

## SECTION 2

### CHAPTER 8

# HARNESSESS, LACING AND TYING

## INTRODUCTION

1. Wire groups and bundles are laced or tied to provide ease of installation, maintenance, and inspection.

2. This chapter describes and illustrates the recommended procedures for harnessing, lacing and tying wire groups or bundles, using knots which will hold tightly under all conditions; and for installing self-clinching plastic cable straps.

## REFERENCE SPECIFICATIONS

3. The following reference specifications are applicable to lacing and tying:

A-A-52080	Tape Lacing and Tying, Nylon
A-A-52081	Tape Lacing and Tying, Polyester
A-A-52083	Tape Lacing and Tying, Glass
A-A-55809	Insulation Tape, Electrical, Pressure Sensitive, Adhesive, Plastic
A-A-59474	Insulation Tape, Electrical, High Temperature, PTFE, Pressure Sensitive
MIL-I-19166	Insulation Tape, Electrical, High Temperature, Glass Fibre, Pressure Sensitive
MIL-I-24391	Insulation Tape, Electrical, Plastic, Pressure-Sensitive
MIL-T-713	Twine, Fibrous, Impregnated, Lacing and Tying
MIL-T-81306	Tool, Forming, for Adjustable Plastic and Metal Cable Straps
MS90387	Tool, Hand, Adjustable, for Plastic and Metal Tiedown Straps
SAE AS 23190	Strap, Clamps, and Mounting Hardware, Plastic and Metal for Cable Harness Tying and Support
SAE AS 33671	Strap, Tiedown, Electrical Components, Adjustable, Self-Clinching, Plastic, Type I, Class 1
SAE AS 33681	Strap, Tiedown, Electrical Components, Identification, Adjustable, Self-Clinching, Plastic, Type 11, Class 1

## DEFINITIONS

### Tying

4. Tying is the securing together of a group or bundle of wires, with individual ties at regular intervals around the group or bundle.

### Lacing

5. Lacing is the securing together of a group or bundle of wires, installed inside enclosures, by means of a continuous cord forming loops at regular intervals around the group or bundle. Except for enclosures, wire groups or bundles should not be laced.

### Wire Group

6. A wire group is two or more wires tied or laced together to give identity to an individual system.

### Wire Bundle

7. A wire bundle is two or more wire groups tied or laced together because they are going in the same direction at the point where the tie is located.

## MATERIALS

### CAUTION

Tape listed in Table 8-1 shall be used for tying or lacing bundles containing coaxial cables, with the exception that plastic Class 1, self-clinching straps in accordance with MIL-S-23190 installed by MS90387 tool, may be used for tying bundles containing coaxial cables. When using self-clinching straps, the MS90387 tool tension must be set to minimum. Coaxial cables containing air or air foam dielectric shall not have self-clinching straps used on them.

8. Use narrow flat tape wherever possible for lacing and tying. Round cord may also be used, but its use is not preferred because cord has a tendency to cut into wire insulation. Use cotton, linen, nylon, or glass fibre cord or tape according to temperature requirements (MIL-T-713). Cotton or linen cord or tape must be pre-waxed to make it moisture and fungus resisting. Nylon tape may be waxed or unwaxed. Nylon cord must be waxed in order to make it hold a knot. Glass fibre cord or tape is usually not waxed.

9. Use either vinyl or glass fibre pressure-sensitive tape, according to temperature requirements. Use pressure-sensitive tape only when its use is specifically permitted.

10. Moulded nylon self-clinching cable straps may be used where the strap temperature does not exceed 85°C.

## GENERAL PRECAUTIONS

11. When lacing or tying wire groups or bundles, observe the following precautions:

- a. Lace or tie bundles tightly enough to prevent slipping, but not so tightly that the cord or tape cuts into or deforms the insulation. Be especially careful when lacing or tying coaxial cable, which has a soft dielectric insulation between the inner and outer conductors.

### CAUTION

Do not use round cord for lacing or tying coaxial cable or bundles THAT contain coaxial cable.

- b. Do not use ties on wire groups or bundles located inside a conduit.
- c. When tying wire bundles behind connectors, start ties far enough back from the connector to avoid splaying of contacts.
- d. **Essential Equipment.** Certification basis of the aircraft requires wiring to each system which must operate to maintain flight control of the aircraft under normal or emergency conditions is to be separately routed from other wiring. Essential engine circuits are to have their wiring so routed as to prevent damage to any circuit for one engine affecting circuits of any other engine. Propeller circuits are to be routed separately from all other circuits.

Table 8-1 Tape Lacing and Tying

Description	Part Number
General Use (Natural) (Finish B, Size 4)	A-A-52080-B-4
General Use (Black) (Finish B, Size 3)	A-A-52080-B-3
Rubber Impregnated Co-axial Cable (Finish C, Size 3)	A-A-52081-C-3
Temperature Resistant Engine Looms (Finish D, Size 2) (Seal knot with Glyptal, PN GE1201)	A-A-52083-D-2 AA52083-2-D

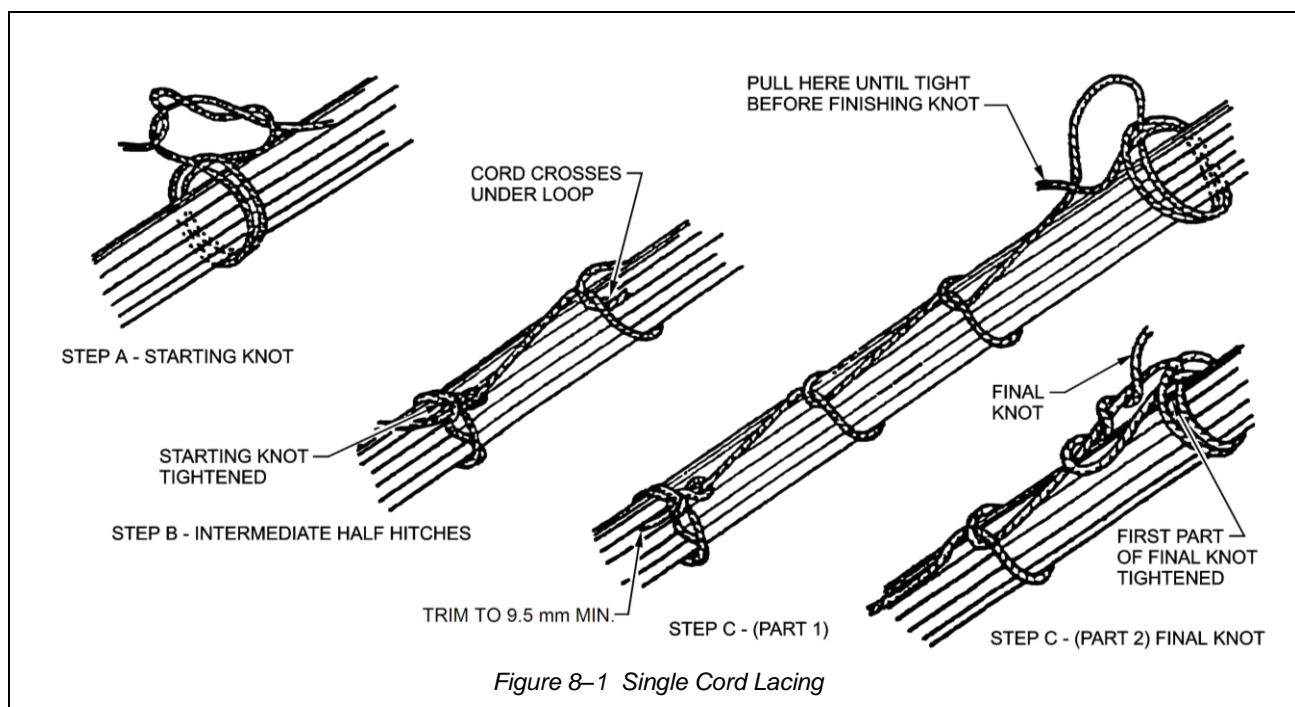


Figure 8-1 Single Cord Lacing

## HARNESS INSTALLATION

**13. Installation Objectives.** Wiring/harness installation is accomplished to conform to the following in order of precedence:

- a. Safety of Flight,
- b. Ease of Maintenance, and
- c. Cost Effectiveness.

**14. Safety of Flight.** Safety of flight is always the prime concern on any accomplished maintenance, and must not be compromised by anyone for any reason.

**15. Ease of Maintenance.** Wiring is installed to achieve the following:

- a. maximum reliability,
- b. minimum interference and coupling between systems,
- c. accessibility for inspection,
- d. accessibility for maintenance, and
- e. prevention of damage.

**16. Cost Effectiveness.** The effectiveness of cost pertains to the contractor but is also dependent upon correct maintenance practices.

**17. Arrangement of Wiring.** Wiring is to be arranged into groups and bundles to facilitate installation and maintenance. Individual groups are spot tied and when these groups are bundled the spot ties are not to be removed.

**18. Bundle and Group Size.** As a design objective, bundles and groups within clamps are to be no more than 50 mm in diameter. High density harnesses are exempt from this requirement. Wiring to high density connectors may be run as a single group, provided all of the wiring in the group is pertinent to a single item, equipment, or system.

**19. High Density Harness Size.** The numbers of wires in a high density harness are to be limited only by efficient and good design. The use of wire sizes larger than AWG 16 is discouraged unless there are also smaller wires in the same harness.

**20. Inspection and Maintenance.** In open wiring, groups are to be installed to permit replacement of the group without the removal of the bundle. High density harnesses are to be designed so that they are readily replaceable in sections.

## LACING

**21.** Continuous lacing may be used only on those wire groups or bundles that are to be installed in panels or junction boxes. Use double cord lacing on groups or bundles larger than 25mm in diameter. Use either single or double cord lacing on groups or bundles 1 inch or less in diameter. For lacing groups that branch off a main bundle, see paragraph 15.

### NOTE

When lacing wire groups or bundles, observe the precautions listed in paragraph 11.

### Single Cord Lacing

**22.** Lace a wire group or bundle with a single cord as follows (see Figure 8-1):

- a. Start the lacing at the thick end of the wire group or bundle with a knot consisting of a clove hitch with an extra loop.
- b. At regular intervals along the wire group or bundle, and at each point where a wire or wire group branches off, continue the lacing with half hitches.

### NOTE

Space half hitches so that the group or bundle is neat and securely held.

- c. End the lacing with a knot consisting of a clove hitch with an extra loop.
- d. Trim the free ends of the lacing cord to 9.5mm minimum.

### Double Cord Lacing

**23.** Lace a wire group or bundle with a double cord as follows (see Figure 8-2):

- a. Start the lacing at the thick end of the wire group or bundle with a bowline on a bight.
- b. At regular intervals along the wire group or bundle, and at each point where a wire group branches off, continue the lacing with half hitches, holding both cords together.

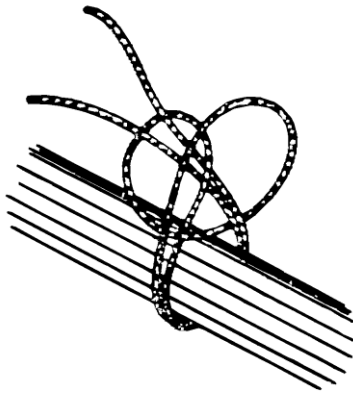
### NOTE

Space half hitches so that the group or bundle is neat and securely held.

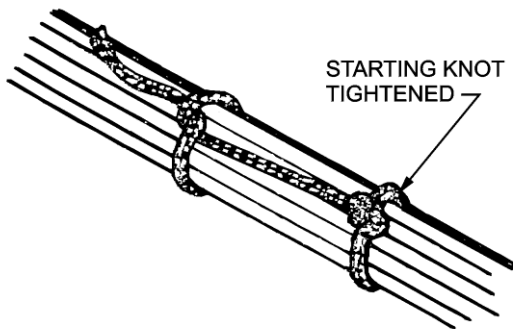
- c. End the lacing with a knot consisting of a half hitch, using one cord clockwise and the other

counter clockwise, and then tying the cord ends with a square knot with an extra loop (see Figure 8-2).

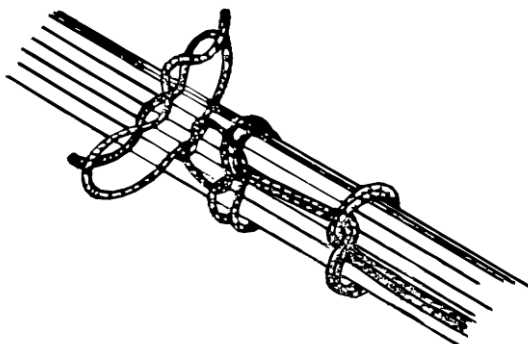
- d. Trim the free ends of the lacing cord to 9.5mm minimum.



STEP A - STARTING KNOT - BOWLINE ON A BIGHT



STEP B - INTERMEDIATE HALF HITCHES



STEP C - FINAL KNOT

Figure 8-2 Double Cord Lacing

### Lacing Branch-Offs

24. Lace a wire group that branches off the main wire bundle as follows (see Figure 8-3):

- Start the branch-off lacing with a starting knot located on the main bundle just past the branch-off point. When single cord lacing is used, make this starting knot as described in paragraph 13, step a; when double cord lacing is used, make it as described in paragraph 14, step a.
- Continue the lacing along the branched off wire group, using regularly spaced half hitches. Where a double cord is used, both cords are held together.

#### NOTE

Space half hitches so that the group or bundle is neat and securely held.

- End the lacing with the regular knot used in single and double cord lacing, as described in paragraph 13, step c, and paragraph 14, step c, respectively.
- Trim the free ends of the lacing cord to 9.5mm minimum.

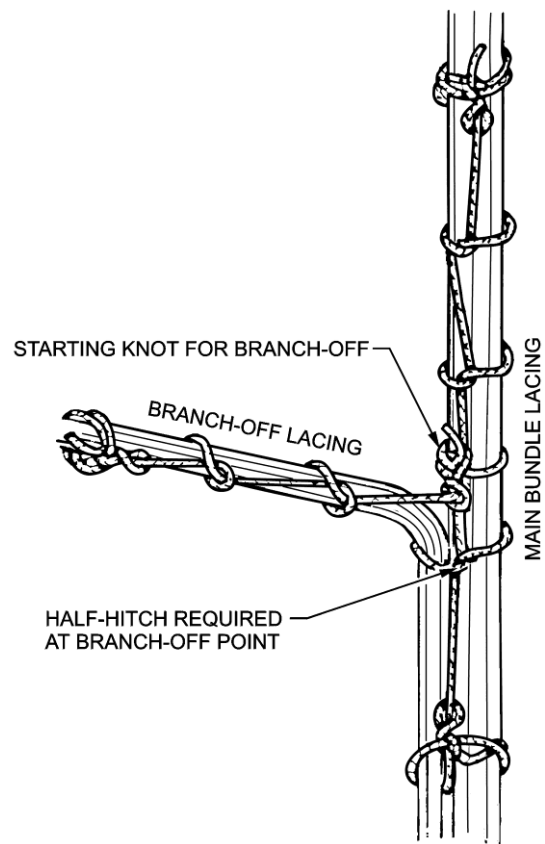


Figure 8-3 Lacing a Branch-Off

## TYING

25. Tie all wire groups or bundles where supports are more than 30cm apart. Space ties 30cm or less apart.

### Making Ties

26. Make ties as follows:

- Wrap cord around wire group or bundle, as shown in Figure 8-4.
- Make a clove hitch, followed by a square knot with an extra loop.
- Trim free ends of cord to 9.5mm minimum.

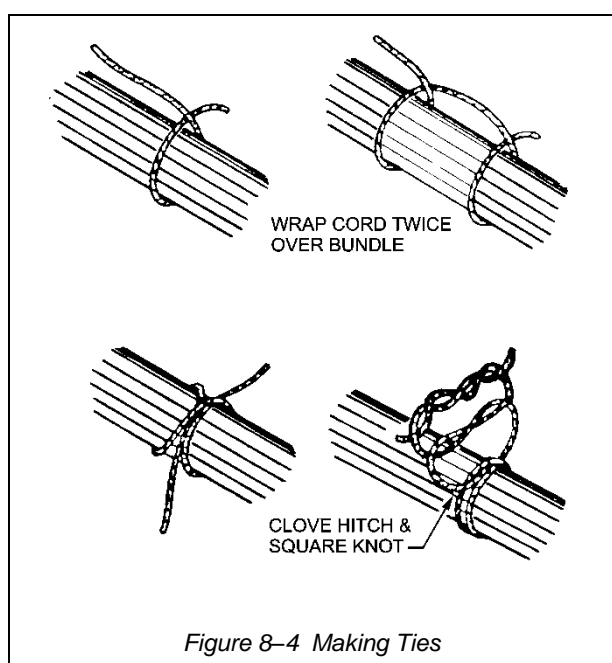


Figure 8-4 Making Ties

### Temporary Ties

27. Temporary ties are used to aid in making up and installing wire groups or bundles. Use coloured cord to make temporary ties; remove these ties when the installation is complete.

#### CAUTION

Cut temporary ties with scissors or diagonal pliers only. Do not use a knife or other sharp edged instrument that may damage the insulation.

### Tying Wire Groups into Wire Bundles

28. Tie wire groups into bundles as described in paragraph 17, treating the wire groups as though they were individual wires.

### Tying Sleeves to Wire Groups or Wire Bundles

29. Secure sleeves to wire groups or bundles by tying.

## SELF-CLINCHING CABLE STRAPS AND SPIRAL WRAP

### Self-Clinching Cable Straps

30. These are adjustable, lightweight, flat plastic straps used for tying and supporting cable assemblies and wire bundles. The strap configuration is shown in. The straps are of two types:

- MS3367 cable securing strap shown by the bold lines in Fig 8-5 and;
- MS3368 identification and securing strap illustrated by the broken lines in Fig 8-5. These straps are available either in black or natural colour.

31. Strap, Tiedown, Black is weather resistant and is to be used where straps are subjected to direct sunlight.

32. Tool tension settings specified in Table 8-2 are for typical wire bundle applications. Settings higher or lower than those specified may be necessary for specific applications.

33. Tiedown straps may be used on wire bundles containing solid dielectric coaxial cables provided that the tension setting on the installation tool is not greater than required to prevent axial slippage.

34. Tiedown straps should NOT be used in the following situations:

- Where total temperature (ambient plus rise) exceeds 85° C.
- Where failure of the strap would permit movement of the wiring against parts which could damage the insulation or foul mechanical linkages.
- Where failure would permit the strap to fall into moving mechanical parts.
- In high vibration areas.
- Outside the fuselage.
- In wheel wells.
- Where exposure to ultraviolet light might exist, unless the straps are resistant to such exposure ie. black coloured straps.
- To tie wire groups or harnesses within bundles.
- On coaxial cables or wire bundles containing coaxial cables which do not have solid dielectrics.

35. Paragraph 25 step f disallows the use of tiedown straps in wheel well applications. Concession is given to use black tiedown straps PN MS3367-3-0 and MS3367-6-0 enclosed in plastic tubing PN G167 or equivalent, to secure wiring in wheel well applications where all other avenues to secure the wiring in accordance with this publication have been exhausted.

36. Tiedown straps conforming to SAE AS23190 can be supplied with either a metal or plastic locking device. Both types are suitable for aircraft use.

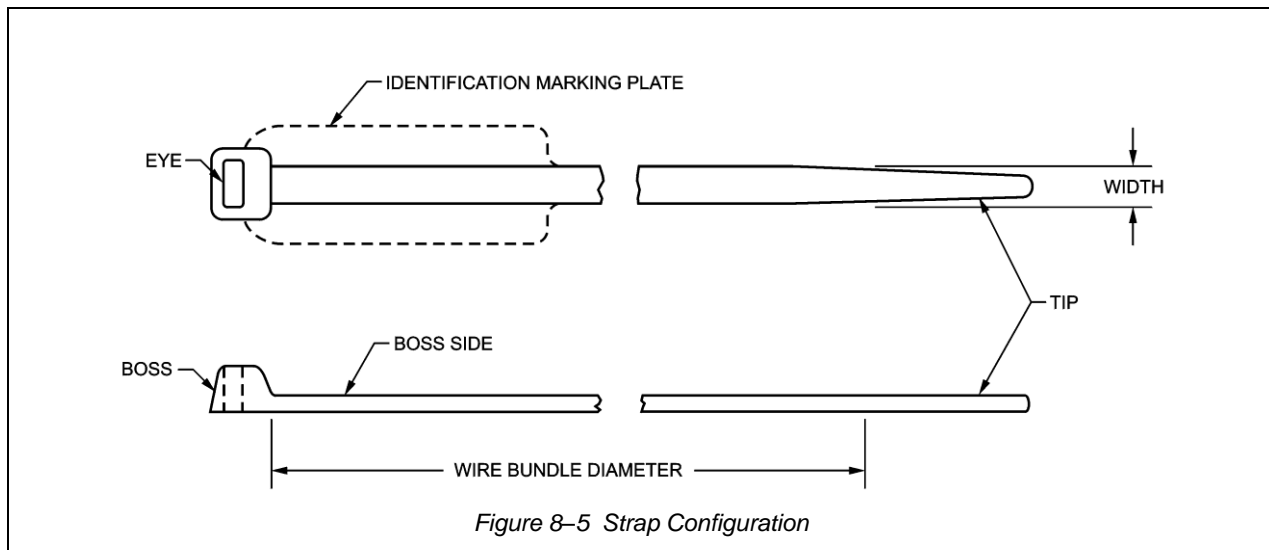


Table 8-2 Self Clinching Cable Straps and Installation Tools

Part Number	Description (Width/Length) [Inches]	Bundle Diameter (Min-Max) mm [Inches]	Tool Part Number	Tool Tension Setting
MS3367-1-0	Strap, Tiedown, Electrical Components, Standard, Black (0.190/6.30)	1.587-44.45 (0.0625 – 1.750)	MS90387-1	6 to 8
MS3367-1-9	Strap, Tiedown, Electrical Components, Standard, Natural (0.190/6.30)	1.587-44.45 (0.0625 – 1.750)	MS90387-1	6 to 8
MS3367-2-0	Strap, Tiedown, Electrical Components, Standard, Black (0.192/13.35)	1.587-101.60 (0.0625 – 4.0)	MS90387-1	6 to 8
MS3367-2-9	Strap, Tiedown, Electrical Components, Standard, Natural (0.192/13.35)	1.587-101.60 (0.0625 – 4.0)	MS90387-1	6 to 8
MS3367-3-0	Strap, Tiedown, Electrical Components, Heavy, Black (0.310/12.0)	4.763-88.90 (0.1875 – 3.5)	MS90387-2	5 to 8
MS3367-3-9	Strap, Tiedown, Electrical Components, Heavy, Natural (0.310/12.0)	4.763-88.90 (0.1875 – 3.5)	MS90387-2	5 to 8
MS3367-4-0	Strap, Tiedown, Electrical Components, Miniature, Black (0.100/2.72)	4.763-15.87 (0.1875 – 0.625)	MS90387-1	1 to 3
MS3367-4-9	Strap, Tiedown, Electrical Components, Miniature, Natural (0.100/2.72)	4.763-15.87 (0.1875 – 0.625)	MS90387-1	1 to 3
MS3367-5-0	Strap, Tiedown, Electrical Components, Intermediate, Black (0.146/4.68)	4.763-31.75 (0.1875 – 1.25)	MS90387-1	3 to 5
MS3367-5-9	Strap, Tiedown, Electrical Components, Intermediate, Natural (0.146/4.68)	4.763-31.75 (0.1875 – 1.25)	MS90387-1	3 to 5
MS3367-6-0	Strap, Tiedown, Electrical Components, Heavy, Black (0.310/26.25)	4.763-203.20 (0.1875 – 8.0)	MS90387-2	5 to 8
MS3367-6-9	Strap, Tiedown, Electrical Components, Heavy, Natural (0.310/26.25)	4.763-203.20 (0.1875 – 8.0)	MS90387-2	5 to 8
MS3367-7-0	Strap, Tiedown, Electrical Components, Standard, Black (0.192/10.2)	1.587-76.2 (0.0625 – 3.0)	MS90387-1	6 to 8
MS3367-7-9	Strap, Tiedown, Electrical Components, Standard, Natural (0.192/10.2)	1.587-76.2 (0.0625 – 3.0)	MS90387-1	6 to 8

#### Cable Strap Installation

37. Using the Military hand tool listed in Table 8-2 and illustrated in Figure 8-6, perform the following:

- a. From Table 8-2 select a strap size and appropriate tool for the wire bundle diameter being secured. (Refer to paragraph 25 for restrictions on strap usage).

- b. Slip strap tip around the bundle with boss side up.
- c. Thread tip through eye then hand pull strap tight against the bundle.
- d. Adjust the tool index line to the tension locator value specified in Table 8-2. If standard changes in the tension adjustment knob does not align the index line with the required tension locator value, the knob may be pulled out and rotated until alignment occurs.
- e. Pass the free end of the cable tie through the slot in the end of the tool, then push tool snugly against the boss.
- f. While holding strap firmly against side of tool and tool face squarely against boss, pump handle several times without fully activating the tool's cutting knife. Once the strap has been stretched to its maximum, squeeze handle slowly and firmly until strap is cut.

#### WARNING

The strap must be cut flush with the boss surface in order to eliminate painful cuts and scratches from protruding strap ends.

- g. Inspect strap end to ensure strap end is flush with boss surface and trim or replace strap as required to ensure strap end is flush with boss surface.
- h. Carry out appropriate disposal of all broken straps and strap ends that were cut off.

#### Spiral Wrap

38. The use of Tube, Plastic, Spiral Wrap (Spirap) as an alternative method to prevent chafing of wiring is discouraged. However, where chafing cannot be avoided using procedures listed in Section 2, Chapter 4, the use of Spirap is approved.

39. Listed in Table 8-3 are identification details for Spirap for use in various environments.

#### LACING AND TYING IN HIGH TEMPERATURE AREAS

40. Use A-A-59474 high temperature insulation tape to tie all wire groups and cable bundles in areas where the temperature may go above 85°C. Use MIL-I-19166 high temperature insulation tape in areas where the temperature may exceed 85°C and dimensional stability of the tape is required. (jet turbine engine areas).

#### WARNING

MIL-I-15126 insulation tape (including the glass fibre type) is highly flammable and should not be used in a high temperature environment. A-A-59474 insulation tape is designed for high-temperature operation (suitable for continuous operation at 260°C) and should be used in high temperature environments at or below 260°C. MIL-I-19166 glass fibre insulation tape is designed for jet turbine engine areas where temperatures may exceed 370°C where dimensional stability and high strength are required.

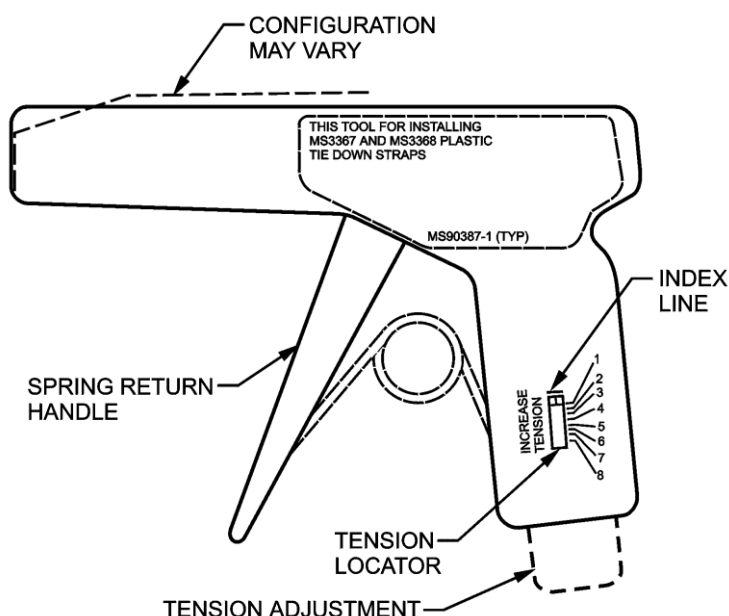


Figure 8-6 MS90387 Adjustable Hand Tools for Installing Self-Clinching Plastic Tiedown Straps

*Table 8-3 Selection of Spirap*

Part Number	Nomenclature	Description (Tube Diameter)
B47287-I-1/2	Tube, Plastic, Spiral Wrap Natural Colour	PTFE (Teflon) (12.7 mm)
B47287-I-3/8	Tube, Plastic, Spiral Wrap Natural Colour	PTFE (Teflon) (9.5 mm)
B47287-I-1/4	Tube, Plastic, Spiral Wrap Natural Colour	PTFE (Teflon) (6.35 mm)
B47287-I-1/8	Tube, Plastic, Spiral Wrap Natural Colour	PTFE (Teflon) (3.17 mm)
B47287-II-1.00	Tube, Plastic, Spiral Wrap Black	Polyamide (Nylon) (25.4 mm)
B47287-II-3/4	Tube, Plastic, Spiral Wrap Black	Polyamide (Nylon) (19.0 mm)
B47287-II-1/2	Tube, Plastic, Spiral Wrap Black	Polyamide (Nylon) (12.7 mm)
B47287-II-1/4	Tube, Plastic, Spiral Wrap Black	Polyamide (Nylon) (6.35 mm)
B47287-II-1/8	Tube, Plastic, Spiral Wrap Black	Polyamide (Nylon) (3.17 mm)