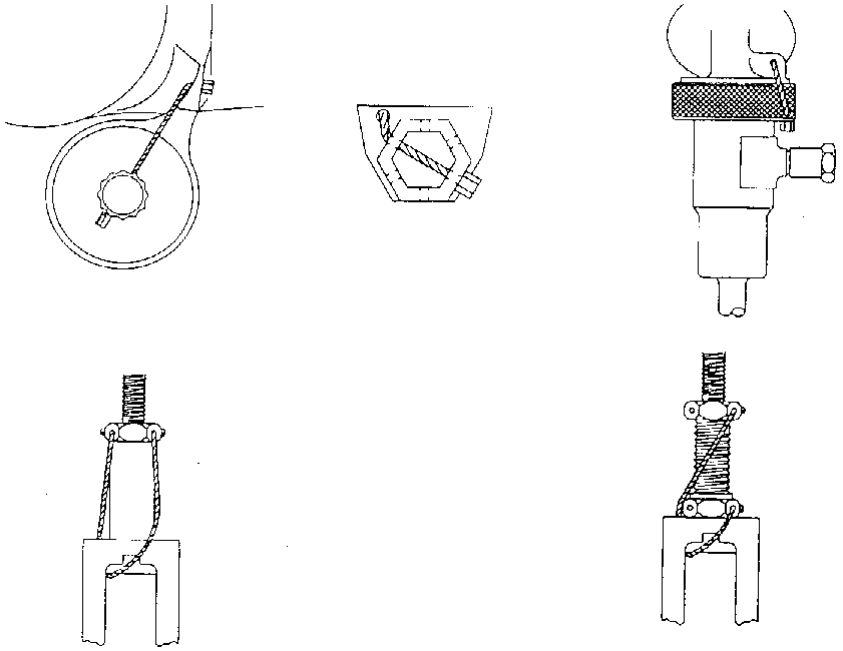


Figure 35 - Safety-cable, typical installation (other applications)

3.4.13 Total Flex

After installing the maximum cable flex limits between termination points shall be inspected, and installed safety cable shall not exceed the limits of Tables 5 and 6, and Figure 37 when light finger pressure (approximately 2 lbf) is applied at mid-span.

Table 5 - Flex limits for 0.022, 0.032, and 0.040 diameter safety cable

A in (mm)	B in (mm)	C in (mm)
0.5 (12.7)	0.125 (3.2)	0.062 (1.6)
1.0 (25.4)	0.250 (6.4)	0.125 (3.2)
2.0 (50.8)	0.375 (9.5)	0.188 (4.8)
3.0 (76.2)	0.375 (9.5)	0.188 (4.8)
4.0 (101.6)	0.500 (12.7)	0.250 (6.4)
5.0 (127.0)	0.500 (12.7)	0.250 (6.4)
6.0 (152.4)	0.625 (15.9)	0.312 (7.9)

Table 6 - Flex limits for 0.062 diameter safety cable

A in (mm)	B in (mm)	C in (mm)
7.0 (177.8)	0.700 (17.8)	0.350 (8.9)
8.0 (203.2)	0.750 (19.1)	0.375 (9.5)
9.0 (228.6)	0.800 (20.3)	0.400 (10.2)
10.0 (254.0)	0.850 (21.6)	0.425 (10.8)
11.0 (279.4)	0.900 (22.9)	0.450 (11.4)
12.0 (304.8)	0.950 (24.1)	0.475 (12.1)

3.4.14 Low Profile Installations

Where safety cable holes are located close to a surface, or where an obstruction is blocking the access of the safety cable installation tool, an elongated ferrule conforming to AS3618 or AS3619 is permitted. It shall be installed in accordance with Figure 36.

3.4.15 Adjacent Surfaces and Components

Avoid routing safety cable where the mid-span area of the cable contacts metal surfaces, electrical wiring, sealing components, or other surfaces. Where these installations cannot be avoided, use of a protective material over the safety cable is recommended.

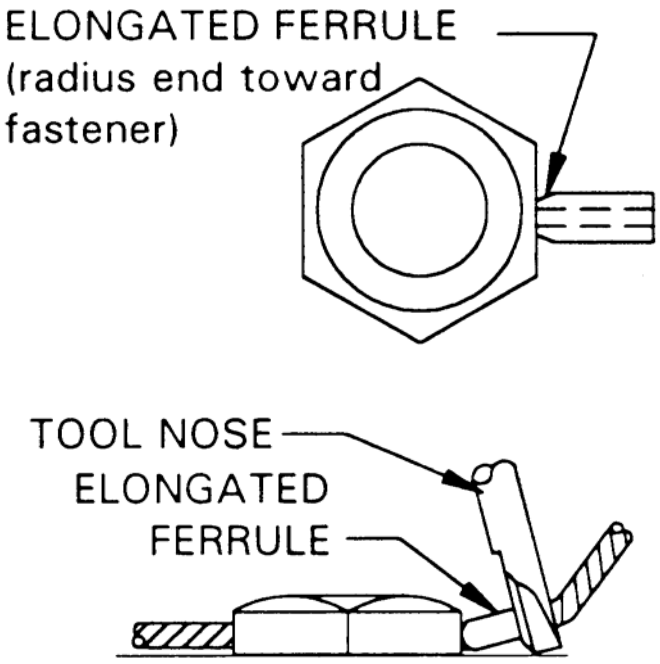
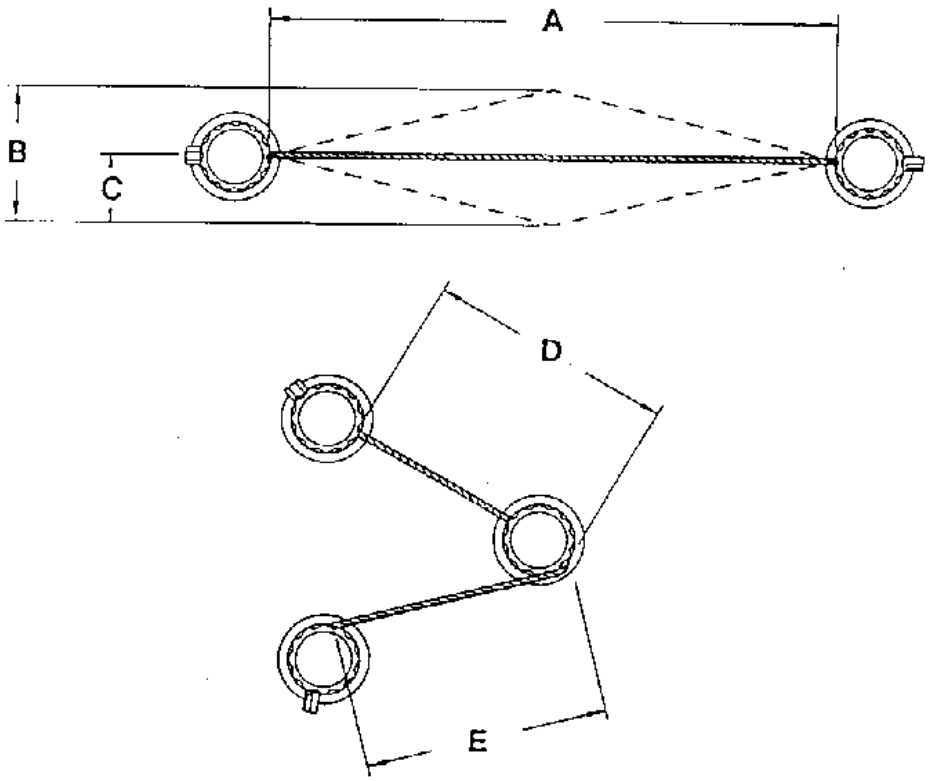


Figure 36 - Low profile installations
(using the AS3618 or AS3619 elongated ferrules)



For Three Bolt Patterns
A = D + E

Figure 37 - Safety-cable flex limits

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 single bendable keys are not reusable and must be replaced with a new key washer after removal. Key washers with multiple bendable keys may be reused after previously used keys are removed and unused keys remain. Key washers must be discarded if cracks are present.

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 Figure 38 so that it will maintain the gap in a tightening direction.

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 Figure 33) 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 Figure 38) may also be bent up at the option of the assembler and may be bent around corner of nut if desired.

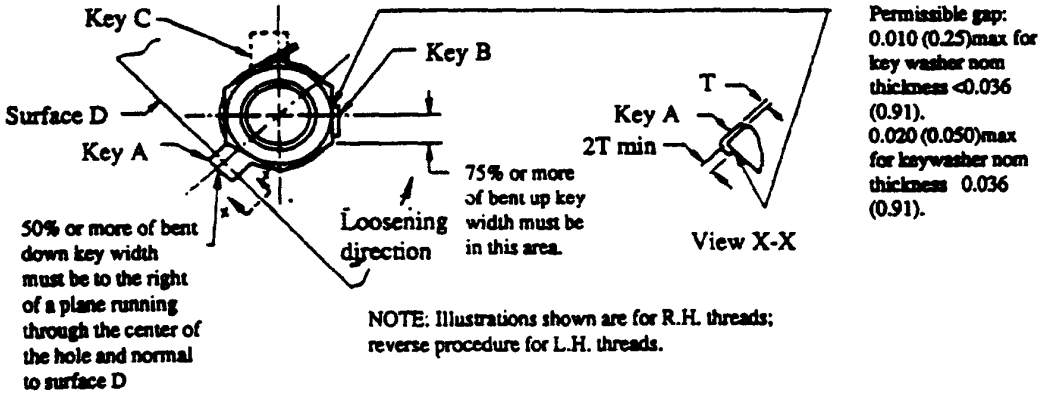


Figure 38 - Key washer stationary surface lock

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 Figure 39 shows keys located in unacceptable position for bending.

NOTE: No technical changes to sections; key washers or cotter pins.

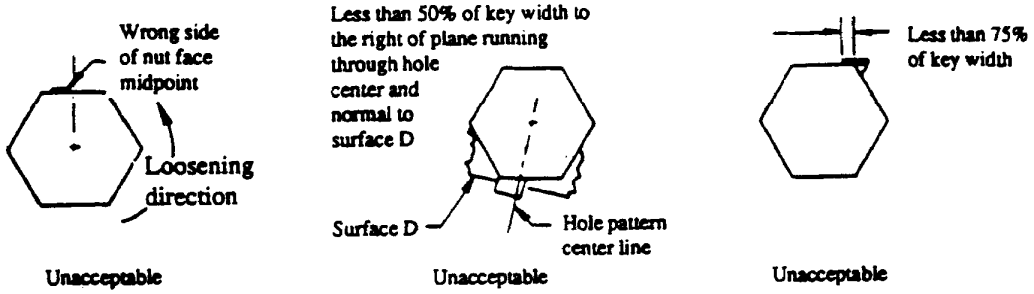


Figure 39 - Unacceptable bent key locations

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 Figure 38, a hole may be drilled to fulfill this function as shown in Figure 40.

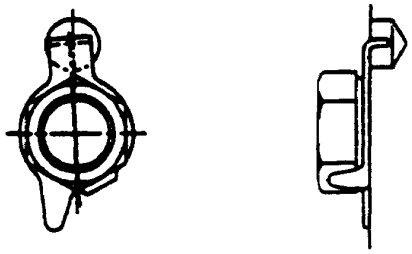


Figure 40 - See AS9276, AS9581, AS9582 for key washers of this type

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.

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 Figure 41). 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.

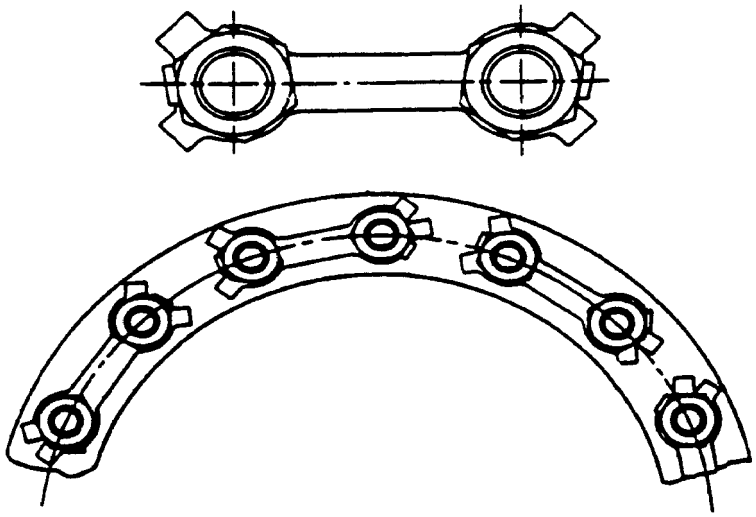


Figure 41 - View showing split line nuts locked with multiple key washers

4.5 Locking Spanner Nuts with Key Washers

4.5.1 Assemble key washer 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 needs to be bent to secure the nut. It is not necessary to bend the tabs into additional slots which may also be favorably aligned. Figures 42 and 43 show typical bearing retention applications. Note that the washer may engage shaft with a single key as in Figure 42 or with a double key as in Figure 43. The double key configuration provides better resistance to shear loads through the key.

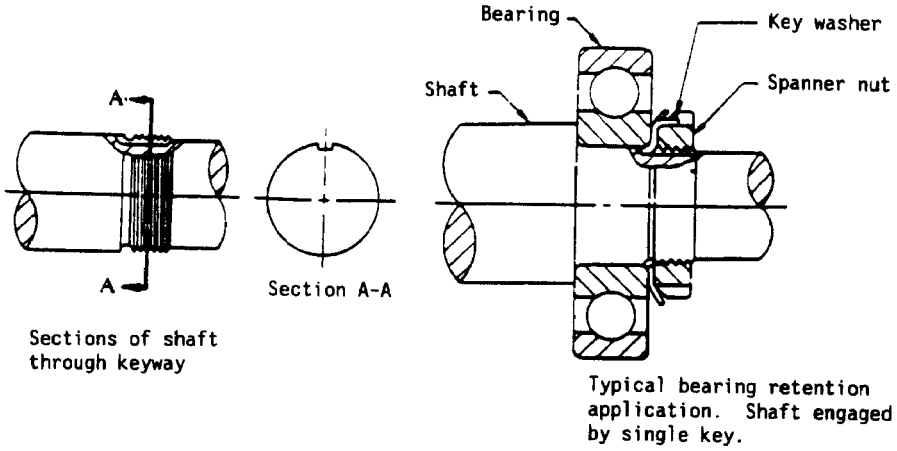


Figure 42 - Typical single key bearing retention application

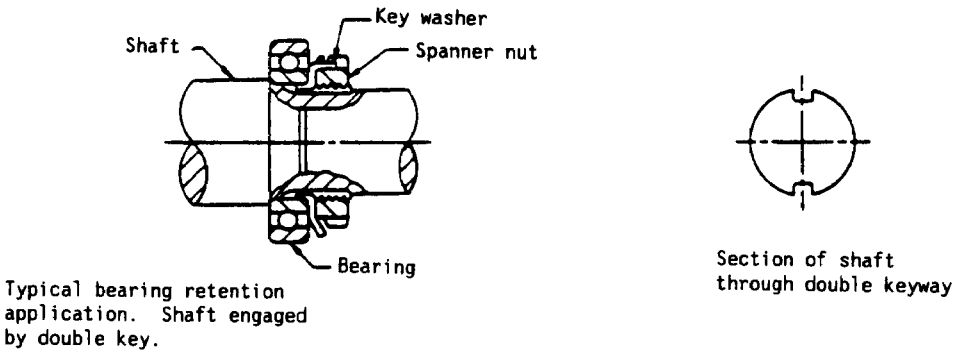


Figure 43 - Typical double key bearing retention application

4.5.1.1 Table 7 references recommended AS and MS part standards for key washers and spanner nuts. See AS462 and AS919 for dimensions of shaft features.

Table 7 - Recommended AS and MS key washers and spanner nuts /1/

Application	Key Washer	Nut
Single Keyway Shaft - Millimeter Series Bearings	AS172201 thru AS172235	AS172236 thru AS172270
Single Keyway Shaft - Inch Series Bearings	AS172271 thru AS172320	AS172321 thru AS172370
Double Keyway Shaft - Millimeter Series Bearings	MS9081, MS9274	AS172236 thru AS172270

/1/ AS part standards (reference document) shown in this table maintain the original MS part designations (part numbers).

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 Figure 44) thereby creating a locked condition.

4.6 Elliptical Key Washers

4.6.1 The installation of 180 degree ellipses shall be accomplished by bending up across one whole face of the hex as shown in Figure 45.

4.7 Cup-Type Key Washer

4.7.1 Lock fastener by dimpling the washer as shown in Figure 46. 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.

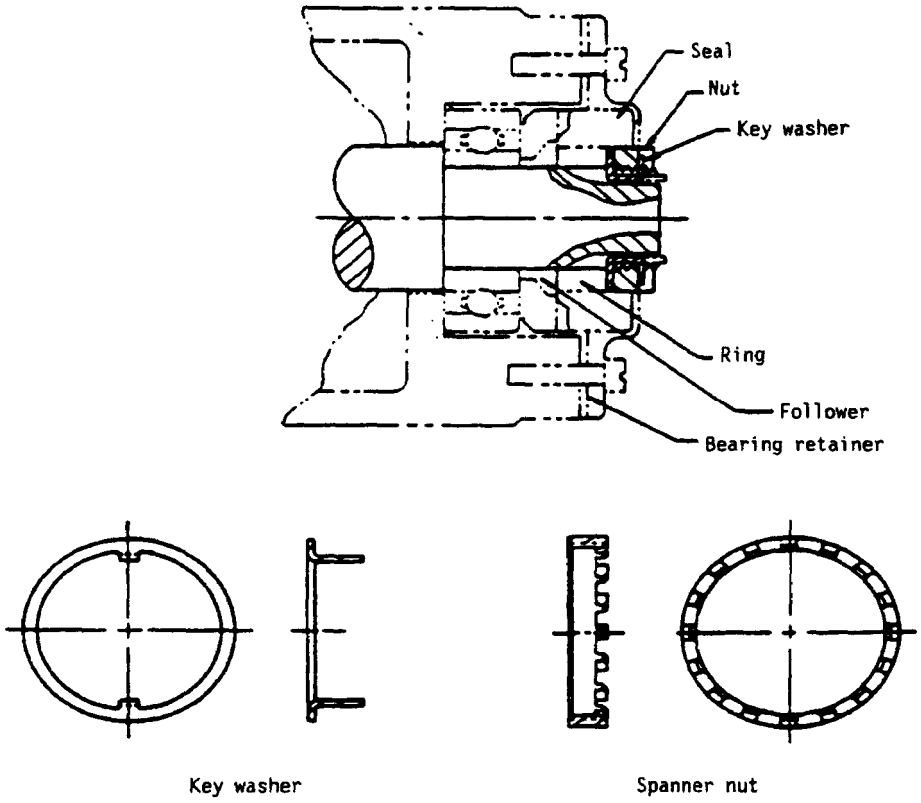


Figure 44 - Key washers and spanner nuts

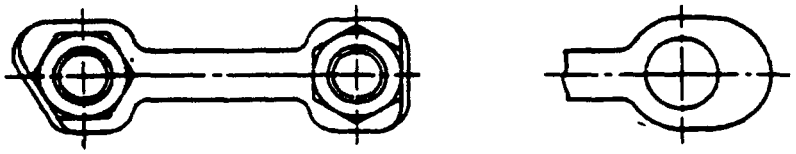


Figure 45 - Elliptical key washers

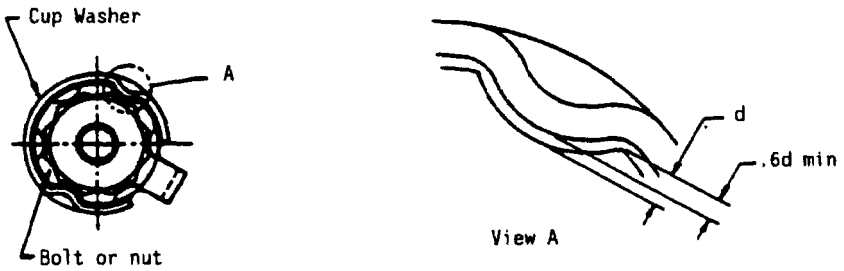


Figure 46 - Cup-type key washers

4.7.1.1 Table 8 gives dimple engagements for AS and MS part standards for cup washers and fasteners.

Table 8 - Recommended dimple engagement for AS and MS standard cup washers and fasteners /1/

Nominal Size in	Nominal Size mm	Bolt	Nut	Cup Washer	Dimple Engagement (0.6 d min) /2/ in	Dimple Engagement (0.6 d min) /2/ mm
0.1900	4.83	AS9676	MS9766-09	MS9684-09	0.026	0.67
0.2500	6.35	AS9677	MS9766-10	MS9684-10	0.025	0.64
0.3125	7.94	AS9678	MS9766-11	MS9684-11	0.024	0.61
0.3750	9.52	AS9679	MS9766-12	MS9684-12	0.023	0.59

/1/ AS part standards (reference document) shown in this table maintain the original MS part designations (part numbers).
/2/ See Figure 46.

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 AS7210, for use up to 700 °F (371 °C); and a corrosion and heat-resistant material, such as AS7211, for use up to 1200 °F (649 °C). See AS123751 through AS123850 and AS9245 (Note: Part numbers for AS9245 use the original MS designation), respectively; these cotter pins range in size from 0.031 inch (0.79 mm) to 0.188 inch (4.78 mm) diameter.

5.2 Locking Nuts with Cotter Pins

5.2.1 The preferred method of cotter pin installation is illustrated in Figure 47. 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 Figure 50). 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 Figure 47. 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.

5.2.1.3 The alternative method of installation to be used in overcoming a clearance problem is shown in Figure 48. This will require longer pins than those outlined in Table 5.

5.2.1.4 Unsatisfactory conditions of locking with cotter pins are indicated in Figure 49. Excessive working of pin should be avoided to prevent breaking.

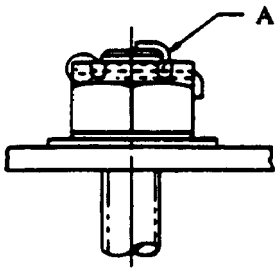


Figure 47 - Preferred installation

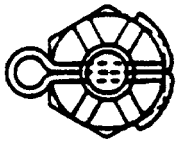


Figure 48 - Alternative installation

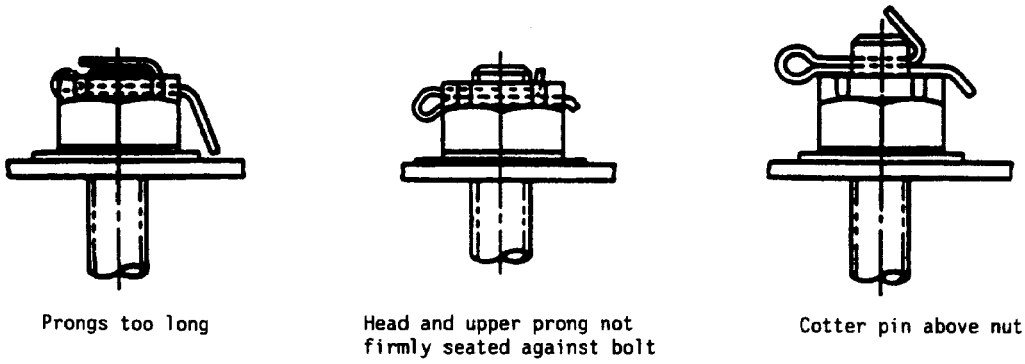


Figure 49 - Unsatisfactory installations

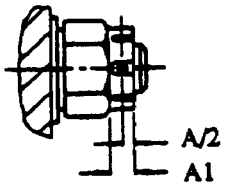


Figure 50 - Location of locking hole in slot of nut

5.2.2 Alignment of Cotter Pin and Holes

Using mean dimensions of the parts to be clamped, select bolt so that the cotter pin hole is approximately midway into the slot of the nut (see Figure 50). If, during assembly, part tolerances accumulate to cause the cotter pin hole to extend more than 25% above the nut castellation, select a new nut or bolt, or place not more than two washers under the nut to obtain proper alignment.

5.2.3 Cotter Pin Size for Preferred Installation

Recommended cotter pin sizes for the preferred installation method are given in Table 8 for standard fastener applications. Longer or shorter cotter pins may be used when required.

5.3 Locking Clevis Pins, Rod End Bearings, etc.

5.3.1 The proper method for installing cotter pins for use with clevis pins, rod end bearings, etc., is illustrated in Figure 51. General rules for this application are as follows:

5.3.1.1 Install the cotter pin with the axis of the eye parallel to the shank of the clevis pin or rod end.

5.3.1.2 Bend the prongs of the cotter pin around the shank of the pin or rod end as illustrated in Figure 51. A standard cotter pin should be chosen with a length approximately equal to twice the diameter of the clevis pin, rod end, etc.

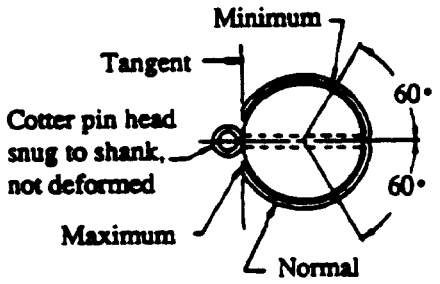
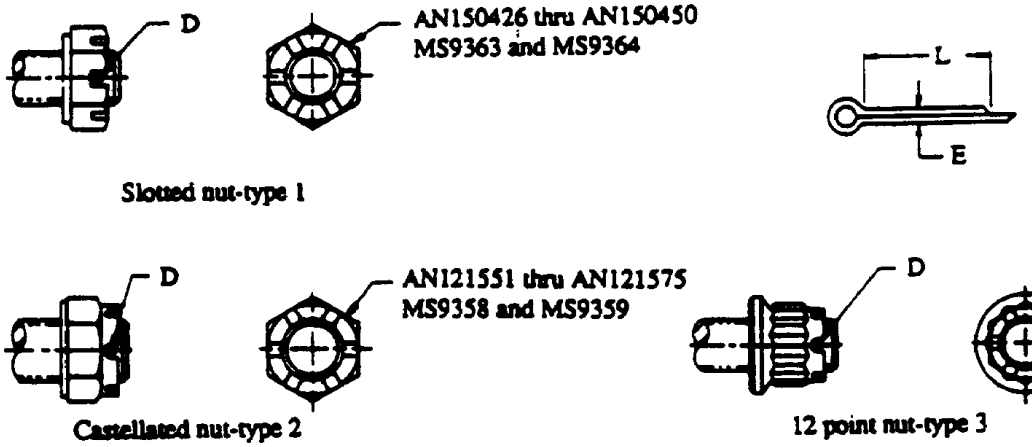


Figure 51

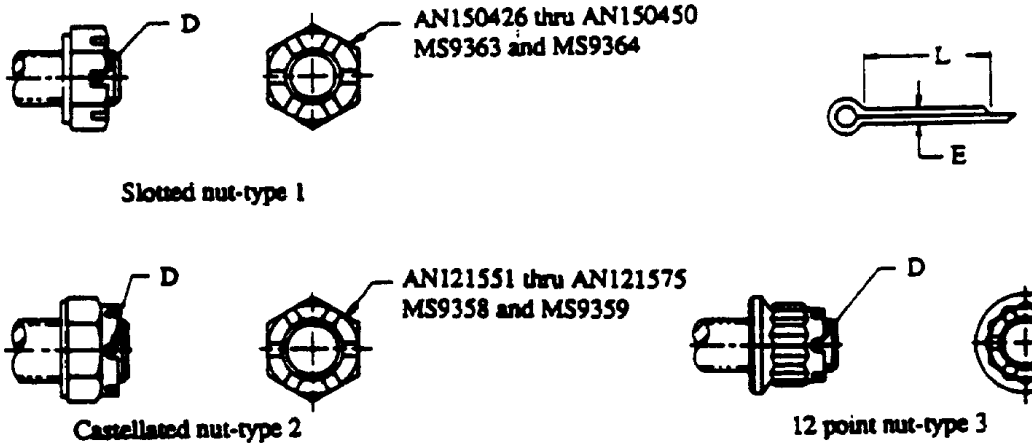
Table 9A - Cotter pin and cotter pin hole data - inches and recommended part numbers



Fastener Size	Cotter Pin Hole ØD	Cotter Pin Hole Chamfer Ø	Nut Type	Recommended Cotter Pin Length L	Recommended Cotter Pin E Ø	Recommended Cotter Pin 800ºF /1/ AS7210	Recommended Cotter Pin 1200ºF /1/ /2/ AS7211
0.1900-32	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
0.2500-28	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
0.3750-24	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
0.5000-20	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	0.126-0.132	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
0.6250-18	0.126-0.132	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
0.7500-16	0.126-0.132	0.178-0.198	1	1.000	0.125	AS123807	MS9245-64
			2	1.125	0.125	AS123808	MS9245-65
0.8750-14	0.126-0.132	0.178-0.198	1	1.125	0.125	AS123808	MS9245-65
			2	1.250	0.125	AS123809	MS9245-66
1.0000-12	0.126-0.132	0.178-0.198	1	1.25	0.125	AS123809	MS9245-66
			2	1.500	0.125	AS123810	MS9245-68

/1/ Maximum recommended temperature.
/2/ Part numbers for AS9245 use the original MS designation.

Table 9B - Cotter pin and cotter pin hole data - millimeters



Fastener Size	Cotter Pin Hole ØD	Cotter Pin Hole Chamfer Ø	Nut Type	Recommended Cotter Pin Length L	Recommended Cotter Pin E Ø	Recommended Cotter Pin 800ºF /1/ AMS7210	Recommended Cotter Pin 1200ºF /1/ AMS7211
0.1900-32	1.66-1.85	2.29-2.79	1	7.92	1.59	AS123770	MS9245-22
			2	9.52	1.59	AS123771	MS9245-23
			3	7.92	1.59	AS123770	MS9245-22
0.2500-28	1.66-1.82	2.29-2.79	1	9.52	1.59	AS123771	MS9245-23
			2	11.13	1.59	AS123772	MS9245-24
			3	9.52	1.59	AS123771	MS9245-23
0.3125-24	1.66-1.82	2.29-2.79	1	11.13	1.59	AS123772	MS9245-24
			2	12.70	1.59	AS123773	MS9245-25
			3	11.13	1.59	AS123772	MS9245-24
0.3750-24	2.39-2.56	3.56-4.06	1	12.70	2.38	AS123788	MS9245-42
			2	14.27	2.38	AS123789	MS9245-43
			3	12.70	2.38	AS123788	MS9245-42
0.4375-20	2.39-2.56	3.56-4.06	1	14.27	2.38	AS123789	MS9245-43
			2	15.88	2.38	AS123790	MS9245-44
			3	14.27	2.38	AS123789	MS9245-43
0.5000-20	2.39-2.56	3.56-4.06	1	15.88	2.38	AS123790	MS9245-44
			2	19.05	2.38	AS123791	MS9245-45
			3	15.88	2.38	AS123790	MS9245-44
0.5625-18	3.21-3.37	4.53-5.02	1	19.05	3.18	AS123805	MS9245-62
			2	22.22	3.18	AS123806	MS9245-63
			3	19.05	3.18	AS123805	MS9245-62
0.6250-18	3.21-3.37	4.53-5.02	1	22.22	3.18	AS123806	MS9245-63
			2	25.40	3.18	AS123807	MS9245-64
			3	22.22	3.18	AS123806	MS9245-63
0.7500-16	3.21-3.37	4.53-5.02	1	25.40	3.18	AS123807	MS9245-64
			2	28.58	3.18	AS123808	MS9245-65
0.8750-14	3.21-3.37	4.53-5.02	1	28.58	3.18	AS123808	MS9245-65
			2	31.75	3.18	AS123809	MS9245-66
1.0000-12	3.21-3.37	4.53-5.02	1	31.75	3.18	AS123809	MS9245-66
			2	38.10	3.18	AS123810	MS9245-68

/1/ Maximum recommended temperature.

6. NOTES

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

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