

## SAFETYING - MAINTENANCE PRACTICES

### 1. General

#### A. Lockwire.

- (1) Inconel (Uncoated), Monel (Uncoated).
  - (a) Used for general lock wiring purposes. Lock wiring is the application of wire to prevent relative movement of structural or other critical components subjected to vibration, tension, torque, etc. Monel to be used at temperatures up to 700°F and inconel to be used at temperatures up to 1500°F. Identified by the color of the finish, monel and inconel color is natural wire color.
- (2) Copper, Cadmium Plated and Dyed Yellow in Accordance with FED-STD 595.
  - (a) This will be used for shear and seal wiring applications. Shear applications are those where it is necessary to purposely break or shear the wire to permit operation or actuation of emergency devices. Seal applications are those where the wire is used with a lead seal to prevent tampering or use of a device without indication. Identified by the color of the finish, copper is dyed yellow.
- (3) Aluminum Alloy (Alclad 5056), Anodized and Dyed Blue in Accordance with FED-STD 595.
  - (a) This wire will be used exclusively for safety wiring magnesium parts.

**NOTE:** Surface treatment which obscures visual identification of safety wire is prohibited.

#### B. Safety Cable.

- (1) Used as an alternative to corrosion-resistant steel lockwire.

#### C. Cotter Pin.

- (1) The selection of material should be in accordance with temperature, atmosphere and service limitations.

#### D. Locking Clips.

- (1) Used to safety turnbuckles.

### 2. Safety Wire

**NOTE:** You can use safety cable as an alternative to safety wire. Refer to Safety Cable Installation, in this section.

#### A. Wire Size.

- (1) The size of the wire should be in accordance with the requirements of Table 201.

**Table 201. Safety Wire**

Material	Number (MS20995-XXX)					
Ni-Cu Alloy (Monel)	NC20	NC32	NC40		NC51	NC91
Ni-Cr-Fe Alloy (Inconel)	N20	N32	N40		N51	N91
Carbon Steel, Zinc-Coated	F20	F32		F41	F47	F91
Corrosion-Resistant Steel	C15	C20	C32	C41	C47	C91
Aluminum Alloy (Blue)	AB20	AB32		AB41	AB47	AB91
Copper (Yellow)	CY15	CY20				

Example of Part Numbers:

MS20995 CY20 = Copper, Shear or Seal Wire, 0.020 inch Diameter

MS20995 AB32 = Aluminum Alloy, Anodized, 0.032 inch Diameter

**NOTE 1:** The dash numbers indicate wire material and diameter in thousandths of an inch.

- (a) 0.032 inch minimum diameter for general purpose lock wiring except that 0.020 inch diameter wire may be used on parts having a nominal hole diameter of less than 0.045 inch; on parts having a nominal hole diameter between 0.045 inch and 0.062 inch with spacing between parts of less than two inches; or on closely spaced screws and bolts of 0.25 inch diameter and smaller.
- (b) 0.020 inch diameter copper wire should be used for shear and seal wire applications.
- (c) When employing the single wire method of locking the largest nominal size wire for the applicable material or part which the hole will accommodate should be used.

### 3. Lockwire Installation

#### A. Method (Refer to Figure 201).

- (1) The double-twist method of lock wiring should be used as the common method of lock wiring. The single wire method of lock wiring may be used in a closely spaced, closed geometrical pattern (triangle, square, circle, etc.), on parts in electrical systems, and in places that would make the single wire method more advisable. Closely spaced should be considered a maximum of two inches between centers.

**CAUTION: Screws in closely spaced geometric patterns which secure hydraulic or air seals, hold hydraulic pressure, or used in critical areas, should use the double-twist method of lock wiring.**

- (2) Use single copper wire method for shear and seal wiring application. Make sure that the wire is so installed that it can easily be broken when required in an emergency situation. For securing emergency devices where it is necessary to break the wire quickly, use copper wire only.

#### B. Spacing.

- (1) When lock wiring widely spaced multiple groups by the double-twist method, three units should be the maximum number in a series.
- (2) When lock wiring closely spaced multiple groups, the number of units that can be lockwired by a twenty-four inch length of wire should be the maximum number in a series.
- (3) Widely spaced multiple groups should mean those in which the fastenings are from four to six inches apart. Lockwiring should not be used to secure fasteners or fittings which are spaced more than six inches apart, unless tie points are provided on adjacent parts to shorten the span of the lockwire to less than six inches.

#### C. Tension.

- (1) Parts should be lock wired to put tension on lock wires when the parts tend to loosen. The lockwire should always be installed and twisted so the loop around the head stays down and does not tend to come up over the bolt head and leave a slack loop.

**NOTE: This does not necessarily apply to castellated nuts when the slot is close to the top of the nut; the wire will be more secure if it is made to pass along the side of the stud.**

- (2) Care should be exercised when installing lockwire, to ensure it is tight but not overstressed.

#### D. Usage.

- (1) A pigtail of 0.25 to 0.50 inch (three to six twists) should be made at the end of the wiring. This pigtail should be bent back or under to prevent it from becoming a snag.
- (2) Safety wire (lockwire) should be new upon each application.
- (3) When castellated nuts are to be secured with lockwire, tighten the nut to the low side of the selected torque range unless otherwise specified, and, if necessary, continue tightening until a slot aligns with the hole.
- (4) In blind tapped hole applications of bolts or castellated nuts on studs, lock wiring should be as described in these instructions.
- (5) Hollow head bolts are safetied in the manner prescribed for regular bolts.
- (6) Drain plugs and cocks may be safetied to a bolt, nut or other part having a free lock hole in accordance with the instructions described in this text.
- (7) External snaprings may be locked if necessary in accordance with the general locking principles as described and illustrated. Internal snaprings should not be lock wired.
- (8) When locking is required on electrical connectors which use threaded coupling rings, or on plugs which employ screws or rings to fasten the individual parts of the plug together, they should be lock wired with 0.020 inch diameter wire in accordance with the locking principles as described and illustrated. It is preferable to lock wire all electrical connectors individually. Do not lock wire one connector to another unless it is necessary to do so.
- (9) Drilled head bolts and screws need not be lock wired if installed into self-locking nuts or installed with lockwashers. Castellated nuts with cotter pins or lockwire are preferred on bolts or studs with drilled shanks, but self-locking nuts are permissible within the limitations of MS33588.
- (10) Lockwire shall not be used to secure or be dependent on fracture as the basis for operation of emergency devices such as handles, switches, guards covering handles, etc., that operate emergency mechanisms such as emergency exits, fire extinguishers, emergency cabin pressure release, emergency landing gear release and the like. However,

where existing structural equipment or safety-of-flight emergency devices require shear wire to secure equipment while not in use, but which are dependent on shearing or breaking of the lockwire for successful emergency operation of equipment, particular care should be exercised to assure that lock wiring under these circumstances will not prevent emergency operations of these devices.

#### 4. Cotter Pin Installation

A. General instruction for the selection and application of cotter pins (refer to Figure 202).

- (1) Select cotter pin material in accordance with temperature, atmosphere and service limitations. Refer to Table 202.

**Table 202. Cotter Pin Material**

Material	Temperature	Service
MS24665 Cotter Pins Carbon Steel	Ambient Temperature up to 460°F	Normal atmosphere cotter pins contacting cadmium plated bolts or nuts.
MS24665 Cotter Pins Corrosion Resistant Steel	Ambient Temperature up to 800°F	Non magnetic requirements cotter pins contacting corrosion resistant steel bolts or nuts in a corrosive atmosphere.

- (2) Cotter pins should be new upon each application.
- (3) When nuts are to be secured to the fastener with cotter pins, tighten the nut to the low side (minimum) of the applicable specified or selected torque range, unless otherwise specified, and if necessary, continue tightening until the slot aligns with the hole. In no case should the high side (maximum) torque range be exceeded.
- (4) Castellated nuts mounted on bolts may be safetied with cotter pins or lockwire. The preferred method is with the cotter pin bent parallel to the axis of the bolt. The alternate method, where the cotter pin is mounted normal to the axis of the bolt, may be used when the cotter pin in the preferred method is apt to become a snag.
- (5) In the event when more than 50 percent of the cotter pin diameter is above the nut castellation, a washer should be used under the nut or a shorter fastener should be used. A maximum of two washers may be permitted under a nut.
- (6) The largest nominal diameter cotter pin (listed in MS24665) which the hole and slots will accommodate should be used; but in no application to a nut, bolt or screw should the pin size be less than the sizes described in Figure 202.
- (7) Install the cotter pin with the head firmly in the slot of the nut, with the axis of the eye at right angles to the bolt shank. Bend prongs so the head and upper prong are firmly seated against the bolt.
- (8) In the pin applications, install the cotter pin with the axis of the eye parallel to the shank of the clevis pin or rod end. Bend the prongs around the shank of the pin or rod end.
- (9) Cadmium plated cotter pins should not be used in applications bringing them in contact with fuel, hydraulic fluid or synthetic lubricants.

#### 5. Locking Clip Installation

A. Safetying Turnbuckles (Refer to Figure 203).

- (1) Prior to safetying, both threaded terminals should be screwed an equal distance into the turnbuckle barrel, and should be screwed in, at a minimum, so no more than three threads of any terminal are exposed outside the body.
- (2) After the turnbuckle has been adjusted to its locking position, with the groove on terminals and slot indicator notch on barrel aligned, insert the end of the locking clip into the terminal and barrel until the "U" curved end of the locking clip is over the hole in the center of the barrel.
  - (a) Press the locking clip into the hole to its full extent.
  - (b) The curved end of the locking clip will latch in the hole in the barrel.
  - (c) To check proper seating of locking clip, attempt to remove pressed "U" end from barrel hole with fingers only. Do not use a tool as the locking clip could be distorted.
- (3) Locking clips are for one time use only and should not be reused.
- (4) Both locking clips may be inserted in the same hole of the turnbuckle barrel or in opposite holes of the turnbuckle barrel.

#### 6. Safety Cable Installation

A. Tools and Equipment.

Name	Number	Manufacturer	Use
Ferrule, Safety Cable	SAE AS4536	Commercially available	To use with the safety cable.
Safety Cable	SAE AS4536	Commercially available	To prevent the movement of structural or other critical components that have had vibration, tension, or torque applied to them.
Safety Cable Application Tool	SCT Series	Daniels Manufacturing Corporation 526 Thorpe Rd. Orlando, FL 32824-8133	To install the Daniels safety cable.
Safety Cable Terminator Tool	BM Series	Bergen Cable Technology, LLC 343 Kaplan Drive Fairfield, NJ 07004	To install the Bergen safety cable.

B. Procedure (Refer to Figure 204).

(1) Make sure that you obey the precautions for the safety cable as follows:

- (a) Wear eye protection when you cut the safety cable.
- (b) Do not use a safety cable or a ferrule more than one time.
- (c) Always discard the safety cable that you remove.
- (d) Make sure that you use the correct type and dimension of safety cable for the applicable procedure.

**NOTE:** Safety cable that is not of the correct type, length, and dimension can break. This can occur when there is more than the specified tension limit for that type and dimension of safety cable.

- (e) Examine the safety cable for kinks, nicks, frayed edges, or other damage. If you find damage on the safety cable, you must discard the cable. Replace it with a new safety cable.
- (f) The maximum span of the safety cable between two fasteners is 6 inches (15.24 cm).
- (g) You must install the safety cable through the holes supplied for safetying. It is not permitted to install the safety cable in other locations not for safetying.
- (h) Do not torque the bolt (or other fastener) to less or more than the specified value to align the holes. This is not permitted.
- (i) Install the safety cable in the two-bolt pattern or the three-bolt pattern.

**NOTE:** The two-bolt pattern is the recommended procedure when there is an even number of fasteners.

- (j) Crimp the ferrule to the safety cable with one of the correct mechanical procedures.
- (k) After installation, you must cut the unwanted safety cable from the ferrule that you crimped.
- (l) The maximum permitted length of the safety cable that can extend from the ferrule is 0.031 inch (0.79 mm).
- (m) Safety the cable to the maximum extension limits. Refer to Table 203 and Figure 204.

- 1 Refer to Figure 204 to find the middle of the span between the two bolts.
- 2 Apply a light force of approximately 2 pounds (8.90 N) to the safety cable at the middle of the span.
- 3 Make sure that the safety cable does not stretch more than the maximum extension limits.

**Table 203. Maximum Extension Limits**

A	B	C
0.5 inch (12.70 mm)	0.152 inch (3.17 mm)	0.062 inch (1.57 mm)
1.0 inch (25.40 mm)	0.250 inch (6.35 mm)	0.125 inch (3.17 mm)
2.0 inches (50.80 mm)	0.375 inch (9.52 mm)	0.188 inch (4.77 mm)
3.0 inches (76.20 mm)	0.375 inch (9.52 mm)	0.188 inch (4.77 mm)

4.0 inches (101.60 mm)	0.500 inch (12.70 mm)	0.250 inch (6.35 mm)
5.0 inches (127.00 mm)	0.500 inch (12.70 mm)	0.250 inch (6.35 mm)
6.0 inches (152.40 mm)	0.625 inch (15.87 mm)	0.312 inch (7.92 mm)

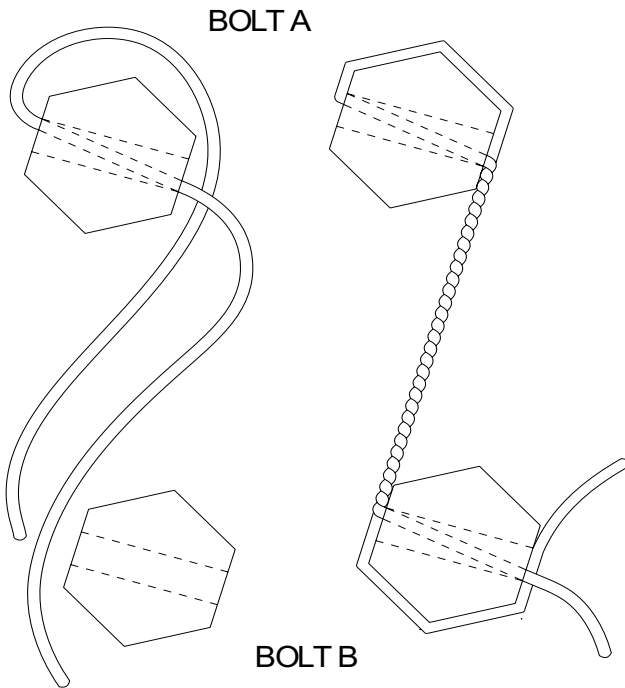
- (2) A fastener will stay tight if you install the safety cable correctly. While movement or tension on the fastener causes it to loosen, the cable tension increases. This will hold the fastener in its position. Refer to Figure 204 for examples of safety cable installation.

**CAUTION: Do not use the safety cable or the ferrule again after you remove it. It can break if you apply too much force to it and cause damage to the equipment.**

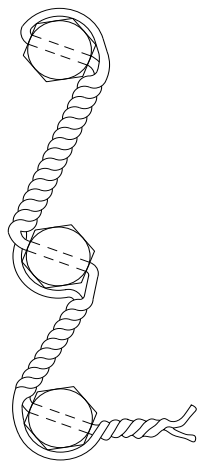
- (3) Install the safety cable through the holes in the fasteners.
- (4) Put a loose ferrule on the safety cable.
- (5) Put the end of the safety cable through the safety cable tool.
- (6) Apply tension to the preset load with the safety cable tool.
- (7) Crimp the ferrule with the safety cable tool.
- (8) Cut the unwanted cable from the crimped ferrule.
  - (a) Make sure that the maximum length of the cable that extends from the ferrule is not more than 0.031 inch (0.79 mm).

Figure 201 : Sheet 1 : Lockwire Safetying

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DOUBLE-WIRE SAFETYING

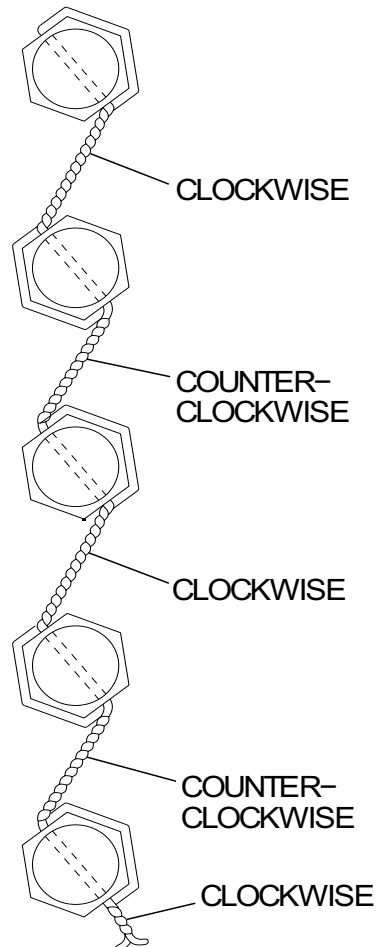


MULTIPLE FASTENER APPLICATION  
 DOUBLE-TWIST METHOD

**STEP 1:** INSERT WIRE THROUGH BOLT A AND BEND AROUND BOLT (IF NECESSARY, BEND WIRE ACROSS BOLT HEAD). TWIST WIRES CLOCKWISE UNTIL THEY REACH BOLT B.

**STEP 2:** INSERT ONE END OF WIRE THROUGH BOLT B. BEND OTHER END AROUND BOLT (IF NECESSARY, BEND WIRE ACROSS HEAD OF BOLT). TWIST WIRES COUNTERCLOCKWISE 1/2 INCH OR 6 TWISTS. CLIP ENDS. BEND PIGTAIL BACK AGAINST PART.

**NOTE:** RIGHT THREADED PARTS SHOWN: REVERSE DIRECTIONS FOR LEFT PARTS.

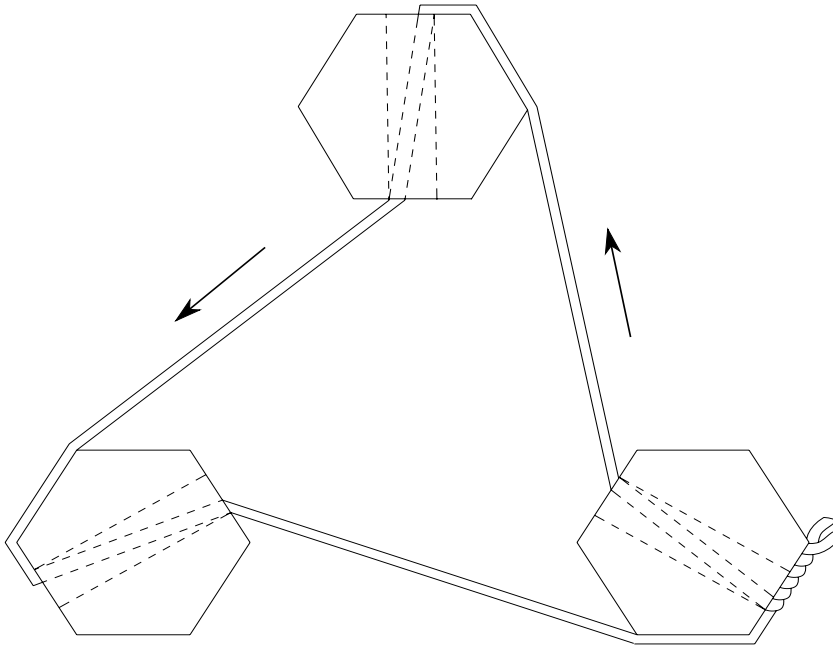


DOUBLE-WIRE SAFETYING  
 MULTIPLE GROUPS

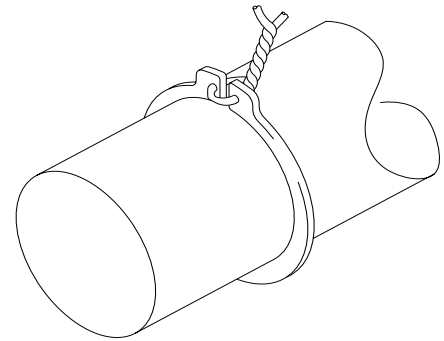
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Figure 201 : Sheet 2 : Lockwire Safetying

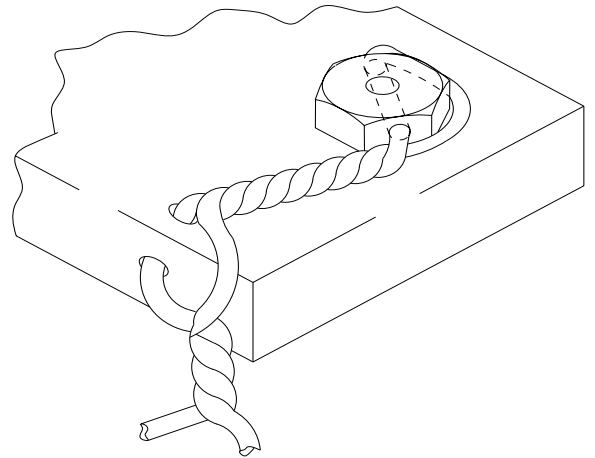
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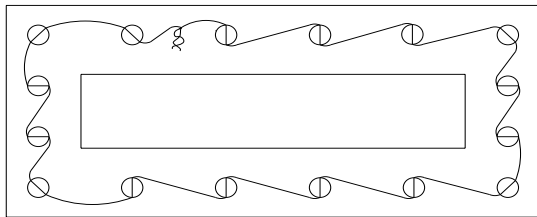
BOLTS IN CLOSELY SPACED, CLOSED GEOMETRICAL PATTERN. SINGLE WIRE METHOD.



EXTERNAL SNAP RING SINGLE-WIRE METHOD



SINGLE FASTENER APPLICATION DOUBLE-TWIST



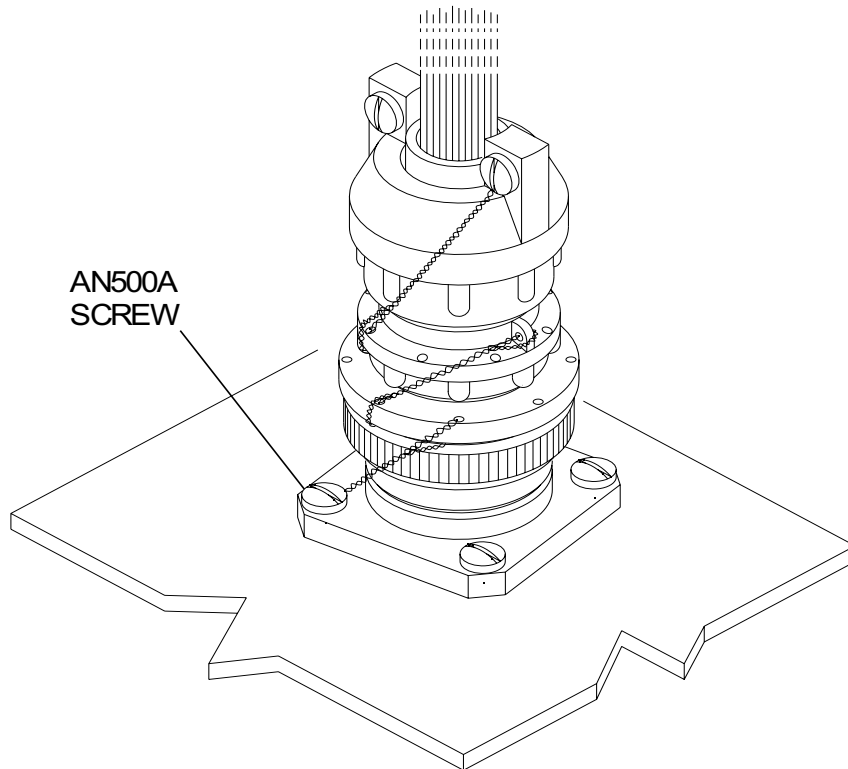
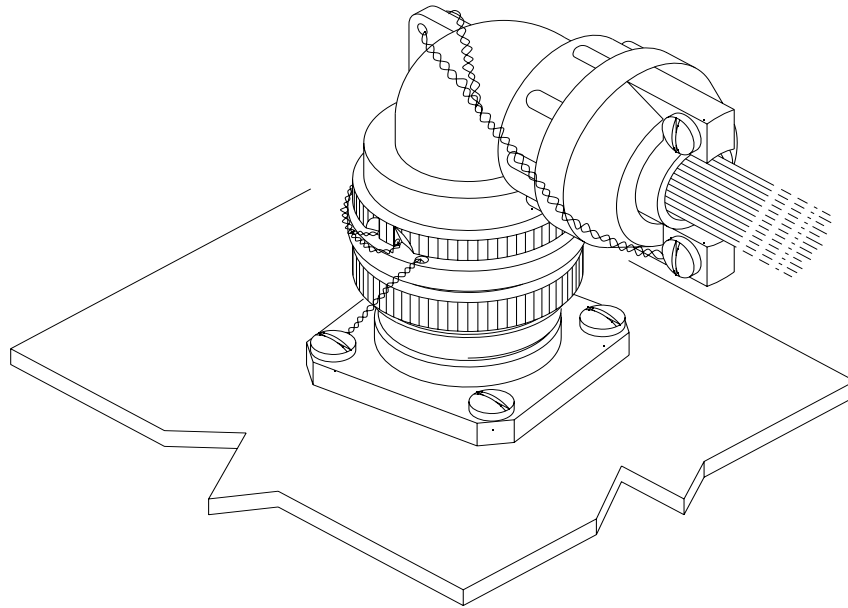
SMALL SCREWS IN CLOSELY SPACED, CLOSED GEOMETRICAL PATTERN, SINGLE WIRE METHOD

**NOTE:** RIGHT THREADED PARTS SHOWN. REVERSE DIRECTION FOR LEFT THREADS

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Figure 201 : Sheet 3 : Lockwire Safetying

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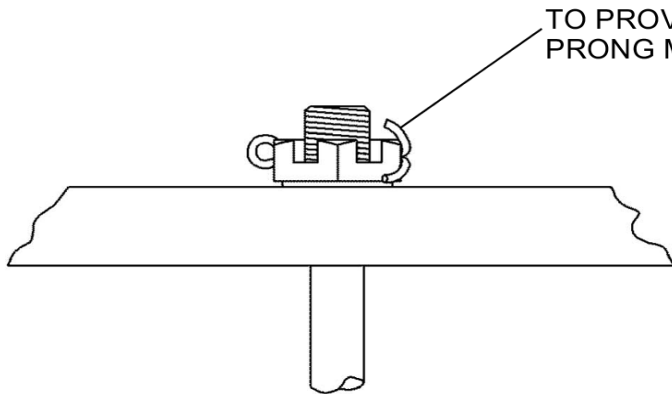


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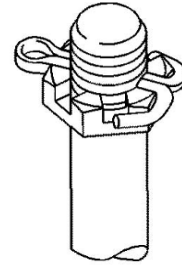


Figure 202 : Sheet 1 : Cotter Pin Safetying

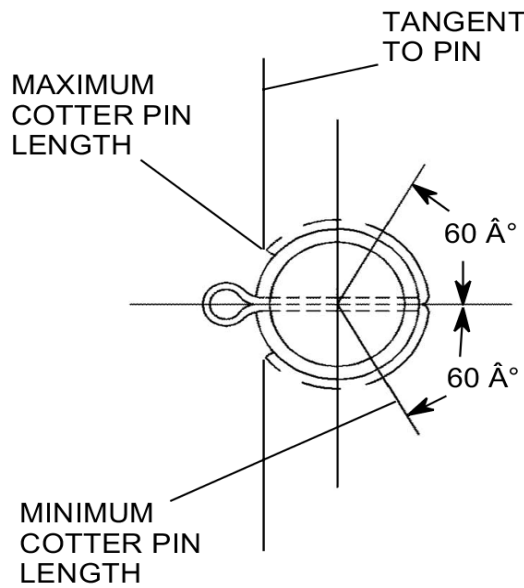
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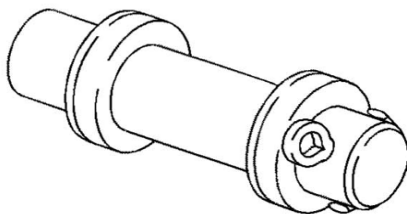
CASTELLATED NUT ON PREFERRED METHOD



CASTELLATED NUT ON ALTERNATE METHOD



THREAD SIZE	MINIMUM PIN SIZE	
	INCH	mm
6	0.028	0.71
8	0.044	1.11
10	0.044	1.11
1/4	0.044	1.11
5/16	0.044	1.11
3/8	0.072	1.83
7/16	0.072	1.83
1/2	0.072	1.83
9/16	0.086	2.18
5/8	0.086	2.18
3/4	0.086	2.18
7/8	0.086	2.18
1	0.086	2.18
1 1/8	0.116	2.95
1 1/4	0.116	2.95
1 3/8	0.116	2.95
1 1/2	0.116	2.95



PIN APPLICATION

XXXXTXXXX

Figure 203 : Sheet 1 : Safeying Turnbuckle Assemblies

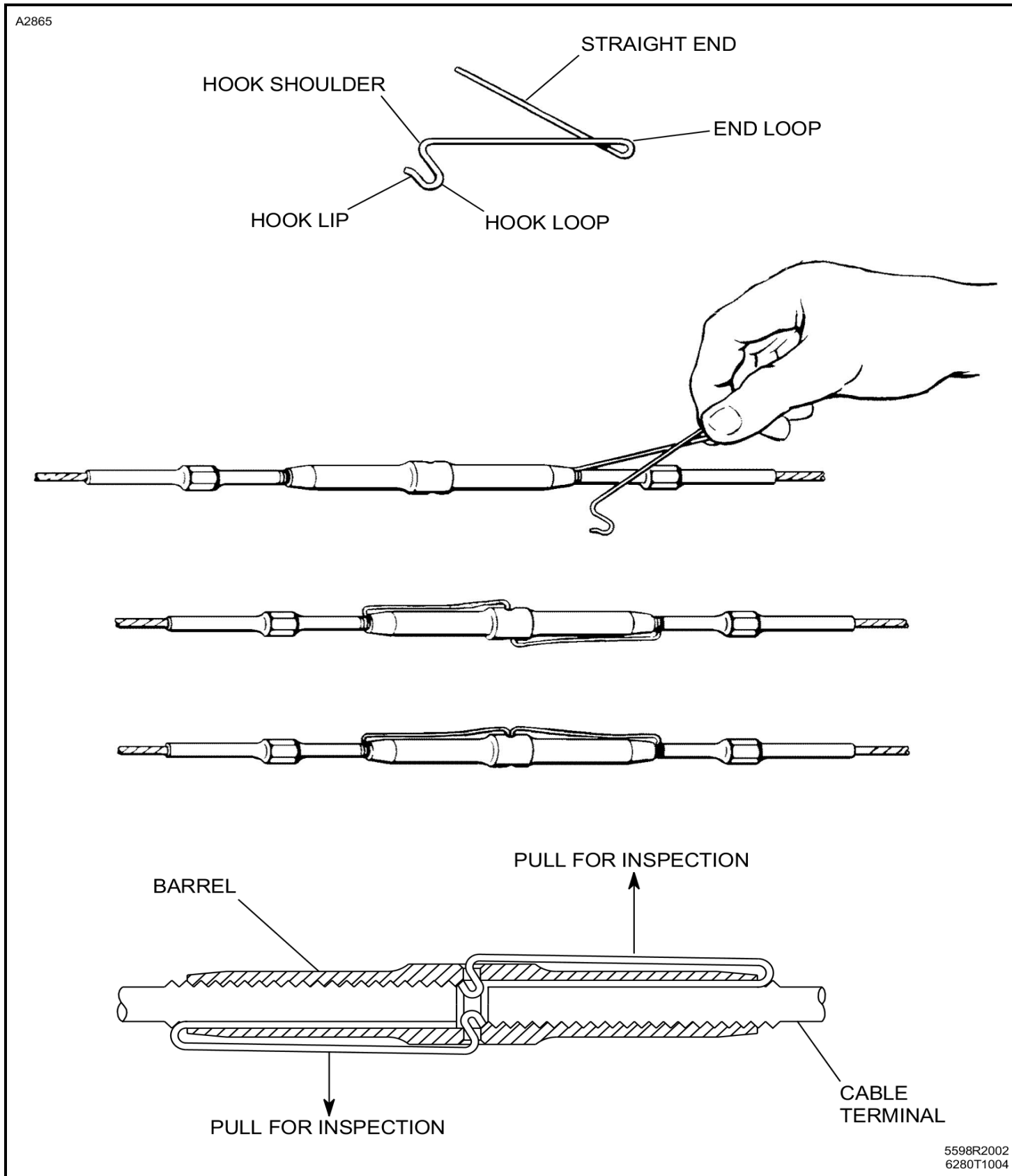
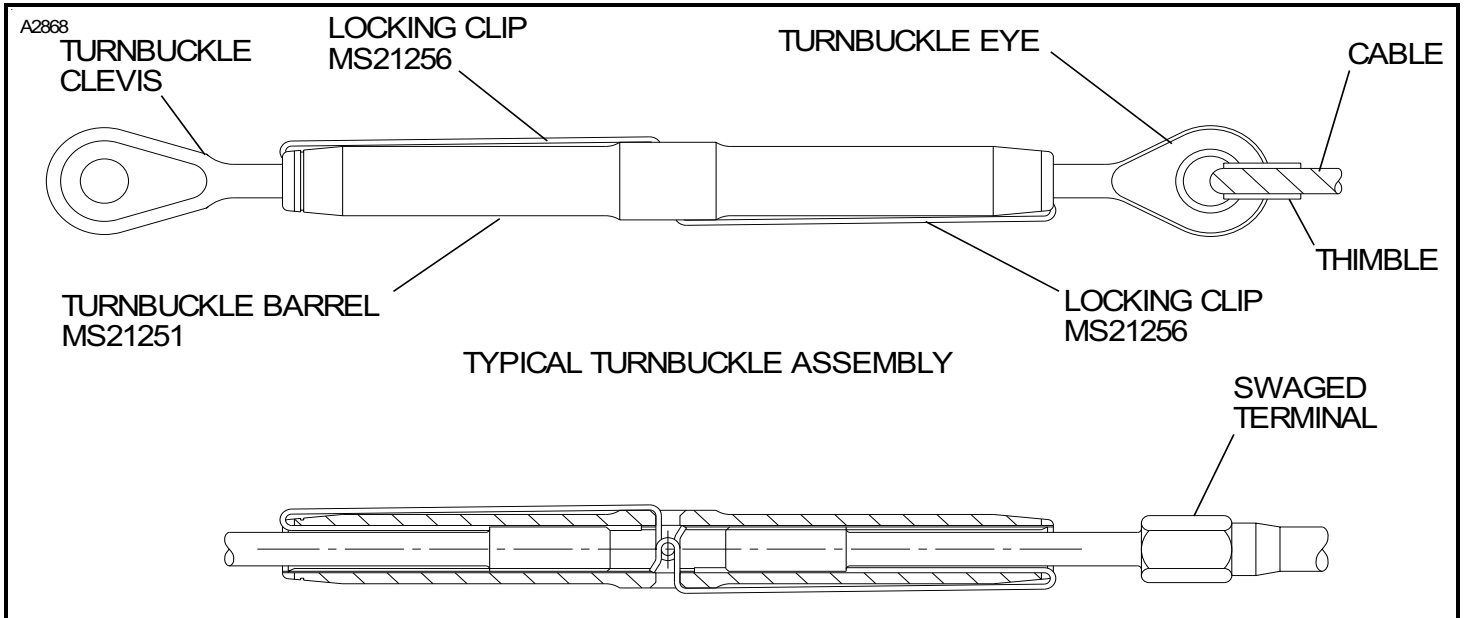


Figure 203 : Sheet 2 : Safeying Turnbuckle Assemblies



METHOD OF ASSEMBLING LOCKING CLIPS, TURNBUCKLE BARREL AND TERMINALS

NOMINAL CABLE DIAMETER	THREAD UNF-3	LOCKING CLIP MS21256 (NOTE 1)	TURNBUCKLE BODY MS21251
1/16	Number 6-40	-1 -2	-B2S -B2L
3/32	Number 10-32	-1 -2	-B3S -B3L
1/8	1/4-28	-1 -2	-B5S -B5L
5/32	1/4-28	-1 -2	-B5S -B5L
3/16	5/16-24	-1 -2	-B6S -B6L
7/32	3/8-24	-2	-B8L
1/4	3/8-24	-2	-B8L
9/32	7/16-20	-3	-B9L
5/16	1/2-20	-3	-B10L

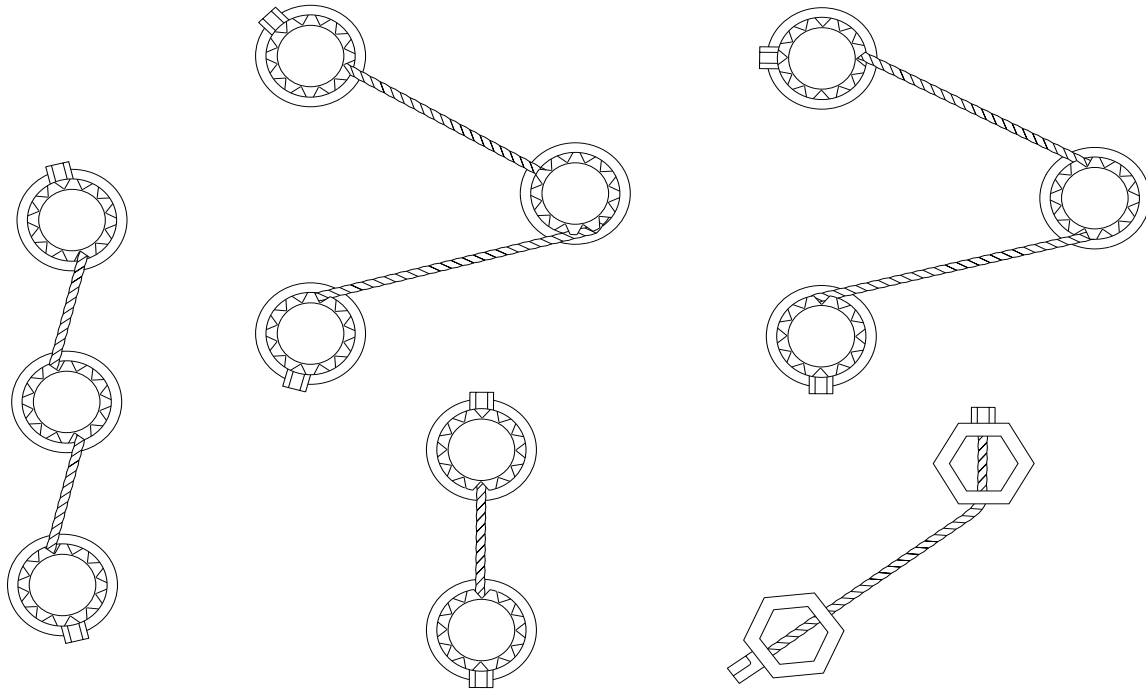
**NOTE 1:** TWO LOCKING CLIPS REQUIRED FOR EACH TURNBUCKLE.

**NOTE 2:** "B" IN TURNBUCKLE BODY DASH NUMBER INDICATES BRASS.  
NO LETTER INDICATES STEEL.

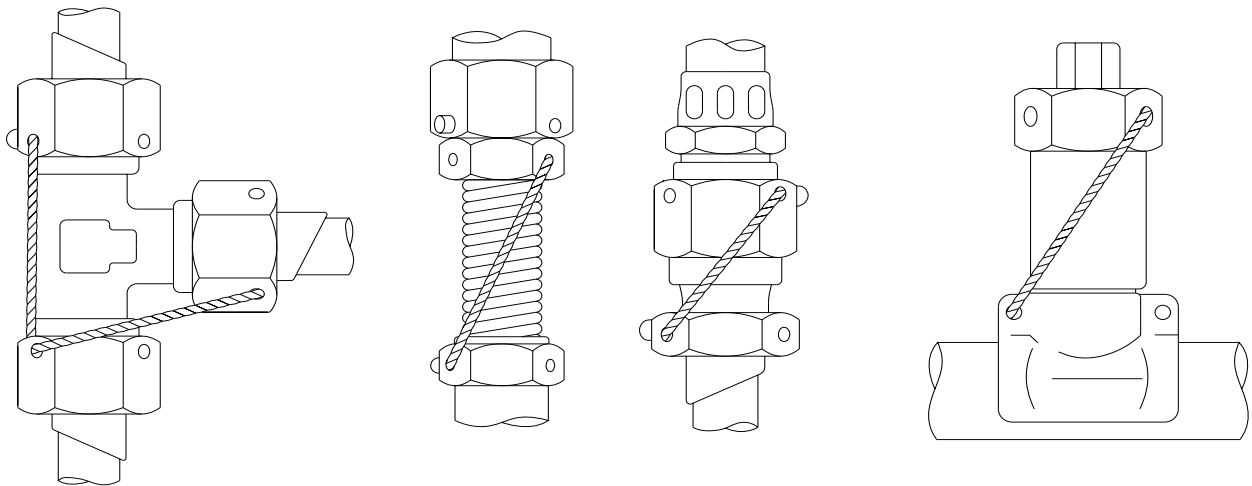
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Figure 204 : Sheet 1 : Safety Cable Installation

A84201



Standard Hardware

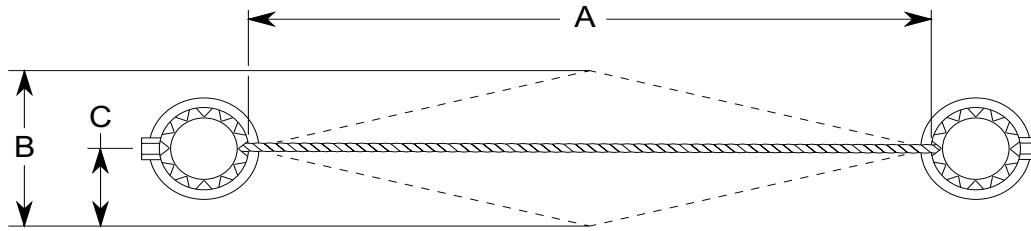


Tube Couplings

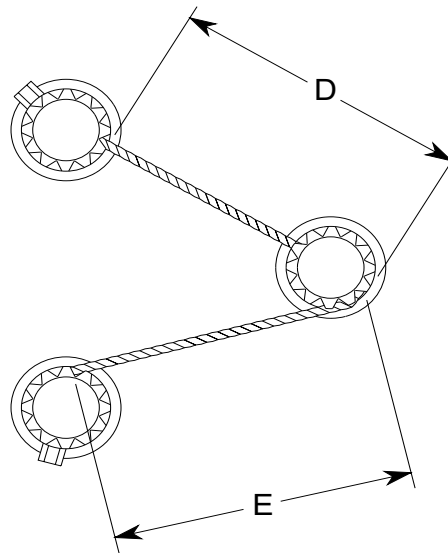
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Figure 204 : Sheet 2 : Safety Cable Installation

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For Three-Bolt Patterns  
 $A = D + E$



Safety Cable Check For Maximum Extension Limits

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