Australian Government
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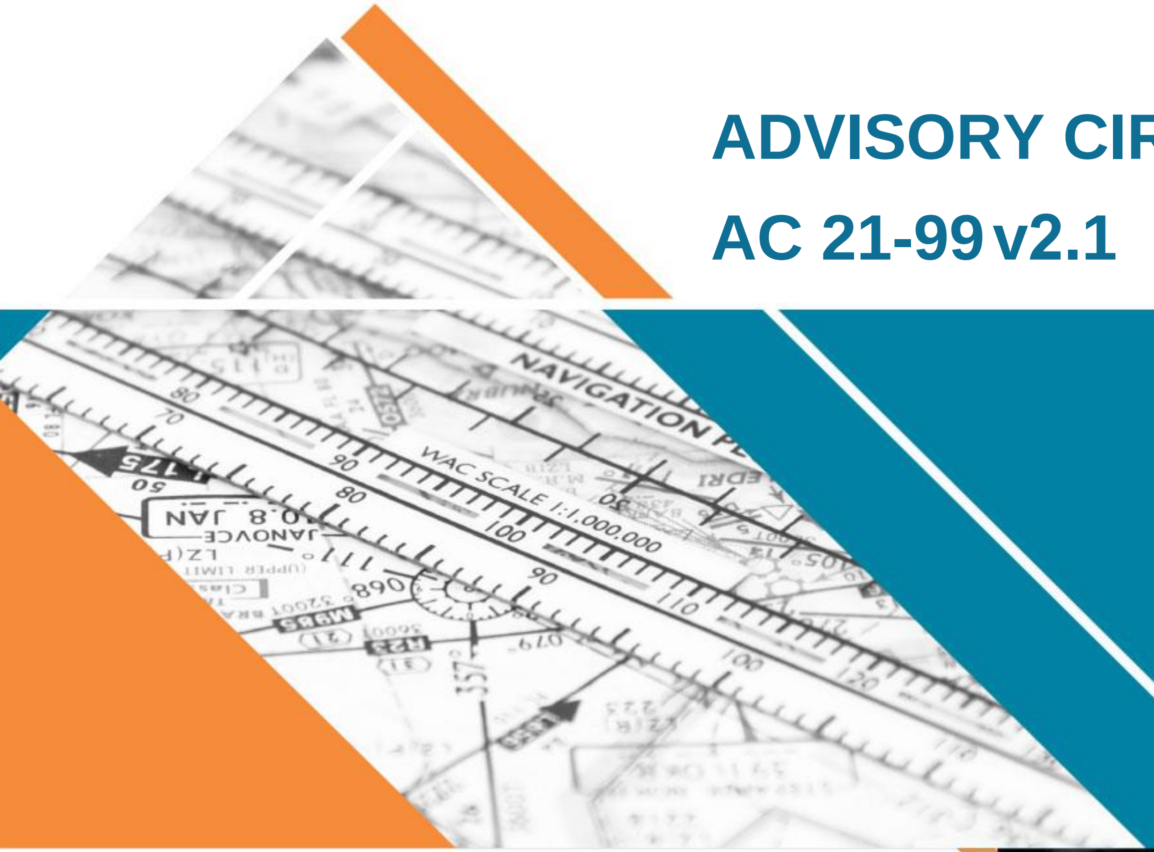

Aircraft wiring and bonding

Date	December 2022
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Advisory circulars are intended to provide advice and guidance to illustrate a means, but not necessarily the only means, of complying with the Regulations, or to explain certain regulatory requirements by providing informative, interpretative and explanatory material.

Advisory circulars should always be read in conjunction with the relevant regulations.

Purpose

This AC provides guidance material for maintenance of aircraft electrical systems and bonding of aircraft.

For further information

For further information, contact CASA's Airworthiness and Engineering Branch (telephone 131 757).

Status

This version of the AC is approved by the Branch Manager, Airworthiness and Engineering.

Note: Changes made in the current version are not annotated. The document should be read in full.

Version	Date	Details
v2.1	December 2022	Administrative review only.
(1)	September 2013	This is the second issue of this Advisory Circular. It has been amended with further guidance on maintenance of aged wiring and a section on the use of solder sleeves to terminate or install shielded cable has been added. Clearer illustrations of crimping tools and related wiring maintenance processes have been provided. The updated Section 2 Chapters are 3, 5, 6, 8, 10, 12 and 17.
(0)	August 2011	Initial AC.

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SECTION 1

CHAPTER 1

INTRODUCTION

GENERAL

1. This AC has been produced to assist personnel engaged in the installation, maintenance and repair of aircraft and ground support equipment (GSE) electrical systems.

2. The satisfactory performance of present-day aircraft depends to a very great extent on the continuing reliability of its electrical system. Improperly or carelessly installed wiring can be a source of both immediate and potential danger, and many malfunctions and failures of an electrical system can be traced to this cause. The performance of the system depends on the quality of the design, plus the workmanship used in producing the installation. The continued proper performance of the system depends on the 'know-how' of the personnel who carry out the inspection, repair and maintenance.

3. It is extremely important therefore, that maintenance and repair operations, as well as the original installation, be carried out in accordance with the best available techniques in order to eliminate possible failures or at least to minimise them.

PURPOSE

4. The purposes for which this AC was written are as follows:

- **a.** To gather together under one cover the recommended practices and techniques to be used for installing, repairing, and maintaining aircraft and GSE electrical wiring.
- **b.** To standardise these techniques and methods so that electrical installations will be uniform.
- **c.** To highlight to all personnel the importance of good workmanship and the failures which may result from poor workmanship.
- **d.** To promote safety by pointing out unsafe practices.

SCOPE

5. This AC covers all general purpose wiring and wiring devices used for the interconnection of equipment in aircraft. It also includes details of thermocouple systems and coaxial, fibre optics, and data bus cabling installed in aircraft. This AC is not intended to replace aircraft manufacturers wiring manuals or recommended practices.

INTENDED USE

6. This AC is intended to be used as a separate manual for general wiring practices, and is primarily used by personnel engaged in maintenance and repair of aircraft wiring systems were no other data exists for repair or maintenance. Its use is recommended for such personnel, except where any procedure contained in it conflicts with any aircraft or equipment specific publication in which case the aircraft or equipment specific document should take precedence.

ARRANGEMENT OF MATERIAL

7. The material is divided into chapters. Each chapter describes and illustrates the recommended procedure for a single operation, or for a series of related operations.

8. The first seven chapters contain procedures for preparing and identifying wire, and for assembling it to connectors, terminals and splices. Later chapters deal with procedures for thermocouple wiring, bonding and grounding, soldering, potting, routing and support of wire bundles, and preparation and installation of busses, terminal blocks, junction boxes, and protective devices.

9. The material in each chapter is arranged as far as possible in the general order in which the operations are performed. Illustrations and tables are located as near as possible to the related text. Each topic is headed by an introduction containing a short description of the subject and its function in the aircraft electrical system. Where necessary for clarity, a list of definitions is included.

10. Also included, after the introduction of applicable chapters, is a listing of applicable specifications for the various materials required and design procedures on which these installation techniques are based. The latest applicable revision of the listed specifications shall apply.

REVISIONS

11. Amendments will be made from time to time to ensure that the material in the manual will always reflect the best current techniques and keep abreast of the new developments in the field. Suggestions for correcting or improving this manual are invited and should be submitted to the Standards Division at CASA, www.casa.gov.au

SECTION 2

CHAPTER 1

WIRE AND CABLE

INTRODUCTION

1. In order to make installation, maintenance, and repair easier, runs of electric wire and cable in aircraft are broken at specified locations by junctions such as connectors, terminal blocks, busses, etc. Before assembly to these junctions, wires and cables must be cut to length, identified, stripped, and if required, tinned.

2. This chapter describes a variety of wire and cables suitable for use in aircraft.

REFERENCE SPECIFICATIONS

3. The following specifications are applicable to aircraft wire and cable preparation:

MIL-C-17	Cable, Radio Frequency, Flexible and Semirigid, General Specification
MIL-C-5756	Cable and Wire Power, Electric, Portable
MIL-C-85485	Cable, Electric, Filter Line, Radio Frequency Absorptive
MIL-DTL-16878	Wire, Electrical, Insulated, General Specification
MIL-DTL-25038	Wire, Electrical, High Temperature and Fire Resistant Aircraft
MIL-DTL-8777	Wire, Electrical Silicone Insulated Copper, 600 Volts, 200°C
MIL-W-22759	Wire, Electric, Fluoropolymer Insulated, Copper or Copper Alloy
MIL-W-7072 (Cancelled)	Wire Electric, 600 Volts, Aluminium, Aircraft
NEMA WC 27500	Cable, Electrical, Shielded and Unshielded, Aerospace
SAE AS 81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy
MIL-DTL-81381	Wire, Electric, Polyimide Insulated, Copper and Copper Alloy

DEFINITIONS

Insulated Wire

4. For the purposes of electric and electronic installation in aircraft, an insulated wire consists of a metal conductor covered with a dielectric or insulating material (refer to Figure 1–1). Insulated wire is usually referred to as “wire” and will be so designated in this manual. Wires used in aircraft contain stranded conductors for flexibility. Insulations may consist of several materials and layers to provide dielectric insulation, thermal protection, abrasion resistance, moisture resistance, and fluid resistance. Wires commonly used in aircraft are described in Table 1–1. Insulations commonly used in aircraft are described in Table 1–2.

Cable

5. The term “cable,” as used in aircraft electrical installations (refer to Figure 1–2), includes the following:

- **a.** Two or more insulated conductors, contained in a common covering, or twisted together without a common covering (multi-conductor cable).
- **a.** One or more insulated conductors with an overall shield, or with an overall shield and a jacket over the shield (shielded cable).
- **b.** Two insulated conductors twisted together (twisted pair).
- **c.** A single insulated centre conductor with a metallic braided outer conductor (coaxial cable). The concentricity of centre and outer conductor is carefully controlled during manufacture to ensure that they are coaxial.

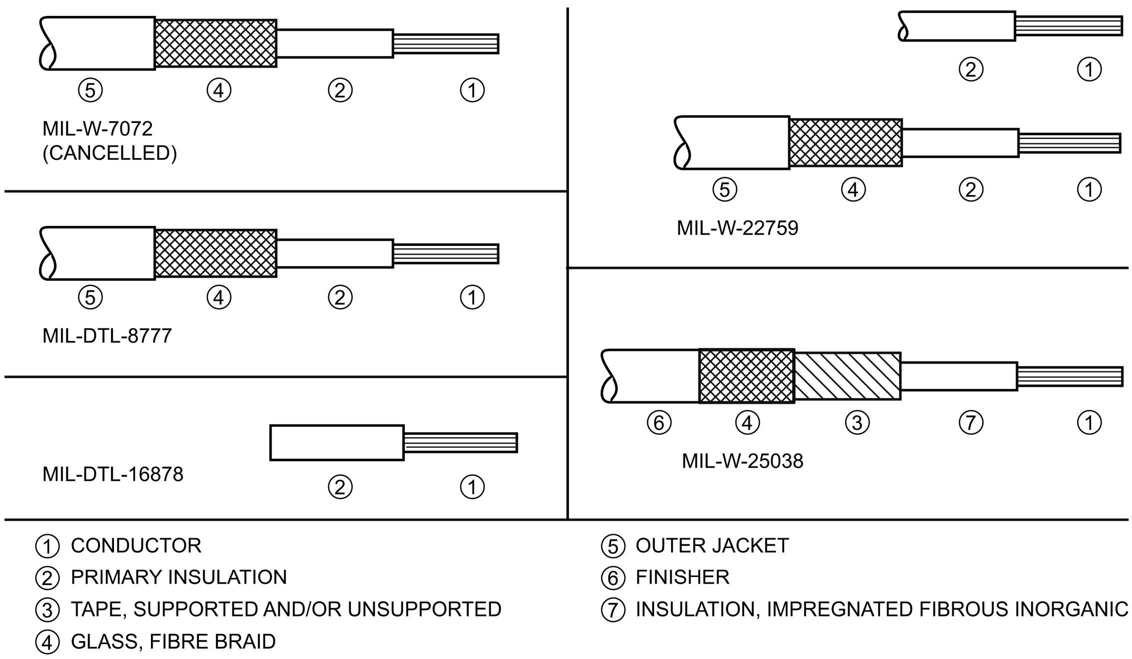


Figure 1- 1 Wires Commonly Used In Aircraft

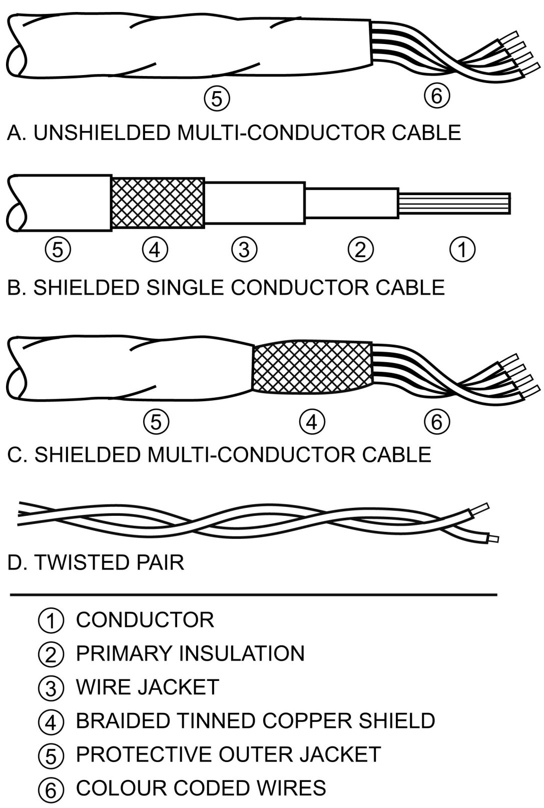


Figure 1- 2 Cables Commonly Used In Aircraft

6. Cables commonly used in aircraft include the following:

MIL-C-17	Cable, Radio Frequency, Flexible and Semirigid (Coaxial)
MIL-C-5756	Single or multiple conductor, rubber insulated conductor, rubber jacket.
MIL-C-85485	Cable, Electric, Filter Line, Radio Frequency Absorptive
NEMA WC 27500	Single or multiple conductor, using any wire listed in Table 1–1, shielded, with tin coated, silver-coated, or nickel-coated copper braid as appropriate and covered with appropriate jacket.

SELECTION OF AIRCRAFT ELECTRICAL WIRE AND CABLE

General

7. Wire and cable is to be of a type suitable for the application. It is to be selected so that the maximum conductor temperature is not exceeded for any combination of electrical loading, ambient temperature and heating effects of bundles, conduits or other enclosures. Factors to be considered include voltage, current, ambient temperature, mechanical strength, abrasion qualities, flexibility and pressure/altitude requirements.

8. This AC limits the installation of specific wire type/gauge in aircraft to replacement of old type wire with a similar type and appropriate gauge as detailed in this chapter or applicable aircraft documentation.

> NOTE
>
> Installation of wire for modification, design or repair for devices used in aerospace applications, should conform to SAE AS 50881, Wiring Aerospace Vehicle.

9. A standard of wire is MIL-W-22759 and is suitable for general aircraft use. Annex C to this chapter details the method of determining the appropriate wire part number. If the part number is not identified:

a. Variants of the original part number may be required ie colour, stranding or insulation type,

b. Other Military Specification wire types should be investigated.

Aluminium Wire

10. The use of aluminium wire for aircraft use is quite limited and whenever replacement of an installed wire is necessary, it may be advantageous to consider copper wire with similar electrical/physical characteristics. Currently there are no appropriate specifications detailing aluminium wire suitable for use in general aviation aircraft. Annex E to this chapter provides details of MIL-W-7072 that was cancelled in 1997. This information may be useful when determining a suitable replacement wire.

> NOTE
>
> Aluminium wire may be used on new aircraft designs and manufacturers information should be used to maintain this type of wire.

Airframe Wire

11. Airframe wire is wire that is specifically designed for use as component interconnection wire in the airframe of aerospace vehicles. Airframe wire is usually classed as normal or medium weight and has two insulation coverings for protection against abrasions. This type of wire should be used where a secondary covering of insulation material is not required. The M22759/34 (tin plated, 150°C) and M22759/43 (silver plated, 200°C) wire is suitable for general airframe wire.

Table 1–1 Airframe Wire Used In Aircraft Electrical Installations

Applicable Specification	**Title/Description**
MIL-DTL-16878	Wire, Electrical, Insulated, General Specification For
MIL-DTL-25038	Wire, Electrical, High Temperature and Fire Resistant, Aircraft
MIL-DTL-81381	Wire, Electric, Polyimide-Insulated, Copper and Copper Alloy
MIL-DTL-8777	Wire, Electrical, Silicone-Insulated, Copper, 600V, 200°C
MIL-W-22759	Wire, Electric, Fluoropolymer Insulated, Copper or Copper Alloy
MIL-W-7072 (Cancelled)	Wire, Electric, 600 Volt, Aluminium, Aircraft, General Specification For
SAE-AS-81044A	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-imide, or Polyarylene Insulated, Copper or Copper Alloy

> NOTE
>
> Stranded conductor wire is used for flexibility. In low temperature wire (150°C), copper or copper alloy strands are tin plated to facilitate soldering. In wire rated at 200°C conductor temperature, silver plating is used to protect the copper from oxidation and to facilitate soldering. Wires for high temperatures (260°C) are nickel plated to prevent oxidation. Nickel plated wire is more difficult to solder, but satisfactory solder connections can be made with proper techniques. It is also more difficult to obtain low resistance crimp terminations on nickel plated wire.

> NOTE
>
> Hookup wire is not to be used in the airframe of aerospace vehicles where the wire or loom is not covered with a secondary insulation (ie PTFE conduit) for abrasion protection.

Hookup Wire

12. Hookup wire is designed for component interconnection inside a box or as an airframe wire only where there is a secondary insulation covering for abrasion protection. Hookup wire is usually classed as lightweight and has only one insulation covering. Hookup wire is normally of a smaller overall diameter than the equivalent gauge airframe wire. M22759/32 (tin plated, 150°C) and M22759/33 (silver plated, 200°C) wire is suitable for general hookup wire.

Specifications

13. Annexes to this chapter contain limited details of each Military Specification wire and cable suitable for aircraft use.

Table 1–2 Common Aircraft Wire Insulations

Type	**Description**
Asbestos	Asbestos is used to provide high temperature and flame resistance. No longer suitable for use due to health and safety issues.
ETFE – (Ethylene-tetrafluoroethylene)	ETFE is a fluoropolymer rated up to 260°C. It is widely used as aircraft wire insulation.
FEP-Fluorocarbon (Fluorinated ethylene propylene)	FEP is rated at 200°C, but will melt at higher temperatures. FEP has properties similar to TFE, but will melt at soldering temperatures.
Glass Braid	Widely used to provide thermal resistance and cut-through resistance. However, it may absorb moisture and its use is becoming less prevalent.
Polyamide (Nylon)	Widely used in low temperature wires as an outer insulation layer for abrasion resistance and fluid resistance.
Polyimide (Kapton)	This material has excellent thermal, abrasion, and cut-through resistance characteristics however due to its susceptibility to arc tracking it's use is discouraged in new installations.
PVC (Polyvinyl Chloride)	PVC is a common wire insulation and is fitted in older aircraft. It is no longer approved for use in manned aerospace applications. It may be used for replacement purposes however alternate insulations should be considered.
Silicone Rubber	Silicone rubber is rated at 200°C. It is highly flexible and self-extinguishing after flame except in vertical runs. The ash produced is non-conducting.
TFE-Fluorocarbon (polytetrafluoroethylene)	TFE or PTFE is widely used as a high-temperature insulation. It will not burn but will vaporise in flame. It will not melt at soldering temperatures. TFE is resistant to most fluids.
XLETFE – Crosslinked Ethylene-tetrafluoroethylene	XLETFE is ETFE that has been irradiated (crosslinked) to produce a tougher insulation.

Limitations

14. Insulation. Except for existing installations, the use of polyvinyl chloride (PVC) insulated wire and cable for manned aerospace applications is prohibited.

15. Kapton. Due to the undesirable properties exhibited by polyimide (Kapton) insulated wiring, its use in aircraft should be avoided wherever practicable.

Wire Temperature Ratings

16. Generally, aircraft electrical wire must be selected to perform continuously in a specified temperature range ie 150°C, 200°C, 260°C or fire resistant. Degradation will occur if the wire is subjected to continuous operation at elevated temperatures. Factors to be considered that will affect the temperature are:

a. Wire Gauge. The wire should be of a gauge to ensure adequate current carrying capacity so that the voltage drops are acceptable.

b. Current Carrying Capacity. The continuous duty current for each wire gauge is specified in Annex I to this chapter.

c. Bundle/Looms **or Conduit.** Annex I to this chapter details current ratings for the following:

(1) wires positioned in free air, and

(2) wires in bundles, conduit or confined areas.

NOTE

The ratings listed in Annex I are based upon bundles of 33 or more wires. For further information on current ratings, refer to SAE AS 50881 or contact the publication sponsor.

d. Aluminium Wire. The use of aluminium wire shall be restricted in applications and should not be:

(1) directly attached to engine mounted accessories or any area of severe vibration, or

e. installed where frequent connection/disconnection is necessary.

f. Aluminium Terminations. Aluminium terminations should conform to SAE AS 70991. Refer to Section 2, Chapter 6 of this publication for details of aluminium terminals.

g. Minimum Wire Size. The minimum wire sizes are specified below unless authorised by specific aircraft publications.

(1) Copper Wire. SAE AS 50881 prohibits the use of wires smaller than 22 AWG for use in aircraft, helicopters and lighter than air vehicles. This restriction is due to maintenance difficulties, however many service aircraft have now been manufactured using 24 AWG and 26 AWG wire. When required, these wires should be repaired/replaced with similar gauge wires. Appropriate precautions should be taken to prevent failure caused by vibration and handling and wires should be adequately supported at each termination. For direct attachment to engine mounted accessories, wire size smaller than 18 AWG should not normally be used, however where 20 AWG wires are required they may be used, provided they are grouped, spot tied and clamped to the connector. If fewer than four 20 AWG wires are used with one connector, insulated tubing is to be used.

(2) Aluminium Wire Size. Aluminium wire is restricted to 8 AWG minimum. (Refer to para 10).

h. Maximum Wire Size. The maximum wire sizes should be as listed below, unless specifically authorised by the applicable aircraft documentation.

(1) Copper wire - 2 AWG.

(2) Aluminium wire - 0 AWG.

Annexes:

A. MIL-DTL-16878 Wire, Electrical, Insulated, General Specification

B. SAE-AS-81044 Wire, Electrical, Crosslinked Polyalkene, Crosslinked Alkane-imide Polymer or Polyarylene Insulated Copper or Copper Alloy

C. MIL-W-22759 Wire, Electric Fluoropolymer Insulated Copper or Copper Alloy

D. MIL-DTL-25038 Wire, Electrical, High Temperature, Fire Resistant and Flight Critical, General Specification

E. MIL-W-7072 Wire, Electric, 600 Volt, Aluminium, Aircraft, General Specification

F. NEMA WC 27500 Standard For Aerospace and Industrial Electrical Cable

G. MIL-DTL-81381 Wire, Electric, Polyimide-Insulated, Copper

H. MIL-C-85485 Cable, Electric, Filter Line, Radio Frequency Absorptive

I. Current Ratings of Wire and Maximum Allowable Nicked or Broken Strands

J. Wire Gauge Comparison

MIL-DTL-16878 WIRE, ELECTRICAL, INSULATED, GENERAL SPECIFICATION

Scope

1. This specification covers unshielded wire for hook-up and lead wiring of electrical and electronic components and equipment. The temperature rating of wire under this specification ranges from -65°C to 260°C, with potential rating from 250Vrms to 5000Vrms.

Specification Sheets

2. Specification Sheets are as follows:

Table 1-A-1 Specification Sheets

Description	MIL-W-16878D	MIL-W-16878E	MIL-W-16878F	MIL-DTL-16878G
600 Volt,105°C, PVC	TYPE B	M16878/1 M16878/17	M16878/1 M16878/17	M16878/1 M16878/17
1000 Volt,105°C, PVC	TYPE C	M16878/2 M16878/18	M16878/2 M16878/18	M16878/2 M16878/18
3000 Volt,105°C, PVC	TYPE D	M16878/3 M16878/19	M16878/3 M16878/19	M16878/3 M16878/19
600 Volt, 200°C/260°C, PTFE	TYPE E	M16878/4 M16878/21 M16878/25 M16878/26	M16878/4 M16878/21 M16878/25 M16878/26	NEMA HP 3 NEMA HP 3 NEMA HP 3 NEMA HP 3
1000 Volt, 200°C/260°C, PTFE	TYPE EE	M16878/5 M16878/22 M16878/27 M16878/28 M16878/34 M16878/35	M16878/5 M16878/22 M16878/27 M16878/28 M16878/34 M16878/35	NEMA HP 3 NEMA HP 3 NEMA HP 3 NEMA HP 3 NEMA HP 3 NEMA HP 3
250 Volt, 200°C/260°C, PTFE	TYPE ET	M16878/6 M16878/20 M16878/23 M16878/24	M16878/6 M16878/20 M16878/23 M16878/24	NEMA HP 3 NEMA HP 3 NEMA HP 3 NEMA HP 3
600 Volt, Silicone Rubber	TYPE F	M16878/7 M16878/29	M16878/7 M16878/29	M16878/7 M16878/29
1000 Volt, Silicone Rubber	TYPE FF	M16878/8 M16878/30 M16878/31 M16878/32	M16878/8 M16878/30 M16878/31 M16878/32	M16878/8 M16878/30 M16878/31 M16878/32
PE, 75°C	TYPE J	M16878/10 M16878/33	M16878/10 M16878/33	M16878/10 M16878/33
FEP, 600 Volt, 200°C	TYPE K	M16878/11	M16878/11	NEMA HP 4
FEP, 1000 Volt, 200°C	TYPE KK	M16878/12	M16878/12	NEMA HP 4
FEP, 250 Volt, 200°C	TYPE KT	M16878/13	M16878/13	NEMA HP 4
XLPE, 600 Volt, 125°C	- - -	M16878/14	M16878/14	M16878/14
XLPE, 1000 Volt, 125°C	- - -	M16878/15	M16878/15	M16878/15
XLPE, 3000 Volt, 125°C	- - -	M16878/16	M16878/16	M16878/16
XLPO, 600 Volt, 105°C	- - -	- - -	M16878/36	M16878/36

Table 1-A-1 Specification Sheets (continued)

Description	MIL-W-16878D	MIL-W-16878E	MIL-W-16878F	MIL-DTL-16878G
EPDM, 600 Volt, 125°C	- - -	- - -	M16878/37	M16878/37
EPDM, 5000 Volt, 125°C	- - -	- - -	M16878/38	M16878/38
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)				
NEMA HP 3 -	Electrical and Electronic PTFE Insulated High Temperature Hook-Up Wire; Types ET (250 Volts), E (600 Volts) and EE (1000 Volts)			
NEMA HP 4 -	Electrical and Electronic FEP Insulated High Temperature Hook-Up Wire; Types KT (250 Volts), K (600 Volts) and KK (1000 Volts).			

Part Number

3. Part numbers under this specification are coded as in the following example:

Table 1-A-2 Part Number Coding

M16878/3	B	C	B	903
Specification Sheet (para 2)	Conductor Material (para 4)	Conductor Size (para 5)	Conductor Stranding (para 6)	Insulation Colour Code (para 7)

Conductor Material

4. Conductor Material is designated by a single letter as follows:

B – Coated Copper

C – Coated Copper-Clad Steel

D – Coated High Strength Copper Alloy

Conductor Size

5. The conductor American Wire Gauge (AWG) size is designated by a single letter as follows:

Table 1-A-3 Conductor Size

AWG	Letter	AWG	Letter
32	A	10	M
30	B	8	N
28	C	6	P
26	D	4	R
24	E	2	S
22	F	1	T
20	G	0	U
18	H	00	W
16	J	000	Y
14	K	0000	Z
12	L		

Conductor Stranding

6. The number of strands making up the conductor is designated by a single letter as follows:

Table 1-A-4 Conductor Stranding

Number of Strands	Letter	Number of Strands	Letter
1	A	133	L
7	B	259	M
10	C	427	M
16	D	665	P
19	E	817	R
26	F	1045	S
37	G	1330	T
41	H	1672	V
65	J	2109	W
105	K		

Insulation Colour Code

7. The insulation colour code is in accordance with the identification coding of MIL-STD-681 and may be one, two, or three digits depending on the number of stripes or bands. The first number is the colour of the insulation; the second number is the colour of the first stripe or band; and the third number is the colour of the second stripe or band. The colours and their corresponding numbers are as follows:

Table 1-A-5 Colour Code

Colour	Number Designator	Colour	Number Designator
Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet (Purple)	7
Orange	3	Grey (Slate)	8
Yellow	4	White	9

SAE-AS-81044 WIRE, ELECTRICAL, CROSSLINKED POLYALKENE, CROSSLINKED ALKANE-IMIDE POLYMER OR POLYARYLENE INSULATED COPPER OR COPPER ALLOY

Scope

1. This specification covers single conductor electric wires made as specified in the applicable specification sheet with tin-coated, silver-coated or nickel-coated copper or copper alloy conductors insulated with crosslinked polyalkene, crosslinked alkane-imide polymer or polyarylene. The crosslinked polyalkene, crosslinked alkane-imide polymer or polyarylene may be used alone or in conjunction with other materials as detailed in the specification sheet.

Specification Sheets

2. Specification Sheets are as follows:

Table 1-B-1 Specification Sheets

Specification No	Title
SAE-AS-81044/5	Wire, Electric, Crosslinked Polyalkene Insulated, Silver-coated Copper, Normal Weight, 600 Volt, 150°C.
SAE-AS-81044/6	Wire, Electric, Crosslinked Polyalkene Insulated, Tin-coated Copper, Normal Weight, 600 Volt, 150°C.
SAE-AS-81044/7	Wire, Electric, Crosslinked Polyalkene Insulated, Silver-coated Copper, High Strength Copper Alloy, Normal Weight, 600 Volt, 150°C.
SAE-AS-81044/8	Wire, Electric, Crosslinked Polyalkene Insulated, Silver-coated Copper, Medium Weight, 600 Volt, 150°C.
SAE-AS-81044/9	Wire, Electric, Crosslinked Polyalkene Insulated, Tin-coated Copper, Medium Weight, 600 Volt, 150°C.
SAE-AS-81044/11	Wire, Electric, Crosslinked Polyalkene Insulated, Silver-coated Copper, Light Weight, 600 Volt, 150°C.
SAE-AS-81044/12	Wire, Electric, Crosslinked Polyalkene Insulated, Tin-coated Copper, Light Weight, 600 Volt, 150°C.

Part Number

3. Part numbers under this specification are coded as in the following example:

Table 1-B-2 Part Number Coding

M81044/5	- 22	- 9
Specification Sheet (para 2)	Conductor Size (AWG)	Insulation Colour Code (para 4)

Colour Chart

4. The colour coding is as follows:

Table 1-B-3 Colour Code

Colour	Number Designator	Colour	Number Designator
Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet (Purple)	7
Orange	3	Grey (Slate)	8
Yellow	4	White	9

MIL-W-22759 WIRE, ELECTRIC FLUOROPOLYMER-INSULATED COPPER OR COPPER ALLOY

Scope

1. This specification covers fluoropolymer-insulated single conductor electric wires made with tin coated, silver coated or nickel-coated conductors of copper or copper alloy as specified in the applicable specification sheet. The fluoropolymer insulation of these wires may be polytetrafluoroethylene (TFE), fluorinated ethylene propylene (FEP), polyvinylidene fluoride (PVF^2), ethylene-tetrafluoroethylene copolymer (ETFE), or other fluoropolymer resin. The fluoropolymer may be used alone or in combination with other insulation materials.

Specification Sheets

2. Specification Sheets are as follows:

Table 1-C-1 Specification Sheets

Specification No	Title
MIL-W-22759/1	Wire, Electric, Fluoropolymer-insulated, TFE and TFE Coated Glass, Silver Coated Copper Conductor, 600 Volt, 200°C.
MIL-W-22759/2	Wire, Electric, Fluoropolymer-insulated, TFE and TFE-Coated Glass, Nickel Coated Copper Conductor, 600 Volt, 260°C.
MIL-W-22759/5	Wire, Electric, Fluoropolymer-insulated, Abrasion Resistant, Extruded TFE, Silver Coated Copper Conductor, 600 Volt, 200°C.
MIL-W-22759/7	Wire, Electric, Fluoropolymer-insulated, Abrasion Resistant, Extruded TFE, Medium Weight, Silver Coated Copper Conductor, 600 Volt, 200°C.
MIL-W-22759/8	Wire, Electric, Fluoropolymer-insulated, Abrasion Resistant, Extruded TFE, Medium Weight, Nickel Coated Copper Conductor, 600 Volt, 260°C.
MIL-W-22759/11	Wire, Electric, Fluoropolymer-insulated, Extruded TFE, Silver Coated Copper Conductor, 600 Volt, 200°C.
MIL-W-22759/12	Wire, Electric , Fluoropolymer-insulated, Extruded TFE, Nickel Coated Copper Conductor, 600 Volt, 260°C.
MIL-W-22759/16	Wire, Electric, Fluoropolymer-insulated, Extruded TFE, Medium Weight, Tin Coated Copper Conductor, 600 Volt, 150°C.
MIL-W-22759/22	Wire, Electric, Fluoropolymer-insulated, Extruded TFE, Silver Coated, High Strength, Copper Alloy Conductor, 600 Volt, 200°C.
MIL-W-22759/32	Wire, Electric, Fluoropolymer-insulated, Cross-Linked Modified ETFE, Light Weight, Tin Coated Copper Conductor, 600 Volt, 150°C.
MIL-W-22759/33	Wire, Electric, Fluoropolymer-insulated, Cross-Linked Modified ETFE, Light Weight, Silver Coated, High Strength, Copper Alloy Conductor, 600 Volt, 200°C.
MIL-W-22759/34	Wire, Electric, Fluoropolymer-insulated, Cross-Linked Modified ETFE, Normal Weight, Tin Coated Copper Conductor, 600 Volt, 150°C.
MIL-W-22759/41	Wire, Electric, Fluoropolymer-insulated, Cross-Linked Modified ETFE, Normal Weight, Nickel Coated Copper Conductor, 600 Volt, 200°C.
MIL-W-22759/43	Wire, Electric, Fluoropolymer-insulated, Cross-Linked Modified ETFE, Normal Weight, Silver-Coated Copper Conductor, 600 Volt, 200°C.

Part Number

3. Part numbers under this specification are coded as in the following example:

Table 1-C-2 Part Number Coding

M22759/1	- 22	- 9
Specification Sheet (para 2)	Wire Size (AWG)	Insulation Colour Code (para 4)

Colour Chart

4. The colour coding is as follows:

Table 1-C-3 Colour Code

Colour	Number Designator	Colour	Number Designator
Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet (Purple)	7
Orange	3	Grey (Slate)	8
Yellow	4	White	9

MIL-DTL-25038 WIRE, ELECTRICAL, HIGH TEMPERATURE, FIRE RESISTANT AND FLIGHT CRITICAL, GENERAL SPECIFICATION

Scope

1. This specification covers insulated single wire for electrical use in flight critical circuits and under short-time emergency conditions involving exposure to flames with temperatures up to 1,093°C (2,000°F). The wire covered by this specification is predominantly used in the engine compartment of aerospace vehicles.

WARNING

This wire may contain asbestos.

2. The use of asbestos products in wire insulation designed for high temperature areas is no longer considered appropriate due to the well documented health problems attributed to this material. Asbestos materials are **NOT** to be used in aircraft electrical systems except under circumstances detailed in the following warning.

WARNING

The introduction of new products and equipment containing asbestos into the environment is not permitted except where it can be demonstrated clearly that no suitable alternative is available and that the use of the product will not create a risk to health.

NOTE

Asbestos has been not been permitted in the manufacture of this wire since 1993 however as it may be impossible to determine the manufacture date of wire fitted to aircraft or held in stock, all wire of this type which has no manufacture date, should be treated as containing asbestos.

3. Where asbestos materials are identified or suspected in aircraft electrical systems, Environmental Health personnel should be contacted to provide advice on appropriate handling procedures. Authorised engineering personnel should then determine the feasibility of replacing the asbestos products with suitable non-asbestos alternatives or, where no alternatives are available, introducing appropriate risk management procedures.

Specification Sheets

4. Specification Sheets are as follows:

Table 1-D-1 Specification Sheets

Specification No	Title
MIL-DTL-25038/1	Wire, Electrical, High Temperature, Fire Resistant and Flight Critical, Normal Weight, 260°C, 600 Volt. **Wire sizes 22 through 12 are inactive for new design. For new design use MIL-W-25038/3.**
MIL-DTL-25038/3	Wire, Electrical, High Temperature, Fire Resistant and Flight Critical, Light Weight, Small Diameter, 260°C, 600 Volt.

Part Number

5. Part numbers under this specification are coded as in the following example:

Table 1-D-2 Part Number Coding

M25038/3	- 22	- 9
Specification Sheet (para 2)	Wire Size (AWG)	Insulation Colour Code (para 4)
Note: For M25038/3, add 'H' to the part number for heavier wall construction.		

Colour Chart

6. The colour coding is as follows:

Table 1-D-3 Colour Code

Colour	Number Designator	Colour	Number Designator
Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet (Purple)	7
Orange	3	Grey (Slate)	8
Yellow	4	White	9

MIL-W-7072 WIRE, ELECTRIC, 600 VOLT, ALUMINIUM, AIRCRAFT, GENERAL SPECIFICATION

(CANCELLED)

Scope

1. This specification covers 600 volt insulated single aluminium conductors capable of continuous operation at a maximum conductor temperature of 105°C (221°F). This wire is suitable for use in aircraft using any combination of electrical loading and ambient temperatures providing that the maximum conductor temperature is not exceeded.

NOTE

This specification and specification sheet were cancelled without replacement in May 1997 and September 1996 respectively. The details below are retained for information purposes only and may be useful when selecting replacement copper wire.

Specification Sheet

2. Specification Sheet is as follows:

Table 1-E-1 Specification Sheet

Specification No	**Title**
MS25191	Wire, Electric, 600 Volt, Aluminium, Aircraft

Part Number

3. Part numbers under this specification are coded as in the following example:

Table 1-E-2 Part Number Coding

M25191	**- 01**	**B**
Specification Sheet (para 2)	Wire Size (para 4)	Insulation Material (para 5)

Wire Size

4. The conductor size is indicated as follows:

Table 1-E-3 Wire Size

Number	Wire Size (AWG)
8	8
6	6
4	4
2	2
1	1
01	0
02	00
03	000
04	0000

Insulation Material

5. **B** – Primary insulation is Polyvinyl Chloride (PVC) with a secondary insulation of Glass Fibre braid impregnated with Nylon finisher. Outer layer is Nylon Fiber Braid impregnated with Nylon finisher.

NEMA WC 27500 STANDARD FOR AEROSPACE AND INDUSTRIAL ELECTRICAL CABLE

Scope

1. This standard contains requirements for finished cables. The component wires are covered by other referenced standards. These cables are intended for signal and low voltage power applications with defined environment or temperature conditions found in commercial aircraft and high performance vehicles.

Classification

1. The cable shall be constructed as follows:

Table 1-F-1 Classification

Type	Description
Unjacketed	2 to 15 colour coded wires, spirally laid without an overall outer jacket.
Jacketed	2 to 15 colour coded wires, spirally laid with an overall outer jacket.
Shielded	A single wire or 2 to 15 colour coded wires spirally laid, with one or two overall shields.
Shielded and Jacketed	A single wire or 2 to 15 colour coded wires spirally laid, with one or two shields and one or two jackets.

Cable Designation

2. Cable shall be identified by a combination of digits and letters (not exceeding 16) in accordance with the following example.

Table 1-F-2 Cable Part Number Breakdown

M27500	-	22	SD	3	T	23
Identification Number	Identification method of cable wire (See Note)	Wire Size (AWG)	Basic wire Specification (Table 1-F-3)	Numbers of Wires	Shield (Table 1-F-4)	Jacket (Table 1-F-5)
Note: Refer to NEMA WC 27500.						

Table 1-F-3 Basic Wire Specification

Symbol	Wire Specification
TE	MIL-W-22759/16
JF	MIL-DTL-25038/3
MH	MIL-W-81044/9
MV	MIL-DTL-81381/10
SB	MIL-W-22759/32
SD	MIL-W-22759/34
SP	MIL-W-22759/43
Note: Refer to NEMA WC 27500	

Table 1-F-4 Shield Identification

Symbol	Shield Material
U	No Shield
T	Tin Coated Copper, 150°C (single shield)
S	Silver Coated Copper, 200°C (single shield)
N	Nickel Coated Copper, 260°C (single shield)
V	Tin Coated Copper, 150°C (double shield)
W	Silver Coated Copper, 200°C (double shield)
Y	Nickel Coated Copper, 260°C (double shield)
Note: Refer to NEMA WC 2750.	

Table 1-F-5 Jacket Identification

Symbol	Jacket Material
00	No Jacket
02	Extruded Clear Nylon, 105°C (single jacket)
05	Extruded Clear FEP, 200°C (single jacket)
06	Extruded White PTFE, 260°C (single jacket)
23	White, Crosslinked, Extruded ETFE, 200°C (single jacket)
52	Extruded Clear Nylon, 105°C (double jacket)
55	Extruded Clear FEP, 200°C (double jacket)
56	Extruded White PTFE, 260°C (double jacket)
Note: Refer to NEMA WC 2750.	

Identification of Cable Wire

3. The insulation color of wires used within the cable shall be as detailed in Table 1-F-6 or Table 1-F-7. Table 1-F-6 details the color coding of wires, ie. White wire with a colored stripe, which is the current preferred method, and would normally be used when installing a new cable into an aircraft during modification etc. Table 1-F-7 details the optional color coding of wires, ie. Solid color wires, which is the method used to identify cable wires currently fitted too many aircraft and should be used when repairing or replacing these existing cables.

Table 1-F-6 Preferred Cable Identification Method

No of Wires in Cable	**Identification Colors for Respective Wires in Cable**														
	Wire Number														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	White														
2	White	Blue													
3	White	Blue	Orange												
4	White	Blue	Orange	Green											
5	White	Blue	Orange	Green	Red										
6	White	Blue	Orange	Green	Red	Black									
7	White	Blue	Orange	Green	Red	Black	Yellow								
8	White	Blue	Orange	Green	Red	Black	Yellow	Violet							
9	White	Blue	Orange	Green	Red	Black	Yellow	Violet	Gray						
10	White	Blue	Orange	Green	Red	Black	Yellow	Violet	Gray	Brown					
11	White	Blue	Orange	Green	Red	Black	Yellow	Violet	Gray	Brown	Blue/ Blue				
12	White	Blue	Orange	Green	Red	Black	Yellow	Violet	Gray	Brown	Blue/ Blue	Orange/ Orange			
13	White	Blue	Orange	Green	Red	Black	Yellow	Violet	Gray	Brown	Blue/ Blue	Orange/ Orange	Green/ Green		
14	White	Blue	Orange	Green	Red	Black	Yellow	Violet	Gray	Brown	Blue/ Blue	Orange/ Orange	Green/ Green	Red/ Red	
15	White	Blue	Orange	Green	Red	Black	Yellow	Violet	Gray	Brown	Blue/ Blue	Orange/ Orange	Green/ Green	Red/ Red	Black/ Black

Note: For cables with 2 to 10 conductors, the wire insulation shall be white with a single colored spiral stripe.
For cables with more than 10 conductors, the wire insulation for conductors 11 to 15 shall be white with double spiral stripes. (Blue/Blue indicates a white base wire with double blue stripes).

Table 1-F-7 Optional Cable Identification Method

No of Wires in Cable	Identification Colors for Respective Wires in Cable														
	Wire Number														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	White														
2	Red	Blue													
3	Red	Blue	Yellow												
4	Red	Blue	Yellow	Green											
5	Red	Blue	Yellow	Green	White										
6	Red	Blue	Yellow	Green	White	Black									
7	Red	Blue	Yellow	Green	White	Black	Brown								
8	Red	Blue	Yellow	Green	White	Black	Brown	Orange							
9	Red	Blue	Yellow	Green	White	Black	Brown	Orange	Violet						
10	Red	Blue	Yellow	Green	White	Black	Brown	Orange	Violet	Gray					
11	Red	Blue	Yellow	Green	White	Black	Brown	Orange	Violet	Gray	Red/ White				
12	Red	Blue	Yellow	Green	White	Black	Brown	Orange	Violet	Gray	Red/ White	Blue/ White			
13	Red	Blue	Yellow	Green	White	Black	Brown	Orange	Violet	Gray	Red/ White	Blue/ White	Yellow/ White		
14	Red	Blue	Yellow	Green	White	Black	Brown	Orange	Violet	Gray	Red/ White	Blue/ White	Yellow/ White	Green/ White	
15	Red	Blue	Yellow	Green	White	Black	Brown	Orange	Violet	Gray	Red/ White	Blue/ White	Yellow/ White	Green/ White	Black/ White

Note: For cables with 1 to 10 conductors, the wire insulation shall be a solid color.
For cables with more than 10 conductors, the wire insulation for conductors 11 to 15 shall be a solid color with a stripe. (Red/White – solid red insulation with a white stripe).

MIL-DTL-81381 WIRE, ELECTRIC, POLYIMIDE INSULATED, COPPER OR COPPER ALLOY (KAPTON)

Scope

1. This specification covers polyimide-insulated single conductor electric wires made with silver coated or nickel coated conductors of copper or copper alloy, as specified in the applicable specification sheet. The polyimide insulation may be used alone or in combination with other insulation materials.

Specification Sheets

2. Specification Sheets are as follows:

Table 1-G-1 Specification Sheets

Specification No	Title
MIL-DTL-81381/7	Wire, Electric, Fluorocarbon/Polyimide Insulated, Light Weight, Silver Coated Copper, 600 Volt, 200°C. Nominal 5.8 Mil Wall.
MIL-DTL-81381/8	Wire, Electric, Fluorocarbon/Polyimide Insulated, Light Weight, Nickel Coated Copper, 600 Volt, 200°C. Nominal 5.8 Mil Wall.
MIL-DTL-81381/9	Wire, Electric, Fluorocarbon/Polyimide Insulated, Light Weight, Silver Coated High Strength Copper Conductor, 600 Volt, 200°C. Nominal 5.8 Mil Wall.
MIL-DTL-81381/10	Wire, Electric, Fluorocarbon/Polyimide Insulated, Light Weight, Nickel Coated High Strength Copper Conductor, 600 Volt, 200°C. Nominal 5.8 Mil Wall.
MIL-DTL-81381/11	Wire, Electric, Fluorocarbon/Polyimide Insulated, Medium Weight, Silver Coated Copper Conductor, 600 Volt, 200°C. Nominal 8.4 or 15.4 Mil Wall.
MIL-DTL-81381/12	Wire, Electric, Fluorocarbon/Polyimide Insulated, Medium Weight, Nickel Coated Copper Conductor, 600 Volt, 200°C. Nominal 8.4 or 15.4 Mil Wall.
MIL-DTL-81381/13	Wire, Electric, Fluorocarbon/Polyimide Insulated, Medium Weight, Silver Coated High Strength Copper Alloy Conductor, 600 Volt, 200°C. Nominal 8.2 or 8.4 Mil Wall.
MIL-DTL-81381/14	Wire, Electric, Fluorocarbon/Polyimide Insulated, Medium Weight, Nickel Coated High Strength Copper Alloy Conductor, 600 Volt, 200°C, Nominal 8.2 or 8.4 Mil Wall.
MIL-DTL-81381/17	Wire, Electric, Fluorocarbon/Polyimide Insulated, Light Weight, Silver Coated Copper Conductor. 600 Volt, 200°C. Nominal 4.6 Mil Wall.
MIL-DTL-81381/18	Wire, Electric, Fluorocarbon/Polyimide Insulated, Light Weight, Nickel Coated Copper Conductor, 600 Volt, 200°C. Nominal 4.6 Mil Wall.
MIL-DTL-81381/19	Wire, Electric, Fluorocarbon/Polyimide Insulated, Light Weight, Silver Coated, High Strength Copper Alloy Conductor, 600 Volt, 200°C. Nominal 4.6 Mil Wall.
MIL-DTL-81381/20	Wire. Electric, Fluorocarbon/Polyimide Insulated, Light Weight, Nickel Coated, High Strength Copper Alloy Conductor, 600 Volt, 200°C. Nominal 4.6 Mil Wall.
MIL-DTL-81381/21	Wire, Electric, Fluorocarbon/Polyimide Insulated, Light Weight, Tin Coated Copper Conductor, 600 Volt, 150°C. Nominal 5.8 Mil Wall.
MIL-DTL-81381/22	Wire, Electric, Fluorocarbon/Polyimide Insulated, Medium Weight, Tin Coated Copper Conductor, 600 Volt, 150°C. Nominal 8.4 or 15.4 Mil Wall.

> NOTE
>
> Polyimide based wiring insulation (commonly known by the Du Pont trade name KAPTON) exhibits a property known as flashover or arc tracking. For this phenomenon to occur, damaged insulation, a conductive path to ground and sufficient voltage and source current capability to sustain arcing are required. When these conditions exist, an arc is produced which converts the insulation to a conductive carbon residue. Additionally, Polyimide insulation is prone to radial cracking which results from hydrolytic degradation in humid environments, and also a property known as memory effect where, after installation, the wire tends to regain its original manufactured lay (ie coiled on a spool). For these reasons, the use of polyimide-insulated wiring in aircraft should be avoided. (Refer to Table 1-G-4 for alternate wires).

Part Number

3. Part numbers under this specification are coded as in the following example:

Table 1-G-2 Part Number Coding

M81381/7	22	9
Specification Sheet (para 2)	Wire Size (AWG)	Insulation Colour Code (para 4)

Colour Chart

4. The colour coding is as follows:

Table 1-G-3 Colour Code

Colour	Number Designator	Colour	Number Designator
Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet (Purple)	7
Orange	3	Grey (Slate)	8
Yellow	4	White	9

Cross Reference of Kapton to Non-Kapton Insulated Wires

5. When selecting a replacement wire, consideration must be given to the specific application and end use. Table 1-G-4, below, provides a direct equivalent for a Kapton wire, however this wire may not be the most appropriate or cost effective option in all applications.

Table 1-G-4. Equivalent Non-Kapton Insulated Wires

KAPTON	NON-KAPTON
M81381/7	M22759/44
M81381/8	M22759/45
M81381/9	M22759/33
M81381/10	M22759/46
M81381/11	M22759/43
M81381/12	M22759/41
M81381/13	M22759/35
M81381/14	M22759/42
M81381/17	M22759/44
M81381/18	M22759/45
M81381/19	M22759/33
M81381/20	M22759/46
M81381/21	M22759/32
M81381/22	M22759/34

MIL-C-85485 CABLE, ELECTRIC, FILTER LINE, RADIO FREQUENCY ABSORPTIVE

Scope

1. This specification covers the requirements for radio frequency absorptive component wires and finished cables that function electrically as distributed low-pass filters.

Specification Sheets

2. Specification Sheets are as follows:

Table 1-H-1 Specification Sheets

Specification No	Title
MIL-C-85485/5	Cable, Electric, Filter Line, Component Wire, Tin-Coated Copper Conductor, Radio Frequency Absorptive, 150°C, 600 Volt.
MIL-C-85485/6	Cable, Electric, Filter Line, Component Wire, Silver-Coated High Strength Copper Alloy Conductor, Radio Frequency Absorptive, 150°C, 600 Volt.
MIL-C-85485/7	Cable, Electric, Filter Line, Unshielded, Unjacketed, Multiple-Component, Radio Frequency Absorptive, 150°C, 600 Volt.
MIL-C-85485/8	Cable, Electric, Filter Line, Shielded, Jacketed, Radio Frequency Absorptive, 150°C, 600 Volt.
MIL-C-85485/9	Cable, Electric, Filter Line, Component Wire, Tin-Coated Copper Conductor, Radio Frequency Absorptive, 150°C, 600 Volt.
MIL-C-85485/10	Cable, Electric, Filter Line, Component Wire, Silver-Coated High Strength Copper Alloy Conductor, Radio Frequency Absorptive, 150°C, 600 Volt.
MIL-C-85485/11	Cable, Electric, Filter Line, Unshielded, Unjacketed, Multiple-Component, Radio Frequency Absorptive, 150°C, 600 Volt.
MIL-C-85485/12	Cable, Electric, Filter Line, Shielded, Jacketed, Radio Frequency Absorptive, 150°C, 600 Volt.

Part Number

3. Part numbers under this specification are coded as in the following example:

Table 1-H-2 Component Wire

M85485	/5	- 22	- 7L
Basic Specification	Specification Sheet	Wire Size	Color Code

Table 1-H-3 Finished Cable

M85485	/8	- 22	U	3	A
Basic Specification	Specification Sheet (para 2)	Wire Size (AWG)	Construction (Tables 1-H-4 & 1-H-5)	Number of Component Wires	Color Code Designator (Table 1-H-6)

Table 1-H-4 Shielded, Jacketed Cable Construction

Letter Code	Conductor Type	Shield Type
T	Tin Coated Copper	Tin Coated Copper
S	Silver Coated Copper	Silver Coated Copper
N	Nickel Coated Copper	Nickel Coated Copper
M	Silver Coated High Strength Copper Alloy	Silver Coated High Strength Copper Alloy
P	Nickel Coated High Strength Copper Alloy	Nickel Coated High Strength Copper Alloy
U	Silver Coated High Strength Copper Alloy	Tin Coated Copper
V	Silver Coated High Strength Copper Alloy	Silver Coated Copper
W	Nickel Coated High Strength Copper Alloy	Nickel Coated Copper
Note: Refer to MIL-C-85485 or publication sponsor for full details.		

Table 1-H-5 Unshielded, Unjacketed Cable Construction

Letter Code	Conductor Type
T	Tin Coated Copper
S	Silver Coated Copper
N	Nickel Coated Copper
M	Silver Coated High Strength Copper Alloy
P	Nickel Coated High Strength Copper Alloy
Note: Refer to MIL-C-85485 or publication sponsor for full details.	

Colour Chart

4. The color of the first component wire shall be light violet, designated by 7L. Any additional component wires shall be light violet with a colored stripe as per Table 1-H-6.

Table 1-H-6 Cable Colour Designation

Component Wire Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Wire Insulation Base Color	Light Violet	Light Violet	Light Violet	Light Violet	Light Violet	Light Violet	Light Violet
Stripe Color	N/A	Blue	Orange	Green	Red	Black	Yellow
Note: Refer to MIL-C-85485 or publication sponsor for full details.							

CURRENT RATINGS OF WIRE AND MAXIMUM ALLOWABLE NICKED OR BROKEN STRANDS

Table 1-I-1 Current Rating Of Wires In Amps (SAE AS 50881)

Conductor Material	**Wire Size**	**Wires in Bundles, Groups or Harnesses** (Note 1)			**Wire in Free Air & Ambient 70°C** (Note 2)		
		Wire Temp Rating			**Wire Temp Rating**		
		105°C	**150°C**	**200°C**	**105°C**	**150°C**	**200°C**
Copper or	22	3	5	6	9	12.5	16
Copper Alloy	20	4	7	9	11	17	21
	18	6	9	12	15	22.5	28
	16	7	11	14	17	26	33
	14	10	14	18	23	35	44
	12	13	19	25	31	47	60
	10	17	26	32	41	62	78
	8	38	57	71	64	90	125
	6	50	76	97	82	125	
	4	68	103	133	110	170	
	2	95	141	179	155		
	1	113	166	210	185		
	1/0	128	192	243	210		
	2/0	147	222	285	240		
	3/0	172	262	335	276		
	4/0	204	310	395	340		
Aluminium	8	30	45				
	6	40	61				
	4	54	82				
	2	76	113				
	1	90	133				
	1/0	102	153				
	2/0	117	178				
	3/0	138	209				
	4/0	163	248				

Notes:

1 Rating for 70°C ambient, 33 or more wires in harness with no more than 20% harness current capacity being used at operating altitude of 60,000 ft.

2 Rating of wires in FREE air at ambient temperature of 70°C.

Table 1-I-2 Maximum Allowable Nicked Or Broken Strands (SAE AS 50881)

Conductor Material	Number of Strands per Conductor	Total Allowable Nicked and Broken Strands
Copper or Copper Alloy	19	2 nicked, none broken
	37	4 nicked, none broken
	Above 37	6 nicked or broken
Aluminium	All numbers of strands	None nicked or broken

WIRE GAUGE COMPARISON

Table 1-J-1 Wire Gauge Comparison

Wire Gauge Number	American Wire Gauge (AWG)		Standard Wire Gauge (UK) (SWG)	
	ConductorDiameter (Inches) [Note 1]	**Conductor Area (Circular Mils)** [Note 2]	**Conductor Diameter (Inches)** [Note 1]	**Area (Circular Mils)** [Note 2]
26	0.020	304	0.018	289
24	0.025	475	0.022	419
22	0.031	754	0.028	661
20	0.039	1216	0.041	1156
18	0.049	1900	0.051	1825
16	0.055	2426	0.060	2645
14	0.069	3831	0.072	3553
12	0.089	5874	0.090	5781
10	0.113	9354	0.113	9120
8	0.173	16983	0.173	17683
6	0.217	26818	0.192	26316
4	0.274	42614	0.268	42642
2	0.340	65500	0.338	67516
0	0.425	104500	0.421	103050
00	0.475	133000	0.477	131479

Notes:

1 Wire diameters and areas are listed for the equivalent wire gauge number. The actual diameter and area of the conductor in an aircraft wire will vary due to the stranding and plating used. Refer to the appropriate military specification or the publication sponsor for exact dimensions.

2 A circular mil is the cross-sectional area of a circular conductor having a diameter of 1 mil (0.001 inch). The circular mil area (CMA) of a conductor is calculated by squaring the diameter (in mils) of the circular conductor. Thus, a wire having a diameter of 4 mils (0.004 inch) has a CMA of 4^2, or 16 circular mils. If the conductor is stranded, the CMA for the conductor is calculated by multiplying the CMA of the strand by the number of strands.

3 Details of terminal lugs and splices and associated tooling are contained in Section2, Chapter 6.

SECTION 2

CHAPTER 2

IDENTIFYING WIRE AND CABLE

INTRODUCTION

1. To make maintenance easier, each interconnecting wire and cable installed in aircraft should be marked with a combination of letters and numbers which identify the wire, the circuit it belongs to, its gauge size, and other information necessary to relate the wire to a wiring diagram. This marking is called the wire identification code. Wire, as received from the manufacturer, is printed with the manufacturer's code, in a contrasting colour, at intervals of one to five feet. This code consists of the specification or MS number and slash or dash number of the wire, and a one, two or three-digit number, indicating the colour of the basic wire insulation and the colour of the stripes (if present). The colour code is as follows:

Black	0	Blue	6
Brown	1	Violet	7
Red	2	Gray	8
Orange	3	White	9
Yellow	4	(includes also uncoloured insulations)	
Green	5		

2. For example, a wire printed with number M22759/34-22-948 would designate a wire constructed in accordance with MIL-W-22759/34, wire size 22, white insulation (9), first stripe yellow (4), and a second stripe of grey (8).

> NOTE
>
> When marking wire with the identification code described in this chapter, it is permissible to over-stamp the manufacturer's printing.

WIRE IDENTIFICATION CODE (BASIC)

3. The basic wire identification code used for all circuits (refer Table 2–1) is described in the following paragraphs and Figure 2–1.

Unit Number

4. Where two or more identical items of equipment are installed in the same aircraft, the unit numbers "1", "2", "3", "4", etc., may be prefixed to differentiate between wires and cables when it is desired that the equipment have the same basic cable identification. To facilitate interchangeability requirements, identical wiring located in left and right wings, nacelles, and major interchangeable structural assemblies may have identical cable identification and the unit number is not required. The unit numbers for circuit functions "R", "S", "T" and "Y", are used only where duplicate complete equipment is installed, and does not apply to duplicate components within a single complete equipment such as duplicate indicators or control boxes.

Circuit Function Letter

5. The circuit function letter is used to identify the circuit function specified in Table 2–1. Where a wire or cable is used for more than one circuit function, the circuit function that is predominant applies. When functional predominance is questionable, the circuit function letter for the wire or cable having the lowest wire number is used.

Wire Number

6. The wire number consisting of one or more digits is used to differentiate between wires in a circuit. A different number shall be used for wire not having a common terminal or connection.

7. Wires with the same circuit function having a common terminal connection or junction will have the same wire number but different segment letters.

8. Beginning with the lowest number, a number is assigned to each wire in numerical sequence, as far as practicable.

Wire Segment Letter

9. A wire segment is a conductor between two terminals or connections. The wire segment letter is used to differentiate between conductor segments in a particular circuit. A different letter is used for wire segments having a common terminal or connection. Wire segments are lettered in alphabetical sequence. The letter "A" identifies the first segment of each circuit starting at the power source. If a circuit contains only one wire segment, the wire segment is marked "A". The letters "I" and "O" are not used as segment letters. Double letters "AA, AB, AC", etc., are used when more than 24 segments are required. Two permanently spliced wires do not require separate segment letters if the splice is used for modification or repair.

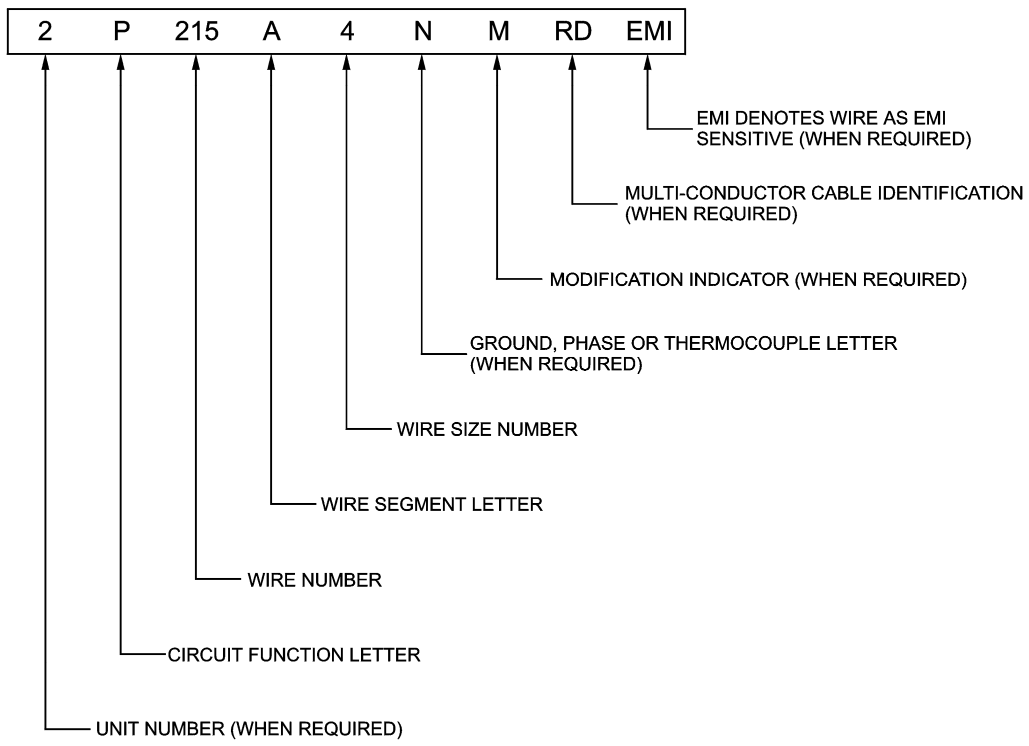


Figure 2–1 Example of Wire Identification Coding

Wire Size Number

10. The wire size number is used to identify the size (AWG) of the wire. For coaxial cables and thermocouple wires, a dash (-) is used in lieu of the wire size number.

Ground, Phase or Thermocouple Letter(s)

11. The letter “N” is used as a suffix to the wire identification code to identify any wire or cable that completes the circuit to the ground network (earth). Such wires and cables shall be capable of being connected to the ground network of aircraft electrical systems without causing malfunctioning of any circuit. For critical and sensitive electronic systems that have interconnecting “ground” leads, but only one segment actually grounded to structure, only the segment actually grounded to structure is identified with the “N” suffix.

12. Phase letter “A”, “B” or “C” shall be used as a suffix on the wire identification code to identify the phase of wires that are in the three-phase power distribution wiring of AC systems.

13. Phase letter “V” shall be used as a suffix on the cable identification code to identify the ungrounded wire or cable that is in a single-phase system.

14. For thermocouple wire, the following suffixes shall be used as applicable:

CHROM – Chromel	CONS – Constantan
ALML – Alumel	COP – Copper
IRON – Iron	

Aluminium Wire

15. For aluminium wire, ALUMINIUM or ALUM shall be added as a suffix to the wire identification code.

Spare Contact Wire Identification

16. Wires attached to spare contacts shall be identified by the contact designation.

Harness Identification

17. When required, each harness shall be identified with the letter W and a distinct numerical suffix. Examples W-1, W-2, W-3, etc.

Wires Added at Modification

18. When additional wires are installed in aircraft during modification, they should be identified by including the letter M as a suffix to the wire

Multi-Conductor Cables

19. Wires within multi-conductor cables are identified with either solid colours or coloured stripe(s) on a white background. Mark these wires in accordance with paragraph 34.

Wires Sensitive to Electromagnetic Interference (EMI)

20. Sensitive wiring is defined as wiring that is especially susceptible to EMI, and is therefore more likely to create disruption of the equipment to which it is connected.

21. A current method for identifying EMI sensitive wires and cables consists of a suffix to the wire number that identifies the susceptibility to EMI and indicates that specific handling instructions are detailed in the aircraft wiring manual. This suffix shall remain at the end of the significant wire number regardless of the requirement for any other suffix. Figure 2–1 provides an example of a wire identification number with the EMI identifier included.

22. The identification of EMI sensitive wiring is dependent on the following:

- **a.** level of shielding or protection applied to the wire (eg. twisted pair, shielded wire etc);
- **b.** electromagnetic susceptibility of the coupled victim equipment;
- **c.** physical separation between the subject wiring and potential electromagnetic sources (including other wires); and/or
- **d.** the type of grounding/bonding methods utilised.

23. Audio and data signals are often the most susceptible to EMI. Other typical waveforms that are more susceptible to EMI have the following characteristics:

- **a.** low voltage,
- **b.** low current, and/or
- **c.** slow rise times.

24. SAE AS 50881 Wiring, Aerospace Vehicle, requires sensitive wiring to be routed to avoid electromagnetic interference. SAE AS 50881 Appendix B allows for, but does not mandate, the identification of EMI sensitive wires and cables with a category code added to the significant wire number. In the past, EMI sensitive wires and cables added during modification of aircraft have been isolated in accordance with the specification, however they have not been identified as EMI sensitive and therefore their integrity may be compromised during subsequent aircraft modification.

Safety of Flight (SOF) Critical EMI Sensitive Wire and Cable

25. Where wires and cables are susceptible to EMI and are identified as critical to the safety of flight (SOF) of the aircraft, they should be identified with red sleeves. (This is in addition to the EMI suffix on the wire identification code). The red sleeves (heat shrink is appropriate) should be a minimum of 50mm in length and positioned at intervals no greater than 375mm along the entire length of the wire or loom, utilising application methods detailed in this manual. Marking of the sleeving to further highlight the EMI sensitivity is optional, but should be consistent with existing aircraft labelling practices and clearly documented in wiring publications.

26. The sleeving procedure detailed above is also appropriate for non-SOF systems that are sensitive to EMI and where interference may affect the air-worthiness of the aircraft.

WIRE AND COMPONENT IDENTIFICATION CODES FOR MODIFICATION

Wire Numbers

27. When additional wires and cables are installed in aircraft during modification they should be appropriately identified in accordance with this publication. Wire numbers in the range 2000 to 4999 inclusive, should be allocated. All wire numbers allocated to modifications should be suffixed with the letter M (eg. L2001A20M). Wires installed within aircraft components and wires less than six inches long need not be numbered.

Electrical Component Numbers

28. Electrical components such as switches, lights, circuit breakers etc. which are installed during modification, should be identified on wiring diagrams using a code letter and sequential number. As different aircraft manufacturers use various code letters for similar components, it is recommended that the coding convention, used by the manufacturer on original aircraft wiring diagrams, be retained.

Table 2–1 Function and Designation Letters

Circuit Function Letter	Circuits	Circuit Function Letter	Circuits
A	**UNASSIGNED**	**B**	**PHOTOGRAPHIC**
			Oil pressure
B	**PHOTOGRAPHIC**		Manifold pressure
	Mapping camera		Fuel pressure
	Camera intervalometer		Propeller anti-icing fluid quantity
	Camera doors		Engine oil quantity
	Camera heaters		Tachometer
	Warning		Synchroscope
			Warning
C	**CONTROL SURFACE**		
	Automatic pilot	**F**	**FLIGHT INSTRUMENT**
	Booster		Bank and turn
	Control tabs		Rate of climb
	Diving brakes		Directional gyro
	Flight		Air position
	Horizontal stabilizer		Ground position
	Landing flaps		Compass (including flux gate and
	Water-rudder position		other stabilized compasses)
	Trim tabs		Gyro horizon
	Wing flaps		Attitude gyro
	Warning		Driftmeter
			Altimeter
D	**INSTRUMENT** (other than flight		Airspeed
	or engine instruments)		Accelerometer
	Ammeter		Pitot-static tube heater
	Oil-flap position		Warning
	Cowl-flap position		
	Coolant-flap position	**G**	**LANDING GEAR, WING FOLDING**
	Air pressure		Actuator
	Free air temperature		Retraction
	Landing gear position		Wheel brakes
	Hydraulic pressure		Down lock
	Cabin pressure		Ground safety
	Carbon monoxide		Wheel steering
	Landing-flap position		Up lock
	Propeller pitch position		Wheel spinning
	Instrument vacuum pump		Warning
	Horizontal-stabilizer position		
	Trim-tab position	**H**	**HEATING, VENTILATING, AND DE-ICING**
	Water pressure		Anti-icing (general)
	Voltmeter		Battery heater
	Clock		
	Cabin heater	**I**	**UNASSIGNED**
	Cigarette lighter		
	De-icing (general)	**J**	**IGNITION**
	Heated flying suits		Booster
	Gallery		Vibrator
	Windshield defroster		Distributor
	Windshield defogger		Electronic
	Windshield de-icer		Magneto ground wiring
	Heater blanket		Warning
	Oil immersion heater		
	Refrigeration	**K**	**ENGINE CONTROL**
	Cabin supercharger		Carburettor air flap
	Ventilation		Blower ratio
	Water heater		Cowl flap, air shutter
			Intercooler flap
E	**ENGINE INSTRUMENT**		Oil cooler shutter
	Carburettor air pressure		Propeller feathering
	Bearing temperature		Propeller synchronizer
	Tailpipe temperature		Propeller pitch
	Carburettor anti-icing fluid quantity		Supercharger regulator
	Fuel mixture		Starter
	Torque meter		Warning
	Brake mean effective pressure		
	Fuel flow	**L**	**LIGHTING**
	Fuel quantity		Approach

Circuit Function Letter	Circuits	Circuit Function Letter	Circuits
E	**ENGINE INSTRUMENTS** (continued)	L	**LIGHTING** (continued)
	Fuel capacity		Cockpit
	Cylinder head temperature		Drift
	Oil temperature		Cabin
	Interior	S	**RADAR**
	Instrument		SA - Altimeter
	Section (fuselage)		SM - Mapping
	Landing		SN - Navigation
	Exterior		SR - Recorder
	Running, position, navigation		SS - Search
	Passing		SW - Warning
	Search		SX – Recognition - transponder
	Taxi		
	Anchor	T	**SPECIAL ELECTRONIC**
	Warning		
			TB - Radar control
M	**MISCELLANEOUS ELECTRIC**		TC - Radio control
	Windshield spray		TD - Airborne announcing
	Bilge pump		TF - Repeat back
	Cargo door		TL - Attitude indicator
	Water distillation		TN - Navigation
	Windshield wiper		TP - Beacon (crash and locator)
	Hoist		TQ - Transmitters and receivers
			TR - Receivers
	Positioner; seat, pedal		TT - Transmitters
N	**UNASSIGNED**	U	**MISCELLANOUES ELECTRONIC**
	TW - Weather devices		Oil-booster pump
	TX - Television transmitters		Oil-scavenger pump
	TY - Television receivers		Throttle control
			Fuel-pump motor
O	**UNASSIGNED**		Oil diverter
			Oil valves
P	**DC POWER**		Water injection
	Wiring in the DC power or power-control system shall be identified by the circuit function letter "P".		Warning
		V	**DC POWER** and DC control cables for AC systems shall be identified by the circuit function letter “V”.
Q	**FUEL AND OIL**		Wiring in the AC power system shall be identified by the circuit function letter “X”.
	Fuel valves		
	Fuel booster-pump motor		
	Mixture control		
	Oil dilution	W	**WARNING AND EMERGENCY** (in addition to those listed under other circuit functions)
	Engine primer		Enclosure release and locks
	Fuel-transfer-pump motor and control		Fire extinguishers
	Fuel-loading-pump motor		Flare release
	Oil-transfer-pump motor and control		Fire detector
	Oxygen heater		Oxygen detector
R	**RADIO** (navigation and communication)		No-smoking sign
	RA – Instrument landing		Fasten-belts sign
	RD – Radio direction finding		Intercrew buzzer or light
	RF - VHF		
	RH - Homing	X	**AC POWER**
	RM - Marker beacon		power circuits common to more than one equipment or system.
	RN - Navigation		
	RX - Recorder		
	RZ - Interphone, headphone	Y	**UNASSIGNED**
	RV - VHF command		
		Z	**UNASSIGNED**

Circuit function and circuit designation letters of electrical and electronic wires and cables should be as specified herein. Typical circuits are listed under their respective circuit functions.

IDENTIFICATION METHODS

29. The identification code, as shown in Figure 2–1 should be applied to wires either horizontally or vertically. The preferred method of identification is to apply the identification marking directly on the wire or cable with a laser wire-marking machine. Use this method wherever possible. If the wire insulation or outer covering will not mark clearly, lengths of insulating tubing (standard or heat shrink) may be laser marked or hot stamped with the identification code and installed on the wire or cable. The following types of wire may require identification by means of sleeves:

a. Unjacketed shielded wire.

b. Thermocouple wires.

c. Multi-conductor cable.

d. High temperature wire.

> **CAUTION**
>
> Do not use metallic markers or bands for identification. Do not use any method of marking that may damage or deform the wire or cable insulation.

> NOTE
>
> Use sleeves only if wire cannot be marked directly.

MARKING OBJECTIVES

30. Which ever method of marking is used, ensure marking is legible, and that colour of marking contrasts with the wire insulation or sleeve.

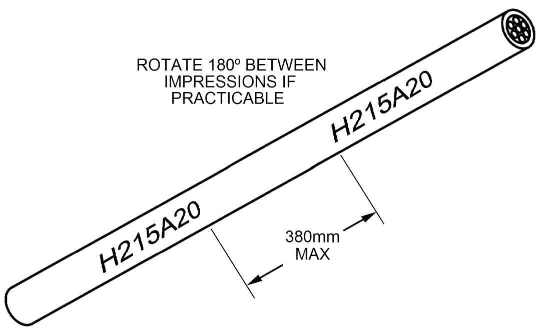


Figure 2–2 Spacing of Identification Marking on Wire and Cable

SPACING OF WIRE IDENTIFICATION

31. Mark wires and cables at intervals of not more than 38cm along their entire lengths (refer Figure 2–2). In addition, mark wires within 75mm of each junction (except permanent splices), and at each terminating point. Wires less than 15cm long need not be marked.

LOCATION OF SLEEVE MARKING

32. When wire or cable cannot be marked directly, install a sleeve, (refer Figure 2–3) marked with the identification number, over the outer covering at each terminating end and at not more than 90cm intervals along the entire length of the wire or cable.

> NOTE
>
> Do not use sleeves to change the identification of wire or cable that has already been marked, except in the case of spare wires in potted connectors.

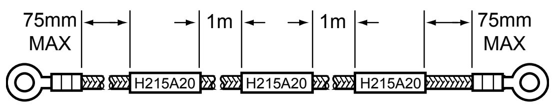


Figure 2–3 Location of Identification Sleeve

MULTICONDUCTOR CABLE IDENTIFICATION

33. Multi-conductor cables may be identified by marking directly onto the outer sheath using a laser marking machine or with pre-marked sleeves (refer Figure 2–4) installed as described in paragraph 44. Immediately following each wire identification number, indicate the colour of the individual conductor as detailed in Figure 2–1 using the following abbreviations:

Black	- BK	Blue	- BL
Brown	- BR	Violet	- VT
Red	- RD	Grey	- GY
Orange	OR	White	- WH
Yellow	- YE	Pink	- PK
Green	- GN	Purple	- PR

34. Individual wires within a cable shall be identified within 75mm of their termination.

COAXIAL CABLE IDENTIFICATION

35. Coaxial cable should NOT be hot-stamped directly. The marking pressure and stress (tension and torsion) applied while the cable moves through the machine can create electrical changes in cables and physical damage in miniature cables. When laser marking is unsuitable for marking coaxial cable, use pre-marked sleeves (refer Figure 2–5) as described in paragraph 43 and 44.

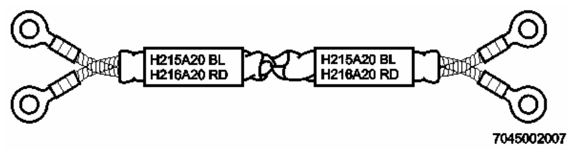


Figure 2–4 Multiconductor Cable Identification

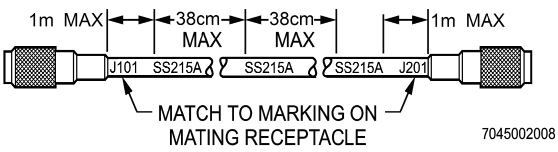


Figure 2–5 Coaxial Cable Identification

THERMOCOUPLE WIRE IDENTIFICATION

36. Thermocouple wire, which is usually duplexed (two insulated conductors laid side by side), may be difficult to mark legibly. Where sleeves are utilised, the wire size in the identification code should be replaced by a dash. The material designation shall be as follows:

CHROM – Chromel	CONS – Constantan
ALML – Alumel	COP – Copper
IRON – Iron	

WIRE IDENTIFICATION AT TERMINAL BOARDS AND ENCLOSURES

37. If possible, mark wires attached to terminal boards and equipment terminals between termination and the point where wire enters the wire bundle (refer Figure 2–6). Identify wires terminating within an enclosure, inside the enclosure, if space permits.

SELECTION OF IDENTIFICATION SLEEVING

38. For general airframe wiring, in most applications, heat-shrinkable polyethylene tubing should be used to identify wire that cannot be marked directly. Available sizes are given in Section 2, Chapter 4.

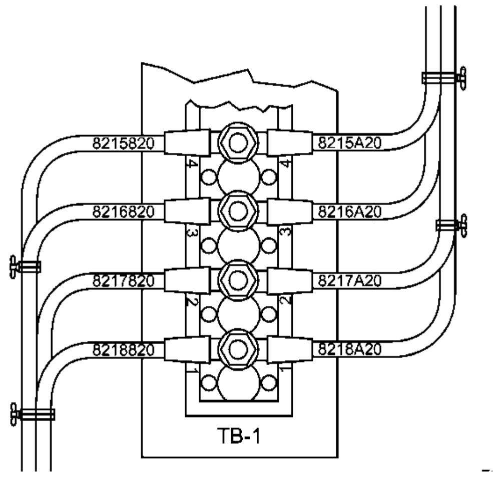


Figure 2–6 Wire Identification at Terminal Board

WIRE MARKING

39. Excimer Laser marking is the recommended wire marking method. It is a rapid, non-contact, non-aggressive printing technique that relies on alteration of the Titanium Dioxide (TiO_2) pigment present in the insulation material. This wire marking method produces a high contrast, high definition, permanent mark on most single wire and multi-core cables without any degradation of the insulation. Laser marking should be carried out in accordance with the manufacturer's instructions.

40. Hot stamp marking directly on to the insulation of aircraft electrical wire and cable is not recommended due to the degradation that may be caused to the insulation and because alternate, improved identification methods are available. Where hot stamp marking is determined to be the most appropriate marking method (eg large conductors and heat shrink sleeving) the details listed in Table 2–2 are provided to assist in the selection of the appropriate marking foil, marking temperature and dwell time.

> NOTE
>
> Store foils at approximately 22°C and 60% relative humidity.

SET-UP OF MARKING MACHINE FOR WIRE STAMPING

41. After selecting the proper machine for the job, set it up for the marking procedure as follows:

- **a.** From Table 2–3, select the correct size type for the wire to be marked. Make up required identification code and insert into type holder, centring type in holder. Use spacers to prevent crowding letters and numbers.

b. Select marking foil of correct width for length of identification code.

CAUTION

Use correct size guide. If guide is too large, wire will not be held firmly and marking will be off centre.

Table 2–2 Marking Foil Identification

Foil Part Number	Colour	Insulation Type	Marking Temperature	Dwell Time
KT26	Black	Teflon	210 to 227°C	Quick
K-36	Black	PVC, Nylon, Polyethylene	163 to 260°C	Medium
K520	Black	ETFE/ECTFE	150°C	Quick

c. Select wire guide into which wire will fit snugly.

d. Install wire guide and roll of marking foil on machine. Slide type holder into slot provided for it.

Table 2–3 Recommended Sizes of Marking Type

Wire Size (AWG)	Letter Height (mm)
26 thru 22	1.6
20 thru 14	2.0
12 thru 0000 & Coaxial Cable	2.8

SET-UP OF MARKING MACHINE FOR SLEEVE STAMPING

42. For stamping identification mark on tubing that has an OD of 6.3 mm or smaller, use the same machine that is used for stamping wire. Set up machine as follows:

a. Select type size and wire guide to suit OD of tubing.

b. Select mandrel (metal rod) of a diameter that will fit snugly inside tubing. Insert mandrel into tubing, and both into the wire guide. If a mandrel of proper size is not available, use a piece of insulated wire of suitable diameter and length.

c. Prepare type to provide required wire number.

d. Select foil and install wire guide, foil, and type holder on machine.

INSTALLING IDENTIFICATION SLEEVES ON WIRING

43. Cut marked tubing into lengths so that marking is approximately centred (refer to Figure 2–7). Install cut lengths of tubing over wire or cable at desired spacing, and tie at each end with clove hitch and square knot. Refer to Section 2, Chapter 8 for method of tying and knotting. When heat shrinkable tubing is used, ties are not required. Before installing heat shrinkable tubing on the wire, make sure that the wires are clean. Instructions for installation of heat shrink sleeving are provided in Section 2, Chapter 4.

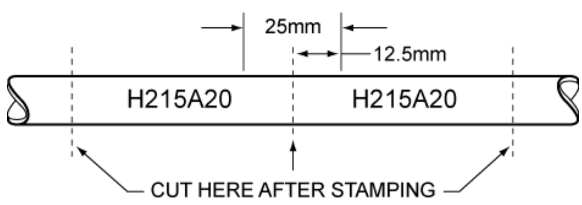


Figure 2–7 Marking on Sleeves

IDENTIFICATION OF WIRE BUNDLES AND HARNESSES

44. Identify wire bundles and harnesses (see Figure 2–8) by one of the following methods:

a. If bundle is not too large, select sleeving of proper size to fit snugly over wire bundle. Stamp with identification marking as described in paragraph 45 and install on bundle approximately 30cm from each terminating end. Tie securely at both ends.

NOTE

Sleeving must be installed on bundle before attaching wires to connectors.

b. Heat shrinkable tubing, marked with the identification code, may also be used, installed as described in Section 2, Chapter 4.

c. Wire bundles up to 100mm in diameter may be identified by means of an MS3368 cable identification strap that incorporates a marking tab (refer Figure 2–8). Install as follows:

(1) Stamp the wire identification code on the marking tab.

(2) Pass the strap around the bundle with the ribbed side of the strap inside.

(3) Insert the pointed end of the strap through the eye, and pull the strap snugly around the bundle.

(4) Feed the tail of the strap through MS90387-1 tool, and slide the tool up to the eye of the cable identification strap.

(5) Squeeze tool handles until strap is snug on the bundle.

(6) Close tool handles all the way to cut off the excess strap.

NOTE

Use of self clinching adjustable plastic cable straps and installing tools is described in Section 2, Chapter 8.

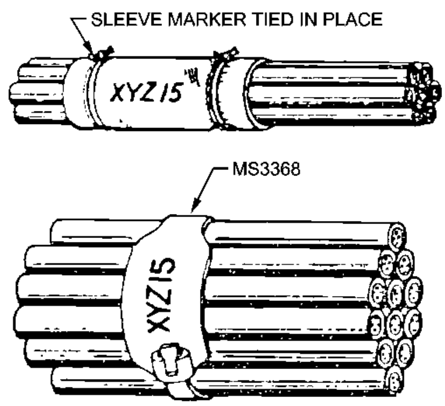


Figure 2–8 Identification of Wire Bundles and Harnesses

SECTION 2

CHAPTER 3

PREPARING WIRE AND CABLE

INTRODUCTION

1. Before wire and cable can be installed in aircraft and connected to components it must be prepared by cutting to the appropriate lengths and preparing the wire ends for attachment to connectors, terminal lugs or solder splices, etc.

CUTTING WIRE AND CABLE

General

2. Cut all wires and cables to lengths given on drawings or wiring diagrams. Cut wire and cable so that cut is clean and square and wire is not deformed (refer Figure 3–1). After cutting, reshape large diameter wire with pliers, if necessary.

> **CAUTION**
>
> Make sure that blades of cutting tools are sharp and free from nicks. A dull blade will deform and extrude wire ends.

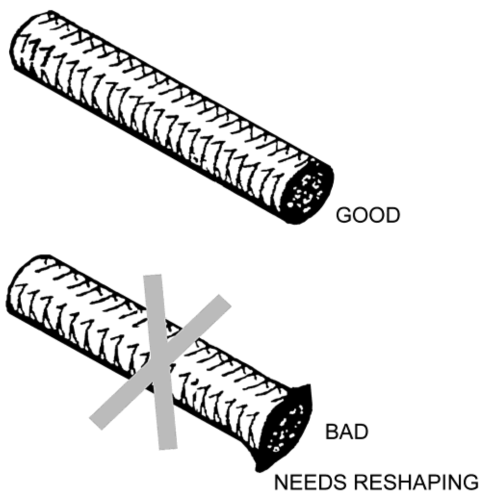


Figure 3- 1 Wires After Cutting

Cutting Copper Wire and Cable

3. To cut heavy gauge copper wires or cables, use a fine tooth hacksaw. A fine tooth hacksaw has 20 or more teeth per inch. See Figure 3–2 Wire Cutting Tools for use of hack saw and saw vice which protects heavy wire during cutting. Heavy or light copper wires can also be cut with bench shears.

4. To cut a few light gauge copper wires, use diagonal pliers as shown in Figure 3–2. Do not attempt to cut wires larger than AWG-8 with diagonal pliers.

Cutting Aluminium Wire

5. Be careful when cutting aluminium wire to avoid deforming the conductors. Aluminium wire is more brittle than copper, and if deformed, aluminium wire should be reshaped carefully.

> **CAUTION**
>
> Never cut aluminium wire with tools that have reciprocating motion, such as a hack saw. Reciprocating cutting action “work hardens” aluminium. This will lead to broken and torn strands.

> **CAUTION**
>
> If cutting tool has been used for other metals, wipe blades clean before cutting aluminium. Copper or steel chips will cause aluminium to corrode.

6. Special cable shears with concave cutting edges such as pruning shears may also be used to cut aluminium wire.

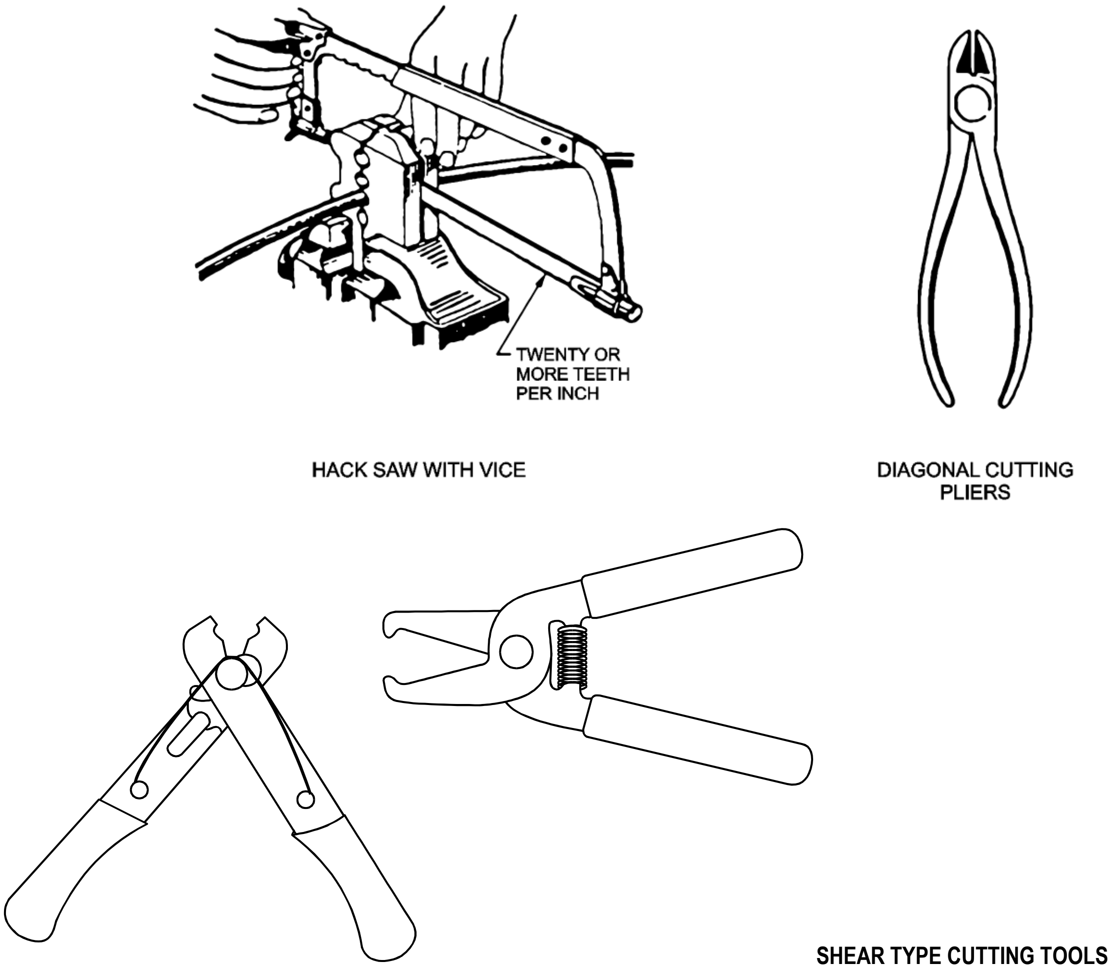


Figure 3- 2 Wire Cutting Tools

STRIPPING WIRE AND CABLE

7. Before wire can be assembled to connectors, terminals, splices, etc, the insulation must be stripped from connecting ends to expose the bare conductor. For attachment to solder type connectors, enough insulation must be stripped so that the conductor will bottom in the solder cup and leave a small gap between the top of the solder cup and cut end of the insulation. Stripping dimensions for MS connectors are found in Section 2, Chapter 10, for RF connectors in Section 2, Chapter 12, and for terminals in Section 2, Chapter 6.

Stripping Methods for Copper Wire

8. Copper wire may be stripped in a number of ways depending on size and insulation.

Stripping Methods for Aluminium Wire

9. Strip aluminium wires very carefully. Take extreme care not to nick aluminium wire as strands break very easily when nicked.

General Stripping Instructions

10. When stripping wire observe the following precautions:

- **a.** When using a hot blade stripper, make sure blades are clean. Clean blades with a brass wire brush as necessary. The hot blade stripper will not strip wire with glass braid or asbestos insulation.
- **b.** Make sure all stripping blades are sharp and free from nicks, dents, etc.
- **c.** When using any type of wire stripper, hold wire perpendicular to cutting blades.

d. Adjust automatic stripping tools carefully. Follow manufacturer's instructions to avoid nicking, cutting, or otherwise damaging any strands. This is especially important for all aluminium wires and for copper wires smaller than No 10. Examine stripped wires for damage and adjust tool as necessary. Cut off and restrip (if length is sufficient); or reject and replace any wires with more than the allowable number of nicked or broken strands given in Table 3–1.

> **NOTE**
> Longitudinal scratches in copper wire are not considered cause for rejection or rework.

Table 3–1 Allowable Nicked or Broken Strands

Wire Size (AWG)	Nicked or Broken Strands
Copper	
22 – 12	None
10	2
8 – 4	4
2 – 0	12
Aluminium, all sizes	None

e. Ensure insulation is clean-cut with no frayed or ragged edges. Trim if necessary.

f. Ensure all insulation is removed from stripped area. Some types of wires are supplied with a transparent layer between the conductor and primary insulation. If this is present, remove it.

g. When using hand plier strippers to remove lengths of insulation longer than 19mm, it is easier to do in two or more operations.

h. Retwist copper strands by hand or with pliers if necessary to restore natural lay and tightness of strands.

i. Precision hand pliers have die type blades that are designed for a specific insulation wall thickness and type of conductor. Table 3–2 lists manufacturers part numbers for one acceptable model. Equivalent tools may be used.

> **CAUTION**
> Due to the differences in the diameter of "General Purpose'' and "Small Diameter" conductors, the blade set used should be the one specified for the wire being stripped.

j. **Precision Blade Wear** - Although these blades are hardened to provide long life, they will wear in time. When the blade no longer provides a satisfactory removal of insulation when used with the correct size and type of wire, it should be replaced.

k. **Cleaning Wire Gripping Surfaces of Precision Tools** - Wire gripping surfaces on precision strippers can become loaded with insulating material in time. This condition causes the wire to slip in the grippers and results in an unsatisfactory strip. Clean these gripping surfaces with a stiff brush as needed.

l. **Wire Cutters** - Shear type wire cutters (PN 45-123 or equivalent) are recommended for cutting wire prior to stripping. Standard diagonal cutting pliers will crush and deform the ends of the conductors and increase the force necessary to slide the slug of insulation off the wire. Smooth cut round ends are also easy to insert into the crimp wells of terminals and contacts.

Stripping Wire with Hot-Blade Stripper

> **CAUTION**
> Ensure adequate ventilation is provided when a hot-blade stripper is used to strip TFE-insulated wire.

11. The procedure for stripping a wire with a hot-blade stripper is as follows:

a. Adjust blades to correct opening for size of wire to be stripped.

b. Adjust stop by means of knurled brass nut on top of hood for desired stripping length between 6.5 and 38mm.

c. Adjust each blade to proper heat by testing on sample pieces of wire. Use minimum heat that will remove insulation satisfactorily without damaging strands.

d. Insert wire until it butts against stop.

e. Press foot pedal to bring heated blades against insulation.

f. Twist wire with lay of strands about 90 degrees and pull out.

> **NOTE**
> Polytetrafluoroethylene (PTFE) which includes all teflon based insulation materials is an inert plastic material that decomposes at approximately 400°C. At this temperature, the Teflon particles become airborne and, if inhaled, can cause a type of poisoning known as POLYMER FUME FEVER, which has influenza like symptoms. The symptoms occur for several hours after exposure and usually subside within 24 to 48 hours.
>
> **WARNING**
> Do not smoke in areas where PTFE materials are used. Do not carry cigarettes or tobacco into PTFE work areas as contamination of these products may occur. After working with PTFE material wash hands thoroughly before smoking. Do not incinerate PTFE waste.

Stripping Kapton Wire with a Hand Stripper

12. The procedure for stripping Kapton wire or cable with a hand stripper is as follows (see Figure 3–3):

- **a.** Insert wire into exact centre of correct cutting slot for wire size to be stripped. (Each slot is marked with wire size).
- **b.** Close handles together as far as they will go.
- **c.** Partially release handles so that the jaws of the stripper remain open and the blades and gripper pads also open to permit removal of the wire.
- **d.** Remove stripped wire.
- **e.** Continue to release handles so that the jaws snap closed and the stripper is ready to use again.

Inspection after Stripping

13. When visually inspecting multi-stranded wire, determine if any of the conditions illustrated in Figure 3-3 exist.

14. When one or more of the conditions below exist but are within tolerance, correct and reshape conductor strands by twisting the strands in the direction of the natural lay of the wire. Do not overtwist.

15. When the conditions in Figure 3-3 exist, but are out of tolerance, cut off the stripped portion and start the procedure again. If the wire length does not permit, restart with a new length of wire.

WARNING

Care should be exercised when smoothing insulation or twisting conductors as nicked, frayed, or broken strands can cause injury.

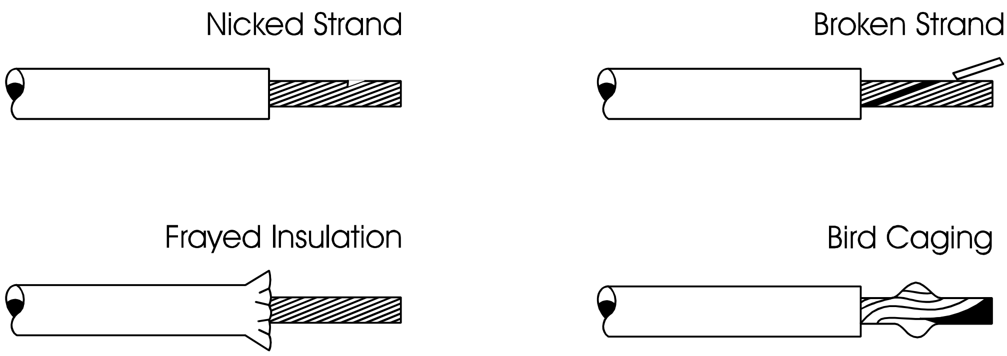


Figure 3-3 Examples to look for when Stripping Multi-Stranded Wire

Stripping Coaxial Cable Using A Knife

16. Cut dimensions are detailed in the manufacturer's instructions.

17. The first cut is to remove the desired length of the outer jacket. After placing the cable on a solid surface, position the knife blade at the desired strip point and press gently, using sufficient pressure to score the jacket without damaging the inner shielding. Cut dimensions are detailed in the manufacturer's instructions or local instructions.

18. The first cut is to remove the desired length of the outer jacket. After placing the cable on a solid surface, position the knife blade at the desired strip point and press gently, using sufficient pressure to score the jacket without damaging the inner shielding. Figure 3-4 illustrates this process.

19. Without damaging the inner shielding, carefully slit the outer jacket, as shown in Figure 3-5.

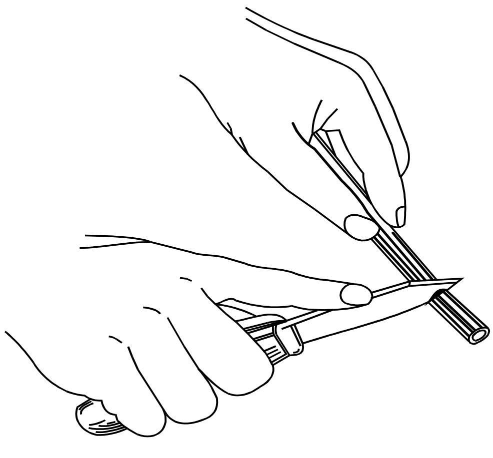


Figure 3-4
Striping Coaxial Cable using a Knife

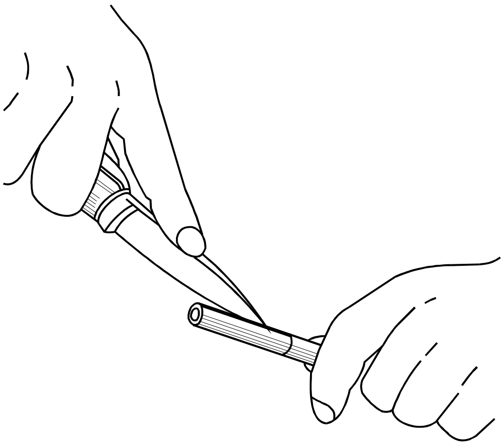


Figure 3-5
Slitting the Outer Jacket of the Wire

20. Peel away the outer jacket to expose the shielding (Figure 3-5).

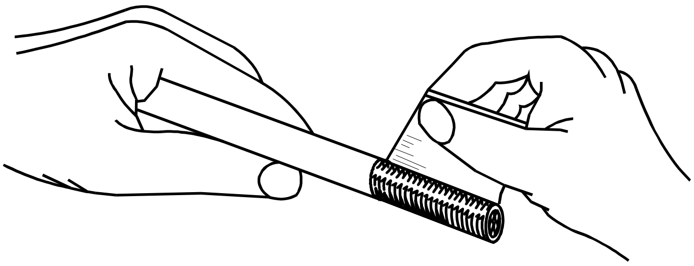


Figure 3-6 Peeling away the Outer Jacket

21. Using the knife, repeat step two removing the insulation surrounding the inner conductor. The finished cable will appear as depicted in Figure 3-7

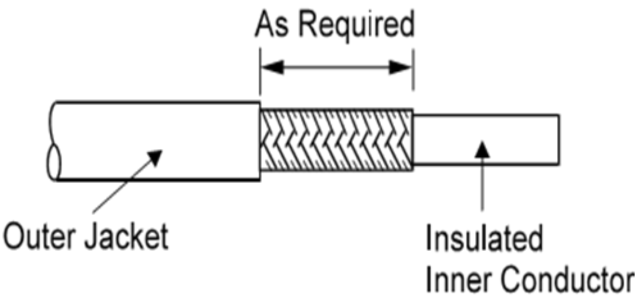


Figure 3-7 Removal of Excess Braiding

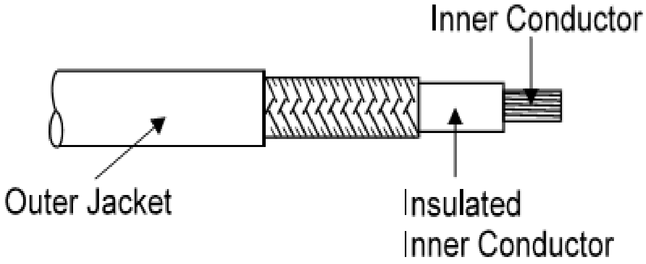


Figure 3-8
Removal of the Insulation Surrounding the Inner Conductor

22. Cut away the excess braiding using side cutters to expose the insulated inner conductor. Be careful not to damage the insulation of the inner conductor with the cutters. Using the knife, repeat step two removing the insulation surrounding the inner conductor. The finished cable will appear as depicted in Figure 3-8.

Table 3–4 Identification of Precision Stripper and Blades

Wire Stripper Identification			
Wire Type	**Gage**	**Stripper PN**	**Blade PN**
MIL-W-22759 /9,/10	16-26 10-14	45-174 45-173	L5563 L5562
/11,/12, /22,/23	16-26 10-14	45-1212 45-1611	L5560 L5559
/16,/17,/32, /33,/34,/35, /41,/42,/43	16-26 10-14	45-1987 45-1611	45-1987-1 45-1611-1
/18,/19	16-26 10-14	45-1551 45-1608	45-1551-1 45-1608-1
/44,/45,/46	16-26 10-14	45-1513 45-1611	45-1513-1 45-1611-1
MIL-W-81044 /6,/7	16-26 10-14	45-171 45-170	L5211 L5210
/9,/10	16-26 10-14	45-174 45-173	L5563 L5562
/12,/13	28-30 16-26 10-14	45-178 45-1513 45-1611	L5561 45-1513-1 45-1611-1
/16,/17	16-26 10-14	45-1610 45-1611	45-1610-1 45-1611-1
MIL-DTL-81381 /1,/2,/5,/6, /7,/8,/9,/10	16-26 10-14	45-1551 45-1609	45-1551-1 45-1609-1
/3,/4	16-26 10-14	45-1610 45-1611	L5563 L5562
/11,/12,/13, /14,/22	16-26 10-14	45-1654 45-1608	45-1654-1 45-1608-1
/17,/18,/19,/20	16-26	45-1672	45-1672-1
/21	16-26	45-1523	45-1523-1
MIL-C-85485 /5,/6,/7,/8,/9, /10,/11,/12	16-26 10-14	45-1924 45-1925	45-1924-1 45-1925-1
Wire Wrap Solid Wire	30 24-30	45-179 45-169	L7625 L9300
General Purpose	26-30 16-26 10-14	45-172 45-171 45-170	L5436 L5211 L5210
Note: Specification MIL-W-81381A and the various commercial specifications used for procuring aerospace wire provide for various wall thickness of insulation. The stripper part numbers identify the strippers and blades for each variation.			

NOTE

When the handles are partially released, the stripper jaws remain open so the wire can be removed without kinking the conductor. (refer to Fig 3-8, step c).

Stripping Dimensions for Assembly to Connectors

23. Stripped length of wires that are to be attached to solder-type connectors should be such that when stripped conductor bottoms in solder cup there will be a gap of approximately 0.76 mm between the end of the cup and the end of the insulation, for inspection purposes.

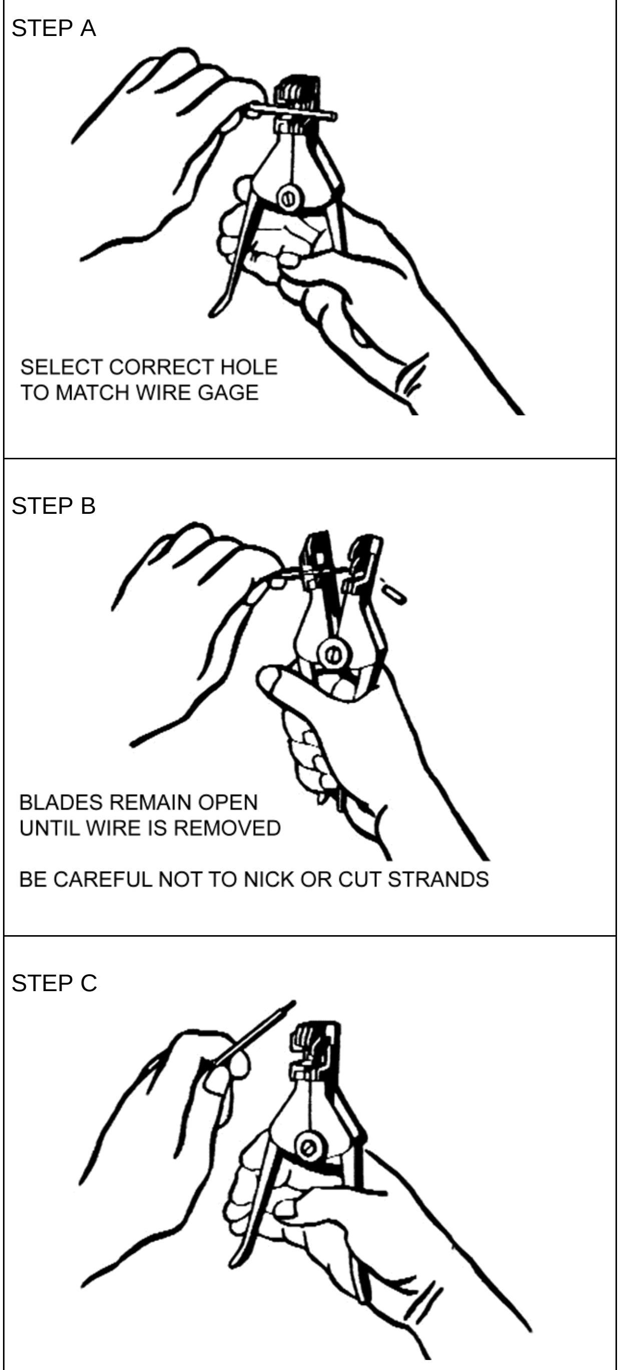


Figure 3-9 Stripping Wire With Hand Stripper

TINNING COPPER WIRE AND CABLE

General

24. Before copper wires are soldered to connectors, the ends exposed by stripping are tinned to hold the strands solidly together. The tinning operation is considered satisfactory when the ends and sides of the wire strands are fused together with a coat of solder. Do not tin wires which are to be crimped to Class K (fireproof) connectors, wires which are to be attached to solderless terminals or splices, or wires which are to be crimped to removable crimp-style connector contacts.

Tinning Methods

25. Copper wires are usually tinned by dipping into flux and then into a solder bath. In the field, copper wires can be tinned with a soldering iron and rosin core solder.

Extent of Tinning

26. Tin conductor for about half its exposed length. This is enough to take advantage of the closed part of solder cup. Tinning or solder on wire above the cup causes wire to be stiff at point where flexing takes place. This will result in wire breakage.

WARNING

Ensure adequate ventilation and exercise care while using a solder pot. Solder Fumes are toxic and the hazard of severe burns exists.

Flux and Solder

27. The solder used is a mixture of 60% tin and 40% lead. Maintain the temperature of the solder pot between 235°C and 260°C, this will keep solder in a liquid state. Skim surface of solder pot as necessary with a metal spoon or blade to keep the solder clean and free from oxides, dirt, etc.

CAUTION

Do not use any other flux or solder for tinning copper wires for use in aircraft electrical systems.

Dip-Tinning Procedure

28. Dip-tin wires smaller than No. 8 about eight or ten at a time. Dip-tin wires size No. 8 and larger individually. (See Figure 3–10).

CAUTION

During tinning operation, take care not to melt, scorch or burn the insulation.

29. The procedure for dip tinning is as follows:

- **a.** Prepare flux and solder as described in paragraph 11.
- **b.** Ensure that exposed end of wire is clean and free from oil, grease, and dirt. Strands should be straight and parallel. Dirty wire should be re-stripped.
- **c.** Grasp wire firmly and dip into dish of prepared flux to a depth of about 3mm.
- **d.** Remove wire and wipe off excess flux.
- **e.** Immediately dip into molten solder. Dip only half of stripped conductor length into solder.
- **f.** Manipulate wire slowly in solder bath until it is thoroughly tinned. Watch the solder fuse to the wire. Do not keep the wire in bath longer than necessary.
- **g.** Remove wire if excess solder is noted and remove excess with solder sucker or equivalent.

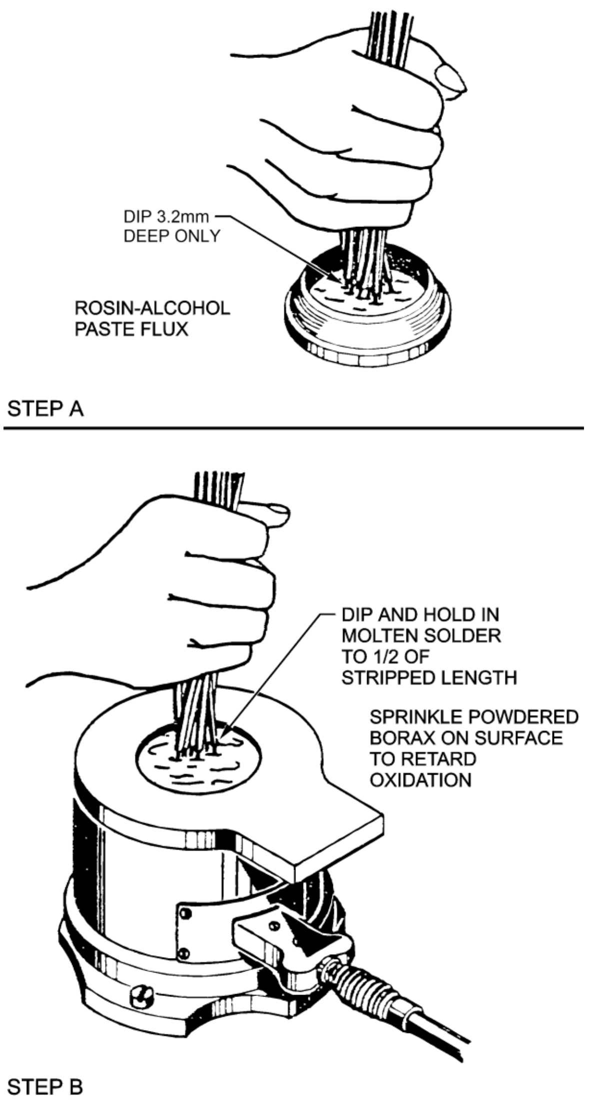


Figure 3-10 Dip-Tinning in Solder Pot

> **NOTE**
> The thickness of the solder coat depends on the speed with which the wires are handled and the temperature of the solder bath. Never shake or whip wire(s) to remove excess flux or solder.

Soldering Iron Tinning Procedure

30. In the field, wires smaller than size No. 10 may be tinned with a soldering iron and rosin-core solder as follows (see Figure 3–11):

- **a.** Select a soldering iron having suitable heat capacity for wire size as listed in Table 3–3. Make sure that the iron is clean and well tinned.
- **b.** Prime by holding iron tip and solder together on wire until solder begins to flow.
- **c.** Move the soldering iron to the opposite side of the wire and tin half of the exposed length of conductor.

Table 3–3 Approximate Soldering Iron Sizes for Tinning

Wire Size (AWG)	Soldering Iron Size (Heat Capacity)
20 - 16	65 Watts
14 & 12	100 Watts

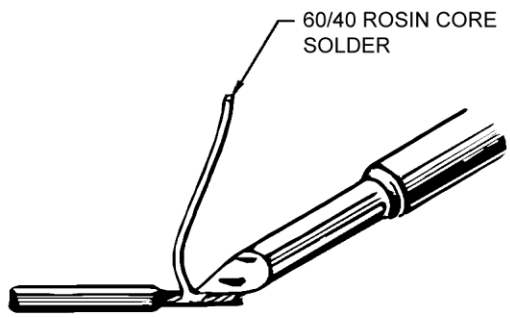


Figure 3- 11 Tinning Wire With Soldering Iron

TERMINATING SHIELDED CABLE

General

31. Shielded cable has a metallic braid over the insulation to provide a barrier against electromagnetic interference. To obtain a satisfactory result from shielded cable, the shield must be unbroken and must extend to a point as near to the end of the conductor as practicable. Shielded cable is either grounded or dead-ended at each end as required by the individual installation.

Stripping Jacket on Shielded Cable

32. Most shielded cable has a thin extruded plastic coating over the shielding braid. Strip this off as far as necessary with a hot blade stripper, as described in paragraph 5. The length of the strip depends on the method of shield termination and type of wire connection. Strip the outer jacket back far enough for ease in working. If no hot-blade stripper is available, use plier type hand strippers for sizes No. 22 through No. 10 and a knife for sizes larger than No. 10. Be careful not to damage the shielding braid.

Coaxial Cable Strippers

33. As their name implies, coaxial cable strippers are used for preparing coaxial cable. Coaxial cable strippers are unique in that they have two blades located on each side of the tool and a round blade attached to the front, as can be seen in Figure 3-12.

34. There are several types of coaxial cable strippers available, so, where available, always make sure the tool instructions are referred to when selecting the correct tool for cable type.

35. As depicted in Figure 3-12, the two blades located on each side of the tool may be adjusted individually to vary the stripping dimension and the depth of the cut. The axial stripping blade attached to the front of the stripper is used to slit the cable axially (along the length of the cable).

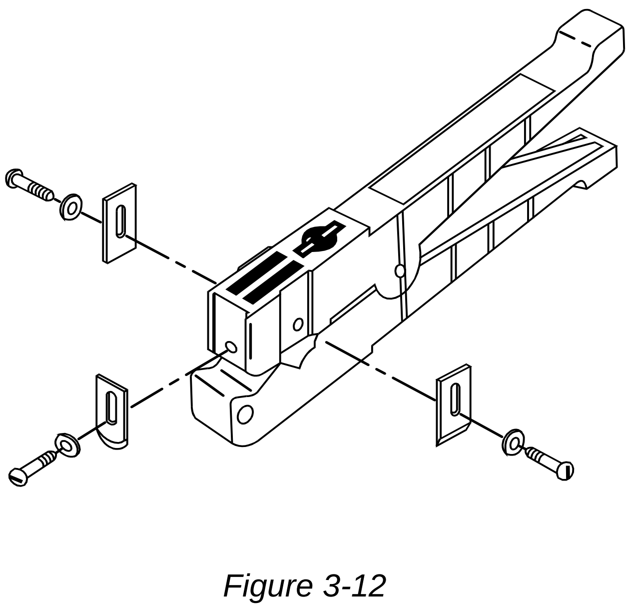


Figure 3-12
Coaxial Cable Strippers

36. To strip coaxial cable using coaxial cable strippers:

- **a.** Adjust the blades to the applicable stripping dimensions, ensuring the depth of the blades is set so that the jacket will be scored without damage to the inner shielding.

b. Position the tool on the cable so that an excess length of cable will be left after the stripping operation is complete.

c. Spin the tool around the cable, as demonstrated in Figure 3-13 until the maximum cutting depth is obtained.

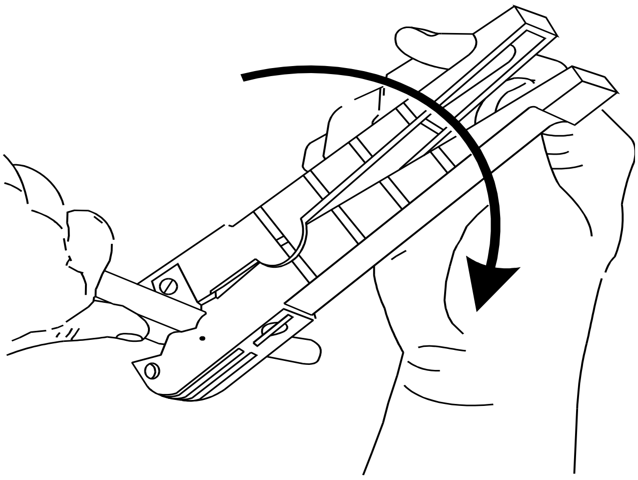


Figure 3-13
Procedure For Stripping Co-axial Cable

d. Slit the cable jacket by simply placing the cable in the front notch of the tool and pulling it through.

e. Peel off the jacket.

f. Steps one to three are repeated to strip the excess shielding. Be careful not to damage the inner dielectric.

g. Remove the excess shielding.

h. The dielectric may be stripped by hand using a knife or by repeating steps one to three.

i. To remove excess dielectric, flex the scored cut to separate the dielectric. Slide the excess dielectric off the inner conductor.

37. Coaxial cable strippers are particularly useful if a large quantity of cables need to be stripped. However, they require accurate setting up that can be time consuming. To strip individual cables, it is often quicker to use a knife.

Grounded Shield Termination

38. Grounded shield termination procedure is as follows:

a. Strip the shielded wire.

b. Comb out the exposed shielding and fold back over the jacket.

c. Ensure that the shield braid strands are flat and smooth.

NOTE

Solder sleeve terminations consist of a heat shrinkable insulation sleeve with an integral solder preformed with flux and thermal indicator, and two integral rings of sealing material. When the solder sleeve is placed over a cable and heated, the solder melts and flows connecting the ground lead to the shield. The outer sleeve shrinks and the thermoplastic insert melts, encapsulating the termination. The result is a soldered, strain relieved, environmentally protected termination. Solder sleeves are available with or without preinstalled leads.

WARNING

Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft.

Use of nitrogen with hot air gun M83521/5-01 in an enclosed area can be hazardous. Ensure area is well ventilated.

CAUTION

Solder sleeves may only be used in areas where the temperature does not exceed 150°C.

NOTE

The heat shrinkable solder sleeves listed in Table 3–4 are qualified to SAE AS 83519 and are appropriate for terminating shielded cables, however they should not to be used in lieu of alternate methods detailed in specific aircraft maintenance publications, without prior engineering approval.

d. Measure the diameters “A, B and C” as shown in Figure 3–14.

e. Select the appropriate size sleeve from Table 3–4.

f. Position the solder sleeve over the assembly so that the solder ring is centred over the shielding as shown in Figure 3–14.

g. Install solder sleeves using approved tooling listed in Table 3–14.

h. Hold assembly horizontal and position sleeve in heat shield.

i. Rotate assembly while heating to achieve proper solder penetration and uniform sleeve shrinkage. About 10 to 30 seconds are required for complete solder melt and flow.

j. Continue to apply heat until solder brightens and starts to flow toward the thermoplastic inserts at either end of sleeve.

k. As soon as the solder flow is observed, withdraw the heat.

l. When the solder joint has been made, hold the work firmly in place until the joint has set. Disturbing the finished work will result in a joint mechanically weak, and with high electrical resistance. Allow solder joints to cool naturally. Do not use liquids or air blasts.

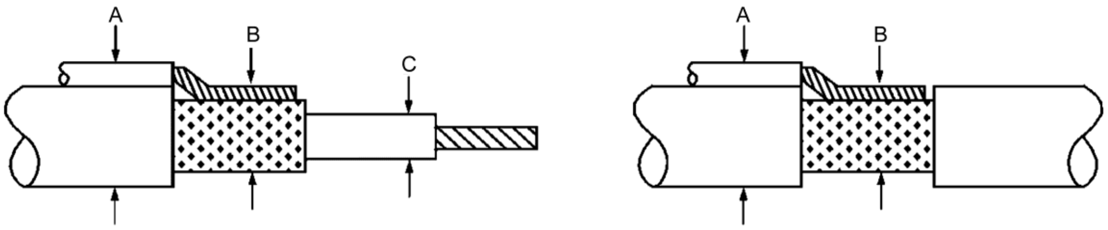


Figure 3-14 Combined Cable Diameter Measurements

Table 3–4 Heat Shrink Solder Sleeves For Tin and Silver Plated Conductors (Splice Temperature rating 150°C) Maximum

Part Number	Gauge of Pre-installed Ground Lead	A Maximum	B Minimum	C Minimum
M83519/1-1	-	2.7	0.9	0.5
M83519/1-2	-	3.7	1.4	0.8
M83519/1-3	-	5.0	2.2	1.3
M83519/1-4	-	6.5	3.3	1.8
M83519/1-5	-	7.6	4.3	2.5
M83519/2-1	20	2.7	0.9	0.5
M83519/2-2	20	3.7	1.4	0.8
M83519/2-3	20	5.0	2.2	1.3
M83519/2-4	20	6.5	3.3	1.8
M83519/2-5	20	7.6	4.3	2.5
M83519/2-6	22	2.7	0.9	0.5
M83519/2-7	22	3.7	1.4	0.8
M83519/2-8	22	5.0	2.2	1.3
M83519/2-9	22	6.5	3.3	1.8
M83519/2-10	22	7.6	4.3	2.5
M83519/2-11	24	2.7	0.9	0.5
M83519/2-12	24	3.7	1.4	0.8
M83519/2-13	24	5.0	2.2	1.3
M83519/2-14	24	6.5	3.3	1.8
M83519/2-15	24	7.6	4.3	2.5
M83519/2-16	26	2.7	0.9	0.5
M83519/2-17	26	3.7	1.4	0.8
M83519/2-18	26	5.0	2.2	1.3
M83519/2-19	26	6.5	3.3	1.8
M83519/2-20	26	7.6	4.3	2.5

- All dimensions are in mm.
- When using a sleeve with a pre-installed lead (M83519/2-*), A is the diameter of the cable only.
- C is the minimum diameter on which the sleeve will seal.

Table 3–5 Heat Shrink Tooling

Part Number	Description	Use
M83521/5-01	Heat Gun Electric	Installation of heat shrinkable items on fuelled aircraft.
IR500	Infra-red Heat Gun	Installation of heat shrinkable items in workshops etc.
CV-5302	Hot Air Blower	Installation of heat shrinkable items in workshops etc.
PR13	Heat Reflector	Short lengths of tubing up to 6.4mm diameter and high temperature solder sleeves.
PR24	Heat Reflector	Smaller molded parts and tubing 25 to 40mm diameter.
PR24A	Heat Reflector	Larger molded parts and tubing over 12mm diameter.

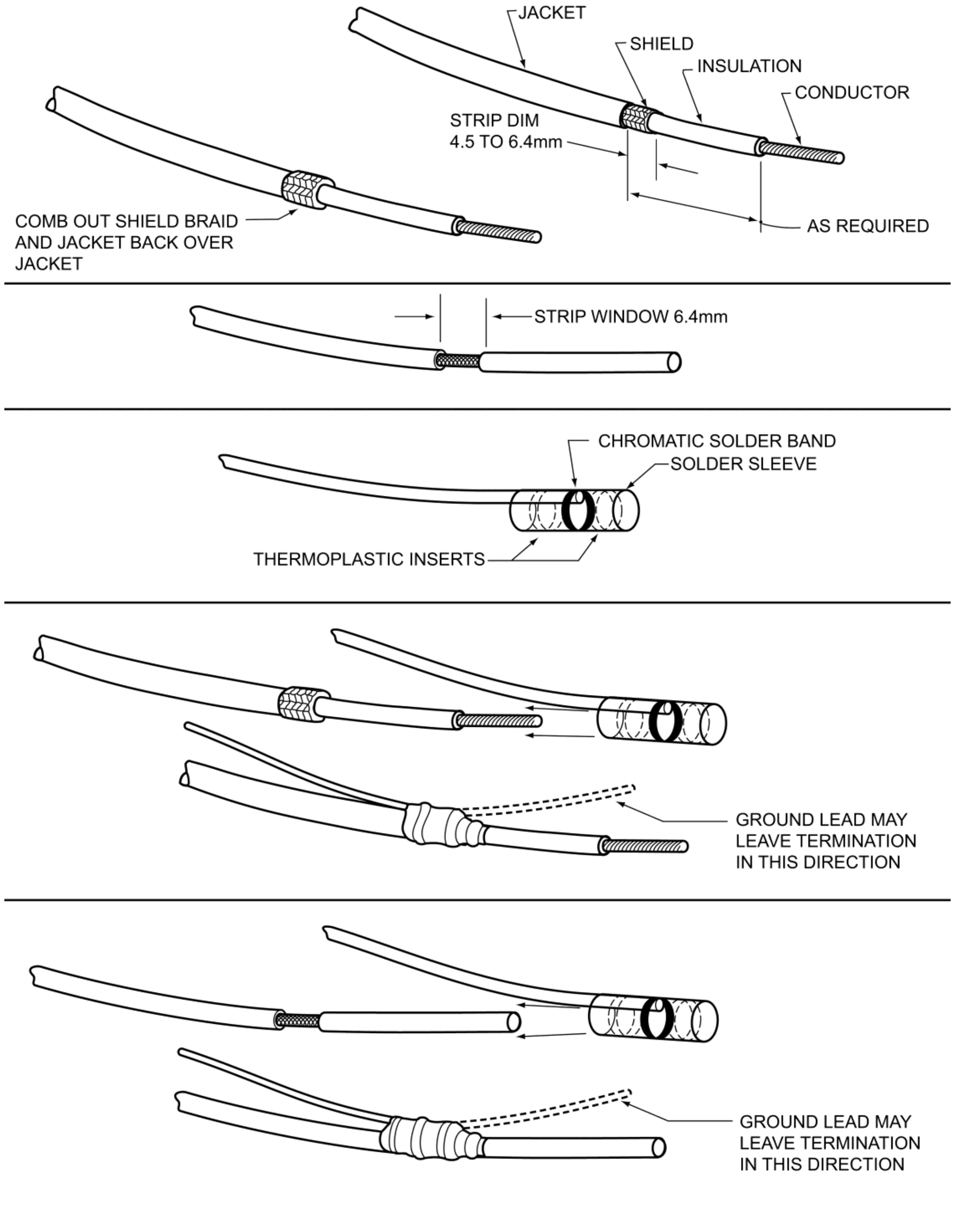


Figure 3-15Solder Sleeve Shield Termination

Ungrounded (Floating) Shield Termination

39. Ungrounded (floating) shield termination procedure is as follows:

- **a.** Strip the shielded wire as shown in Figure 3–14.
- **b.** Comb out the exposed shielding and fold back over the jacket.
- **c.** Select the appropriate size solder sleeve from Table 3–4.
- **d.** Make sure that the shield strands are flat and smooth.
- **e.** Position the solder sleeve over the assembly so that the solder ring is centred over the folded back shielding.

> **WARNING**
>
> Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft.
>
> Use of nitrogen with hot air gun M83521/5-01 in an enclosed area can be hazardous. Ensure area is well ventilated.

> **CAUTION**
>
> Solder sleeves may only be used in areas where the temperature does not exceed 150°C.

f. Hold assembly horizontal and position sleeve in heat shield.

g. Rotate assembly while heating to achieve proper solder penetration and uniform sleeve shrinkage. About 10 to 30 seconds are required for complete solder melt and flow.

h. Continue to apply heat until solder brightens and starts to flow toward the thermoplastic inserts at either end of sleeve.

i. As soon as the solder flow is observed, withdraw the heat.

j. When the solder joint has been made, hold the work firmly in place until the joint has set. Disturbing the finished work will result in a joint mechanically weak, and with high electrical resistance. Allow solder joints to cool naturally. Do not use liquids or air blasts.

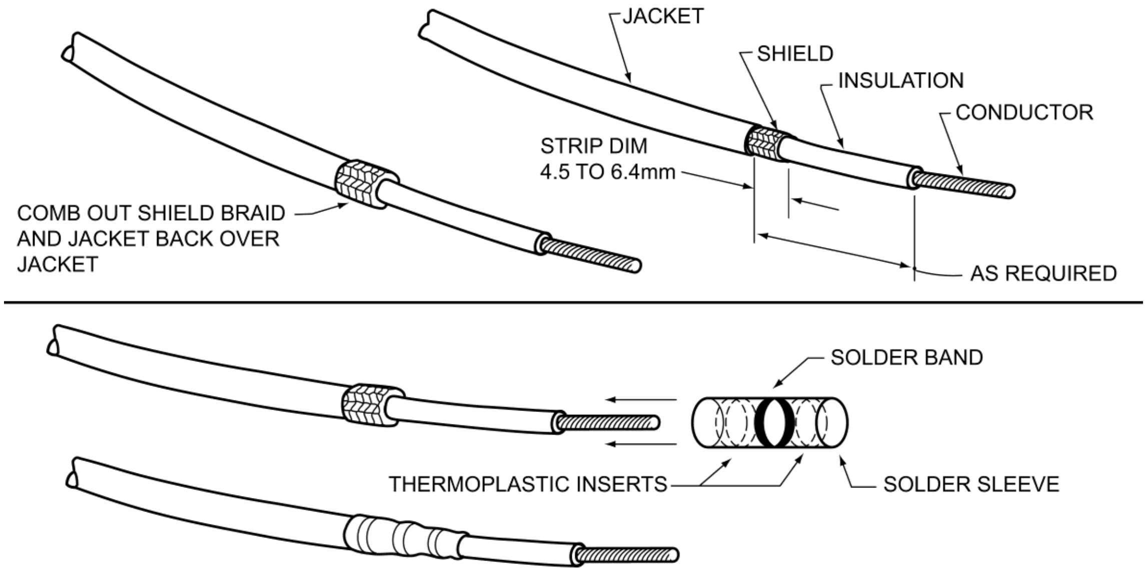


Figure 3- 16 Solder Sleeve Floating Shield Termination

Types of Solder Sleeves

40. As with any component used to maintain aircraft, solder sleeves should conform to a specification. The Military Spec styles of solder sleeve termination are the M83519/l, and M83519/2.

41. The M83519/l, (shown in Figure 3-16) and the M83519/2, (shown in Figure 3-17), are identical in construction, function and use, except that the M83519/2 contains a pre-tinned ground lead.

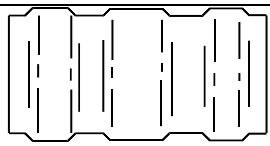


Figure 3-17
The M83519/l Type of Solder Sleeves

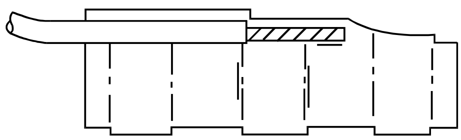


Figure 3-18
The M83519/2 Type of Solder Sleeves

Solder Sleeve Heating Tools

42. Proper application of heat is important to produce a reliable solder connection and sealing of the solder sleeve. The sleeves are designed to be installed using a hot air source or alternately an infra-red heating tool.

43. The type of tool selected will depend largely on the work environment; ie whether you are working in a workshop or on an aircraft. If working on an aircraft, the tool must be portable and present no risk of igniting fuel vapour.

44. The three heating tools in common use are:

a. infrared heating tool,

b. compressed air/nitrogen heating tool, and

c. turbofan type heat gun.

Infrared Heating Tool

45. The infrared heating tool is a self-contained portable unit. The main components are labelled in Figure 3-19. Infrared heat tools offer several advantages over other methods of heating solder sleeves including faster shrinking and solder flow. Also being less complicated, they are easier to set up.

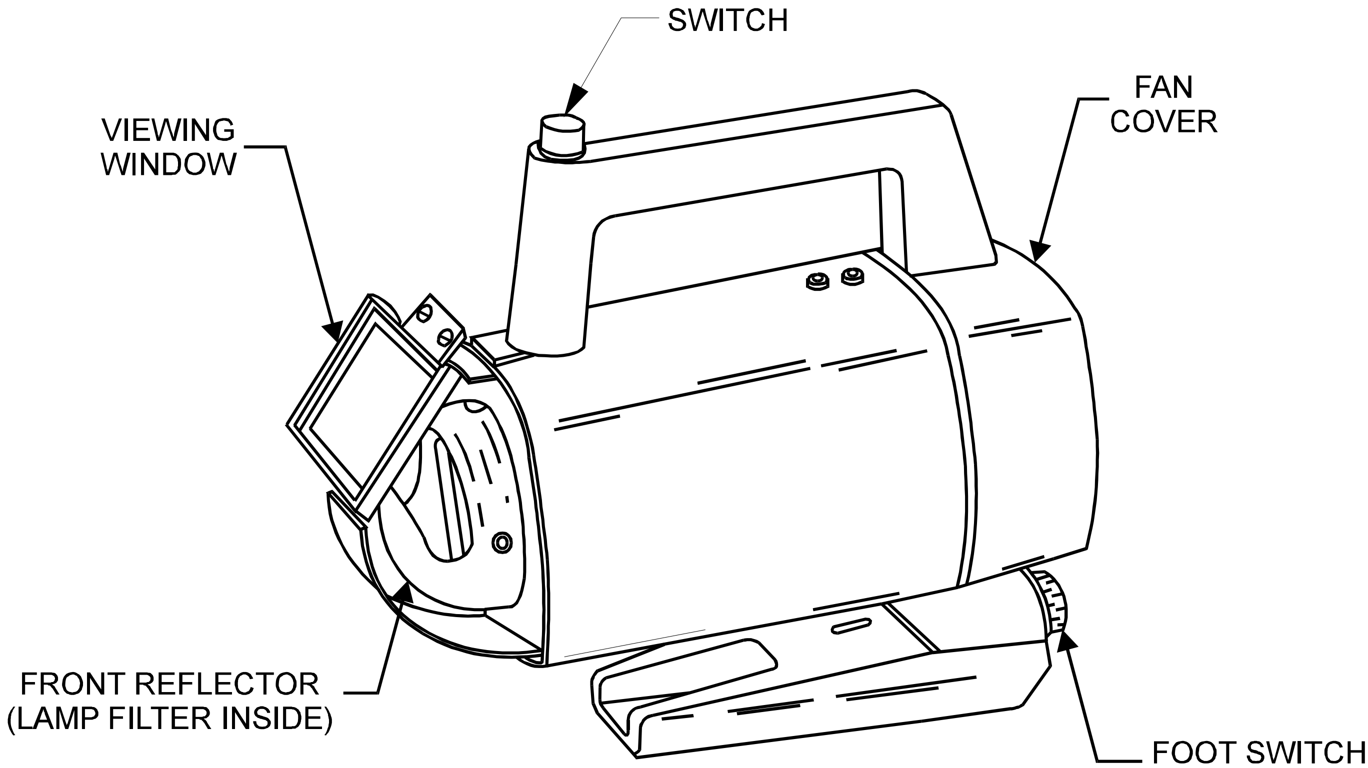


Figure 3-19
Infrared Heating Tool

Compressed Air/Nitrogen Heating Tool

46. The compressed air/nitrogen heating tool (illustrated in Figure 3-20) is a portable source of heat for use with heat-shrinkable tubing and solder sleeves. As the unit is fully enclosed, it is approved for use on fuelled aircraft. To operate, the heating tool must be connected to an external source of compressed air/nitrogen and power.

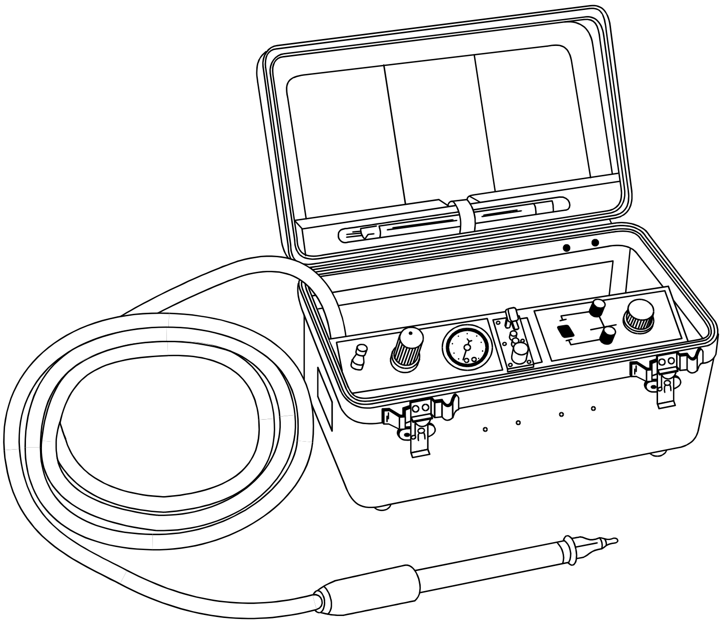


Figure 3-20
Compressed Air/Nitrogen Heating Tool

47. When operating the compressed air/nitrogen heating tool, the following warnings apply:

Warning

The nozzle and output air from the heat gun get very hot. Use extreme care while operating the heat gun to avoid serious burns.

The use of nitrogen with the heat gun in an enclosed area can be hazardous. Discharge of nitrogen into a poorly ventilated area can result in asphyxiation.

Do not use electrical power from an aircraft under repair. Aircraft power should be off during repair of aircraft electrical systems. Use electrical power from a ground power unit.

Turbofan Type Heat Gun

48. The Thermogun Mark II heating tool, illustrated in Figure 3-21, is a rugged stand mounted or hand held hot air tool. The heating tool has been engineered with a turbo fan driven blower and a double jacketed element housing for heavy duty use. It has features such as adjustable side vents for limited temperature control, and a wide variety of hot air reflectors. The Thermogun provides precise control when terminating a broad range of heat shrinkable products including boots and tubing up to 75 mm in diameter.

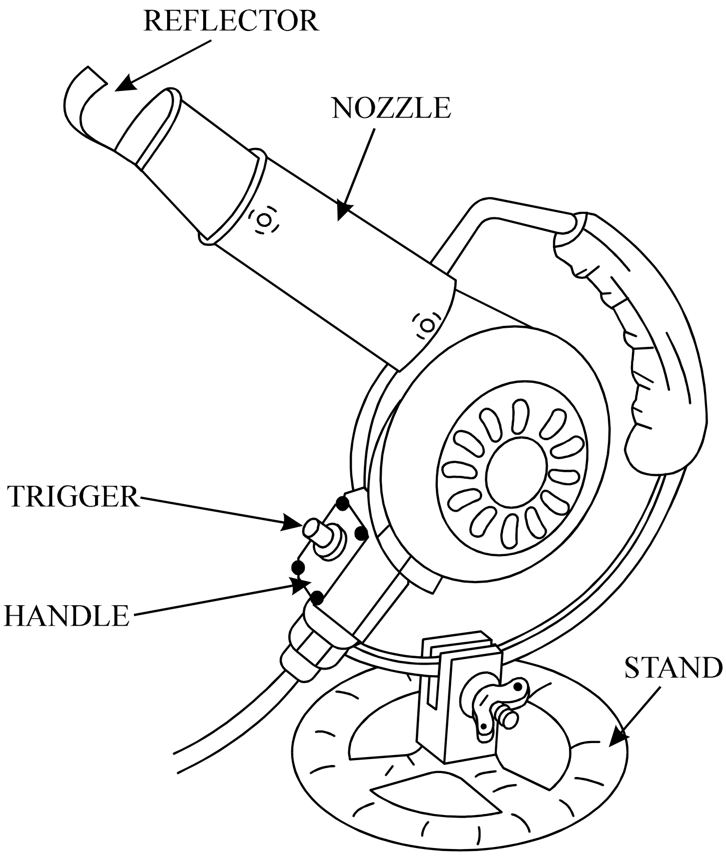


Figure 3-21 Turbofan Type Heat Gun

49. There are numerous models and variations of the turbofan type heat guns available. The following description of operation is similar for most turbofan type heat guns.

Pre-operation

50. Before using the heating tool, carry out the following:

a. Visually check the reflector for foreign material accumulation.
b. If accumulation is found, remove the reflector by pulling it straight off the nozzle.
c. Clean foreign material off reflector surfaces with a soft cloth and isopropyl alcohol.

Warning
Isopropyl alcohol is flammable. Do not use in the presence of sparks, heat or flame.

d. Install the reflector being careful not to touch the reflective surface.

Reflector Selection

51. Heating tool attachments consist of a range of reflectors. These reflectors are attached to the nozzle of the heating tool and concentrate the heated output around the material. Note, the exact reflectors supplied will vary according to the make and model of the heating tool. A selection of the various reflectors you may encounter are as follows:

a. Termination sleeve reflector. Used for heating solder termination sleeves and shrinking small diameter tubing.

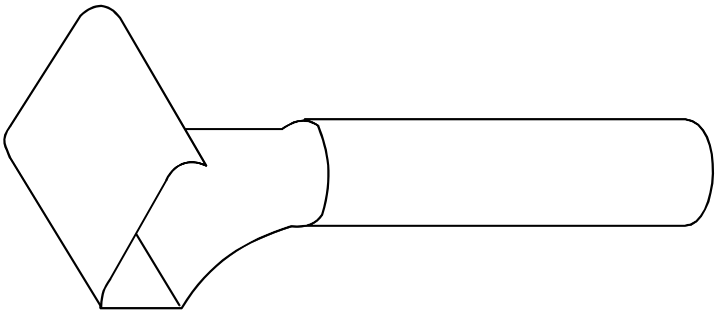


Figure 3-22Termination Sleeve Reflector

b. Miniature termination sleeve reflector. Used for heating small solder termination sleeves and making terminations in a confined area.

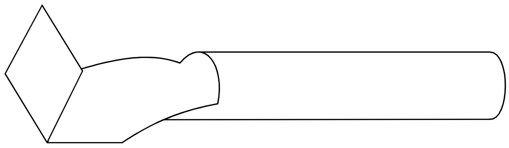


Figure 3-23 Miniature Termination Sleeve Reflector

c. Boot and tubing reflector. - Used for shrinking tubing and moulded components such as strain-relief boots and potting caps.

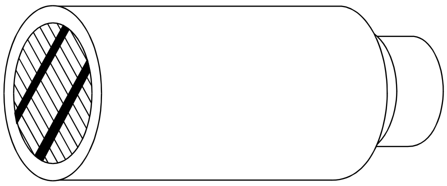


Figure 3-24 Boot and Tubing Reflector

d. Needle point reflector. Used where a lower, more precise air-flow is required to terminate micro-miniature connectors, or to repair or modify low temperature insulated wire terminations.

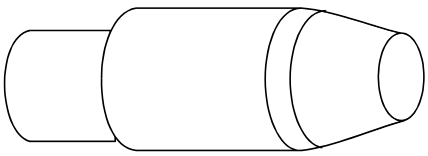


Figure 3-25 Needle Point Reflector

e. Large boot and tubing reflector. Used for installing large diameter tubing and moulded parts.

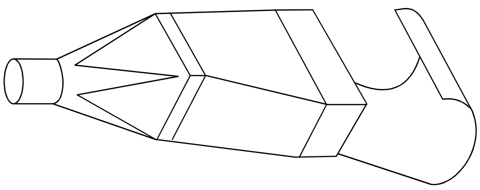


Figure 3-26 Large Boot And Tubing Reflector

Operation

52. To operate the heat guns, proceed as follows:

> **Warning**
>
> Do not use heat guns with electric motors when working on aircraft that have not been defueled and purged. Sparks generated by the electric motors may ignite fuel vapour.
>
> Nozzle and output air of heat guns get very hot. Use extreme care while operating a heat gun to avoid serious burns.

a. Select the appropriate reflector for the application.

b. Install the reflector on the front of the heat gun nozzle by pushing the reflector straight on.

c. Check the power requirement of the tool being used and plug the cord into the appropriate power supply.

d. Prepare the assembly to be heated (this will be covered in detail in the next section).

e. Turn the heating tool on and allow a short warm up period.

f. Place the assembly into the heating area.

g. Observe the assembly during the heating process. After the assembly has received sufficient heat, remove the assembly from the heating area and turn the heat gun off.

h. Inspect the assembly for correct forming (this will also be covered in detail in the next section).

Post Operation

53. After using the heating tool, proceed as follows:

a. Disconnect the power connector from the power source.

b. Allow a few minutes for the reflector to cool.

c. Visually check the reflector for foreign material accumulation. If material is found, clean as described in the pre-operation procedure.

Cable Preparation

54. Before terminating the shielded wire, the cable needs to be prepared. To prepare the shielded cable, use one of the following methods applicable to the intended application:

a. For centre stripped cables rated above 125°C, prepare as per dimensions illustrated in Figure 3-27.

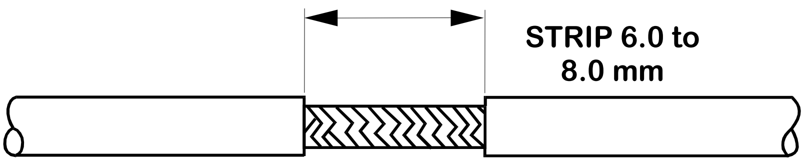


Figure 3-27
Preparation of Centre Stripped Cable

b. For end stripped cables rated above 125°C, prepare as per dimensions illustrated in Figure 3-28.

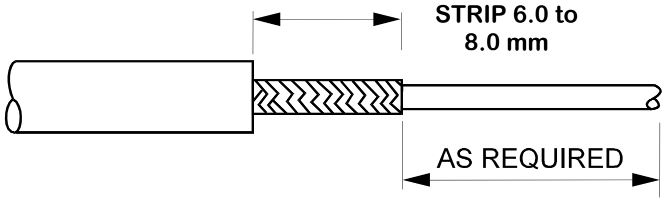


Figure 3-28
Preparation of End Stripped Cable

c. For cables rated between 105°C and 125°C, or to build up the diameter of small cables, fold back the braid and prepare as per dimensions illustrated in Figure 3-29.

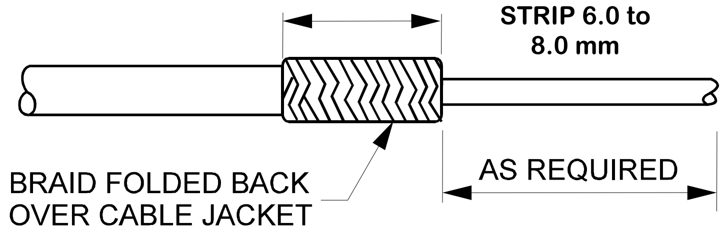


Figure 3-29 Preparation of End Stripped Braided Cable

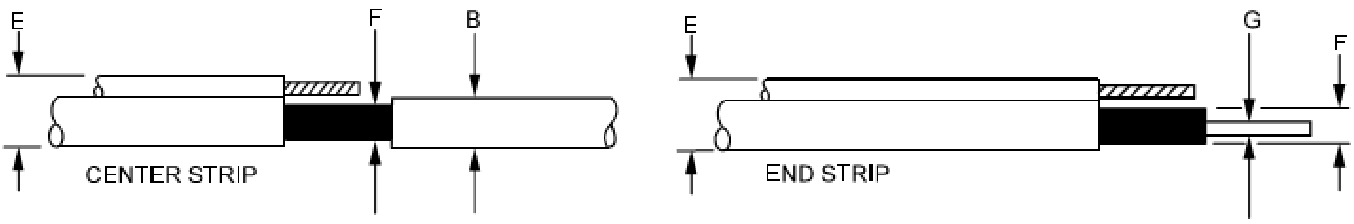
d. To provide proper sealing and connection, the solder sleeve must be selected by size and cable dimensions

Installation of the Mil Spec M83519/1 Solder Sleeve

55. The M83519/1 solder sleeve does not have a pre-installed ground lead so it will be required to prepare a ground lead prior to installation. The procedure to manufacture a ground lead and install the solder sleeve is as follows:

a. Select and prepare a ground lead suited to application from a relevant aircraft wiring publication. Strip one end to the dimension as illustrated in Figure 3-30.

Figure 3-30 Installation of the M83519/1 Solder Sleeve



TERMINATOR SIZE	CABLE DIMENSIONS (mm)¶				IDENTIFICATION NUMBER
	B max.	E max.	F max.	G max.	
1	2.0¶	2.7¶	0.9¶	0.5¶	SO XX1R
2	2.7¶	3.7¶	1.4¶	0.8¶	SO XX2R
3	4.3¶	5.0¶	2.2¶	1.3¶	SO XX3R
4	6.0¶	6.5¶	3.3¶	1.8¶	SO XX4R
5	7.0¶	7.6¶	4.3¶	2.5¶	SO XX5R

b. Assemble the cable, ground lead, and solder sleeve ensuring no strands protrude to puncture the sleeve, as illustrated in Figure 3-31. Note, the ground lead can enter the sleeve from either side.

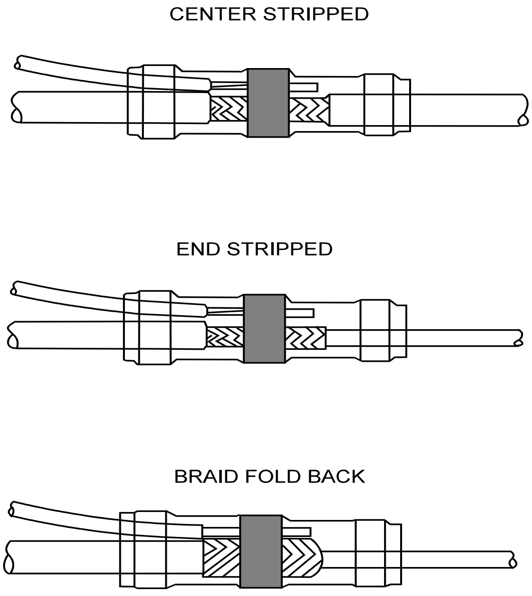


Figure 3-31 Examples of Solder Sleeve Assembles

c. Apply heat directly at the solder preform using a suitable heat gun deflector. Remove from heat when the solder melts and wets to the shield braid and ground lead, as illustrated in Figure 3-32.

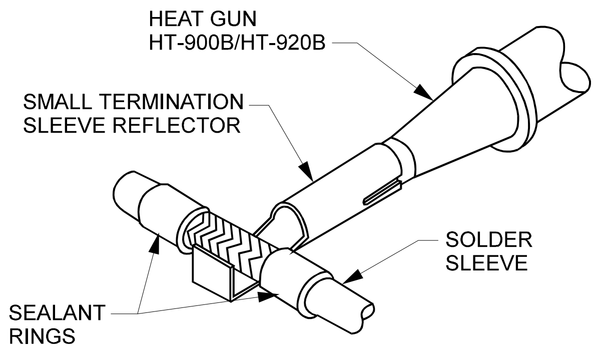


Figure 3-32 Installation of the M83519/1 Solder Sleeve

Note

The collapse of the solder preform does not indicate solder flow. Continue to apply heat until the solder flows and forms a fillet between the shield and the ground lead.

If necessary, heat each end of the sleeve to complete shrinkage of the tubing and inserts.

Warning

Do not handle the termination when hot as serious burns will result. Allow the termination to cool prior to handling.

56. Inspect the termination according to the following guidelines:

a. Unacceptable Termination (Insufficient Heat)

- The thermal indicator is clearly visible as a dull red colour.

- The original shape of the solder preform is clearly visible.
- The sealing inserts have not flowed.
- The contour of the braid and/or lead is blocked by solder.

b. Acceptable Termination (Minimum Solder Flow)

- The thermal indicator shows slight traces of dull red colour.
- The solder has lost all its original shape.
- The sealant inserts have melted and flowed along the wires.
- The shield and lead contours are visible.
- A definite fillet is visible between lead and shield.

c. Acceptable Termination (Maximum Solder Flow)

- The dull red colour has disappeared from the thermal indicator.
- A definite fillet is clearly visible between the lead and shield.
- The joint area is visible despite the browning sleeve.

d. Unacceptable Termination (Overheated)

- The joint area is not visible because of severe darkening of the outer sleeve.
- The solder fillet is not visible along the lead and shield interface.
- Wire insulation is damaged outside of the sleeve.
- Re-shrink, if necessary, until acceptable conditions exist.
- If an overheated condition has occurred, cut out the damaged termination and start the procedure again.

e. Installation of the M83519/2 Solder Sleeve

- Installation of the M83519/2 solder sleeve is the same as the M83519/1 with the exception of the ground lead preparation not being required as it is pre-installed.

SECTION 2

CHAPTER 4

ELECTRICAL WIRING INSTALLATION

INTRODUCTION

1. This chapter describes recommended procedures for installing electrical wiring and related accessories in ADF aircraft.

REFERENCE SPECIFICATIONS

2. The following specifications are applicable to electrical wiring installation:

AN742	Clamp, Loop, Plain, Support, Aircraft
AN936	Washer, Tooth Lock
AN960	Washer Flat
MIL-DTL-23053	Insulation, Sleeving, Electrical, Heat Shrinkable
MIL-DTL-25038	Wire, Electrical, High-Temperature, Fire Resistant and Flight Critical
MIL-DTL-5593	Hose, Aircraft, Low- Pressure, Flexible
MIL-DTL-8777	Wire Electrical, Silicone Insulated, Copper, 600-Volt, 200°C
MIL-DTL-8794	Hose, Elastomeric - Hydraulic Fluid, Oil and Fuel Resistant
MIL-I-631	Insulation, Electrical, Synthetic-Resin Composition, Non-rigid
MIL-K-81786	Kit, Maintenance, Electrical-Electronic, Cable and Cable Harness
MIL-PRF-46846	Rubber, Synthetic, Heat Shrinkable
MIL-PRF-8516	Sealing Compound, Polysulfide Rubber, Electric Connectors and Electric Systems, Chemically Cured
MIL-T-81714	Terminal Junction Systems Environment Resistant
MIL-W-22759	Wire, Electric, Fluoropolymer Insulated, Copper or Copper Alloy
MIL-W-81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy
MS18029	Cover Assembly, Electrical, For MS27212 Terminal Board Assembly
MS21919	Clamp. Cushioned, Support, Loop-Type, Aircraft
MS25036	Terminal, Lug, Crimp Style, Copper, Insulated, Ring-Tongue, Bell Mouthed, Type II, Class 1
MS25274	Cap, Electrical Wire End, Crimp Style, Type II, Class 1
MS25435	Terminal, Lug, Crimp Style, Straight Type for Aluminium Aircraft Wire, Class 1
MS3373	Strip, Mounting, Nut Insulating, for MS27212 Terminal Board
MS35489	Grommet, Synthetic and Silicone Rubber, Hot Oil and Coolant Resistant
MS51957	Screw, Machine-Pan Head, Cross-Recessed, Corrosion Resisting Steel, UNC-2A
NAS1070	Washer, Plain, Oversize for Aluminium Terminals
NASM21042	Nut, Self-Locking, 450°F, Reduced Hexagon, Reduced Height, Ring Base , Non-corrosion Resistant Steel
NASM21266	Grommet, Plastic, Edging
NASM22529	Grommet, Edging
NASM25440	Washer For Use with Aircraft. Aluminium Terminals
NASM35338	Washer, Lock-Spring, Helical, Regular Medium Series
NASM35649	Nut, Plain, Hexagon Machine Screw, UNC-2B
NASM35650	Nut, Plain, Hexagon, Machine Screw, UNF-2B
NASM961	Washer, Flat, Electrical
NEMA WC27500	Standard for Aerospace and Industrial Electrical Cable
SAE AS25281	Clamp, Loop, Plastic, Wire Support
SAE AS27212	Terminal Board. Assembly, Moulded-In Stud, Electric
SAE AS50881	Wiring, Aerospace Vehicle
SAE AS 6136	Conduit, Electrical, Flexible, Shielded, Aluminium Alloy for Aircraft Installation
MIL-I-7444	Insulation Sleeving, Electrical, Flexible
SAE AS735	Clamp, Loop-Type, Bonding

DEFINITIONS

3. The following definitions are applicable to electrical wiring installation:

- **a.** **Open Wiring.** Any wire, wire group, or wire bundle not enclosed in a covering.
- **b.** **Wire Group.** Two or more wires tied together to retain identity of the group.
- **c.** **Wire Bundle.** Two or more wire groups, tied together because they are going in the same direction at the point where the tie is located.
- **d.** Wire Harness. Wire group or bundle tied together as a compact unit (open harness) or contained in an outer jacket (enclosed harness). Wire harnesses are usually prefabricated and installed in the aircraft as a single assembly.
- **e.** Electrically Protected Wiring. Those wires which have protection against overloading, through fuses, circuit breakers, or other current-limiting devices.
- **f.** Electrically Unprotected Wiring. Those wires (generally from generators to main buss distribution points) which do not have protection from fuses, circuit breakers or other current-limiting devices.

WIRE TYPES

4. The wires most commonly used in aircraft electrical systems are in accordance with the specifications listed in Table 4–1. See Section 2, Chapter 1, for details of conductor, insulation, voltage and temperature.

WIRE GROUPS AND BUNDLES

Wire Separation

5. Specification SAE AS50881 restricts the grouping or bundling of certain wires, such as electrically unprotected power wiring, and wiring to duplicate vital equipment. Do not add such wires to existing bundles unless specifically authorised.

Size of Wire Bundle

6. Wiring specifications generally limit the size of wire bundles to 5 cm diameter.

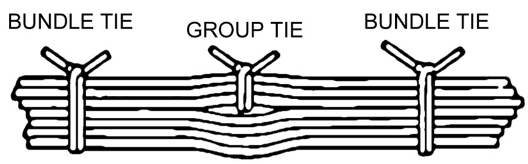


Figure 4- 1 Group and Bundle Ties

Identity of Groups Within Bundles

7. When several wires are grouped at junction boxes, terminal boards, panels, etc., retain the identity of the group within a bundle by spot ties, as shown in Figure 4–1.

Combing Wires

8. Comb out all wires, except those listed in paragraph 9, so that wires will be parallel to each other in a group or bundle.

Twisting Wires

9. When specified on applicable engineering drawings, twist together the following wires:

- **a.** Wiring in vicinity of magnetic compass or flux valve.
- **b.** Three-phase distribution wiring.
- **c.** Other wires (usually sensitive circuit avionic wiring) as specified on engineering drawings.

10. Twist wires so they lie snugly against each other, making approximately the number of twists given in Table 4–2. Check wire insulation for damage after twisting. If insulation is torn or frayed, replace the wire.

Table 4–1 Wire Types

600 Volts or Under			
General Purpose	**Aluminium**	**High Temperature**	**Fire Resistant**
MIL-W-22759	N/A	MIL-DTL-8777 *MIL-W-22759	MIL-DTL-25038
Cable, Shielded and Jacketed			
NEMA WC27500			
*MIL-W-22759 covers wire rated at 600 volts and 1000 volts			

Table 4–2 Twists Per 30cm

Wire Size	#22	#20	#18	#16	#14	#12	#10	#8	#6	#4
2 Wires	10	10	9	8	7.5	7	6.5	6	5	4
3 Wires	10	10	8.5	7	6.5	6	5.5	5	4	3

Spliced Connection in Bundles

11. Locate spliced connections in wire groups or bundles so that they can be inspected. Stagger splices as shown in Figure 4–2 so that the bundle does not become excessively enlarged. Ensure that all non-insulated splices are covered by shrinkable tubing or by plastic sleeves securely tied at both ends. Splices are subject to the restrictions of SAE AS50881. Splices are subject to the following restrictions:

a. There shall be no more than one splice in any one wire segment between any two connectors or other disconnect points, except as stated in sub-para e.

b. Splices in bundles shall be staggered and shall not increase the size of the bundle, so as to prevent the bundle from fitting in its designated space or cause congestion that will adversely affect maintenance.

c. Splices shall not be used to salvage scrap lengths of wire.

d. Splices shall not be used within 30cm of a termination device, except as stated in sub-para e.

e. Splices may be used within 30cm of a termination device when attaching to the pigtail spare lead of a potted termination device, to splice multiple wires to a single wire, or to adjust the wire sizes so that they are compatible with the contact crimp barrel sizes.

f. Splices may be used to repair manufactured harnesses or installed wiring when approved by an appropriate engineering authority.

g. Splices shall not be used on firing or control circuits associated with ordnance or explosive sub-systems.

NOTE

Splices may be used if incorporated in the original design or authorized by an engineering change.

h. The application of splices shall be under design control and shall be authorized by engineering drawings.

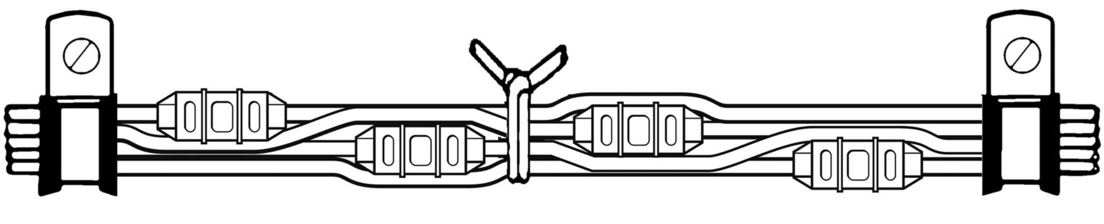


Figure 4- 2 Staggered Splices in Wire Bundles

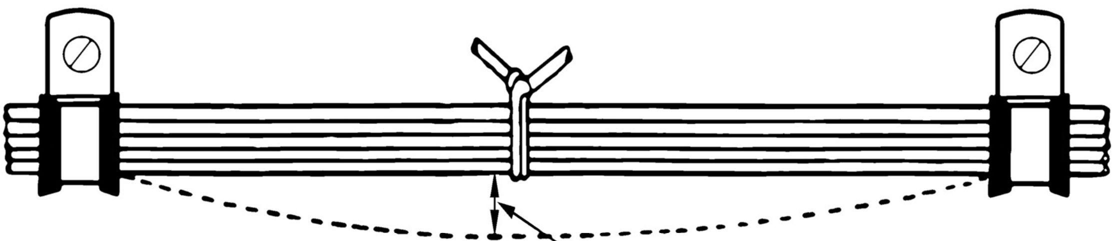


Figure 4- 3 Slack Between Supports

Slack

12. Do not install single wires or wire bundles with excessive slack. Slack between support points such as cable clamps should normally not exceed 12.7mm. (See Figure 4–3.) This is the maximum that it should be possible to deflect the wire with moderate hand force. This may be exceeded if the wire bundle is thin and the clamps are far apart but the slack must never be so great that the wire bundle can touch any surface against which it may abrade. Allow a sufficient amount of slack near each end for any or all of the following:

- **a.** To permit ease of maintenance.
- **b.** To allow replacement of terminals at least twice.
- **c.** To prevent mechanical strain on the wires, cables, junctions, and supports.
- **d.** To permit free movement of shock-and-vibration mounted equipment.
- **e.** To permit shifting of equipment, for purposes of maintenance, while installed in the aircraft.

Bend Radii

13. Bend individual wires to a minimum radius of ten times the outside diameter of the wire, except that at terminal boards where the wire is suitably supported at each end of the bend, a minimum radius of three times the outside diameter of the wire is acceptable. Bend wire bundles to a minimum radius of ten times the outside diameter of the largest wire in the bundle.

CAUTION

Never bend coaxial cable to a smaller radius than six times the outside diameter.

14. When it is not possible to hold the bending radius of single wires to the above limits, enclose bend in tight plastic tubing for at least 5cm each side of the bend.

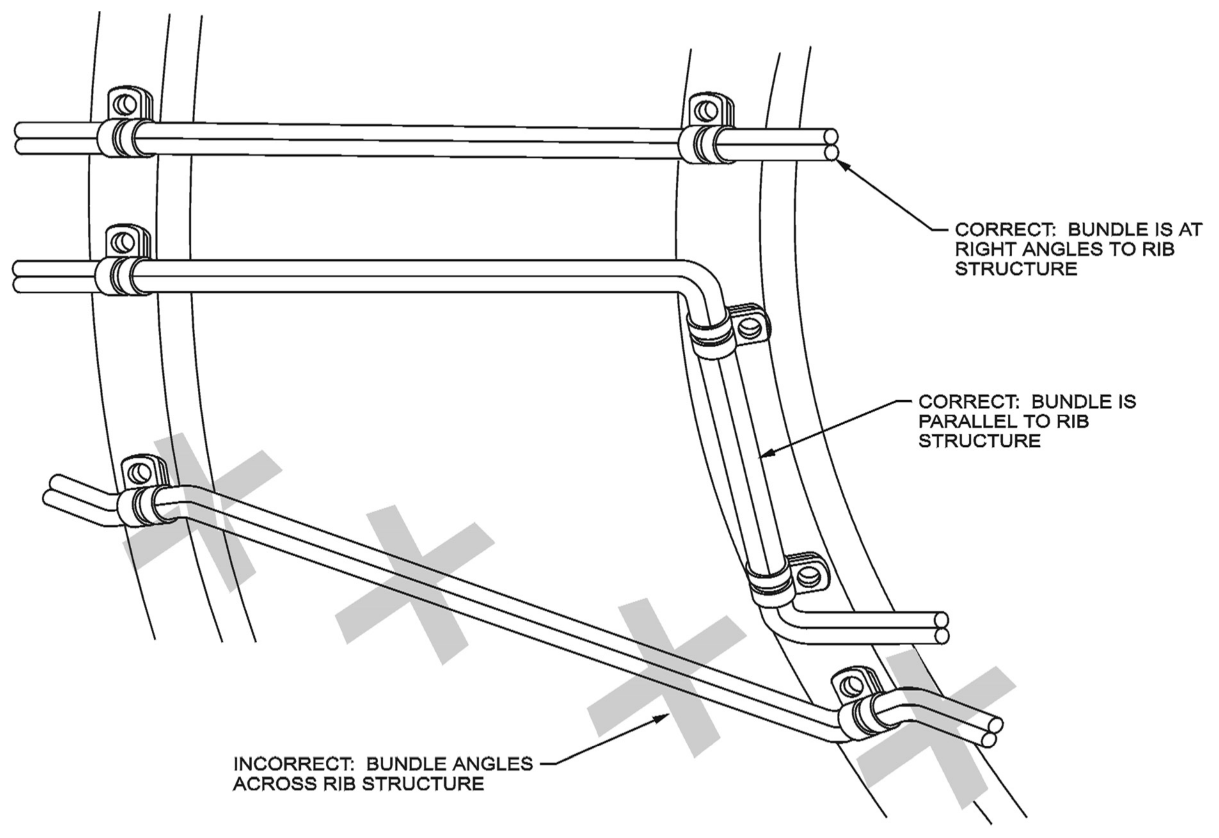


Figure 4- 4 Routing Bundles

ROUTING AND INSTALLATION

Drip Loop

15. Where wiring is dressed downward to a connector, terminal block, panel or junction box, a drip loop shall be provided in the wiring to prevent fluids or condensation from running into the components.

General Instructions

16. Install wiring so that it is mechanically and electrically sound, and neat in appearance. Wherever practicable, route wires and bundles parallel with, or at right angles to, the stringers or ribs of the area involved, as shown in Figure 4–4.

> NOTE
>
> Route coaxial cable as directly as possible. Avoid unnecessary bends in coaxial cable. Locate attachments at each frame rib on runs along the length of the fuselage, or at each stiffener on runs through the wings.

General Precautions

17. When installing electrical wiring in aircraft, observe the following precautions:

- **a.** Do not permit wire or wire bundles to have moving, frictional contact with any other object.
- **b.** Do not permit wire or wire bundles to contact sharp edges of structure, holes, etc. (Refer to paragraph 20.)
- **c.** Do not use any installation tools other than those specifically authorized.
- **d.** Do not damage threads of attaching hardware by over-tightening or cross-threading.
- **e.** Do not subject wire bundles to sharp bends during installation. (Refer to paragraph 13.)
- **f.** Do not allow dirt, chips, loose hardware, lacing tape scraps, etc., to accumulate in enclosures or wire bundles.
- **g.** Do not hang tools or personal belongings on wire bundles.
- **h.** Do not use installed wire bundles or equipment as footrests, steps, or handholds.
- **i.** Do not compensate for wires that are too long by folding wire back on itself and hiding such folds within bundles.
- **j.** Do not twist or pull wire bundles during assembly or installation so that pins are pulled from connectors, or connectors or wires are otherwise damaged.
- **k.** Do not stretch wires to mate connectors; allow sufficient slack to permit easy mating.
- **l.** Do not paint electrical wires, connectors, switches or other electrical devices.

Support

18. Bind and support wire and wire bundles to meet the following requirements:

- **a.** Prevent chafing of cables.
- **b.** Secure wires and wire bundles routed through bulkheads and structural members.
- **c.** Fasten wires in junction boxes, panels, and bundles for proper routing and grouping.
- **d.** Prevent mechanical strain that would tend to break the conductors and connections.
- **e.** Prevent arcing or overheated wires from causing damage to mechanical control cables.
- **f.** Facilitate re-assembly to equipment and terminal boards.
- **g.** Prevent interference between wires and other equipment.
- **h.** Permit replacement or repair of individual wires without removing the entire bundle.
- **i.** Prevent excessive movement in areas of high vibration.
- **j.** Use of mounting plate, P/N TC-92, for wire bundle support is recommended in areas where self-clinching cable straps are used.

Protection

19. Install and route wires and wire bundles to protect them from the following:

- **a.** Chafing or abrasion.
- **b.** High temperature.
- **c.** Use of wire bundles as handholds, footrests, or steps, or as support for personal belongings and equipment.
- **d.** Damage by personnel moving within the aircraft.
- **e.** Damage from cargo stowage or shifting.
- **f.** Damage from battery acid fumes, spray, or spillage.
- **g.** Damage from solvents and fluids.
- **h.** Abrasion in wheel wells where exposed to rocks, ice, mud, etc.

Protection Against Chafing

20. Install wires and wire groups so they are protected against chafing or abrasion in locations where contact with sharp surfaces or other wires would damage the insulation. Damage to the insulation may result in short circuits, malfunction, or inadvertent operation of equipment. Use approved cable clamps to support wire bundles at each hole through a bulkhead. (See Figure 4–5.) If wires come closer than 6.3mm to edge of hole, install a suitable grommet in hole as shown in Figure 4–6.

CAUTION

Do not depend on insulating sleeving as protection against abrasion or chafing, or as a substitute for good routing practice.

Protection Against High Temperature

21. To prevent wire insulation deterioration, keep wires separate from high temperature equipment such as resistors, exhaust stacks, heating ducts, etc. The amount of separation is specified by engineering drawings. If wires must be run through hot areas, insulate the wires with high temperature material such as fibreglass, or PTFE. Additional protection in the form of conduit may be specified by engineering drawing.

CAUTION

Never use a low temperature insulated wire to replace a high temperature insulated wire.

22. Many coaxial cables have soft plastic insulation such as polyethylene. These are especially subject to deformation and deterioration at elevated temperatures. Avoid all high temperature areas with these cables.

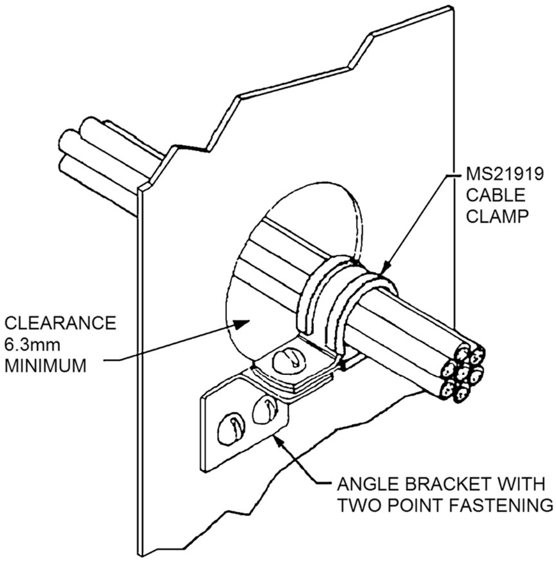


Figure 4- 5 Cable Clamp at Bulkhead Hole

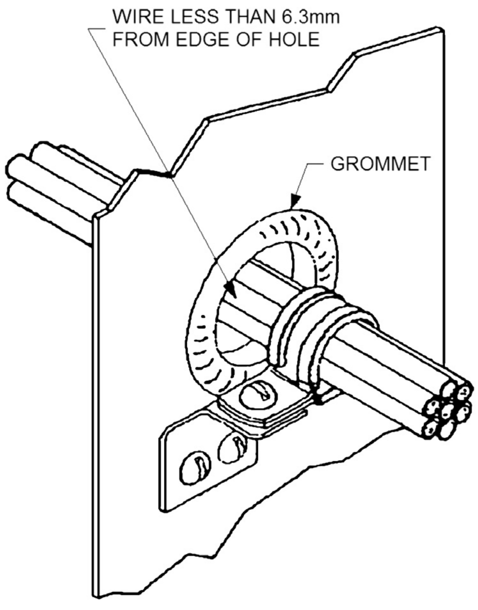


Figure 4- 6 Cable Clamp and Grommet at Bulkhead Hole

Use of Asbestos in Aircraft

23. In the past asbestos products were used to protect wire insulation in high temperature areas. This is no longer considered appropriate due to the well documented health problems attributed to this material. Asbestos materials are NOT to be used in aircraft electrical systems.

24. Where asbestos materials are identified or suspected in aircraft electrical systems, Environmental Health personnel should be contacted to provide advice on appropriate handling procedures. Authorised engineering personnel should then determine the feasibility of replacing the asbestos products with suitable non-asbestos alternatives or, where no alternatives are available, introducing appropriate risk management procedures.

Protection Against Personnel and Cargo

25. Install wire bundles so they are protected by the structure. Use structure or conduit to prevent pinching against the airframe by cargo. Locate wire bundles so that personnel are not tempted to use sections of the wire runs as handholds or ladder rungs.

Protection Against Battery Acids

26. Never route any wires below a battery. Inspect wires in battery areas frequently. Replace any wires that are discoloured by battery fumes.

Protection Against Solvents and Fluids

27. Avoid areas where wires will be subjected to damage from fluids. Wires and cables installed in aircraft bilges shall be installed at least 15cm from the aircraft centreline. If there is a possibility that the wire without a protective outer jacket may be soaked in any location, use plastic tubing to protect it. This tubing should extend past the wet area in both directions and be tied at each end if the wire has a low point between the tubing ends. The lowest point of the tubing should have a 3mm drainage hole as shown in Figure 4–7. Punch the hole in the tubing after the installation is complete and the low point definitely established. Use a hole punch to cut a half circle. Be careful not to damage any wires inside the tubing when using the punch. Tape (non-adhesive) used as a wrap around the wires and cables shall also have drainage holes at the low points.

CAUTION

If it is necessary to move or repair wires which have a protective jacket with a drainage hole at the low point, make sure drainage hole is still at the low point afterward. If the location of the low point has changed, punch a new hole in the protective jacket at the new low point.

Protection in Wheel Wells and Wing Folds

28. Wires located in wheel wells and wing folds are subject to many additional hazards such as exposure to fluids, pinching, and severe flexing in service. Make sure that all wire bundles are protected by sleeves of flexible tubing securely held at each end. There should be no relative movement at the point where flexible tubing is secured. Inspect these wires and the insulating tubing carefully at very frequent intervals. Replace wires and/or tubing at the first sign of wear. There should be no strain on attachments when parts are fully extended but slack should not be excessive.

Separation from Plumbing Lines

29. When wiring must be routed parallel to combustible fluid or oxygen lines for short distances, maintain as much fixed separation as possible, 15cm or more. Route the wires on a level with, or above, the plumbing lines. Space clamps so that if a wire is broken at a clamp it will not contact the line. Where a 15cm separation is not possible, clamp both the wire bundle and the plumbing line to the same structure to prevent any relative motion. If the separation is less than 50mm but more than 12.7mm, use a nylon sleeve over the wire bundle to give further protection. Use two cable clamps back to back, as shown in Figure 4–8, to maintain a rigid separation only (not for bundle support).

CAUTION

Do not route any wire so that it can possibly come closer than 12.7mm to a plumbing line. Factory installed wiring within 12.7mm of a fluid line should be moved when possible. If moving the wiring is not possible, the wiring should be wrapped, tied, and clamped to maintain separation from the fluid line.

CAUTION

Never support any wire or wire bundle from a plumbing line carrying flammable fluids or oxygen. Clamps may be used only to Ensure separation.

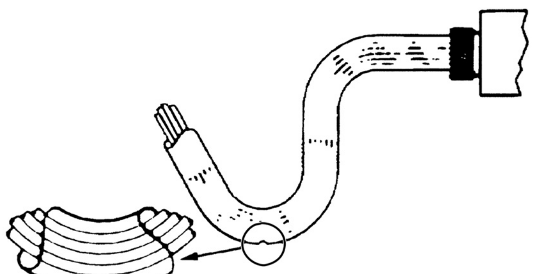


Figure 4- 7 Drainage Hole in Low Point of Tubing

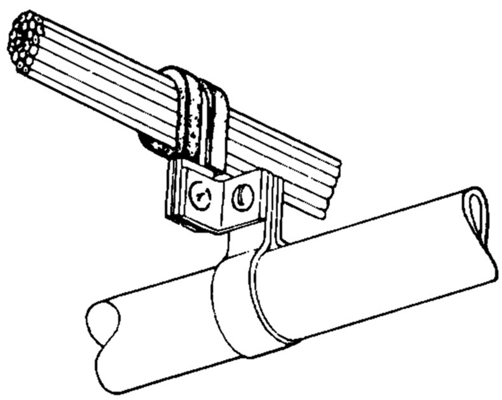


Figure 4- 8 Separation of Wires From Plumbing Lines

Separation from Control Cables

30. Route wiring to maintain a minimum clearance of 7.6cm from control cables. If this is not possible, install mechanical guards to prevent contact of wiring with control cables.

Installation of EMI Sensitive Wiring

31. Unless engineering justification is provided to establish alternative procedures, the following requirements shall be met to reduce the possibility of EMI:

- **a.** Wires and cables classified as EMI sensitive may be grouped together in the same loom, but they shall not be grouped together with any other wires and cables.
- **b.** Appropriate clearance (either as far as practical or as defined by the OEM) shall be maintained between wires, cables and looms classified EMI sensitive and other equipment, wires, cables and looms.
- **c.** Wires, cables and looms that are EMI sensitive and are required to cross other wires, cables or looms, should do so at right angles, while maintaining the maximum clearance; and
- **d.** Appropriate levels of EMI protection (shielding, double-shielding, twisted pairs etc) should be applied to wire(s) and looms as required.

32. When aircraft wiring manuals are amended during the modification process, details of all special handling instructions for EMI sensitive wires, cables and looms, including the level of susceptibility, separation and marking requirements, shall be included.

CONDUIT

Introduction

33. Conduit is used to protect electric wire and cable from abrasion, corrosive fluids, high temperatures, RF interference, and damage from cargo handling or activities of aircraft personnel. Extensive use of conduit is undesirable because of weight therefore it is used only in areas where harmful conditions exist, in parts of aircraft hard to get at for permanent installation, and in short runs compatible with its protective function.

34. Conduit is available in metallic or non-metallic (plastic) form. Metallic conduit is either rigid or flexible; non-metallic conduit is flexible.

METALLIC CONDUIT

Damage Limitations

35. The damage limitations are as follows:

- **a.** **Cuts.** Cuts are acceptable provided cut does not extend into the interior of the conduit.
- **b.** **Chafing.** Chafing is permissible provided damage does not extend into the interior of the conduit, and the conduit is repositioned to prevent further chafing.
- **c.** **Bends.** Bends are acceptable provided bends do not decrease interior area sufficiently to prevent freedom of movement of the wire bundle. Bends that cause the conduit to interfere with other parts are unacceptable.
- **d.** **Dents.** Minor dents are acceptable provided they do not decrease the interior area sufficiently to prevent freedom of movement of the wire bundle throughout the length of the conduit.

36. Metallic conduit is either rigid or flexible. Rigid metal conduit is aluminium or aluminium alloy tubing. Aluminium flexible conduit conforms to Specification SAE AS 6136, which covers two types: Type I - bare flexible conduit, and Type II - rubber-covered flexible conduit. Brass flexible conduit conforms to SAE AS 25064. Flexible, aluminium conduit is used only when it is impracticable to use rigid conduit, such as in areas where the necessary bends are so complex as to interfere with installation, or where there is relative motion between the conduit ends. Flexible brass conduit is used instead of flexible aluminium in areas where it is necessary to minimise RF interference, or in areas of high temperature.

Selection of Conduit Size

37. The protected wire or wire bundle diameter must not be more than 80% of the inside diameter of the conduit. (See Figure 4–9)

> NOTE
>
> Rigid metallic conduit is supplied in outside diameter sizes. Subtract twice the wall thickness to obtain the inside diameter. Flexible metallic conduit is supplied in inside diameter sizes; no calculation of diameter is necessary.

38. Determine conduit length to accommodate length of wire to be installed in conduit between connections so that when conduit is installed there is no strain on the wires or ferrules.

Bending Metallic Conduit

39. Bends in metallic conduit should be kept to a minium. Table 4–3 provides details of minimum bend radii.

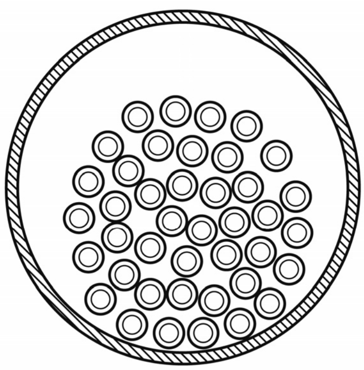


Figure 4- 9 Capacity Limits for Conduit

Table 4–3 Bend Radii for Rigid Conduit

Nominal Tube OD (mm)	Minimum Bend Radii (mm)
3.175	9.525
4.75	14.275
6.35	19.05
9.525	28.575
12.7	38.1
15.875	47.625
19.05	57.15
12.4	76.2
31.75	95.25
38.1	114.3
44.45	133.35
50.8	152.4

NON-METALLIC CONDUIT

40. Non-metallic conduit is made of flexible plastic tubing, conforming to Military Specifications MIL-I-631 or MIL-I-7444. There is no specification for rigid non-metallic conduit; phenolic tubing is sometimes used.

HEAT-SHRINKABLE TUBING

41. In certain applications heat shrinkable tubing may be an appropriate alternate to flexible conduit. Details of various types of heat-shrinkable tubing are listed below.

SAE AMS-DTL-23053/4, Class 2

42. Table 4–4 provides details of SAE AMS-DTL-23053/4 Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Dual-Wall, Outer Wall Crosslinked, Class 2 (Flame Retardant). This sleeving consists of an outer wall which shrinks and an inner wall that flows when heated. It is rated from -55°C to 110°C and has a dielectric strength of 500 volts/mil. Heat shrinkable dual wall sleeving is suitable for one step potting, encapsulating, or moisture sealing of electrical components.

SAE AMS DTL-23053/5, Class 1

43. Table 4–5 provides details of SAE AMS-DTL-23053/5 Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Flexible, Crosslinked, Class 1 (Flame Resistant). This sleeving is rated from -55°C to 135°C and has a dielectric strength of 500 volts/mil. Heat shrinkable flexible polyolefin sleeving is suitable for light duty harness jackets, wire colour coding, marking or identification.

SAE AMS-DTL-23053/8

44. Table 4–6 provides details of SAE AMS-DTL-23053/8 Insulation Sleeving, Electrical, Heat Shrinkable, Polyvinylidene Fluoride, Semi-Rigid, Crosslinked. This sleeving is clear and is rated from -55°C to 175°C. It has a dielectric strength of 800 volts/mil up to 12.7mm diameter and 600 volts/mil over 12.7mm diameter. Heat shrinkable semi-rigid polyvinylidene fluoride sleeving is suitable for wire or termination strain relief.

SAE AMS-DTL-23053/12

45. Table 4–7 provides details of SAE AMS-DTL-23053/12 Insulation Sleeving, Electrical, Heat Shrinkable, Polytetrafluoroethylene. This sleeving is produced in 5 classes (which relate to wall thickness) and is rated from -67°C to 250°C. It has a dielectric strength of 800 volts/mil. This sleeving is suitable for use in areas where resistance to flame and high temperature is required.

Table 4–4 SAE AMS-DTL-23053/4, Class 2

Part Number (Note 1)	Minimum Inside Diameter Expanded (mm)	After Unrestricted Shrinkage	
		Minimum Inside Diameter (mm)	Total Wall Thickness (mm)
M23053/4-201-*	6.05	3.18	0.74 ± 0.13
M23053/4-202-*	9.02	4.75	0.74 ± 0.13
M23053/4-203-*	12.07	6.35	0.76 ± 0.13
M23053/4-204-*	18.09	9.53	0.89 ± 0.13
M23053/4-205-*	24.13	12.70	1.07 ± 0.13
M23053/4-206-*	36.20	19.05	1.19 ± 0.13

Notes:

1. * is replaced with appropriate number to indicate colour. (0-Black, 2-Red, 4-Yellow, 9-White, etc.)

Table 4–5 SAE AMS-DTL-23053/5, Class 1

Part Number (Note 1)	Minimum Inside Diameter Expanded (mm)	After Unrestricted Shrinkage	
		Minimum Inside Diameter (mm)	Total Wall Thickness (mm)
M23053/5-101-*	1.17	0.58	0.41 ± 0.08
M23053/5-102-*	1.60	0.79	0.43 ± 0.08
M23053/5-103-*	2.36	1.17	0.51 ± 0.08
M23053/5-104-*	3.18	1.58	0.51 ± 0.08
M23053/5-105-*	4.75	2.36	0.51 ± 0.08
M23053/5-106-*	6.35	3.18	0.64 ± 0.08
M23053/5-107-*	9.53	4.75	0.64 ± 0.08
M23053/5-108-*	12.70	6.35	0.64 ± 0.08
M23053/5-109-*	19.05	9.53	0.76 ± 0.08
M23053/5-110-*	25.40	12.70	0.89 ± 0.13
M23053/5-111-*	38.10	19.05	1.02 ± 0.15
M23053/5-112-*	50.80	25.40	1.14 ± 0.18
M23053/5-113-*	76.20	38.10	1.27 ± 0.20
M23053/5-114-*	19.60	50.80	1.40 ± 0.23

Notes:

1. * is replaced with appropriate number to indicate colour. (0-Black, 2-Red, 4-Yellow, 9-White, etc.)

Table 4–6 SAE AMS-DTL-23053/8

Part Number (Note 1)	Minimum Inside Diameter Expanded (mm)	After Unrestricted Shrinkage	
		Minimum Inside Diameter (mm)	Total Wall Thickness (mm)
M23053/8-001-C	1.17	0.58	0.25 ± 0.05
M23053/8-002-C	1.60	0.79	0.25 ± 0.05
M23053/8-003-C	2.36	1.17	0.25 ± 0.05
M23053/8-004-C	3.18	1.58	0.25 ± 0.05
M23053/8-005-C	4.75	2.36	0.25 ± 0.05
M23053/8-006-C	6.35	3.18	0.31 ± 0.08
M23053/8-007-C	9.53	4.75	0.31 ± 0.08
M23053/8-008-C	12.70	6.35	0.31 ± 0.08
M23053/8-009-C	19.05	9.53	0.43 ± 0.08
M23053/8-010-C	25.40	12.70	0.48 ± 0.08
M23053/8-011-C	38.10	19.05	0.51 ± 0.08
Notes: 1. * is replaced with appropriate number to indicate colour. (0-Black, 2-Red, 4-Yellow, 9-White, etc.)			

Table 4–7 SAE AMS-DTL-23053/12

Part Number (Note 1)	Minimum Inside Diameter Expanded (mm)	After Unrestricted Shrinkage	
		Minimum Inside Diameter (mm)	Total Wall Thickness (mm)
Class 1 - Thick Wall			
M23053/12-101-*	4.22	3.30	0.76 ± 0.13
M23053/12-102-*	6.35	4.90	0.76 ± 0.13
M23053/12-103-*	8.38	6.53	0.76 ± 0.13
M23053/12-104-*	10.54	8.13	0.76 ± 0.13
M23053/12-105-*	12.65	9.73	0.76 ± 0.13
M23053/12-106-*	14.73	11.38	0.76 ± 0.15
M23053/12-107-*	16.92	12.95	0.76 ± 0.15
M23053/12-108-*	19.00	14.53	0.76 ± 0.15
M23053/12-109-*	21.08	16.18	0.76 ± 0.15
M23053/12-110-*	23.24	17.78	0.81 ± 0.15
M23053/12-111-*	25.4	19.41	1.01 ± 0.18
M23053/12-112-*	29.72	22.63	1.14 ± 0.18
M23053/12-113-*	33.78	25.91	1.27 ± 0.20

Part Number (Note 1)	Minimum Inside Diameter Expanded (mm)	After Unrestricted Shrinkage	
		Minimum Inside Diameter (mm)	Total Wall Thickness (mm)
Class 2 - Standard Wall			
M23053/12-201-*	1.27	0.69	0.30 ± 0.05
M23053/12-203-*	1.52	0.99	0.40 ± 0.07
M23053/12-206*	2.16	1.37	0.40 ± 0.07
M23053/12-208-*	3.05	1.83	0.40 ± 0.07
M23053/12-212-*	4.32	2.57	0.40 ± 0.07
M23053/12-216-*	6.10	3.58	0.51 ± 0.10
M23053/12-220-*	9.40	5.69	0.51 ± 0.10
M23053/12-224-*	11.43	7.90	0.51 ± 0.10
M23053/12-227-*	11.94	8.54	0.64 ± 0.15
M23053/12-230-*	19.05	13.31	0.64 ± 0.15
M23053/12-232-*	28.78	19.96	0.90 ± 0.20
M23053/12-233-*	33.28	23.14	0.90 ± 0.20
M23053/12-234-*	38.10	26.31	0.90 ± 0.20
Class 3 - Thin Wall			
M23053/12-301-*	0.86	0.38	0.23 ± 0.05
M23053/12-303-*	1.17	0.56	0.25 ± 0.07
M23053/12-306-*	1.52	0.99	0.30 ± 0.07
M23053/12-308-*	1.93	1.24	0.30 ± 0.07
M23053/12-312-*	3.05	1.83	0.30 ± 0.07
M23053/12-316-*	4.82	2.57	0.30 ± 0.07
M23053/12-320-*	6.10	3.58	0.38 ± 0.10
M23053/12-324-*	9.40	5.69	0.38 ± 0.10
M23053/12-327-*	10.92	7.06	0.38 ± 0.10
M23053/12-330-*	11.94	8.81	0.38 ± 0.10
Class 4 - Very Thin Wall			
M23053/12-401-*	1.27	0.64	0.15 ± 0.05
M23053/12-403-*	1.52	0.97	0.15 ± 0.05
M23053/12-406-*	2.16	1.37	0.15 ± 0.05
M23053/12-408-*	2.79	1.60	0.15 ± 0.05
M23053/12-412-*	4.32	2.51	0.20 ± 0.05
M23053/12-416-*	6.10	3.53	0.20 ± 0.05
M23053/12-420-*	9.40	5.44	0.25 ± 0.07
M23053/12-424-*	11.45	7.65	0.25 ± 0.07
M23053/12-426-*	11.94	8.81	0.25 ± 0.07

Part Number (Note 1)	Minimum Inside Diameter Expanded (mm)	After Unrestricted Shrinkage	
		Minimum Inside Diameter (mm)	Total Wall Thickness (mm)
Class 5 - High Shrink Thin Wall			
M23053/12-501-*	1.98	0.64	0.23 ± 0.05
M23053/12-503-*	4.75	1.27	0.30 ± 0.05
M23053/12-506-*	9.53	2.44	0.30 ± 0.05
M23053/12-508-*	12.70	3.66	0.38 ± 0.10
M23053/12-512-*	19.05	5.69	0.38 ± 0.10
M23053/12-514-*	25.40	7.06	0.38 ± 0.10
M23053/12-516-*	38.10	10.16	0.38 ± 0.10
M23053/12-518-*	50.80	13.20	0.51 ± 0.13
M23053/12-520-*	63.50	16.51	0.51 ± 0.13
M23053/12-522-*	76.20	19.69	0.51 ± 0.13
M23053/12-524-*	88.90	22.86	0.51 ± 0.13
M23053/12-526-*	101.60	26.04	0.51 ± 0.13
			0.51 ± 0.13

Notes:

1. * is replaced with appropriate number to indicate colour. (0-Black, 2-Red, 4-Yellow, 9-White, etc.)

Use of Heat-Shrinkable Tubing

46. Heat-shrinkable tubing conforming to SAE AMS-DTL-23053 (except those manufactured from PVC), may be used to identify, colour code, or strain relieve wires and wire terminations or for cable jacketing and repair. The procedure is as follows:

- **a.** Refer to Table 4–4, Table 4–5, Table 4–6 and Table 4–7 and select a tubing type and size that conforms to the use requirements.
- **b.** Position the tubing as required over the item to be covered.

> **WARNING**
>
> Heat guns with electric Motors are not explosion proof and are not approved for use in hazardous locations or where explosion proof equipment is required. Compressed air/nitrogen heat gun M83521/5-01 or equivalent are the only heat guns that may be used in hazardous locations.

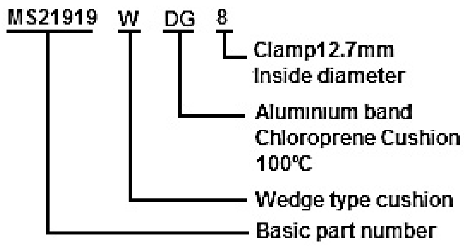
> **WARNING**
>
> Heating the heat shrink tubing and Polyurethane insulated wire or cables above 315°C will cause Polyurethane coatings to release irritating gases.

- **c.** Use a hot-air gun or compressed air type heater as a hot air source. Use the appropriate hot-air reflector on the nozzle of the heating tool to shrink the tubing quickly and evenly.
- **d.** Remove the heat as soon as the heat-shrinkable tubing conforms to the component being covered. Allow to cool for 30 seconds before handling.

CABLE CLAMPS

Chloroprene Cushion Clamps

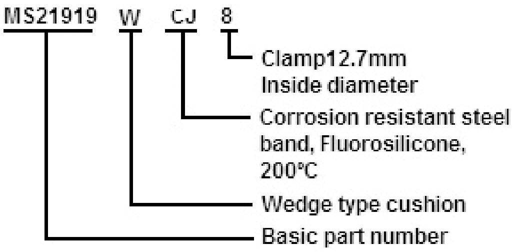
47. The Chloroprene cushion clamps listed in Table 4–8 are intended for general purpose clamping applications including electrical wire bundle clamping. A part number example is listed below:



48. Chloroprene cushion clamps are for general purpose use in areas exposed to petroleum based hydraulic fluids and occasional fuel splash. They have excellent ozone resistance however they are not resistant to phosphate ester based fluids and are not suitable for use on titanium tubing. Their colour is black with a blue stripe on both edges.

Fluorosilicone Cushion Clamps

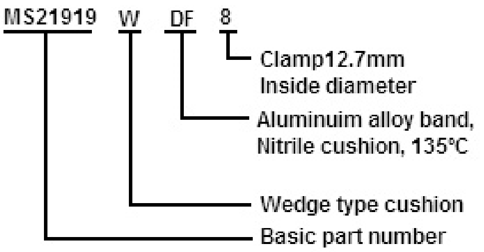
49. The Fluorosilicone cushion clamps listed in Table 4–9 are intended for clamping applications, including electrical wire bundle clamping, in elevated temperature, fluid contaminated areas. A part number example is listed below:



50. Fluorosilicone cushion clamps are for elevated temperature usage in areas contaminated with petroleum based fluids. They are unaffected by ozone however they are not resistant to phosphate ester based fluids. Their colour is solid blue.

Nitrile Cushion Clamps

51. The Nitrile cushion clamps listed in Table 4–10 are intended for clamping applications, including electrical wire bundle clamping, in fuel or fuel vapour areas. A part number example is listed below:



52. Nitrile cushions are for use in fuel immersion and fuel vapour areas. They have good ozone resistance however they are not resistant to phosphate ester based fluids. Not to be used on Titanium tubing. Their colour is solid yellow.

Table 4–8 Chloroprene Cushion Clamps

Part Number	Inside Diameter (mm)	Part Number	Inside Diameter (mm)
MS21919WDG2	3.18	MS21919WDG16	25.40
MS21919WDG3	4.75	MS21919WDG17	26.97
MS21919WDG4	6.35	MS21919WDG18	28.58
MS21919WDG5	7.92	MS21919WDG19	30.15
MS21919WDG6	9.53	MS21919WDG20	31.75
MS21919WDG7	11.10	MS21919WDG21	33.32
MS21919WDG8	12.70	MS21919WDG24	38.10
MS21919WDG9	14.27	MS21919WDG26	41.28
MS21919WDG10	15.88	MS21919WDG28	44.45
MS21919WDG11	17.45	MS21919WDG30	47.63
MS21919WDG12	19.05	MS21919WDG32	50.80
MS21919WDG13	20.62	MS21919WDG36	57.15
MS21919WDG14	22.22	MS21919WDG40	63.5
MS21919WDG15	23.08	MS21919WDG48	76.2

Table 4–9 Fluorosilicone Cushion Clamps

Part Number	Inside Diameter (mm)	Part Number	Inside Diameter (mm)
MS21919WCJ2	3.18	MS21919WCJ16	25.40
MS21919WCJ3	4.75	MS21919WCJ17	26.97
MS21919WCJ4	6.35	MS21919WCJ18	28.58
MS21919WCJ5	7.92	MS21919WCJ19	30.15
MS21919WCJ6	9.53	MS21919WCJ20	31.75
MS21919WCJ7	11.10	MS21919WCJ21	33.32
MS21919WCJ8	12.70	MS21919WCJ24	38.10
MS21919WCJ9	14.27	MS21919WCJ26	41.28
MS21919WCJ10	15.88	MS21919WCJ28	44.45
MS21919WCJ11	17.45	MS21919WCJ30	47.63
MS21919WCJ12	19.05	MS21919WCJ32	50.80
MS21919WCJ13	20.62	MS21919WCJ36	57.15
MS21919WCJ14	22.22	MS21919WCJ40	63.5
MS21919WCJ15	23.08	MS21919WCJ48	76.2

Table 4–10 Nitrile Cushion Clamps

Part Number	Inside Diameter (mm)	Part Number	Inside Diameter (mm)
MS21919WDF2	3.18	MS21919WDF16	25.40
MS21919WDF3	4.75	MS21919WDF17	26.97
MS21919WDF4	6.35	MS21919WDF18	28.58
MS21919WDF5	7.92	MS21919WDF19	30.15
MS21919WDF6	9.53	MS21919WDF20	31.75
MS21919WDF7	11.10	MS21919WDF21	33.32
MS21919WDF8	12.70	MS21919WDF24	38.10
MS21919WDF9	14.27	MS21919WDF26	41.28
MS21919WDF10	15.88	MS21919WDF28	44.45
MS21919WDF11	17.45	MS21919WDF30	47.63
MS21919WDF12	19.05	MS21919WDF32	50.80
MS21919WDF13	20.62	MS21919WDF36	57.15
MS21919WDF14	22.22	MS21919WDF40	63.5
MS21919WDF15	23.08	MS21919WDF48	76.2

Installation of Cable Clamps

53. Install MS21919 cable clamps as shown in Figure 4–10. The mounting screw should be above the wire bundle, if possible. It is also desirable that the back of the cable clamp rest against a structural member. Use hardware, as shown in Figure 4–11, to mount cable clamps to structure. Be careful not to pinch wires in cable clamp. If the wire bundle is smaller than the nearest clamp size, or if a clamp of the proper size is not available, wrap the wire bundle with the necessary number of turns of insulating tape so that the bundle will be held securely in the clamp. If the clamp can not be installed without pinching and/or crushing the wiring harness, replace the clamp with the next larger clamp size that will securely hold the harness in place.

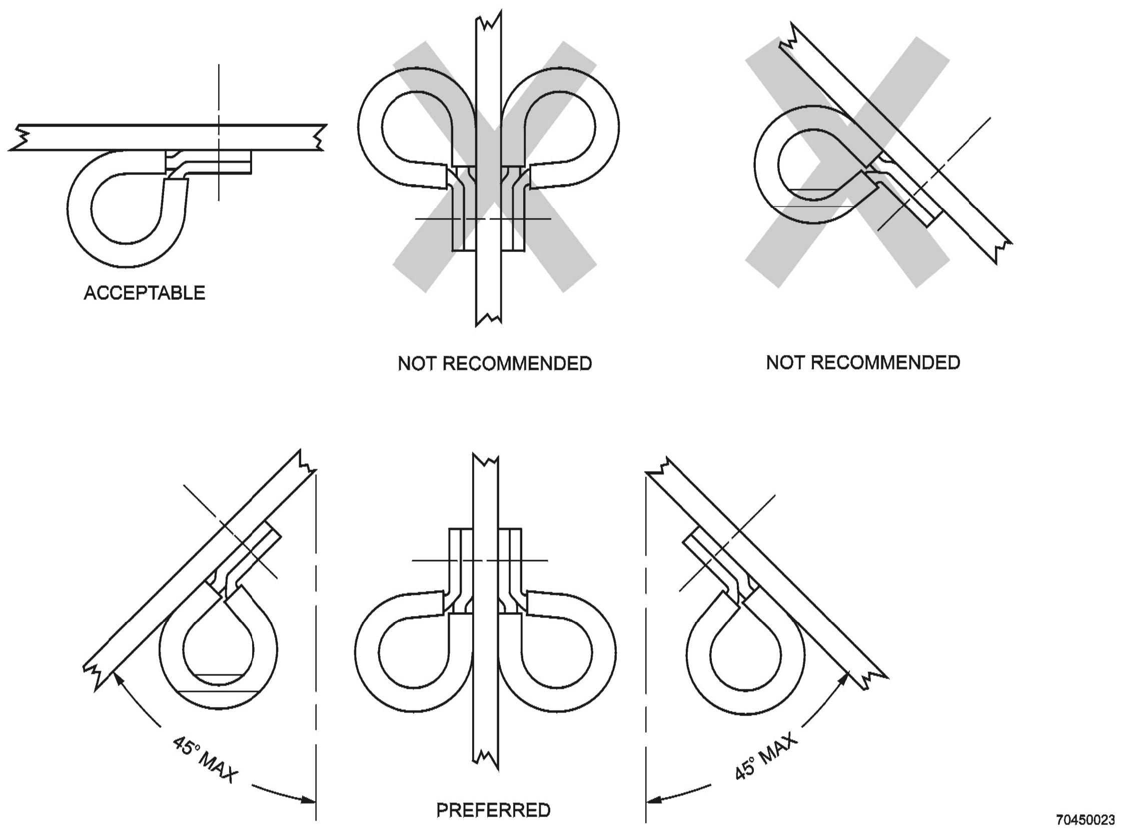


Figure 4- 10 Preferred Angle for Cable Clamps

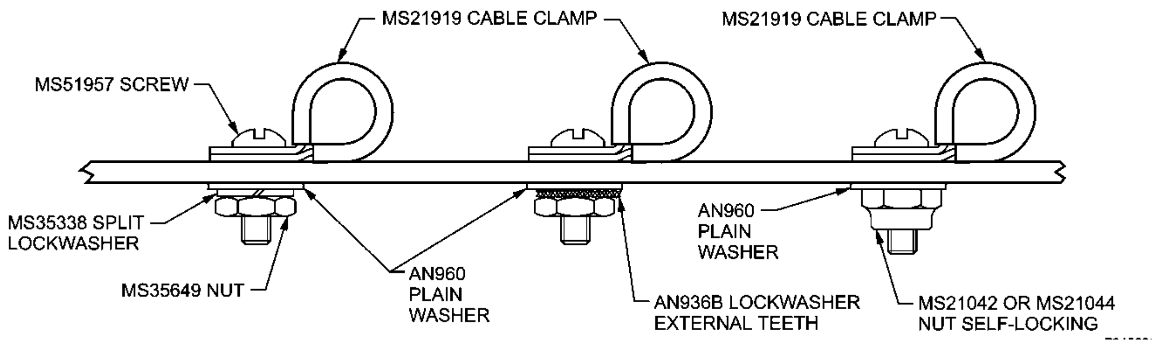


Figure 4- 11 Typical Mounting Hardware for MS21919 Cable Clamps

NOTE

MS21919 cable clamps are cushioned with insulating material to prevent abrasion of wires. Never use metal clamps without cushions to hold wires

54. MS25281 nylon cable clamps may be used to support wire bundles up to 50mm in diameter in open wiring, or inside junction boxes and on the back of instrument panels. When installing nylon cable clamps, use a large diameter metal washer under the screw head or nut securing the clamp.

WARNING

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

CAUTION

Do not use nylon cable clamps where the ambient temperature may exceed 85°C.

NOTE

MS25281 plastic cable clamps, spaced at intervals not to exceed 60cm, may be used for wire support provided every fourth clamp is a rubber cushion type (MS21919W). The use of plastic cable clamps on other than horizontal runs should be avoided unless the installation is such that slack cannot accumulate between clamping points.

55. Mount cable clamps directly to "Z" members of structure. Use angle bracket with two mounting screws if structural member is angled as shown in Figure 4–12.

56. Where additional clearance is required between cable and aircraft structure or equipment, a cable clamp standoff may be used. Suitable standoffs are identified in Table 4–11

57. A tool to facilitate the installation of cable clamps is shown in Figure 4–13; a similar tool manufactured to Federal Specification GGGP00477 is available. Similar to conventional multiple slip joint pliers, the tool compresses and holds the clamp with the securing bolt in place while a nut is being installed on the bolt. The tool is particularly useful for installing clamps in restricted areas and for installing groups of two or three clamps.

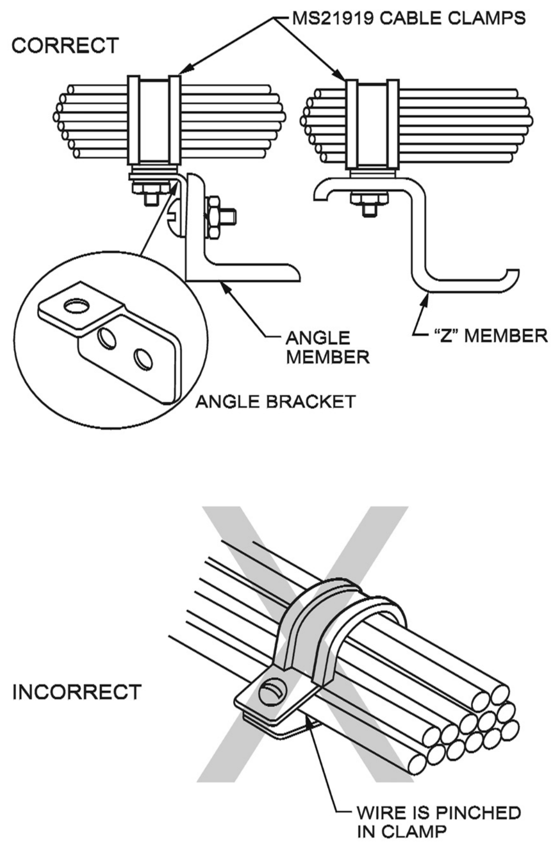


Figure 4- 12 Attaching Cable Clamp to Structure

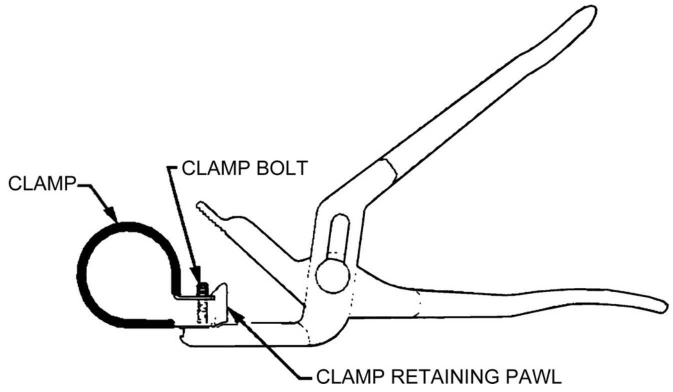


Figure 4- 13 Tool for Installing Cable Clamp

Installing Cable Clamps to Tubular Structure

58. Use AN735 clamps without cushions for clamping to tubular structure. The clamps must fit tightly but should not deform when locked in place. Attach wire bundle in MS21919 cable clamp to the AN735 clamp with AN hardware as shown in Figure 4–14.

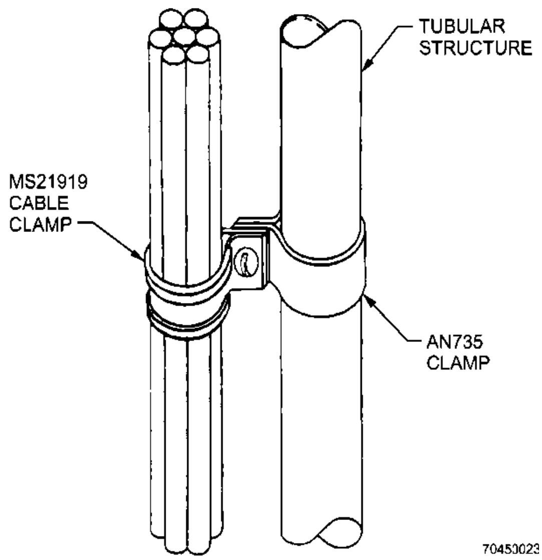


Figure 4- 14 Installing Cable Clamps to Tubular Structure

Installing Grommets

59. Military Standard grommets are available in rubber, nylon, and TFE. Select grommet suitable for the environmental conditions from Table 4–12. If it is necessary to cut a nylon grommet in order to install it, make the cut at an angle of 45 degrees as shown in Figure 4–15. Cement the grommet in place with general purpose cement, with the cut at the top of the hole. When installing caterpillar grommets, cut the grommet to the required length, making sure to cut square across the teeth as shown in Figure 4–16. Cement the grommet in place with general purpose cement, with the cut at the top of the hole.

Table 4–11 Cable Clamp Standoff Identification

Part Number	Standoff Length (mm)	Thread Size
L35064A2B075	19.6	0.1640-32UNJC (8/32)
L35064A2B100	25.4	0.1640-32UNJC (8/32)
L35064A2B125	31.75	0.1640-32UNJC (8/32)
L35064A2B150	38.10	0.1640-32UNJC (8/32)
L35064A2B175	44.45	0.1640-32UNJC (8/32)
L35064A2B200	50.8	0.1640-32UNJC (8/32)
L35064A2C075	19.6	0.1900-32UNJF (10/32)
L35064A2C100	25.4	0.1900-32UNJF (10/32)
L35064A2C125	31.75	0.1900-32UNJF (10/32)
L35064A2C150	38.10	0.1900-32UNJF (10/32)
L35064A2C175	44.45	0.1900-32UNJF (10/32)
L35064A2C200	50.8	0.1900-32UNJF (10/32)

Table 4–12 Grommets - Temperature Limitations of Material

Standard	Material	Upper Temperature Limit
MS35489	Rubber, Hot Oil & Coolant Resistant	120°C
MIL-C-22529 & MS21266	Nylon	85°C
MIL-C-22529 & MS21266	TFE	260°C

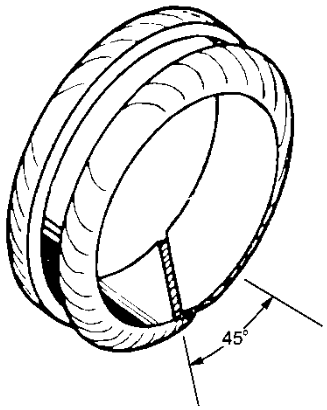


Figure 4- 15 Split Grommet

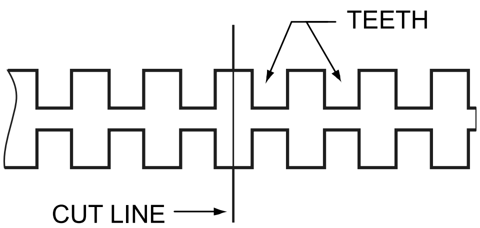


Figure 4- 16 Cutting Caterpillar Grommet

CONNECTIONS TO TERMINAL BOARDS AND BUSBARS

Connecting Terminal Lugs to Terminal Boards

60. Install terminal lugs on MS27212 terminal boards in such a way that they are locked against movement in the direction of loosening. (See Figure 4–17.) See Table 4–13 for MS27212 terminal board specifications, A maximum of four lugs or three lugs and one bus shall be connected to any one stud.

> NOTE
>
> MS27212 terminal boards are used as a replacement for previously used NAS191 and MS25123 terminal boards.

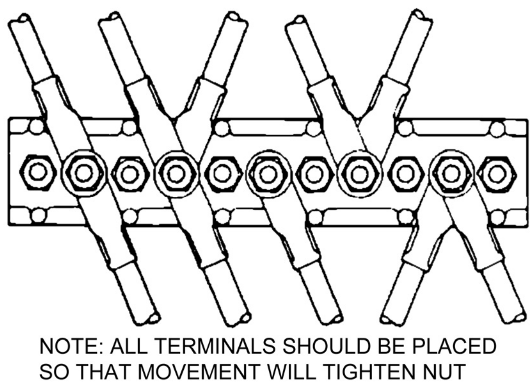
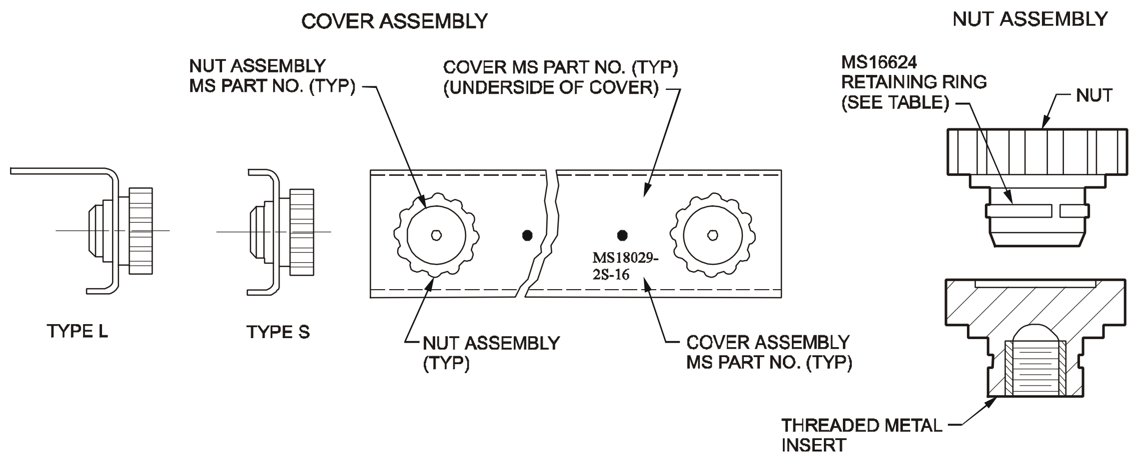


Figure 4- 17 Connecting Terminal Lugs to Terminal Board

Table 4–13 MS27212 Terminal Boards and Covers

Terminal Board MS Part Number	Stud Thread	Application Torque Steel	Number of Studs	Cover Part Number
MS27212-1-20	6-32UNC-2A	8-10	20	MS18029 - 1(*) - (N)
MS27212-2-16	10-32UNC-2A	20-29	16	MS18029 - 2(*) - (N)
MS27212-3-8	1/4-28UNF-2A	60-70	8	MS18029 – 3(*) - (N)
MS27212-4-8	5/16-24UNF-2A	90-140	8	MS18029 – 4(*) - (N)
MS27212-5-8	3/8-24UNF-2A	115-175	8	MS18029 - 5(*) - (N)

Note: Terminal boards and covers are procured in full lengths with number of studs indicated. Cut to suit needs at installation.



Cover Assembly Part Number	Cover Part Number Type L Type S	Studs Maximum (N)	Nut Assembly Dash No.	Threaded Metal Insert	Retaining Ring Part Number
MS18029 - 1(*) - (N)	-11L - (N) - 11S - (N)	20	21	.138-32UNC-2B	MS16624-1040
MS18029 - 2(*) - (N)	-12L - (N) - 12S - (N)	16	22	.190-32UNC-2B	MS16624-1040
MS18029 - 3(*) - (N)	-13L - (N) - 13S - (N)	8	23	.250-28UNF-2B	MS16624-1062
MS18029 - 4(*) - (N)	-13L - (N) - 13S - (N)	8	24	.312-24UNF-2B	MS16624-1062
MS18029 - 5(*) - (N)	-13L - (N) - 13S - (N)	8	25	.375-24UNF-2B	MS16624-1062
MS18029 - 6(*) - (N)	-14L - (N) - 14S - (N)	16	26	.164-32UNC-2B	MS16624-1040

NOTES:

1. (*) Use letter L or S to indicate type cover desired.
   (N) Indicates the number of studs in a MS27212 terminal board assembly to be covered.
2. Example of part number:
   MS18029-2S-16 indicates a cover assembly for a MS27212 terminal board assembly having 16 studs. This cover assembly will consist of the following:
   1. MS18029-12S-16 type S cover.
   2. MS18029-22 nut assemblies.
   3. Part number shall be marked on top of cover.
3. Cover assemblies are not to be used in installations where the temperature exceeds 245°C.
4. A minimum of three threads must be exposed after terminal stacking on the end studs for cover installation.

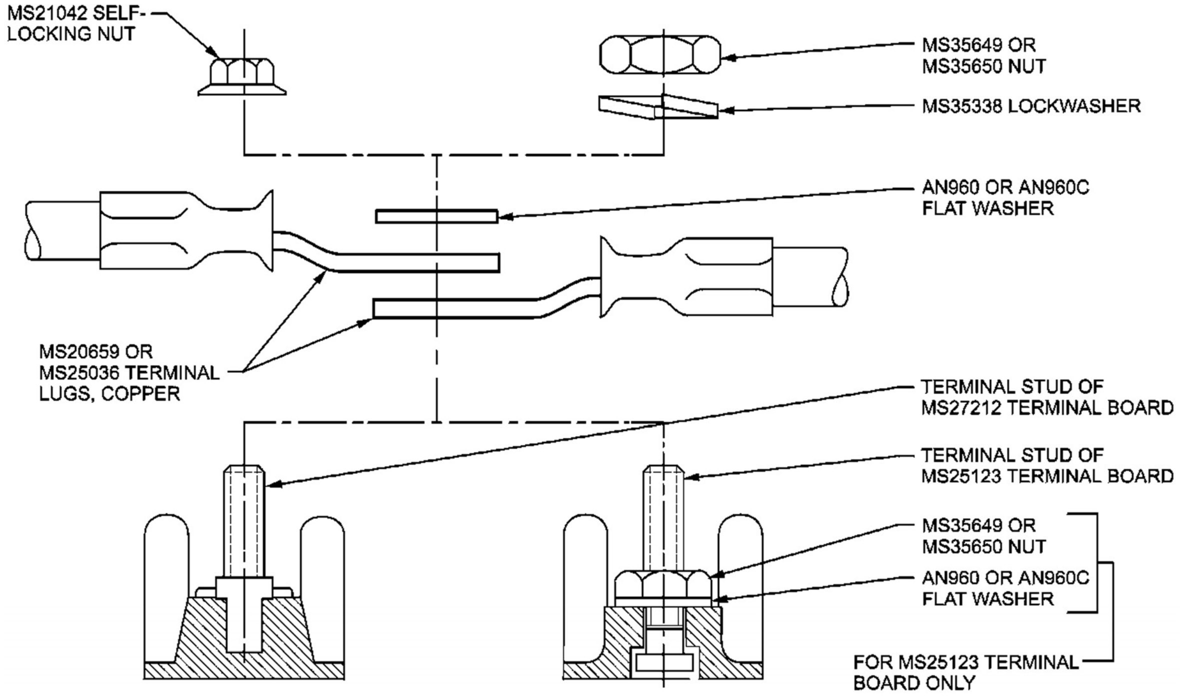


Figure 4- 18 Hardware for Wiring Terminal Boards With Copper Terminals

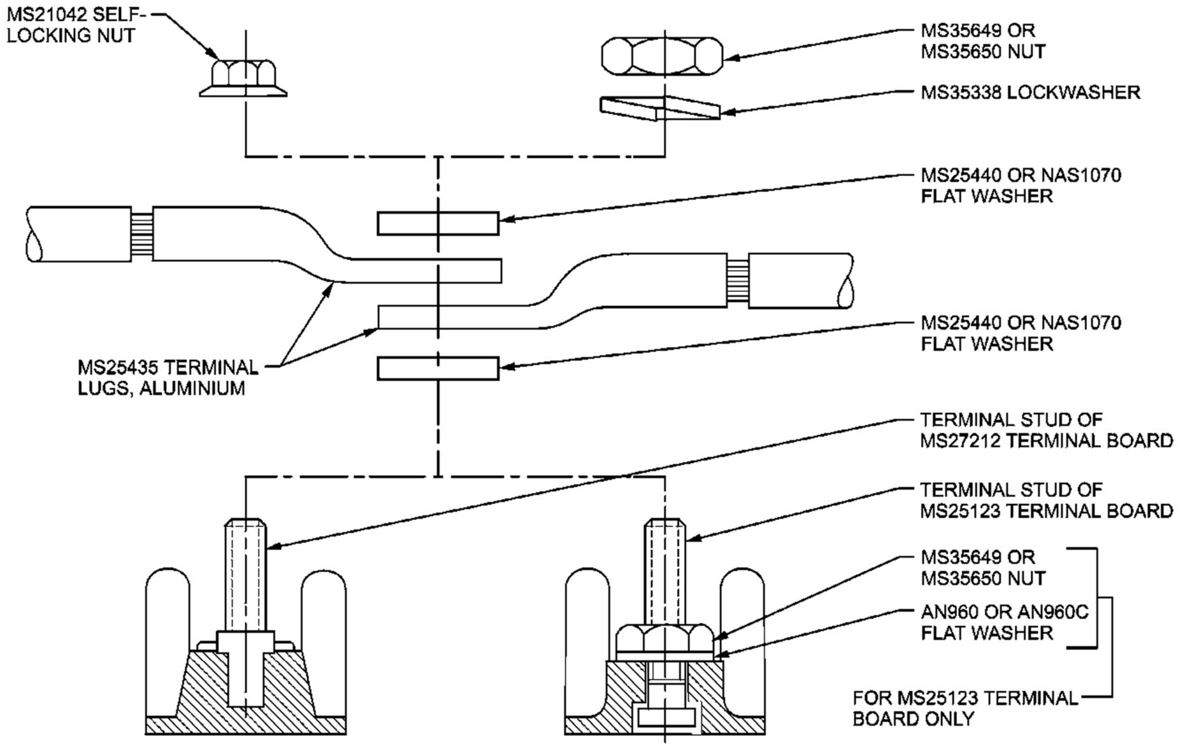


Figure 4- 19 Hardware for Wiring Terminal Boards With Aluminium Terminals

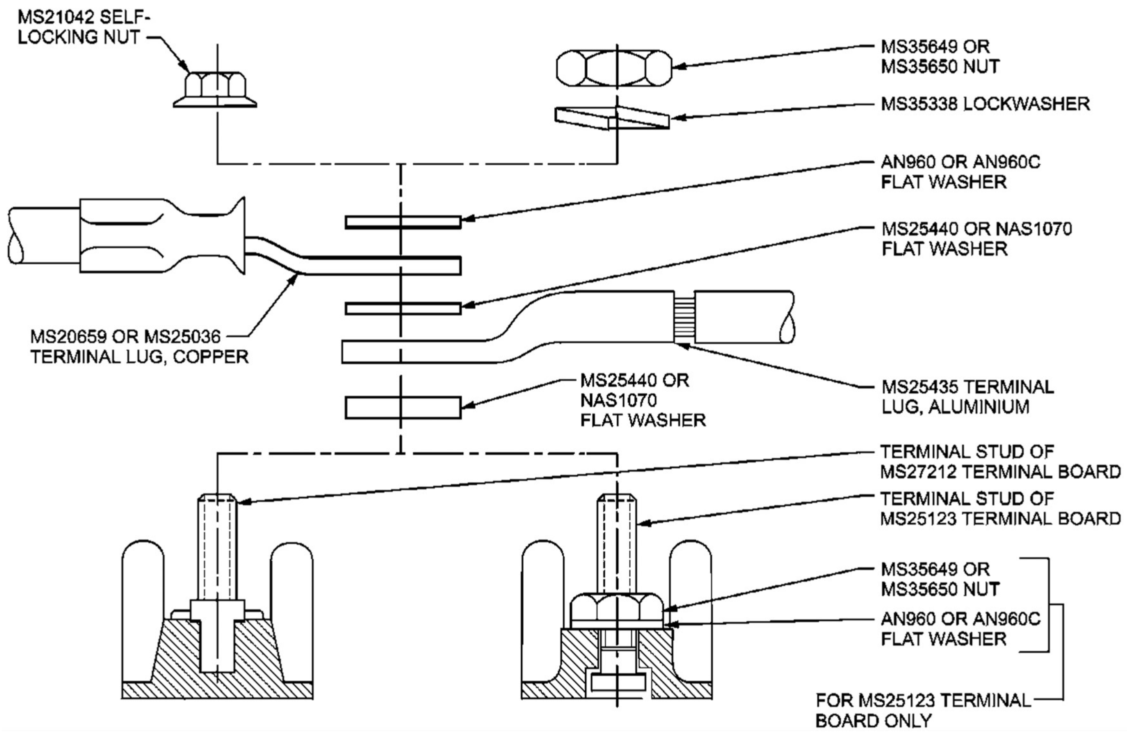


Figure 4–20 Hardware for Wiring Terminal Boards With Combination of Terminals

Hardware for Wiring Terminal Boards

61. MS25123 terminal boards have studs secured in place with a AN960 or AN960C flat washer and a MS35649 or MS35650 steel nut. Place copper terminal lugs directly on top of the MS35649 or MS35650 nut. Follow with a AN960 or AN960C flat washer, a MS35338 split steel lockwasher, and a MS35649 or MS35650 steel nut; or a AN960 or AN960C flat washer and a MS21042 self-locking all metal nut.

CAUTION

Do not use AN960D aluminium washers.

62. MS27212 terminal boards have studs moulded in and therefore do not require hardware for attaching studs to the terminal board. Use same hardware for installing terminal lugs for MS25123 terminal boards (refer to paragraph 56 and Figure 4–18). Mounting screws are insulated with MS3373 insulators when using MS27212 terminal boards.

63. Place aluminium terminal lugs over a MS25440 or NAS1070 plated flat washer of the correct size for terminal and stud (see Table 4–14). Follow the terminal lugs with another MS25440 or NAS1070 flat washer, a MS35338 split steel lockwasher and either a MS35649 or MS35650 nut or a MS21042 self-locking all metal nut. See Figure 4–19 for details of this assembly.

CAUTION

Do not place any washer in the current path between two aluminium terminal lugs or between two copper terminal lugs.

CAUTION

Never place a lockwasher directly against the tongue or pad of an aluminium terminal or busbar.

64. To join a copper terminal lug to an aluminium terminal lug, place a MS25440 or NAS1070 flat washer over the nut that holds the stud in place. Follow with the aluminium terminal lug, another MS25440 washer, the copper terminal lug, AN960 or AN960C plain washer, MS35338 split steel lockwasher, and MS35649 or MS35650 plain nut or MS21042 self-locking nut. See Figure 4–20 for details.

Table 4–14 Washers for Use with Aluminium Terminal Lugs

NAS No.	MS No.	Terminal Size	Stud Size
	MS25440-3	8, 6, 4,	No. 10
NAS 1070-416	MS25440-4	8, 6, 4, 2, 1, 1/0	6.35mm
NAS 1070-516	MS25440-5	8, 6, 4, 2, 1, 1/0, 2/0	7.92mm
NAS 1070-616	MS25440-6	8, 6, 4, 2, 1, 1/0, 2/0	9.53mm
NAS 1070-716	MS25440-6A	3/0, 4/0	9.53mm
NAS 1070-816	MS25440-8	2, 1, 1/0, 2/0	12.70mm

CAUTION

Do not use AN960D aluminium washers.

Installation Torques for Large Copper Terminals

65. Use a torque wrench to tighten nuts on studs that have a diameter of 9.5mm or larger. This will provide appropriate pressure to ensure good electrical contact. The tightening torques for steel studs are as listed in Table 4–15.

Installation Torques for Aluminium Terminals

66. Use a torque wrench to tighten nuts over any stack-up containing an aluminium terminal lug. The tightening torques for aluminium studs are listed in Table 4–16.

Table 4–15 Installation Torques for Copper Terminals (Inch Pounds of Torque)

Stud Size	Plain Nuts	Self-locking Nuts
0.375 – 24	110 – 120	115 – 125
0.500 – 20	135 – 150	150 – 170

Table 4–16 Installation Torques for Aluminium Terminals (Inch Pounds of Torque)

Stud Size	Nut Torque
No. 10	40
6.35mm	100
7.92mm	135 – 165
9.53mm	220 – 250
12.70mm	440 – 470

Connecting Terminal Lugs to Busbars

67. In order to obtain maximum efficiency in the transfer of power, the terminal lug and the busbar should be in direct contact with each other so that the current does not have to go through any of the attaching parts, even if these are good current carrying materials. As illustrated in Figure 4–21 through Figure 4–24, the above applies whether the terminal lugs and the busbar are of the same or of different materials.

Cleaning Busbars When Making Connections

68. Clean all busbar areas before making new connections or replacing old connections. See Section 2, Chapter 15 for procedure to be followed in cleaning busbars. The cleaned surface of an aluminium busbar is coated with a petrolatum-zinc dust compound which is left on the surface while the connection is made.

Hardware for Connection to Busbars

69. Cadmium plated steel hardware is used to secure terminals to busbars. Use split lockwashers under hex nuts and under self-locking nuts. Use plated steel plain washers between lockwashers and copper terminals. Use flat washers (MS25440) between lockwashers and aluminium terminals. As shown in Figure 4–21 through Figure 4–24, the head of the screw or bolt can be located on the terminal side or the busbar side, as required to simplify the installation.

70. Use a cadmium plated steel split lockwasher MS35338 under the head of every bolt or screw and also under the nut, as shown in Figure 4–21.

71. Use cadmium plated steel flat washers (MS25440) in contact with aluminium. The washer diameter must be at least equal to the tongue diameter of the terminal. See Table 4–14. Do not select a washer so large that it will ride on the barrel of the terminal. After tightening connection, use soft cloth to wipe off excess petrolatum-zinc compound left in place in accordance with paragraph 66.

Precautions When Replacing Existing Connections

72. Observe the following precautions when replacing existing terminal lug connections to busbars:

a. Check all flat washers. Replace bent washers Replace washers that have scratched plating or paint on faying surface.

b. Clean busbar connection areas by approved methods. (See Section 2, Chapter 15.)

c. Check plated copper terminal lugs before connecting to an aluminium busbar. If plating is scratched, replace terminal lug.

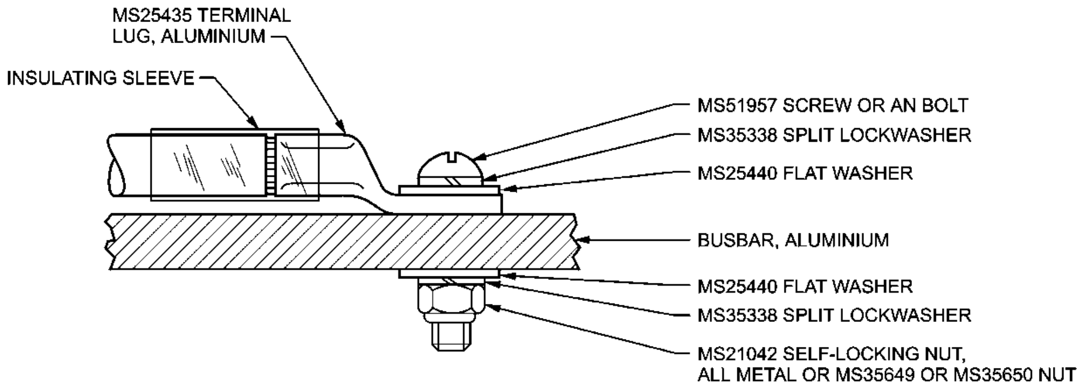


Figure 4–21 Connecting Aluminium Terminal to Aluminium Busbar

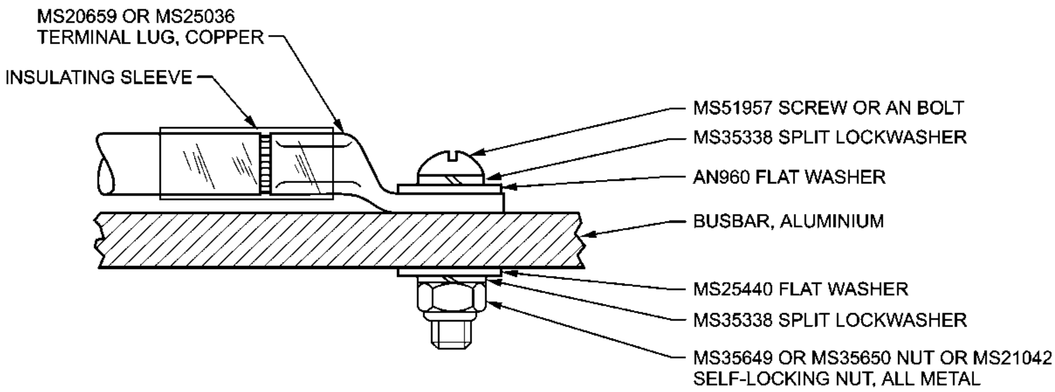


Figure 4–22 Connecting Copper Terminal to Aluminium Busbar

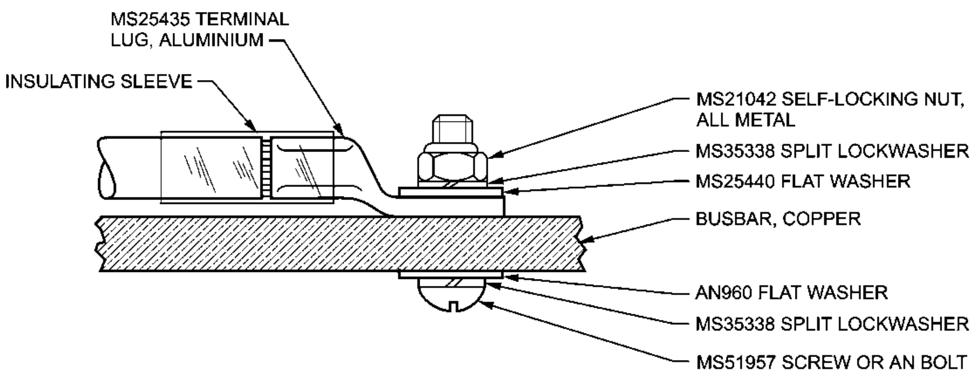


Figure 4–23 Connecting Aluminium Terminal to Copper Busbar

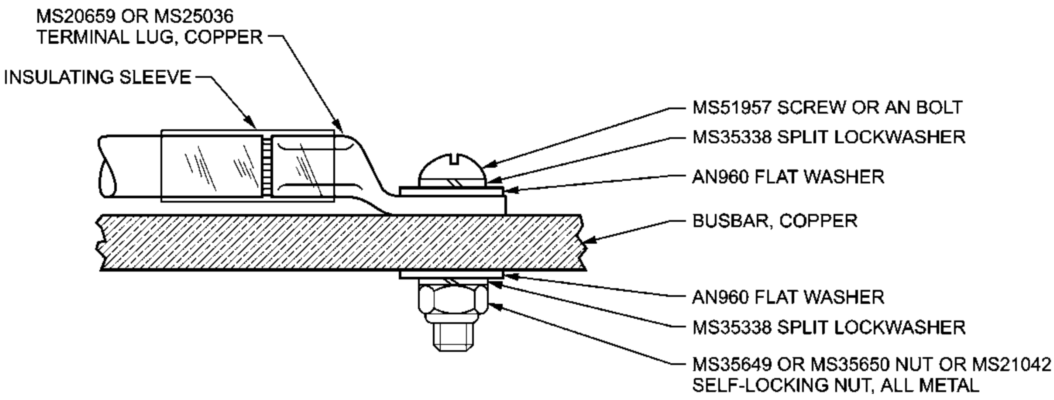


Figure 4–24 Connecting Copper Terminal to Copper Busbar

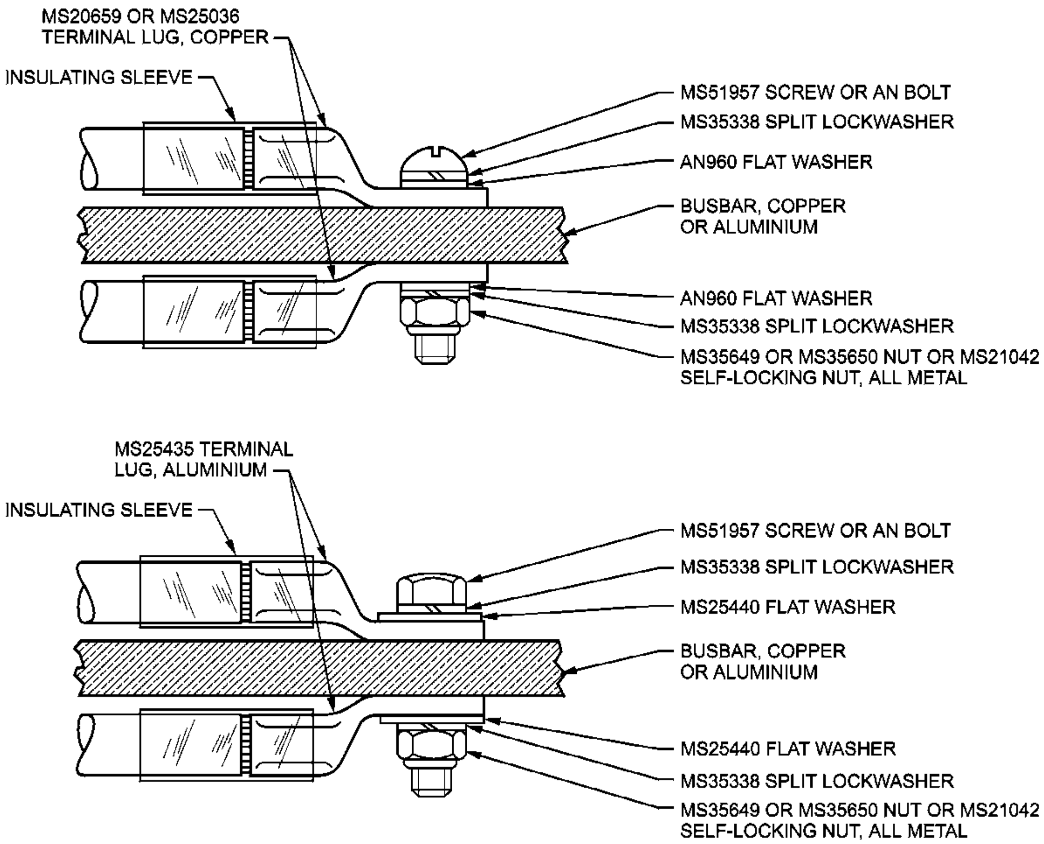


Figure 4–25 Connecting Two Terminals to Same Point on Busbar

Connecting Two Terminals to Same Point on Busbar

73. Terminal lugs must always be in direct contact with busbar. As shown in Figure 4–25, connect one terminal lug to top of busbar and the other to bottom.

NOTE
Terminal lug offset is positioned so that barrel cannot contact busbars. This allows proper seating of tongue on busbar.

Protection of Busbars Against Accidental Shorting

74. Busbars are usually enclosed in panels or junction boxes to protect them against accidental shorting. If the busbars are not enclosed, it is desirable to use some protective coating. A good protective coating which is easily applied is MIL-PRF-8516 Sealing Compound. This is applied thickly with a spatula or short bristled brush to the cleaned busbar prior to assembly of connections. Mask all areas where connections will be made. Use pressure sensitive tape for masking. See detailed instructions for applying and curing sealing compound in Section 2, Chapter 11. Remove masking tape after sealing compound is cured by cutting into compound next to tape with a razor blade and peeling tape from the masked area.

75. Busbars can also be protected by slitting a piece of insulating tubing and wrapping it around the busbar after all connections are made. Select insulating tubing which has large enough diameter to permit a generous overlap when tying it in place. See Figure 4–26 for cutting and tying details.

CAUTION

Do not bend terminal lugs to an angle greater than 90 degrees. Do not subject terminal lugs to more than one bending operation.

Connecting Terminal Lugs to Equipment

76. When connecting wired terminal lugs to terminals on switches, relays, and other equipment, the terminal lugs may be bent at the barrel tongue junction if necessary to permit installation. When bending is required, keep the bend radius as large as possible, while keeping the bend as small as possible. If protection from adjacent equipment or personnel is necessary, exposed terminal lugs may be covered with an easily removable non-corrosive sealant, such as RTV3145 or equivalent.

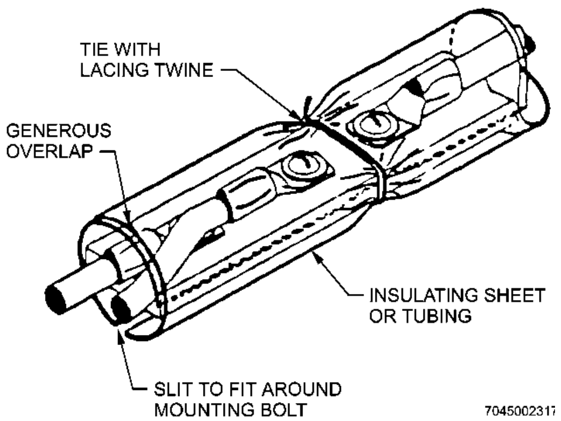


Figure 4–26 Insulating Tubing Around Busbar

INSTALLATION OF WIRES IN CONDUIT

Conduit Capacity

77. Measure the bundle wires before installing in conduit. In accordance with Specification SAE AS50881, the bundle diameter must not exceed 80% of the internal diameter of the conduit. (See Figure 4–27)

CAUTION

No ties or splices are permitted inside a conduit.

Feeding Wires into Conduit

78. Feed wires through a short length of conduit by taping the end of the bundle together and pushing it gent1y through. Longer runs of conduit or conduit with complex bends will require a leader. Make a leader out of a flannel or other soft cloth patch attached to a string long enough to pass completely through the conduit. The patch should fit loosely in conduit. (See Figure 4–28.) Use compressed air at no more than 240kPa (35psi) to blow patch and attached string through the conduit. Tie wire bundle securely to string and tape over junction to cover all wire ends. Pull string through conduit while careful1y feeding wires into other end. After wire is installed, remove tape and detach string.

Supporting Wires at End of Rigid Conduit

79. Use an MS21919 cable clamp to support wires at each end of conduit. Place the cable clamp in a direct line with the conduit end to prevent chafing of wires at end of conduit. Place cable clamp as close to end of conduit as practicable, but never more than 25cm away. (See Figure 4–29.)

NOTE

Do not leave wire slack inside conduit. Wires should be free, but not taut, inside conduit.

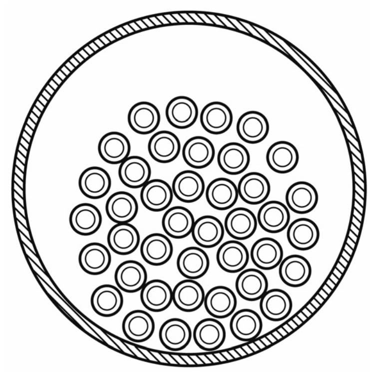


Figure 4–27 Conduit Capacity

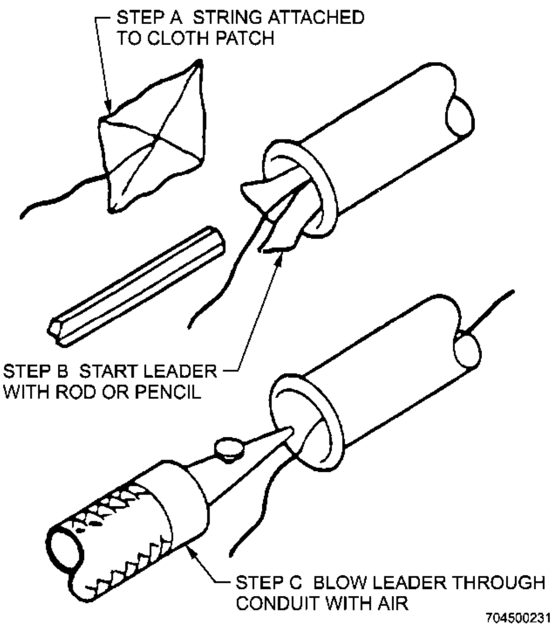


Figure 4–28 Leader for Conduit

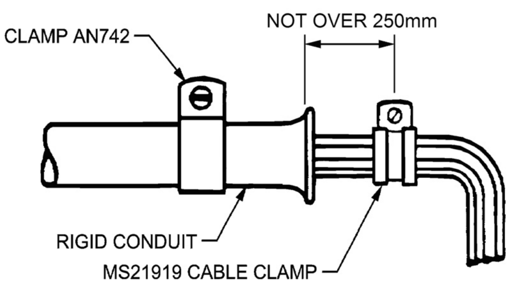


Figure 4–29 Support for Wire at Conduit End

INSTALLATION OF CONNECTORS

Assembly of Connectors to Receptacles

80. Assemble connectors to receptacles as follows:

WARNING

Unless otherwise required by specific equipment technical data, power should be removed from the affected circuit to avoid shock hazard and possible arcing of connectors.

CAUTION

Do not use excessive force to mate connectors to receptacles.

a. Locate the proper position of the plug in relation to the receptacle by aligning the key of one part with the groove or keyway of the other part.

CAUTION

Do not twist wire bundle excessively to achieve proper matching of plug and receptacle.

b. Start the plug into the receptacle with a light forward pressure and engage the threads of coupling ring and receptacle.

c. Alternately push in the plug and tighten the coupling ring until the plug is completely seated.

CAUTION

Never use a torque wrench or pliers to lock coupling rings.

d. Use a strap wrench or padded conduit pliers to tighten coupling rings 1/16 to 1/8 turn beyond finger tight if space around connector is too small to obtain a good finger grip. Self-locking connectors are coupled until the moveable indicator is aligned with index marks on coupling ring. (See Figure 4–31.) In fully mated condition locking indicator shall be aligned within orange colour band.

NOTE

There shall be no relative movement between body of connector and coupling ring. This condition represents a properly seated connector.

Disassembly of Connectors from Receptacles

81. Disassemble connectors as follows:

> **WARNING**
>
> Unless otherwise required by specific equipment technical data, power should be removed from the affected circuit to avoid shock hazard and possible arcing of connectors.

- **a.** Use a strap wrench or padded pliers to loosen coupling rings which are too tight to be loosened by hand.
- **b.** Alternately pull on the plug body and unscrew coupling ring until connector is separated.

> **CAUTION**
>
> Do not pull on attached wires.

- **c.** Protect disconnected plugs and receptacles with caps to keep debris from entering and causing faults.

Coding of Connectors

82. As a design objective, receptacles whose plugs are interchangeable are not located in close proximity to each other. However, when installation requirements are such that these receptacles are in adjacent locations, use clamps on the plug wires or assemble plugs and receptacles so as to use one of the alternate insert positions, to make it physically impossible to connect a plug into the wrong receptacle. Also, colour-code the connector plug body and the flange or mounting area of the receptacle.

- **a.** Use one bright colour, such as red, green, or yellow, for each matching pair.
- **b.** Paint only the shell of plugs - not the coupling rings.
- **c.** Paint only the mounting flange of the receptacle.

> NOTE
>
> Avoid painting the threaded surfaces or insulators of plugs or receptacles.

Special Precautions for Connectors with Resilient Inserts

83. When assembling or installing miniature MS connectors with resilient inserts, observe the following special precautions:

- **a.** Before mating connectors, check that contacts are not splayed or bent. When mating connectors, make sure that plug is inserted straight into the receptacle before tightening coupling ring.
- **b.** Avoid, where possible, locating connectors of the same shell size adjacent to each other, whether they have different insert arrangements or not.
- **c.** Locate receptacles where they are clearly visible and accessible to aid in keying and inserting plug. This will help to avoid bending receptacle pins while seeking proper polarization.
- **d.** Position receptacle so large keyway is at top if mounted vertically or at forward end if mounted horizontally.

> **CAUTION**
>
> Do not misconnect plugs and receptacles by forcing pins into the resilient insert, either by misalignment of properly mating connectors or by joining connectors with identical shells but differently keyed insert arrangements.

- **e.** When mating connectors with bayonet lock coupling, make sure that all locking rivets of the coupling are engaged.

> **CAUTION**
>
> Be careful not to lock the plug while cocked, i.e., two locking rivets engaged and one not engaged.

Mounting Connectors

84. Before mounting receptacles to the back of a panel or bulkhead, make sure there is sufficient clearance to couple the plug to the receptacle. Make sure that mounting hardware does not interfere with the installation of the locking ring.

Installing Conduit on Connectors

85. When installing a stepped-down conduit on the back shell of a connector having large wires (size No. 8 or larger), add an additional back shell to the connector before installing the conduit. This will allow the wire bundle to decrease in diameter gradually and prevent sharp bends in the wires. (See Figure 4–30)

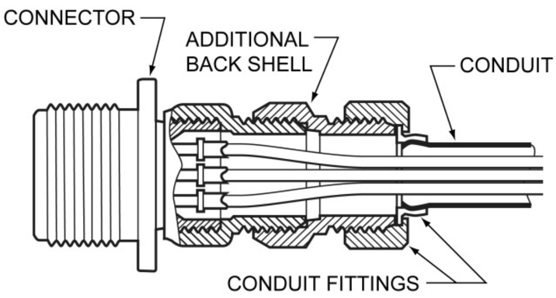


Figure 4–30 Installing Conduit on Connector Back Shell

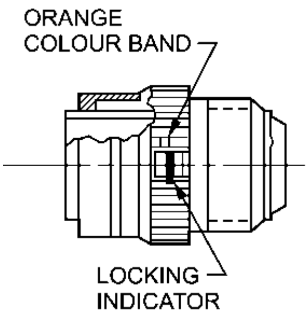


Figure 4–31 Self-Locking Connector

INSTALLATION OF WIRE IN JUNCTION BOXES

Lacing or Tying in Junction Boxes

86. Wire bundles can be either laced or tied with spot ties. Lacing and tying procedures are described in Section 2, Chapter 8.

> **CAUTION**
>
> Use nylon cable straps on wire bundles containing coaxial cable in accordance with Section 2, CHAPTER 7.

Support Inside Junction Boxes

87. Use MS21919 cable clamps to support wires across hinged doors so that wires will be twisted and not bent when the door is opened. See Figure 4–32 for correct and incorrect methods of support.

88. Attach wire bundles to walls of junction box to prevent chafing or abrasion against terminal studs or other items in box. Tie up slack (required for terminal rework) to prevent snagging.

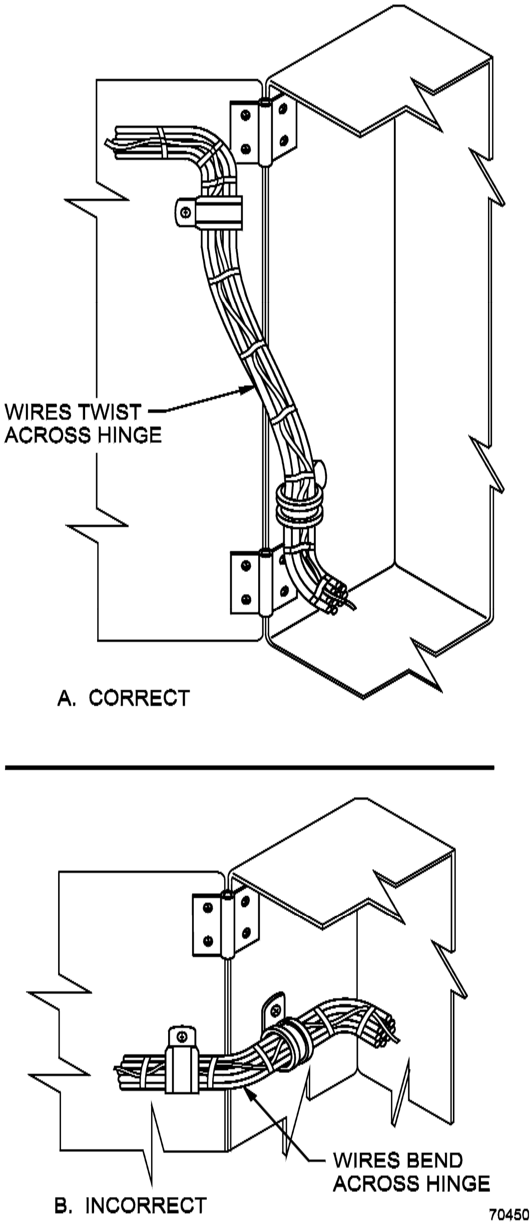


Figure 4–32 Support Inside Junction Box

TERMINAL JUNCTION SYSTEM

89. The MIL-T-81714 terminal junction system is designed to replace the open, screw type terminal blocks found in older aircraft. There are two systems designated, MIL-T-81714, Series I, and MIL-T-81714, Series II. The Series I system utilizes a pin contact on the wire. The Series II system utilizes a socket contact on the wire.

90. The components making up the Series I terminal junction system are as follows:

a. Terminal junction modules:

(1) Feedback type - all connections made to one side of module. (See Figure 4–33 and Figure 4–34.)

(2) Feedthrough type - connection carried through from one side to the other of the module. (See Figure 4–37.)

b. Tracks or frames (holders) for modules. (See Figure 4–33 and Figure 4–37.)

c. Wire splices, removable contact. (See Figure 4–38 and Figure 4–39.)

91. The components making up the Series II terminal junction system are as follows:

a. Terminal junction modules:

(1) Feedback type - all connections made to one side of module, non-electronic and electronic. (See Figure 4–35.)

(2) Distribution type - different size contacts bussed together.

(3) Grounding type - all connections grounded to the panel, stud mount and flange mount. (See Figure 4–36.)

b. Wire splices, removable contact, non-electronic and electronic. (See Figure 4–38 and Figure 4–39.)

c. Tracks or frames (holders) for modules. (See Figure 4–35.)

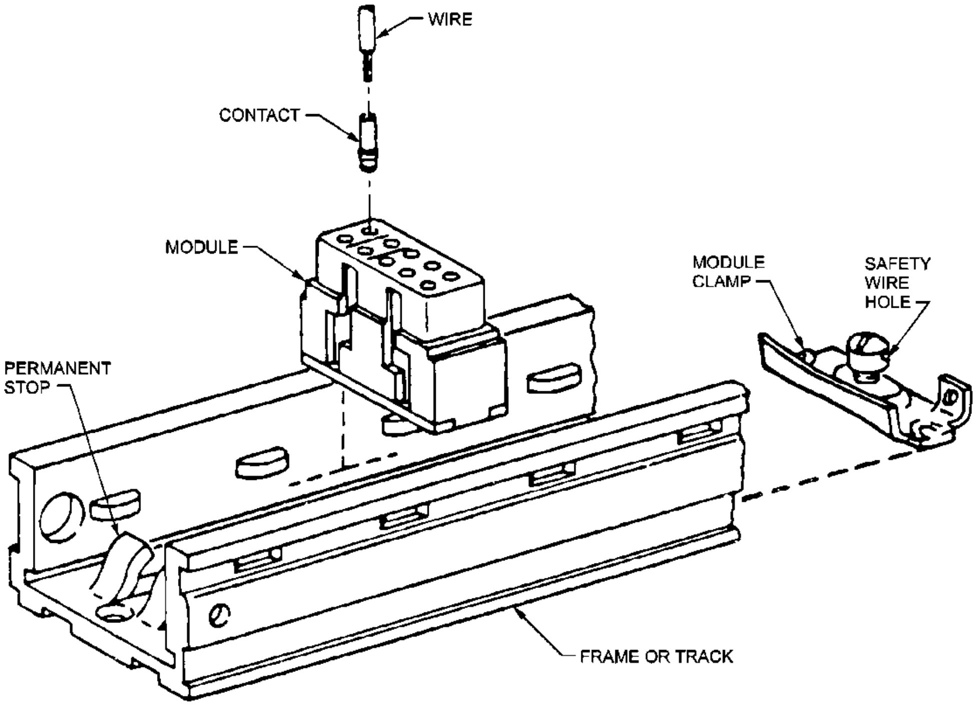


Figure 4–33 Feedback Terminal Junction Assembly Series I

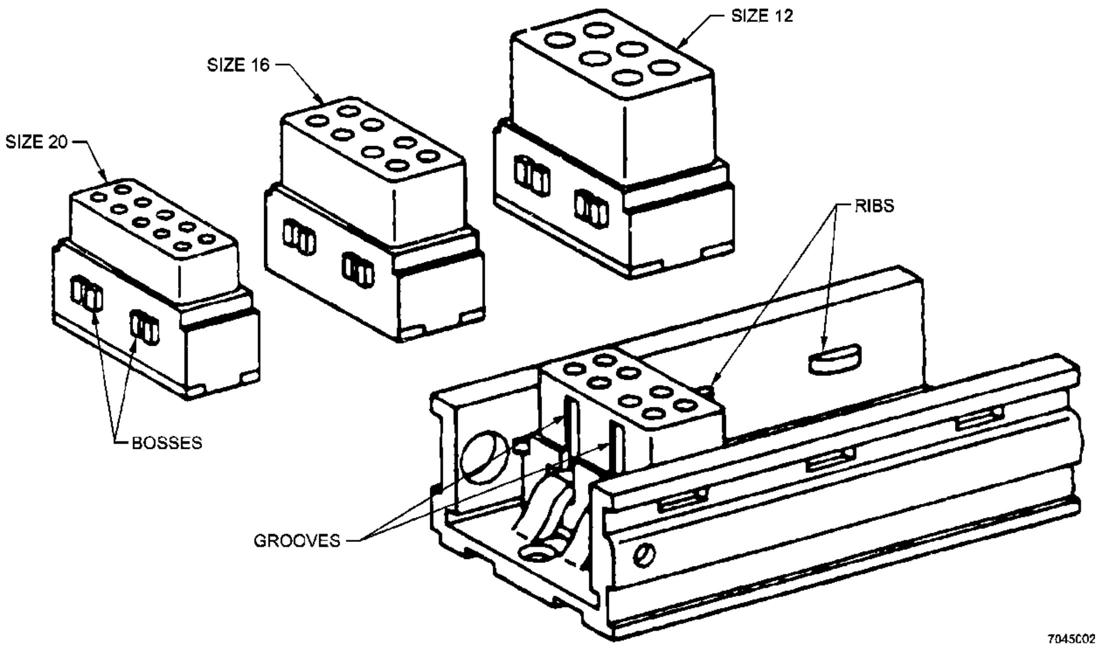


Figure 4–34 Feedback Terminal Junction Assembly Series I

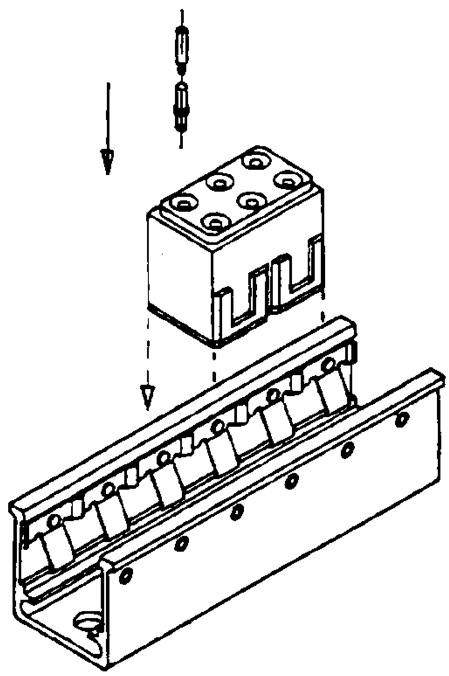


Figure 4–35 Feedback Terminal Junction Assembly Series II

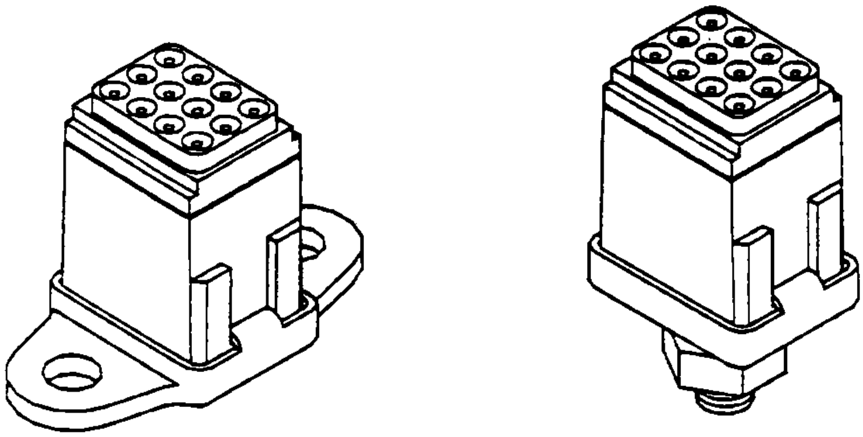


Figure 4–36 Grounding Junction Assembly Series II

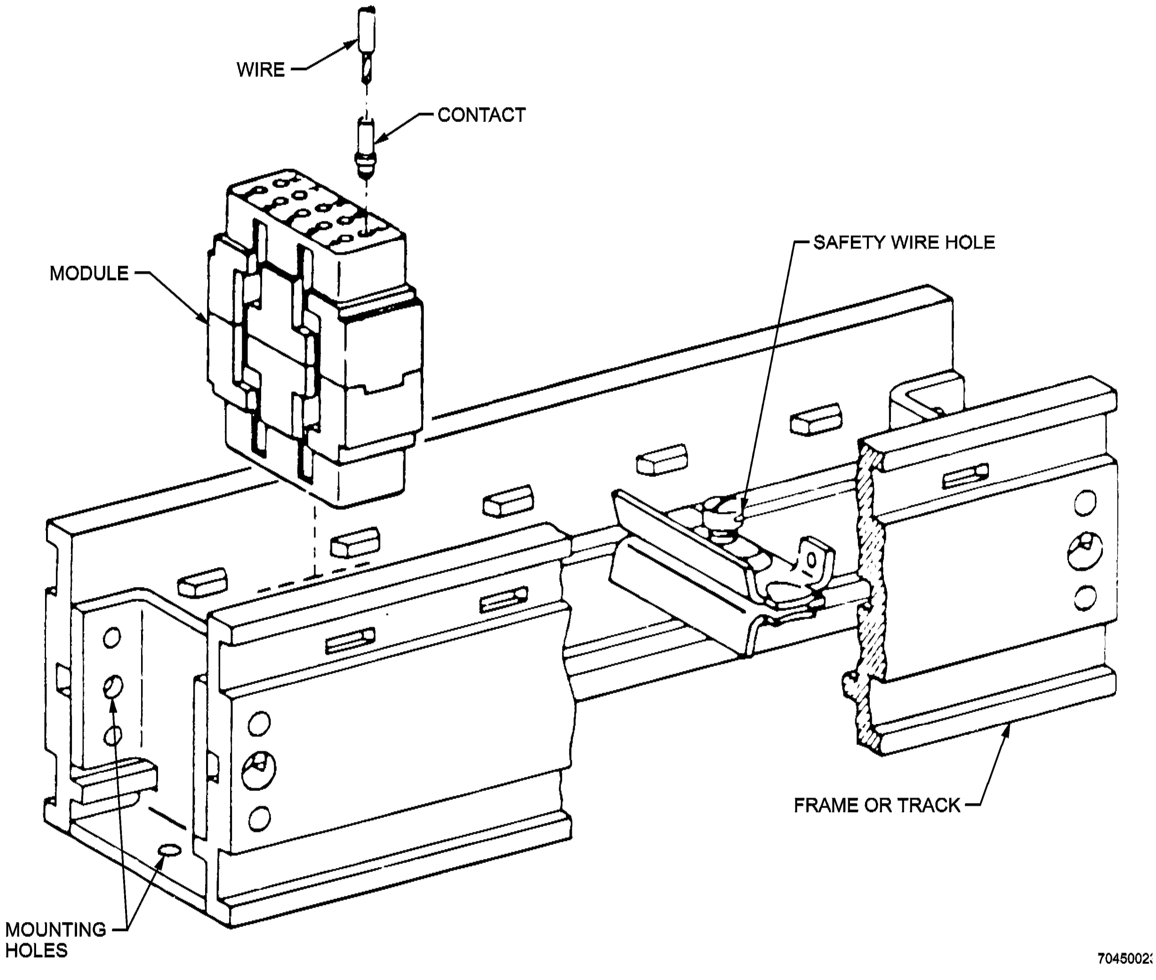


Figure 4–37 Feed-Through Terminal Junction Assembly Series I

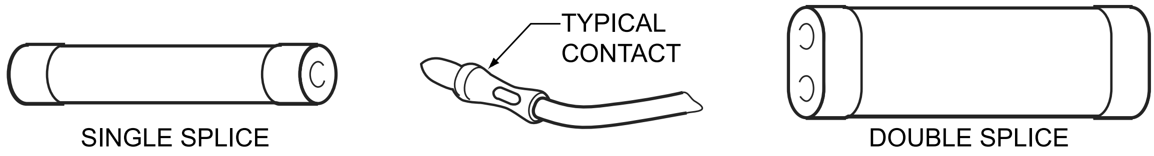


Figure 4–38 Removable Contacts and Wire Splices Series I

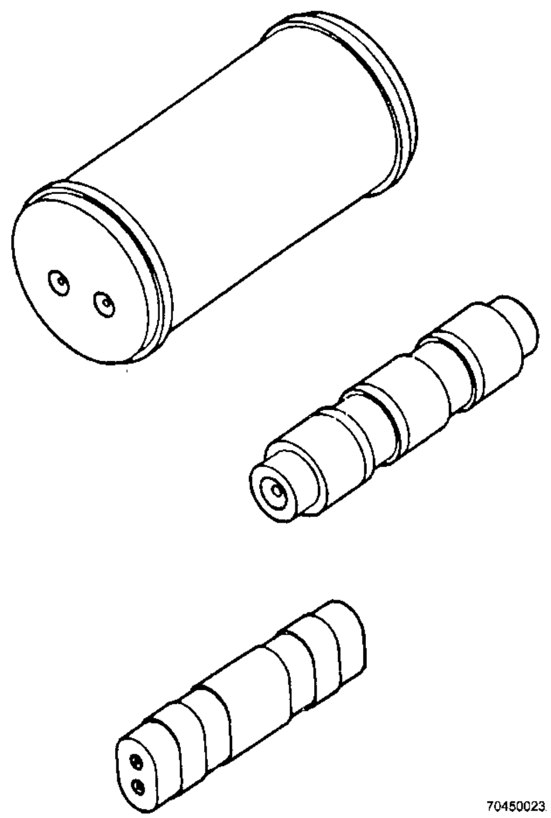


Figure 4–39 Removable Contacts and Wire Splices Series II

Classification

92. Terminal junction modules and spices are class D.

Class D	200°C max	Environmental type, fluid resistant
All other classes (class A, B and C) are inactive in favour of class D.		

Availability of Terminal Junction System Components

93. The wire terminal contacts are available in five sizes for Series I and four sizes for Series II, as listed in Table 4–18. The tracks are available in two basic types, feedback and feedthrough, as listed in Table 4–17. The modules available are feedback, feedthrough, distribution and grounding. The splices available are single and double as listed in Table 4–17.

Identification

94. The components of the terminal junction system are identified in Figure 4–41 for Series I, and Figure 4–42 for Series II. For actual part number breakdown see MIL-T-81714 specification sheets.

Installation and Removal of Modules from Tracks

95. Installation and removal of Series I modules from the tracks is accomplished as follows (See Figure 4–33 , Figure 4–34 and Figure 4–37):

- **a.** Loosen screw in locking clamp and slide clamp to end of rail containing indexing marks.
- **b.** Insert module into rail next to locking clamp, with module indexing indicator on same side as rail indicator.

NOTE
Modules can be installed in only one position in rail.

- **c.** Slide module against fixed stop at opposite end of rail.
- **d.** Install additional modules as required, sliding them against last previously installed module.
- **e.** Slide locking clamp against last module and tighten screw securely.

96. Removal of modules is accomplished by reversing the procedures given above.

97. Series II modules are individually installed, retained and removed. The installation of modules in the track is accomplished as follows (See Figure 4–35 and Figure 4–40):

- **a.** To insert, press the module into the track assembly by hand until a definite stop is felt and an audible click is heard.
- **b.** To remove, slide the double-sided tool (module extraction tool M81714/69) down the indents of the module to the maximum depth to unlock the retaining clips. Holding tightly, remove both tool and module.

Table 4–17 Component Identification

Series I		
Module		
Type	Size	Spec. Sheet
Feedback	22D 22 20 16 12	M81714/17 M81714/1 M81714/2 M81714/3 M81714/4
Feedthrough	22 20 16 12	M81714/6 M81714/7 M81714/8 M81714/9
Splice		
Type	Size	Spec. Sheet
Single	All	M81714/11
Double	All	M81714/12
Track		
Type	Size	Spec. Sheet
Feedback	All	M81714/5
Feedthrough	All	M81714/10
Series II		
Module Feedback		
Type	Size	Spec. Sheet
Non-electrical	All	M81714/60
Distribution	All	M81714/61
Electronic	All	M81714/62
Grounding	All	M81714/63
Splice		
Type	Size	Spec. Sheet
Single	All	M81714/65
Double	All	M81714/66
Track		
Type	Size	Spec. Sheet
Feedback	All	M81714/67

Table 4–18 Wire Range Accommodations

Series I			
Mating Size	Wire Barrel	Conductor Size	Insulation O.D.
20	22D	28, 26 24, 22	0.76/ 1.37
16	22	26, 24 22	0.86/ 1.52
16	20	24, 22 20	1.02/ 2.11
14	16	20, 18 16	1.65/ 2.77
12	12	14, 12	2.46/ 3.61
Series II			
Mating Size	Wire Barrel	Conductor Size	Insulation O.D.
22	22	26, 24 22	0.76/ 1.37
20	20	24, 22 20	0.86/ 1.52
16	16	20, 18 16	1.02/ 2.11
12	12	14, 12	1.65/ 2.77

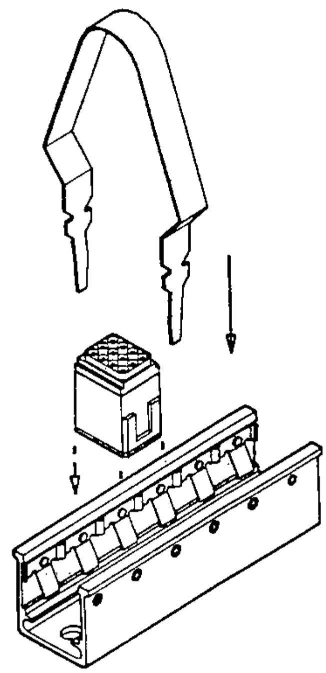


Figure 4–40 Installation and Removal of Modules

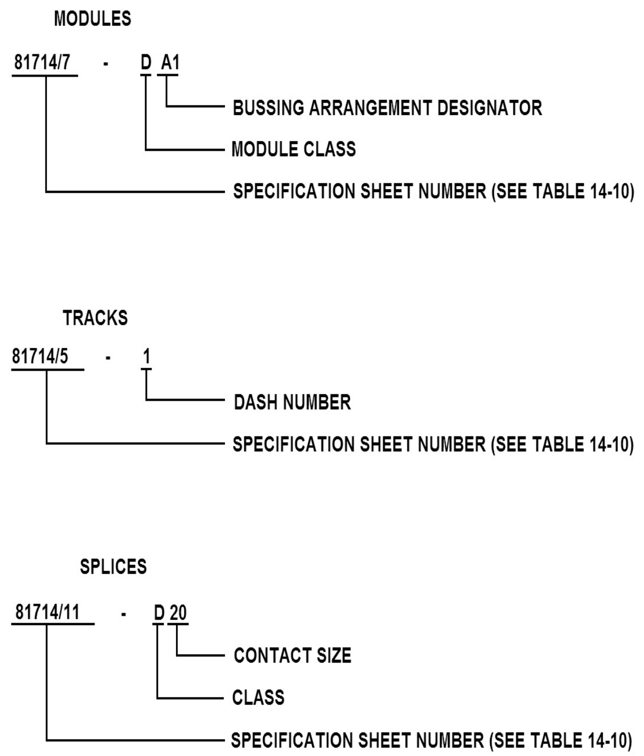


Figure 4–41 Components of Terminal Junction System – Series I

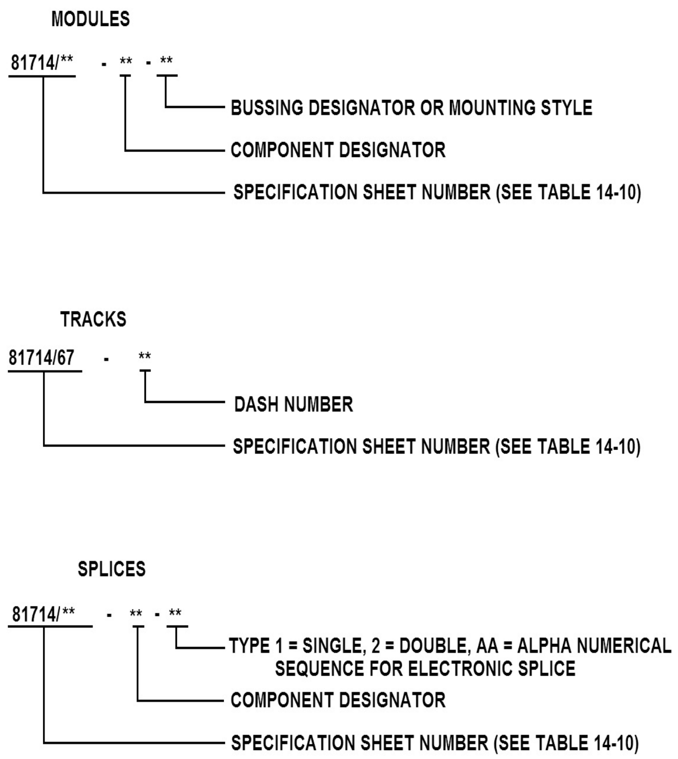


Figure 4–42 Components of Terminal Junction System – Series II

Table 4–19 Crimping Tools for TJS Terminals

Module Block Size	Contact Part No.	Bin Code	Mating End Size	Wire Barrel Size	Wire Size Range	Crimping Tools Basic	Crimping Tools Positioner or Turret	Contact Ins/Rem Tools
Series I								
22D	M39029/1-507	507	20	22D	22-28	M22520/2-32	M22520/2-32	M81968/14-01 or MS27534-22D or M81969/8-01 and M81969/8-02
22	M39029/1-100	100	16	22	22-26	M22520/2-01	M22520/2-11	M81969/14-10 or MS27534-20
20	M39029/1-101	101	16	20	20-24	M22520/2-01 M22520/1-01	M22520/2-11 M22520/1-02 (blue)	M81969/14-10 or MS27534-20
16	M39029/1-102	102	14	16	16-20	M22520/2-01	M22520/1-02 (blue)	M81969/14-03 or MS27534-16
12	M39029/1-103	103	12	12	12-14	M22520/2-01	:2520/1-02 (yellow)	M81969/14-04 or MS27534-12
Series I								
22	M39029/22-191	191	22	22	22-26	M22520/7-01	M22520/7-11	M81968/16-04
20	M39029/22-192	192	20	20	20-24	M22520/1-01	Daniels No. Th343 (red)	M81969/14-10
16	M39029/22-193	193	16	16	16-20	M22520/1-01	Daniels No. Th343 (blue)	M81969/14-03
12	M39029/22-605	605	12	12	12-14	M22520/1-01	M22520/1-16	M81969/16-03

Crimping of Terminals

98. The terminals are crimped on the wires, using the appropriate crimping tool as indicated in Table 4–19. Crimping is accomplished as follows:

a. Burn through the insulation with a hot wire stripper. Do not remove the insulation at this point. This will protect the wire from contamination and the strands from splaying. Recommended wire stripping dimensions are as follows:

Series	Contact Size	Wire Stripping Dimensions (mm)
I	20 and 22	3.18 to 3.96
	16 and 12	5.54 to 6.35
II	22,20,16	5.26 + 0.76
	12	5.72 + 0.51

NOTE

Wires may be stripped by any of the methods listed in Section 2, Chapter 3.

- **b.** Place the contact into the crimp tool (of the selected wire size) with the contact crimp barrel facing up.
- **c.** Remove the small piece of burnt insulation from the wire, taking care not to pinch the insulation with the finger nails.
- **d.** Insert the bare wire into the open end of the contact barrel. Push the wire in until it bottoms. Squeeze the crimp tool. (The crimp tool will release the contact only when the full crimping cycle has been performed.)
- **e.** Check that the wire is crimped correctly by looking at the inspection hole on the side of the contact crimp barrel. Visibility of the bare wire in the contact inspection hole indicates that the wire has been properly inserted.

Insertion and Extraction of Terminals

99. Insertion and extraction of the contacts are accomplished through use of the applicable tool, see Table 4–19. All the tools are of the same basic design but differ in size and all are colour-coded. The tools, squared at the middle for strength and ease in handling, have tapered tubes at each end: one for insertion and one for removal of the contact.

100. Insertion is accomplished as follows:

- **a.** Hold the coloured half of the appropriate insertion/removal tool between the thumb and forefinger and lay the wire to be inserted along the slot, leaving about 12.7mm of wire protruding. Then snap the wire into the tool. (See Figure 4–43)
- **b.** Pull the wire back through the tool, until the tip of the tool seats against the shoulder of the contact.
- **c.** Holding the module block with the cavities facing you, slowly push the contact straight in to the cavity.
- **d.** A firm stop will be evident when the contact is locked in place in the module block. Then let go of the wire and pull out the tool.

101. Removal is accomplished as follows:

- **a.** With the module facing you, snap the white end of the appropriate size double-ended plastic tool over the wire of the contact to be removed. (See Figure 4–44.)
- **b.** Slowly slide the tool along the wire into the insert cavity until it engages the contact rear and a positive resistance is felt. At this time, the contact retaining fingers are in the unlocked position.
- **c.** Press the wire of the contact to be removed against the serrations of the plastic tool and pull both the tool and the contact wire assembly out.

NOTE

No insertion-extraction tool, whether plastic or metal, should be subjected to mishandling or left loose among tools in a toolbox. They should be stored and carried in a separate container to prevent being damaged. Their tapered ends in particular shall be protected when the tool is not in use. The tips of all tools shall be inspected prior to use. Tools with broken, cracked, or bent tips shall not be used.

NOTE

All cavities shall be filled with contacts. Sealing plugs will be inserted in the cavities in the rear of all unwired contacts.

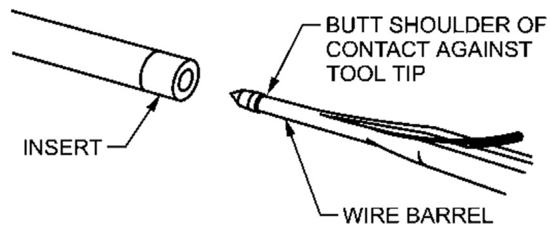


Figure 4–43 Contact Insertion in Removable Contact Wire Splices

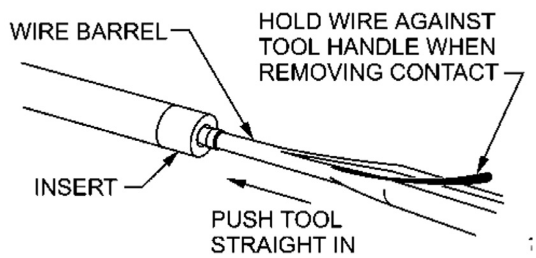


Figure 4–44 Contact Removal from Removable Contact Wire Splices

Insulation Repair

102. Unless otherwise specified by design or official directive, wire/cable that has insulation damage, and the centre conductor itself is not damaged, may be repaired if approved by authorised engineering officer. Damaged area must not be in excess of 7.6cm in length, and no more than two damaged areas in a three foot section.

Repair may be made with a non-adhesive backed tape, such as those listed in Table 4–20, utilizing the following procedures:

a. Wrap tape around the cable for one complete turn, beginning 5cm from the damaged area.

b. Using the same continuous length of tape, spiral wrap with a 50% overlap, wrap to a point 5cm past the damaged area. Terminate by wrapping one complete turn around the cable then cut the tape.

c. With nylon lacing string, spot tie both ends to the tape and at 25mm intervals over the entire length.

Table 4–20 Insulation Repair Tape

Colour	Adhesive Type	Specification
Black	Self-bonding	MIL-I-46852
Red	Self-bonding	MIL-I-46852
Black	Non-adhesive	MIL-S-1103GE
NOTE Silicone rubber tapes shall not be used where they will be exposed to fluids such as jet fuels, hydraulic fluids, engine oils, silicone damping fluid (DC-200), etc. These fluids may cause silicone rubber tapes to swell and/or lose adhesive properties.		

SECTION 2

CHAPTER 5

WIRING MAINTENANCE PRACTICES – INCLUDING REPAIRING WIRE AND CABLE

INTRODUCTION

1. All wiring should be maintained so that it is mechanically and electrically sound and neat in appearance. It is imperative to prevent or significantly reduce potential contamination or debris from coming into contact with the wiring and components during all maintenance, repairs and modifications. This begins with an awareness of potential wiring contamination, and remembering to install appropriate protection (e.g., plastic sheeting), as necessary, to cover avionics/electrical wiring and components.

2. A "clean-as-you-go" process helps to maintain the integrity of the installation. Care should be taken to protect wire bundles and connectors during work, and to ensure that all shavings, debris and contamination are cleaned up after work is completed.

3. Aircraft wiring is sometimes damaged during normal operation and maintenance. This chapter provides information on general maintenance techniques and the methods that may be relevant in repairing various types of wire and cable.

4. Always follow the manufacturer's repair process but for those aircraft that do not have repair processes for the wiring installations then an acceptable methods of maintaining the original electrical and mechanical integrity are set out in in this document and FAA A.C. 43-13 –1B & 2A.

NOTE
Where practicable, damaged wire or cable should be replaced from one termination to the next.

WIRING MAINTENANCE PRACTICES

5. Following maintenance, care should be taken to ensure the routing is in accordance with manufacturers' documentation. The wiring must be adequately supported throughout its length. A sufficient number of supports must be provided to prevent undue vibration of the unsupported lengths. All wires and wire groups should be maintained and be routed or installed to protect them from:

a. Chafing or abrasion

b. High temperature

c. Being used as handholds

d. Damage by personnel moving within the aircraft

e. Damage from cargo stowage or shifting

f. Damage from battery acid fumes, spray, or spillage

g. Damage from solvents and fluids.

6. Specific routing and installation procedures are described in the aircraft maintenance/wiring diagram manuals. In general terms, the following items can be considered guidelines when conducting wiring maintenance:

7. Protection Against Chafing. Wires and wire groups should be protected against chafing or abrasion in those locations where contact with sharp surfaces or other wires would damage the insulation. Cable clamps should be used to support wire bundles and maintain spacing at each hole through a bulkhead. If wires come closer than 3/8 inch (10mm) to the edge of the hole, a suitable grommet should be used in the hole Sometimes it is also necessary to cut nylon or rubber grommets to facilitate installation. In these instances, after insertion, the grommet can be secured in place with general-purpose cement. The cut should be at the top of the hole, and made at an angle of 45 degrees to the axis of the wire bundle hole.

8. Protection Against High Temperature. To prevent insulation deterioration, wires should be kept separate from high-temperature equipment, such as resistors, exhaust stacks, or pneumatic ducts. The amount of separation is normally specified by engineering drawings. Some wires must invariably be run through hot areas. These wires must be insulated with high temperature material. A low-temperature insulation wire should never be used to replace a high-temperature insulation wire. Many coaxial cables have soft plastic insulation, such as polyethylene, which is especially subject to deformation and deterioration at elevated temperatures. All high temperature areas should be avoided when installing cables insulated with plastic or polyethylene.

9. Protection Against Solvents and Fluids. One frequently encountered hindrance to inspections is dirt and grime. Consult the manufacturer's maintenance instructions for recommendation on materials suitable for cleaning electrical connectors and wires. For wire inspections, a soft cloth, such as a cotton glove, can be used to clean individual wires. With any cleaning process, care should be taken not to remove wire markings and ID tape. In addition, airplanes are often pressure washed with a general purpose detergent. Moderate pressure and a general purpose detergent are not harmful to wiring, but water under high pressure can penetrate components such as connectors and splices. Moisture penetration into components tends to increase with elevated water temperatures.

10. Engine and APU Wire Harnesses. Consideration should be given to the refurbishment of engine and APU wire harnesses during engine and APU maintenance visits due to the harsh environment.

11. Protection of Wires in the Wheel Well Area. Typically, wire bundles in this area should be mechanically protected. These wires and their protective devices should be inspected carefully at frequent intervals. There should be no strain on attachments when parts are fully extended, slack should not be excessive.

12. Routing Precautions. When wiring must be routed parallel to combustible fluid or oxygen lines for short distances, as much fixed separation as possible should be maintained. Specific separation standards should be available in manufacturer documentation. However, when such information is unavailable, a six-inch minimum separation may be used as a guideline, and no wire should be routed nearer than ½ inch to a plumbing line. The wires should be on the level with, or above, the plumbing lines. Clamps should be spaced so that if a wire is broken at a clamp, it will not contact the line. When a specified separation is not possible, both the wire bundle and the plumbing line can be clamped to the same structure to prevent any relative motion. A wire or wire bundle should not be supported from a plumbing line that carries flammable fluids or oxygen. Wiring should be routed to maintain a manufacturer recommended minimum clearance from control cables. When a manufacturer-specified clearance is not given, coordinate with the Original Equipment Manufacturer.

13. Connectors. A connector should be disconnected from a receptacle in the following manner:

a. Use connector pliers to loosen coupling rings, which are too tight to be loosened by hand.

b. Alternately pull on the plug body and unscrew the coupling ring until the connector is separated.

c. Protect disconnected plugs and receptacles to keep contamination from entering and causing faults.

d. Do not use excessive force, and do not pull on attached wires.

e. Use only approved contact cleaners do not use oil based water displacement products unless the connector is properly cleaned prior to re-installation

f. When reconnecting, special care should be taken to ensure the connector body is fully seated, the jam nut is fully secured, and no tension is on the harness.

14. Conduits are used in aircraft installation for protection of wires and cables. Conduits are available in metallic and non-metallic material, both in rigid and flexible form. When selecting conduit size, a general recommendation is to select the inside diameter of the conduit to be about 25% larger than the maximum diameter of the conductor bundle. Conduits are vulnerable to abrasion at the ends. Suitable fittings are affixed to the conduit ends in such a manner that a smooth surface comes in contact with the conductor within the conduit. When fittings are not used, the conduit ends should be flared to prevent wire insulation damage. The conduit should be supported by clamps along its run. Many of the common conduit problems can be avoided by proper attention to the following details:

15. Do not use a conduit as a handhold or footstep.

16. Ensure drain holes are provided at the lowest point in a conduit run and are clear. Drilling burrs should be carefully removed from the drain holes.

17. Ensure that the conduit is supported to prevent chafing against the structure and to avoid stressing its end fittings. Damaged conduit sections should be repaired to prevent damage to the wires or wire bundle. The minimum acceptable tube bend radii for a rigid conduit as prescribed by the manufacturer's instructions should be followed. Kinked or wrinkled bends in a rigid conduit are normally not acceptable. Transparent adhesive tape is recommended when cutting flexible tubing with a hacksaw to minimize fraying of the braid.

18. Cleaning. Care must be taken whenever wiring is being cleaned, especially as the aircraft and its wiring age. In general, wire insulation may become brittle, so displacement or moving of wiring during cleaning must be kept to the absolute minimum. Careful identification of the most appropriate cleaning methodology is very important. Vacuuming, perhaps in combination with light sweeping of wiring and wire bundles with soft brushes, to remove dirt and debris may be preferred. Additionally, significant damage can be done to wire insulation and other electrical system components with the inappropriate use of cleaning solvents.

19. Wire Marking. Some wiring, due to either or both gauge and wire type is unsuitable for "Hot Stamp" marking as defect reporting has identified a significant number of insulation failures due to damage from this process. Care must be used and the recommended temperatures, pressures and dwell time for hot stamping must be followed. After marking an insulation test should be carried out to determine the integrity of the insulation. Preferentially the alternate process of inkjet and UV laser marking should be used.

SINGLE WIRE REPAIR

20. If an aircraft wire is damaged at a single point and there is sufficient slack in the wire, the damaged wire should be repaired with a single splice. If a wire is damaged along its length, the damaged segment must be cut out and replaced with a jumper wire and two splices (Figure 5–1).

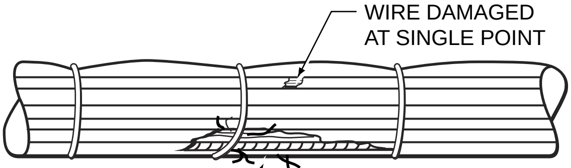


Figure 5–1 Damage Assessment

2. Carry out repairs as follows:

a. Cut cable ties and remove cable clamps as required to access wire damage.

b. Work damaged wires to outside of wire bundle. Pull slack in wire toward damaged area to prevent strain on splice.

c. If more than one wire is to be spliced and wires are not colour coded or otherwise identified, tag wires before proceeding.

d. Cut out the segment of wire with conductor or insulation damage. If a jumper wire is required, cut out at least 15cm of the damaged wire to allow room for splicing (Figure 5–2).

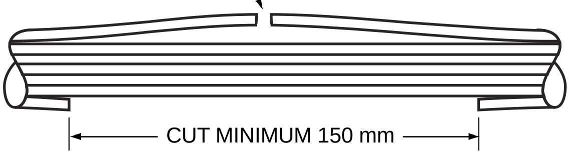


Figure 5–2 Removing Damaged Area

e. If more than one jumper wire is to be installed, stagger splice positions by varying lengths of sections that are cut out of the damaged wires.

f. Determine type and gauge of wire to be replaced from wire identification code or wiring diagram.

g. Cut replacement wire 12.7mm longer than removed segment.

h. From Table 5–1, select applicable splice for wire being replaced.

WARNING

Dry cleaning solvent P-D-680, type II is flammable. Avoid eye and skin contact or breathing of vapours. Appropriate protective equipment is required.

i. Clean 50mm of insulation, at wire ends to be spliced, with dry cleaning solvent.

j. Strip wire insulation appropriate length for selected splice.

k. Slide splice sealing sleeve over one end of stripped wire (Figure 5–3).

Table 5–1 Splice Selection

Wire Gauge	Splice Part Number	Colour Band	Crimp Tool	Crimp Die
26, 24, 22, 20	M81824/1-1	Red	M22520/5-01 or M22520/10-01	M22520/5-103 or M22520/10-104
20, 18, 16	M81824/1-2	Blue	M22520/5-01 or M22520/10-01	M22520/5-103 or M22520/10-104
16, 14, 12	M81824/1-3	Yellow	M22520/5-01 or M22520/10-01	M22520/5-102 or M22520/10-103

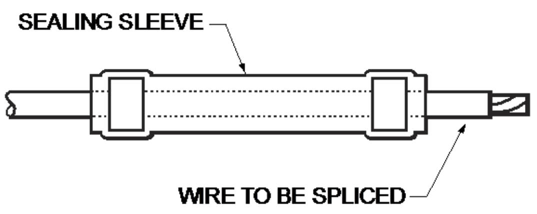


Figure 5–3 Sealing Sleeve placed on One Wire End

l. Using appropriate crimping tool and die (Table 5–1) crimp splice to wire ends (Figure 5–4)

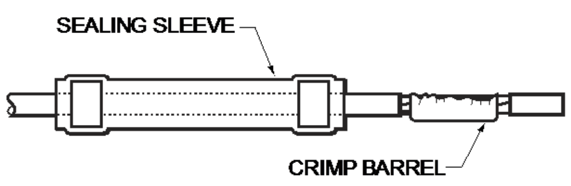


Figure 5–4 Correctly Installed Crimp Barrel

m. Centre sealing sleeve over crimp barrel (Figure 5–5).

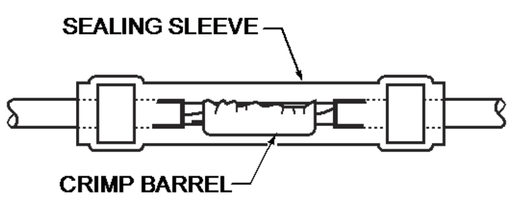


Figure 5–5 Sealing Sleeve Centred over Crimp Barrel

WARNING

Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft

WARNING

Use of nitrogen with hot air gun M83521/5-01 in an enclosed area can be hazardous. Ensure area is well ventilated.

n. Shrink sealing sleeve using hot air gun with small termination reflector. Shrink middle first and move heat towards one end until sealant melts and begins to flow out of sleeve (Figure 5–6). Repeat for other end. Allow to cool.

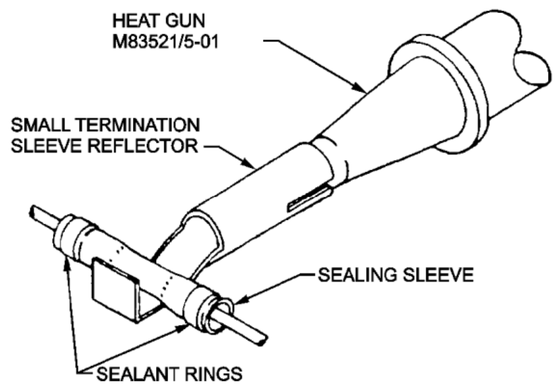


Figure 5–6 Splice Sealing

o. If installing a jumper wire, repeat steps i to n.

p. Work repaired wires into the bundle ensuring splices remain staggered (Figure 5–7).

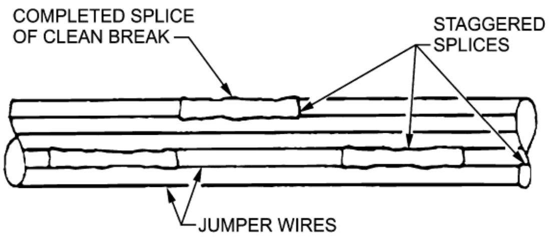


Figure 5–7 Completed Splices

q. Replace cable clamps and cable ties removed for access.

MULTI-CONDUCTOR CABLE REPAIR

21. The following paragraphs provide details of procedures, components and tooling for the repair of multi-conductor cables.

> NOTE
> Where practicable, damaged cable should be replaced from one termination to the next.

22. Unshielded Cable Repair. Carry out repairs as follows:

a. Cut cable ties and remove cable clamps as required to access cable damage.

> **CAUTION**
> When scoring cable jacket, ensure conductor insulation is not damaged.

b. Using a sharp blade or knife, score cable jacket around the cable and along the length of the damaged area (Figure 5–8).

c. Flex cable at score marks until jacket separates.

d. Remove jacket to gain access to damaged wires (Figure 5–9).

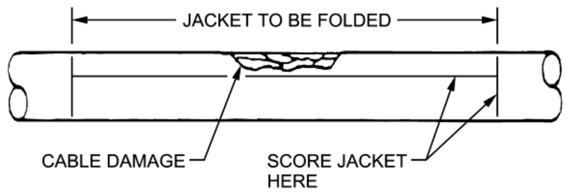


Figure 5–8 Scored Jacket on Multi-Conductor Cable

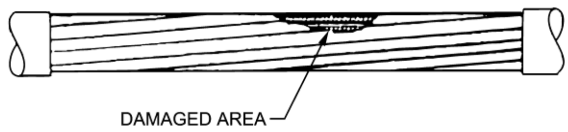


Figure 5–9 Damage Assessment

e. If more than one wire is to be spliced and wires are not colour coded or otherwise identified, tag wires before proceeding.

f. Cut out the segment of wire with conductor or insulation damage. If a jumper wire is required, cut out at least 15cm of the damaged wire to allow room for splicing (Figure 5–10).

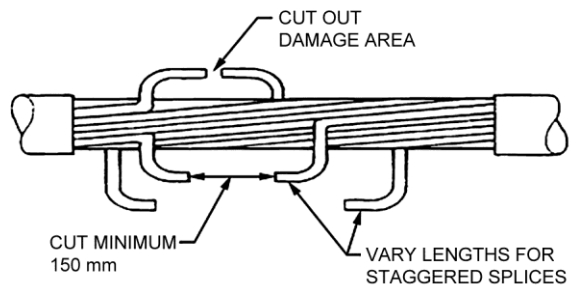


Figure 5–10 Removing Damaged Area

g. If more than one jumper wire is to be installed, stagger splice positions by varying lengths of sections that are cut out of the damaged wires.

h. Determine type and gauge of wire to be replaced from wire identification code or wiring diagram.

i. Cut replacement wire 12.7 mm longer than removed segment.

j. Select applicable splice for wire being replaced from Table 5–2.

Table 5–2 Splice Selection

Wire Gauge	Splice Part Number	Colour Band	Crimp Tool	Crimp Die
26, 24, 22, 20	M81824/1-1	Red	M22520/5-01 or M22520/10-01	M22520/5-103 or M22520/10-104
20, 18, 16	M81824/1-2	Blue	M22520/5-01 or M22520/10-01	M22520/5-103 or M22520/10-104
16, 14, 12	M81824/1-3	Yellow	M22520/5-01 or M22520/10-01	M22520/5-102 or M22520/10-103

WARNING

Dry cleaning solvent P-D-680, Type II is flammable. avoid eye and skin contact and breathing of VAPOURS. appropriate Protective equipment is required.

k. Using dry cleaning solvent, clean 50 mm of insulation at wire ends to be spliced.

l. Strip wire insulation appropriate length for selected splice.

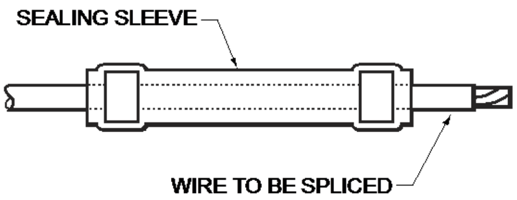


Figure 5–11 Sealing Sleeve Placed on One Wire End

m. Slide splice sealing sleeve over one end of stripped wire (Figure 5–11).

n. Using appropriate crimping tool and die (Table 5–2) crimp splice to wire ends (Figure 5–12).

o. Centre sealing sleeve over crimp barrel (Figure 5-13).

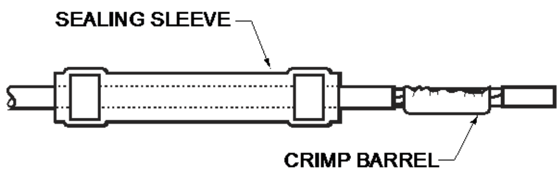


Figure 5–12 Correctly Installed Crimp Barrel

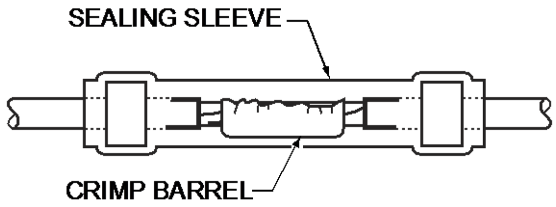


Figure 5–13 Sealing Sleeve Centred Over Crimp Barrel

WARNING

Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft.

WARNING

Use of nitrogen with hot air gun M83521/5-01 in an enclosed area can be hazardous. Ensure area is well ventilated.

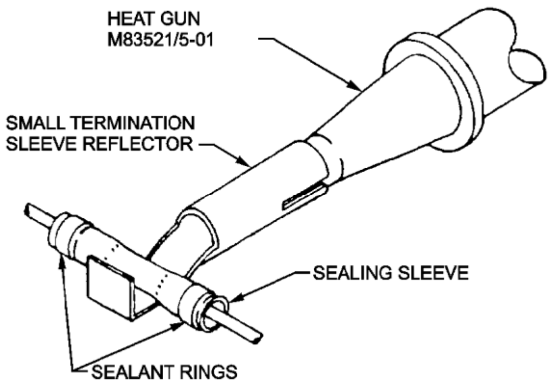


Figure 5–14 Splice Sealing

p. Shrink sealing sleeve using hot air gun with small termination reflector. Shrink the middle first and heat towards one end until sealant melts and begins to flow out of sleeve (Figure 5–14).

q. Repeat for other end. Allow to cool. If installing a jumper wire, repeat steps l. to p.

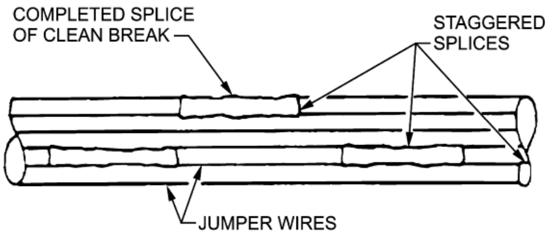


Figure 5–15 Completed Splices

r. Work repaired wires into the bundle ensuring splices remain staggered (Figure 5–15).

NOTE
When applying insulating tape, hands should be free of dirt and oil.

s. Apply insulating tape starting 12.7 mm before repaired area. Wrap tape one complete turn around cable parallel to jacket cut line (Figure 5–16).

t. Keeping tape stretched firmly, begin wrapping around cable in a single layer, spiral wrap, using a 50% overlap.

u. Continue wrapping until cable is wrapped 12.7 mm beyond repair area.

v. Terminate tape by wrapping one complete turn around cable, keeping tape at a right angle to axis of bundle.

w. Spot tie both ends of insulating tape (Figure 5–16).

x. Replace cable clamps and cable ties removed for access.

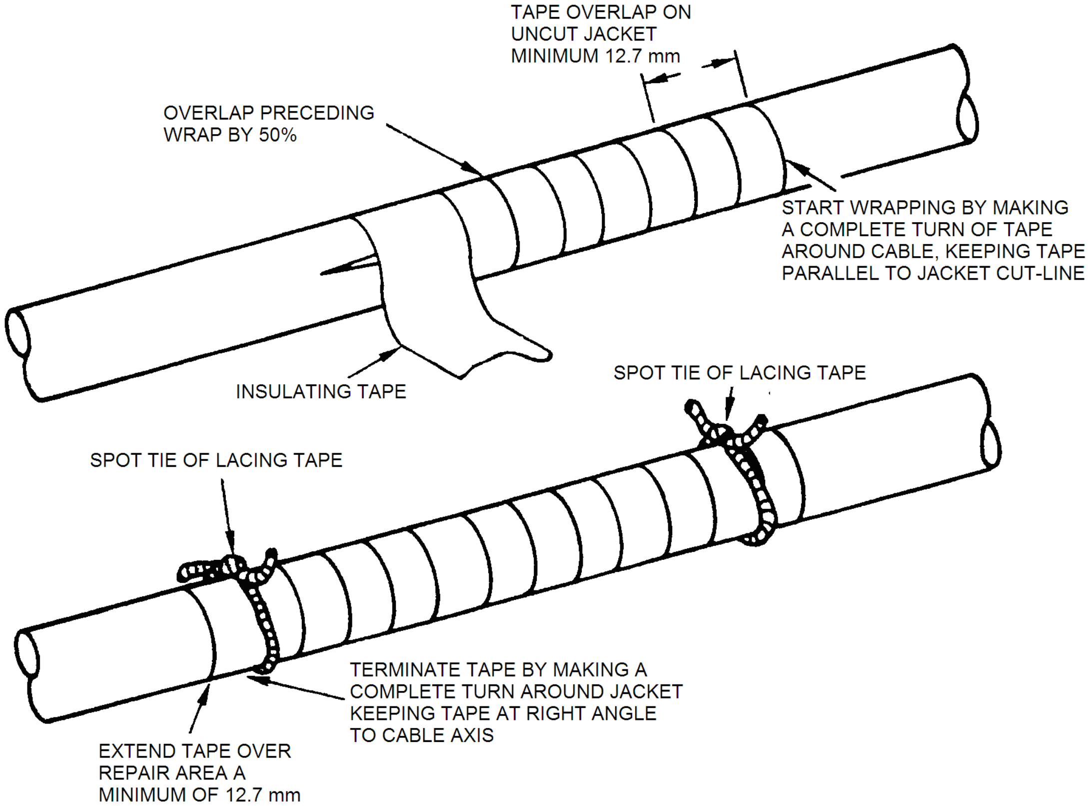


Figure 5–16 Taping Cable Jacket

23. Shielded Cable Repair. Carry out repairs as follows:

> NOTE
> This procedure calls for cutting all conductors in the cable to allow installation of the repair braid and insulation tubing.

a. Cut cable ties and remove cable clamps as required to access cable damage.

b. Select shield repair kit according to the outside diameter of the damaged cable jacket (Table 5–3).

c. Using a sharp blade, score cable jacket around the cable and along the length of the damaged area (Figure 5–17).

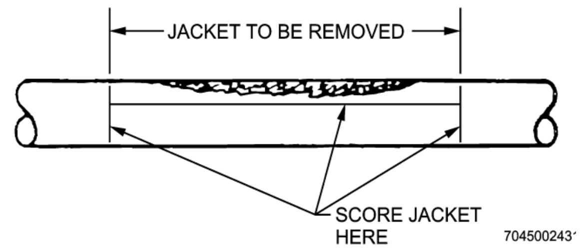


Figure 5–17 Scored Jacket

d. Flex cable at score marks until jacket separates.

e. Remove jacket.

f. Using small scissors or diagonal cutter, remove shield, taking care not to damage underlying wire insulation (Figure 5–18).

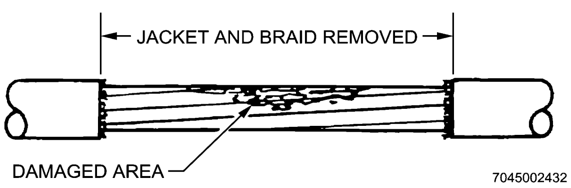


Figure 5–18 Damaged Multi-conductor Cable

g. If wires are not colour coded or otherwise identified, tag all wires before proceeding.

h. Cut wires to remove damage. If a segment of damaged wire must be cut out, remove at least 50 mm total length. (Figure 5–19). If damage is at a single point, damaged wire can be cut at the point of damage.

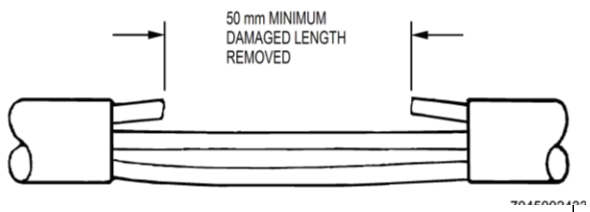


Figure 5–19 Wire With Damaged Section Removed

i. Cut undamaged wires at staggered locations (Figure 5–20).

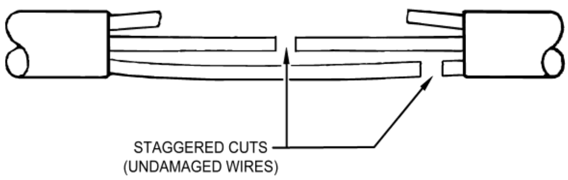


Figure 5–20 Undamaged Wires Cut at Staggered Locations

j. Slide tubing and braid from shield repair kit, over one cable end (Figure 5–21). Tape tubing and braid away from repair area.

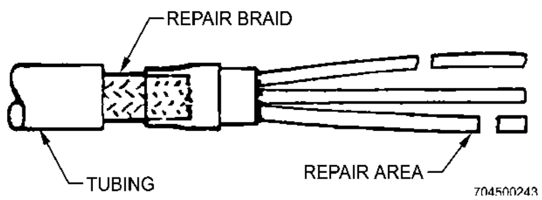


Figure 5–21 Tubing and Braid Located on Cable End

k. If damaged sections of wire have been removed ensure that the removed sections are at least 50 mm long, to allow room for splicing.

l. If more than one jumper wire is to be installed, stagger splice positions by varying lengths of sections that are cut out of the damaged wires.

m. Determine type and gauge of wire to be replaced from cable identification code or wiring diagram.

n. Cut replacement wire appropriate length to match removed segment (Figure 5–22).

Table 5–3 Shield Repair Kit Selection

Repair Kit	**Cable Parameters**		**Kit Components**		
Part Number	**Number of Conductors**	**Conductor Size Range**	**Conductor Splice Part Number**	**Splice Quantity**	**Shield Splice Part Number**
M81824/5-1 or D-150-0168	1	26-24-22-20	M81824/1-1	1	M81824/4-1
M81824/5-2 or D-150-0169	1	20-18-16	M81824/1-2	1	M81824/4-2
M81824/5-3 or D-150-0170	1	16-14-12	M81824/1-3	1	M81824/4-3
M81824/5-4 or D-150-0174	2	26-24-22-20	M81824/1-1	2	M81824/4-4
M81824/5-5 or D-150-0175	2	18-16	M81824/1-2	2	M81824/4-5
M81824/5-6 or D-150-0176	2	14	M81824/1-3	2	M81824/4-6
M81824/5-7 or D-150-0177	2	12	M81824/1-3	2	M81824/4-7
M81824/5-8 or D-150-0178	3 or 4	26-24	M81824/1-1	4	M81824/4-4
M81824/5-9 or D-150-0179	3 or 4	22-20	M81824/1-1	4	M81824/4-5
M81824/5-10 or D-150-0180	3 or 4	18-16	M81824/1-2	4	M81824/4-6
M81824/5-11 or D-150-0181	3 or 4	14-12	M81824/1-3	4	M81824/4-7

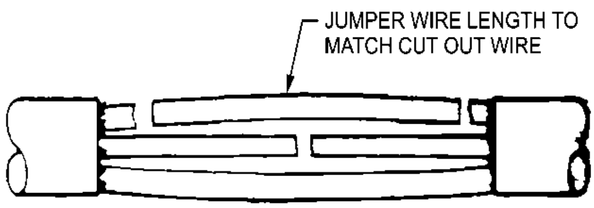


Figure 5–22 Jumper Wire Cut to Match Removed Segment

o. Carry out wire splicing procedure as detailed in paragraph 3, steps i to n.

p. When all wires have been reconnected, remove 12.7 mm of cable jacket at each end by carefully scoring around cable and along length to be stripped (Figure 5–17).

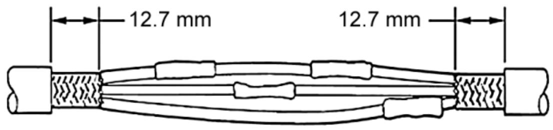


Figure 5–23 Jacket Removed

q. Slide repair braid along cable and centre over repaired area (Figure 5**–**24).

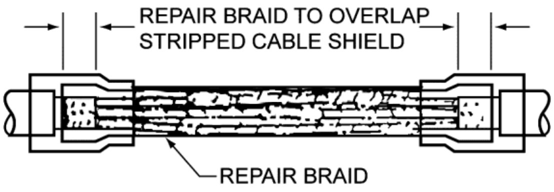


Figure 5–24 Repair Braid Centred Over Repair Area

> **WARNING**
>
> Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft.

> **WARNING**
>
> Use of nitrogen with hot air gun M83521/5-01 in an enclosed area can be hazardous. Ensure area is well ventilated.

r. Heat one end of the repair braid using hot air gun fitted with appropriate size reflector. Apply heat to the overlapping shield area until the solder melts and the sleeve shrinks onto the cable. Continue heating until solder flows into braid strands. Allow to cool undisturbed until solder solidifies (Figure 5–25).

s. Repeat step r. for opposite end.

t. Slide heat shrink tubing over repaired area and centre (Figure 5–26).

u. Heat tubing using hot air gun fitted with appropriate size reflector. Start in the middle and heat until tubing shrinks moving out to one end. Repeat for other end.

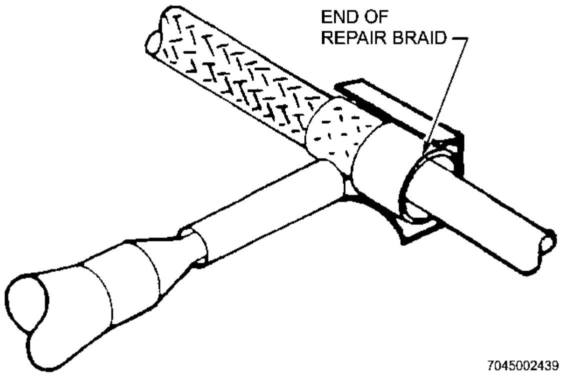


Figure 5–25 Heating Repair Braid

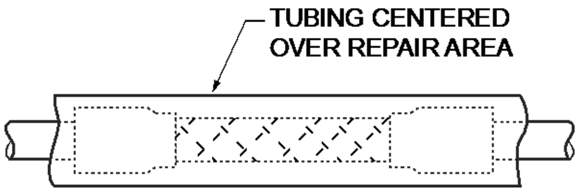


Figure 5–26 Tubing Centred Over Repaired Area

MIL-STD-1553 DATA BUS CABLE REPAIR

24. The following paragraphs provide general information on MIL-STD-1553 data bus system and the tooling, materials, and procedures for repair of the data bus.

25. The 1553B Data Bus is a computerized and multiplex digital data distribution system for the many functions of command, control, communications, and intelligence designed for military aircraft. A twinax cable of 78 ohms was selected to provide the transmitted digital information with the required protection from magnetic and electrostatic interference including nuclear electromagnetic pulse. Therefore, complete shielding of the pair along the transmission path as well as within the multi-pin connector must be maintained.

> NOTE
>
> While the information and procedures contained in this supplement are appropriate for repairing MIL-STD-1553 data bus cables, aircraft specific repair procedures take precedence.

Single Shield Cable with Solder Sleeve Primary Splice.

26. Prepare the cable using the following procedure:

a. Remove 31mm of cable jacket (Figure 5–27).

b. Trim shield to 9mm from cable jacket.

c. Strip primary conductors 12.7mm and pre-tin.

d. Trim fillers flush with shield.

27. Assemble as follows:

a. Place D-150-0124-01 outer sleeve and D150-0124-02 shield splice (small end first) onto one cable.

b. Insert primary conductors in D-150-0124-03 primary splice assembly.

c. Overlap conductors under solder preforms.

d. Use a holding fixture to hold wires in alignment.

WARNING

Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft.

WARNING

Use of nitrogen with hot air gun M83521/5-01 in an enclosed area can be hazardous. Ensure area is well ventilated.

e. Heat solder preforms until they melt and form a fillet along wires.

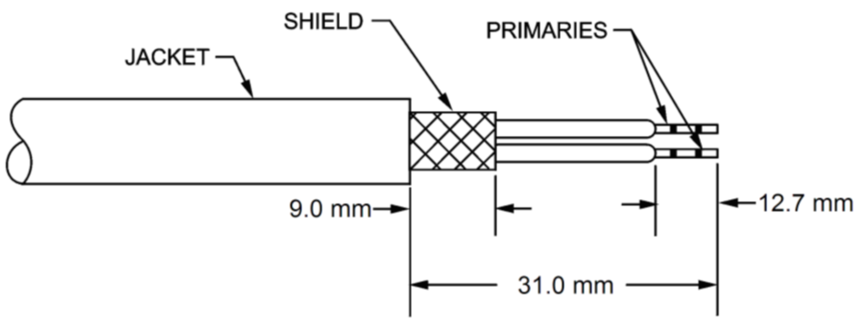


Figure 5–27 Single Shield Cable Strip Dimensions

Table 5–4 Tooling

Name	Part Number
Crimp Tool	AD-1377 or M22520/10-01 with die M22520/10-104
Holding Fixture	AD-1319
Hot Air Gun	M83521/5-01
Databus Harness Tester (Aircraft specific test leads required)	S2476N

Table 5–5 Materials

Name	Part Number
Splice Kit Solder Sleeve 24-22 AWG Single Shield	D-150-0124
Splice Kit Mini-Seal Crimp 24-22 AWG Double Shield	D-150-0133
Splice Kit Solder Sleeve 24-22 AWG Double Shield	D-150-0134
Splice Kit Mini-Seal Crimp 24-22 AWG Single Shield	D-150-0167

> NOTE
> The thermal indicator will lose its colour when sufficient heat has been applied to make the joint.

f. Heat ends of sleeves until inserts melt and flow along wires.

g. Perform inspection (Paragraph 17).

h. Centre D-150-0124-02 shield splice sleeve over splice and exposed cable shields.

i. Using heat gun, heat centre of sleeve until solder melts and shield and tube recover.

j. Move sleeve slowly through heat to one end of shield to keep sleeve recovering.

k. Apply additional heat for 5 to 10 seconds to final 12.7mm of sleeve shield to ensure sufficient heat transfer to the cable to make a good joint.

l. Apply heat to end of sleeve until ring melts and flows along cable jacket.

m. Repeat for other end of sleeve.

n. Perform inspection (Paragraph 19).

o. Centre D-150-0124-01 strain relief sleeve over completed splice.

p. Apply heat in centre of sleeve and move it through the heat until it has recovered onto the assembly.

q. Perform inspection (Paragraph 20).

Double Shield Cable With Solder Sleeve Primary Splice

28. Prepare the cable using the following procedure:

a. Remove 43mm of cable jacket (Figure 5–28).

b. Trim shield to 18mm from cable jacket, then trim outer shield to 9mm from cable jacket.

c. Strip primary conductors 12.7mm and pre-tin primaries.

d. Trim fillers flush with shields.

29. Assemble as follows:

a. Place D-150-0134-01 outer sleeve and D150-0134-02 shield splice (small end first) onto one cable.

b. Insert primary conductors in D-150-0134-03 primary splice assembly.

c. Overlap conductors under solder preforms.

d. Use a holding fixture to hold wire in alignment.

> **WARNING**
>
> Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft.

> **WARNING**
>
> Use of nitrogen with hot air gun M83521/5-01 in an enclosed area can be hazardous. Ensure area is well ventilated.

e. Using heat gun, heat solder preforms until melted and form a fillet along the conductors.

> NOTE
>
> The thermal indicator will lose its colour when sufficient heat has been applied to make the joint.

f. Heat ends of sleeves until inserts melt and flow along wires

g. Perform inspection (Paragraph 17).

h. Centre D-150-0134-02 shield splice sleeve over splice and exposed cable shields.

i. Using heat gun, heat centre of sleeve until solder melts and shield and tube recover.

j. Move sleeve slowly through heat to one end of shield to keep sleeve recovering.

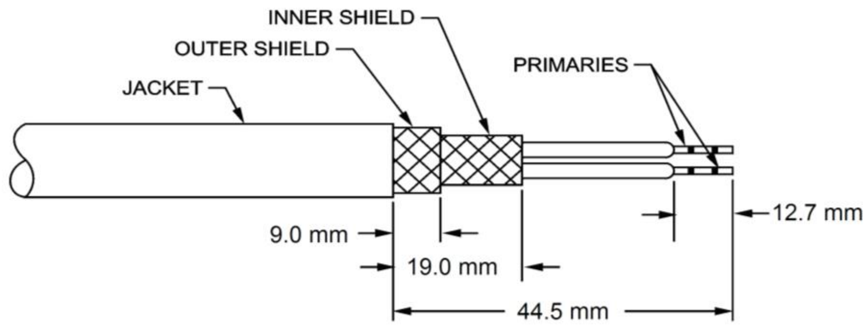


Figure 5–28 Double Shield Cable Strip Dimensions

k. Apply additional heat for 5 to 10 seconds to final 12.7mm of sleeve to ensure sufficient heat transfer to the cable shield to make a good joint.

l. Apply heat to end of sleeve until rings melt and flow along cable jacket.

m. Repeat for other end.

n. Perform inspection (Paragraph 19).

o. Centre D-150-0134-01 strain relief sleeve over completed splice.

p. Apply heat in centre of sleeve and move it through the heat until it has recovered onto the assembly.

q. Perform inspection (Paragraph 20).

Single Shield Cable with Miniseal Crimp Primary Splice

30. Prepare the cable using the following procedure:

a. Remove 56mm of cable jacket (Figure 5–29).

b. Trim shield to 9mm from cable jacket.

c. Cut one primary 23mm from cable jacket.

d. Strip both primaries 7mm.

e. Trim fillers flush with shield.

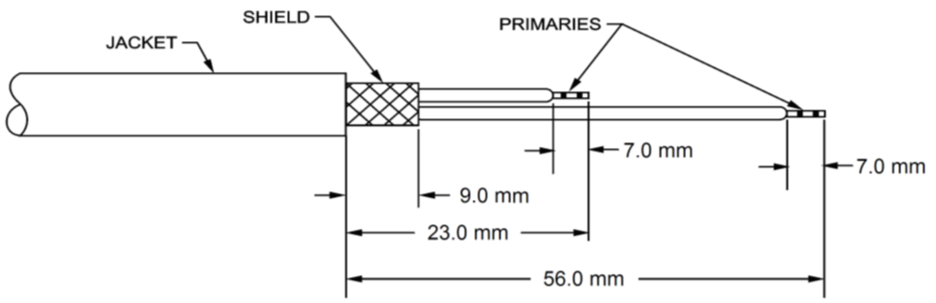


Figure 5–29 Single Shield Cable Strip Dimensions for Mini-Seal Crimp

31. Assemble as follows:

a. Place D-150-0167-04 outer sleeve and D-150-0167-01 shield splice (small end first) onto one of the cables.

b. Place one D-150-0167-03 sealing sleeve onto longer lead of each cable.

c. Crimp matching primaries into opposite ends of D-150-0167-02 crimp splice.

d. Centre D-150-0167-03 sleeves over splices.

WARNING

Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft.

WARNING

Use of nitrogen with hot air gun M83521/5-01 in an enclosed area can be hazardous. Ensure area is well ventilated.

e. Using heat gun, apply heat to centre of sleeves until recovered and then heat ends until sealing rings melt and flow along wires.

NOTE

The thermal indicator will lose its colour when sufficient heat has been applied to make the joint.

f. Heat ends of sleeves until inserts melt and flow along wires.

g. Perform inspection (Paragraph 18).

h. Centre D-150-0167-01 shield splice sleeve over splice and exposed cable shield.

i. Heat centre of sleeve until solder melts and shield and tube recover.

j. Move sleeve slowly through heat to one end of shield to keep sleeve recovering.

k. Apply additional heat for 5 to 10 seconds to final 0.5 inch (12.7mm) of sleeve to ensure sufficient heat transfer to cable shield to make a good joint.

l. Apply heat to end of sleeve until rings melt and flow along cable jacket.

m. Repeat for other end of sleeve.

n. Perform inspection.

o. Centre D-150-0167-04 strain relief sleeve over completed splice.

p. Starting at centre of sleeve, move sleeve through heat until it has recovered onto assembly.

q. Perform inspection.

Double Shield Cable with Miniseal Crimp Primary Splice

32. Prepare the cable using the following procedure:

a. Remove 71mm of cable jacket (Figure 5–30).

b. Trim shield to 19mm from cable jacket, then trim outer shield to 9mm from cable jacket.

c. Cut one primary 32mm from cable jacket.

d. Strip primaries 7mm.

e. Trim fillers flush with shield.

33. Assemble as follows:

a. Place D-150-0133-04 outer sleeve and D-150-0133-02 shield splice (small end first) onto one cable.

b. Place one D-150-0133-04 sealing sleeve onto longer lead of each cable.

c. Crimp matching primaries into opposite end of D-150-0133-03 crimp splice.

d. Centre D-150-0133-04 sleeves over splices.

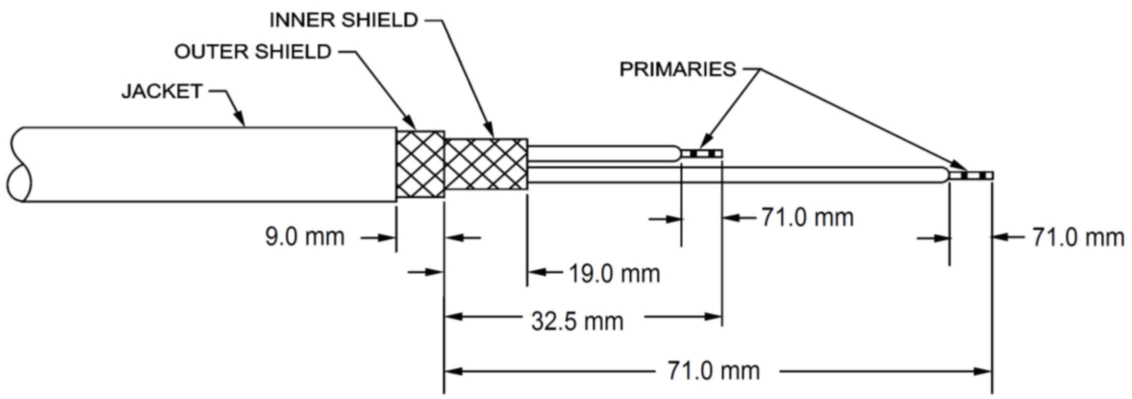


Figure 5–30 Double Shield Cable Strip Dimensions for Mini-Seal Crimp

WARNING
Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft.

WARNING
Use of nitrogen with hot air gun M83521/5-01 in an enclosed area can be hazardous. Ensure area is well ventilated.

e. Using heat gun, apply heat to centre of sleeves until recovered and then heat ends until sealing rings melt and flow along wires.

NOTE
The thermal indicator will lose its colour when sufficient heat has been applied to make the joint.

f. Heat ends of sleeves until inserts melt and flow along wires.

g. Perform inspection (Paragraph 18).

h. Centre D-150-0133-02 shield splice sleeve over splice and exposed cable shield.

i. Apply heat to centre of sleeve until solder melts and shield and tube recover.

j. Move sleeve slowly through heat to one end of shield to keep sleeve recovering.

k. Apply additional heat for 5 to 10 seconds to final 12.7mm of sleeve to ensure sufficient heat transfer to cable shield to make a good joint.

l. Apply heat to end of sleeve until rings melt and flow along cable jacket.

m. Repeat for other end of sleeve.

n. Perform inspection.

o. Centre D-150-0133-01 strain relief sleeve over completed splice.

p. Starting from centre of sleeve, move sleeve through heat until it has recovered onto assembly.

q. Perform inspection.

Inspection

34. Solder sleeve splices must be inspected for the following:

- **a.** Conductors must be overlapped a minimum 9mm.
- **b.** Fillet length must be a minimum 6mm.
- **c.** Sealing rings must have flowed along the wire.
- **d.** Sleeve must not have discoloured to the degree that joint cannot be inspected.
- **e.** Sleeve must not be cut or split.
- **f.** Strands of conductor must not be sticking through the sleeve.

35. Mini-Seal splices must be inspected for the following:

- **a.** Conductors must be visible at point where they enter crimp barrel.
- **b.** Both indentations of crimp, must be on crimp barrel.
- **c.** Sealing sleeve inserts must have flowed along wire insulation.
- **d.** Sleeve must not have discoloured to the degree that crimp barrel cannot be inspected.
- **e.** Sleeve must not be cut or split.

36. Shield splices must be inspected for the following:

- **a.** Sleeve/shield must be recovered along its entire length.
- **b.** Sleeve must be recovered tightly around cable jacket.
- **c.** Sealing rings must have flowed along cable jacket.
- **d.** Sleeve must not have discoloured to the degree that the joint cannot be inspected.
- **e.** Sleeve must not be cut or split.
- **f.** Strands must not be sticking through of sleeve.

37. Outer sleeves must be inspected for the following:

- **a.** Sleeves must be recovered tightly onto assembly along its full length.
- **b.** An adhesive bead should be visible at ends of sleeve.
- **c.** Sleeve must not be cut or split.

Testing

38. On completion of the inspection procedure the data bus should be tested to ensure there are no short circuits, shorts to shield, open circuits or crossovers, using test equipment detailed in Table 5–4, or equivalent.

SECTION 2

CHAPTER 6

SOLDERLESS TERMINATIONS AND SPLICES

INTRODUCTION

1. Electric wires are terminated with solderless terminal lugs to permit easy and efficient connection to and disconnection from terminal boards, busbars, and other electrical equipment. Solderless splices join electric wires to form permanent continuous runs.

2. This chapter describes recommended methods for terminating copper and aluminium wires, using solderless terminal lugs. It also describes recommended methods for permanently joining (splicing) wires, using solderless splices. (Termination of thermocouple wires is covered in Section 2, Chapter 16.)

REFERENCE SPECIFICATIONS

3. The following specifications are applicable to solderless terminations and splices:

MIL-DTL-22520	Crimping Tools, Wire Termination, General Specification For
MIL-S-81824	Splice, Electric, Permanent, Crimp Style, Copper, Insulated, Environment Resistant
MIL-T-81714	Terminal Junction System (TJS), Environment Resistant General Specification For
SAE AS70991	Terminals, Lug and Splice, Crimp Style, Aluminium, for Aluminium Aircraft Wire
SAE AS7928	Terminals, Lug: Splices, Conductor: Crimp Style, Copper, General Specification For

DESCRIPTION

4. Solderless terminal lugs and splices are plated copper or aluminium, and are pre-insulated or uninsulated, depending on the application. Terminal lugs and splices for high temperature applications are silver or nickel plated copper and are insulated with TFE (or a similar material).

NOTE

Use only copper terminations on copper wire and aluminium terminations on aluminium wire. Only environment resistant sealed splices shall be used as permanent electrical wire splices on aircraft.

5. Terminal lugs are available in four styles: straight, 90 degree upright, angle, and flag, for use under different applications. Figure 6–1 shows typical terminal lugs and splices. Terminal lugs and splices are crimped to wires by means of hand or power crimping tools. Power tools may be portable or stationary (bench-mounted). Typical crimping tools are illustrated where they are mentioned in the procedures. Environmental sealed splices (MIL-S-81824) are the only permanent splices that should be used on aircraft. Potted non-environmental splices may be used as a temporary/emergency repair and shall be replaced as soon as practicable.

End Caps, Splices, Terminal Lugs and Crimp Tools

6. Only Class I end caps, splices, terminal lugs and crimping tools qualified to SAE AS 70991, SAE AS 7928, MIL-S-81824 or MIL-DTL-22520 are recommended for use on aircraft unless otherwise authorised by an appropriate engineering authority. Class I terminations are approved for the replacement of Class II terminations or non-qualified terminations fitted by the manufacturer or specified in the aircraft/equipment IPB.

7. Terminal Lugs, splices, end caps and tooling are classified as follows:

- **a.** Class I Terminal Lugs and Splices and End Caps – Lugs, splices and end caps that conform to all the requirements of the applicable specification when installed with the specified crimping tools.
- **b.** Class I Tools are those which meet all the requirements of the applicable specification.
- **c.** Class II Terminal Lugs, Splices and End Caps - lugs, splices and end caps that conform to the material and marking requirements of the specification and are replaceable by Class I terminals. They conform to the performance requirements of the specification when crimped with a tool having crimping dies and motion conforming to the terminal manufacturer's drawing.
- **d.** Class II tools, terminal lugs, end caps and splices should not to be used on aircraft.
- **e.** The types and styles of terminal lugs, splices and end caps are listed in Annex A, Table 6–A–1.

TERMINATING SMALL COPPER WIRES WITH PRE-INSULATED TERMINAL LUGS

8. Small copper wires (sizes No. 26 thru No. 10) are terminated with solderless pre-insulated straight copper terminal lugs conforming to SAE AS 7928. (See Annex A, Table 6–A–1.) As shown in Figure 6–2, the insulation is part of the terminal lug and extends beyond its barrel, so that it will cover a portion of the wire insulation; this makes the use of an insulation sleeve unnecessary. In addition, pre-insulated terminal lugs have an insulation support (a metal reinforcing sleeve) beneath the insulation for extra supporting strength on the wire insulation. Most pre-insulated terminals accommodate more than one size of wire. The insulation is colour coded and the range of wire sizes is marked on the tongue to identify the wire sizes that can be terminated with each of the terminal lug sizes.

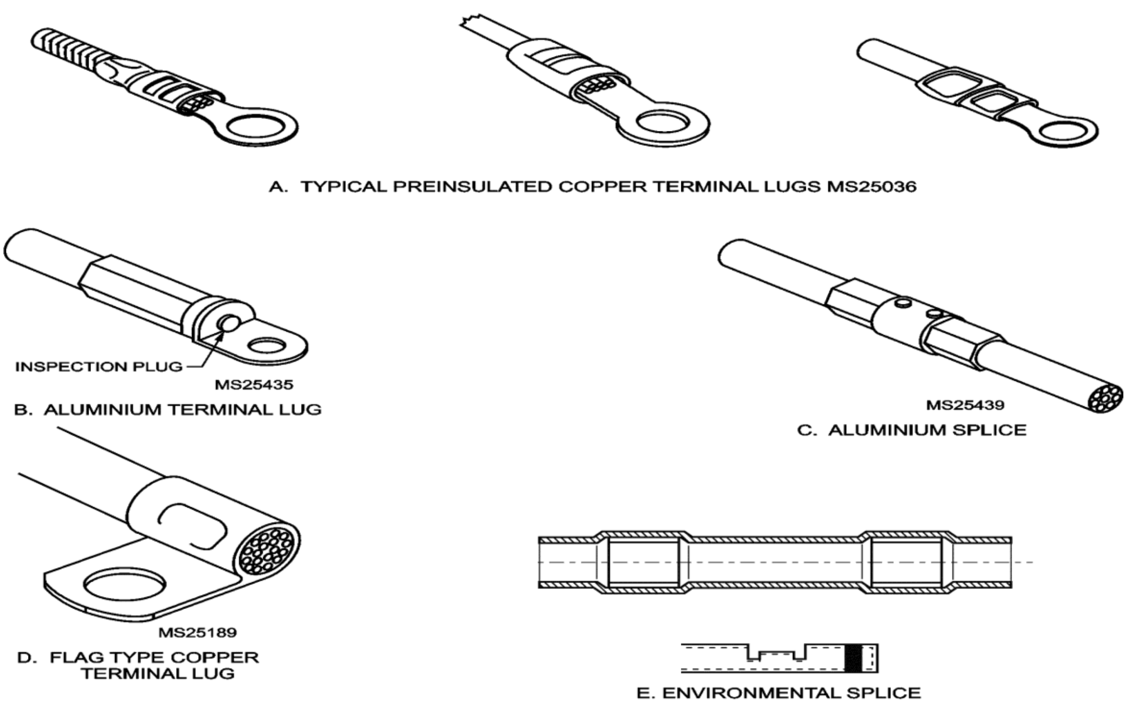


Figure 6–1 Solderless Terminal Lugs and Splices

CAUTION

Using tin plated terminals on nickel plated wire may not achieve appropriate voltage drop and tensile strength requirements. Refer to SAE AIR 1263.

High Temperature Terminal Lugs

9. Appropriately rated high temperature terminal lugs shall be used on high temperature wire where the termination is located in a high temperature area. Where wire termination is in a low temperature area, standard crimp terminals may be used. Table 6–2 provides details of tools and terminations that are considered suitable for use on high temperature wire.

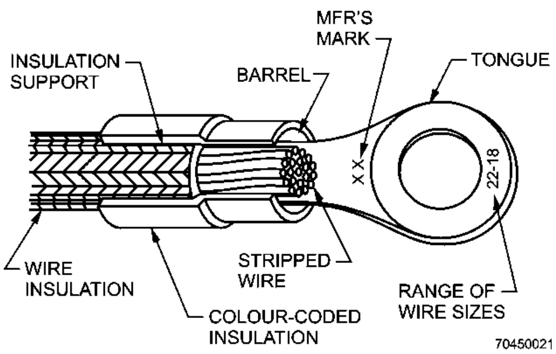


Figure 6–2 Preinsulated Terminal Lug – Cut-Away

Colour of Terminal Lug Installation	To Be Used On Wire Size(s)
Yellow with Black Stripe	26
Yellow with Blue Stripe	24
Yellow	26 or 24
Red with Green Stripe	22
Red with Red Stripe	20
Red with White Stripe	18
Red	22, 20 or 18
Blue with Blue Stripe	16
Blue with Green Stripe	14
Blue	16 or 14
Yellow with Yellow Stripe	12
Yellow with Brown Stripe	10
Yellow	12 or 10

Table 6–1 Colour Coding of Copper Terminal Lug Insulation

Gold Plated PIDG Ring Tongue Insulated Terminals Rated to 260°C (500°F)			
Terminal Part Number	**Stud Size**	**Wire Size**	**Tool Part Number (AMP)**
1-332433-0	6	22-20	69692-1
332434	8	22-20	
1-332434-0	10	22-20	
332453	6	18-16	69693-1
332454	8	18-16	
1-332454-0	10	18-16	
Nickel Plated Ring Tongue Terminals Rated to 343°C (650°F) Uninsulated with Insulation Support			
323151	6	22-16	46673
323152	8	22-16	
323153	10	22-16	
Nickel Ring Tongue Terminals Rated to 649°C (1200°F) Uninsulated with Insulation Support			
321892	6	22-16	46673
321893	8	22-16	
321894	10	22-16	

Crimping Tools

10. Only tools qualified to MIL-DTL-22520 are to be used for crimping terminal lugs. These tools crimp the barrel to the conductor, and simultaneously form the insulation support to the wire insulation.

> **CAUTION**
>
> With some of the smaller gauge thin wall wires, insulation can be inadvertently inserted and crimped in the terminal barrel.

Hand Tool Description

11. All approved hand crimping tools have a self-locking ratchet, which prevents the tool from opening until crimp is complete. This mechanism must never be disassembled since it ensures proper crimping closure. The M22520/5 and M22520/10 tools are the approved tools to be used in crimping sizes 26 through 10, end caps, splices and terminal lugs. The M22520/5-01 and M22520/10-01 crimp tools have removable dies for crimping 26 through 10 terminal (wire barrel) sizes see Figure 6–3.

Hand Tool Inspection

12. Dies and other working parts of crimping tools used for electrical terminations become worn in service and this can result in unsatisfactory terminations. An effective means to ensure a serviceable termination is to monitor the condition of the tool by regular testing. The standard tools are checked by means of a GO/NOGO gauge for assurance of quality crimps. For good crimping results, gauging should be carried out prior to each series of crimping operations. Replace or repair hand tools, which are out of tolerance. The details contained in Table 6–3 are provided for in-service inspection gauging of M22520/5-01 and M22520/10-01 tools and dies. Prior to performing the gauging test, ensure that both the crimping tool jaws and the shafts of the gauge are clean and free of damage.

Millivolt Drop and Tensile Strength Test

13. When gauging tools are unavailable, testing can be accomplished by carrying out a millivolt drop and tensile strength test on a completed crimp (Refer to Annex D).

Table 6–3 Gauging Tools

Die Part Number	Die Cavity Size	Gauge Part Number
M22520/5-100	12 – 10	M22520/3-9
M22520/5-100	26 – 14	M22520/3-10
M22520/5-101	26 – 20	M22520/3-11
M22520/5-102	16 – 12	M22520/3-12
M22520/5-103	20 – 16	M22520/3-13
M22520/5-103	26 – 20	M22520/3-14
M22520/10-100	12 – 10	M22520/3-9
M22520/10-101	26 – 14	M22520/3-10
M22520/10-102	26 – 20	M22520/3-11
M22520/10-103	16 – 12	M22520/3-12
M22520/10-104	20 – 16	M22520/3-13
M22520/10-104	26 – 20	M22520/3-14

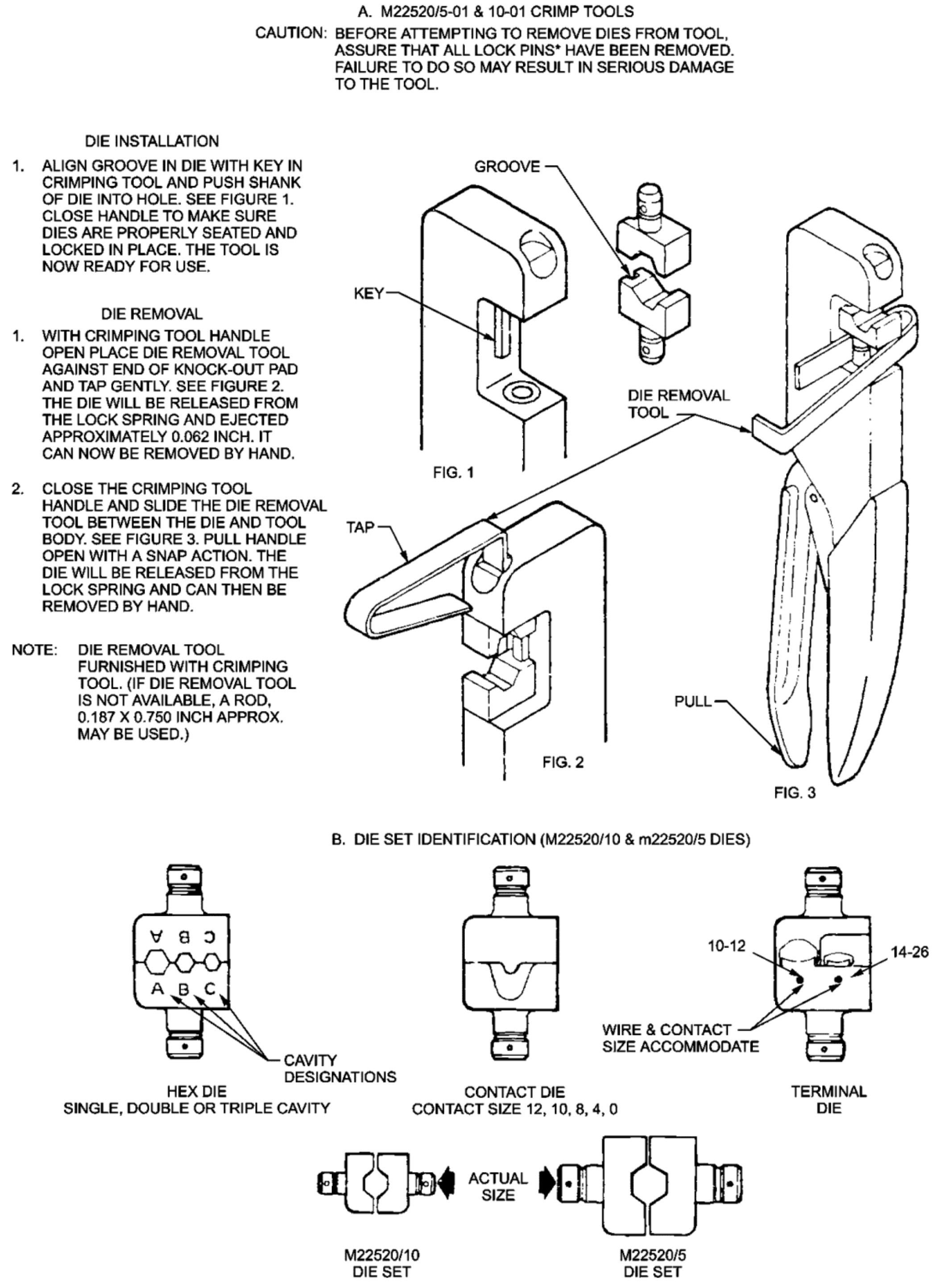


Figure 6–3 Crimp Tools and Dies (Sheet 1 of 2)

C. DIES FOR CRIMPING TERMINAL LUGS, SPLICES AND END CAPS

1. WITH DIES OPEN (SEE FIG. A) PLACE TERMINAL, SPLICE OR END CAP IN PROPER CAVITY. SIZES ARE STAMPED BELOW EACH CAVITY ON SIDE OF DIE.

2. LOCATE TERMINAL, SPLICE OR END CAP WITH LOCATOR (SEE FIG. B). TERMINAL SHOULD LOCATE WITH FLANGE OVER THE TOP OF THE LOCATOR. SPLICE IS CENTERED WITH NOTCH IN SPLICE RESTING ON THE LOCATOR. END CAPS LOCATE AGAINST THE FACE OF THE LOCATOR. INSERT WIRE TO PROPER DEPTH.

3. CLOSE HANDLE OF TOOL UNTIL DIES ARE CLOSED AND RATCHET RELEASES. THE CRIMP IS NOW COMPLETE. (SEE FIG. C).

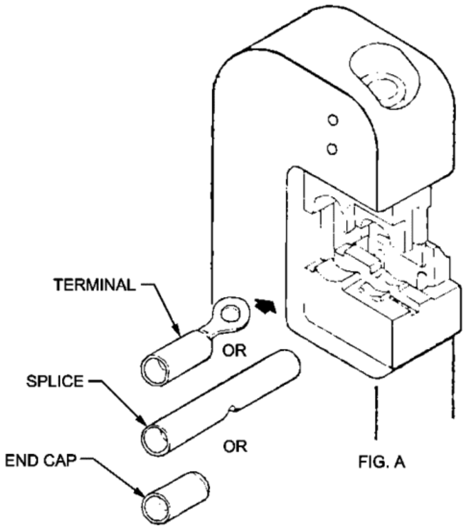


FIG. A

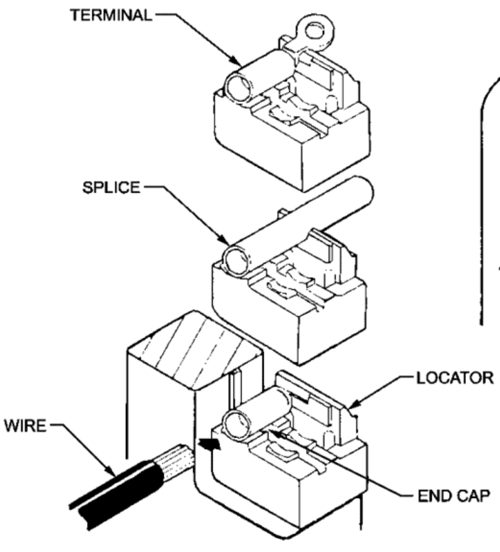


FIG. B

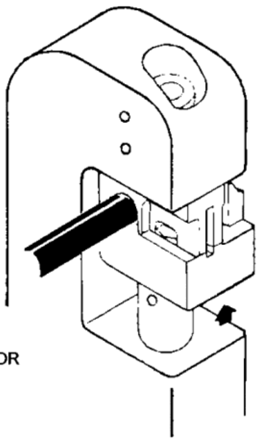


FIG. C

Figure 6–3 Crimp Tools and Dies (Sheet 2 of 2)

Table 6–4 Dies and Gauges for Power Tool MS25441

Terminal Lug Size	Die Part Number (For Head MS25441-1)	MS Gauge Part Number
Insulated Terminals		
8	MS23002-8	MS23003-8
6	MS23002-6	MS23003-6
4	MS23002-4	MS23003-4
2	MS23002-2	MS23003-2
1	MS23002-1	MS23003-1
1/0	MS23002-01	MS23003-01
2/0	MS23002-02	MS23003-02
3/0	MS23002-03	MS23003-03
4/0	MS23002-04	MS23003-04
Uninsulated Terminals		
8	MS90485- 8	MS90486-8
6	MS90485-6	MS90486-6
4	MS90485-4	MS90486-4
2	MS90485-2	MS90486-2
1	MS90485-1	MS90486-1
1/0	MS90485-01	MS90486-01
2/0	MS90485-02	MS90486-02
3/0	MS90485-03	MS90486-03
4/0	MS90485-04	MS90486-04
Aluminium Terminals		
8	MS25442-8A	MS25472- 1
6	MS25442-6A	MS25472-2
4	MS25442-4A	MS25472-3
2	MS25442-4A	MS25472-4
1	MS25442-1A	MS25472-5
1/0	MS25442-01A	MS25472-6
2/0	MS25442-02A	MS25472-7
3/0	MS25442-03A	MS25472-8
4/0	MS25442-04A	MS25472-9

Crimping Procedure for M22520/5 and M22520/10 Hand Tools

14. Hand crimp pre-insulated copper terminal lugs in the No. 26 - No. 10 wire size range with M22520/5 or M22520/10 hand tools as follows:

- **a.** Strip wire insulation using one of the recommended stripping procedures detailed in Section 2, Chapter 3. (Stripping lengths are provided in Table 6–4).
- **b.** Check tool for correct adjustment in accordance with paragraph 12. Tools out of adjustment must be returned to the manufacturer for repair.
- **c.** Insert terminal lug, tongue first, into wire side of hand tool barrel crimping jaws, until terminal lug barrel butts flush against tool stop on the locator. (See Figure 6–3 for correct insertion method).
- **d.** Squeeze tool handles slowly until tool jaws hold terminal lug barrel firmly in place, but without denting it.
- **e.** Insert stripped wire into terminal lug barrel until wire insulation butts flush against near end of wire barrel. (See Figure 6–2 or Figure 6–4.)
- **f.** Squeeze tool handles until ratchet releases.
- **g.** Remove completed assembly and examine it for proper crimp in accordance with paragraph 36.

CAUTION

With some of the smaller gauge thin wall wires, insulation can be inadvertently inserted and crimped in the terminal wire barrel.

Table 6–5 Wire Stripping Lengths for Small Copper Terminal Lugs

Wire Size	Stripping Length (mm)
26 and 24	4.0
22 and 20	4.7
18, 16 and 14	6.4
12 and 10	7.0

TERMINATING LARGE COPPER WIRES

15. Copper terminal lugs of two styles (straight and flag) are used to terminate copper wires sizes No. 8 through No. 4/0. The style to be used depends on existing space conditions. These terminal lugs are available uninsulated in both types and pre-insulated in the straight type. Straight pre-insulated terminal lugs conform to SAE AS 7928 (see Annex A, Table 6–A–1). As shown in Figure 6–2, pre-insulated terminal lugs have the insulation extending beyond the wire barrel, so that it will cover a portion of the wire insulation. This makes the use of a separate insulating sleeve unnecessary. Straight uninsulated terminal lugs conform to SAE AS 7928 and MS20659. Flag uninsulated terminal lugs conform to SAE AS 7928 and MS25189.

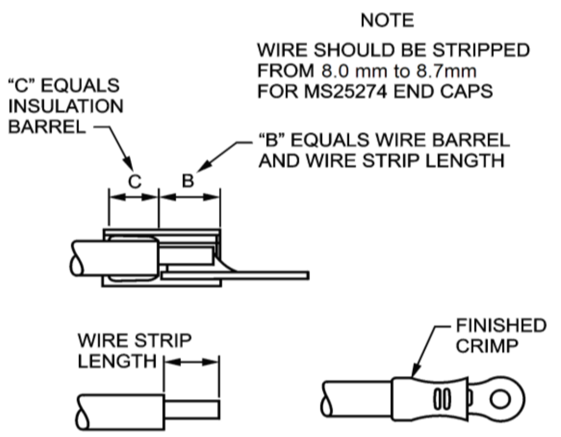


Figure 6–4 Proper Insertion of Stripped Wire in Insulated Terminal Lug for Crimping

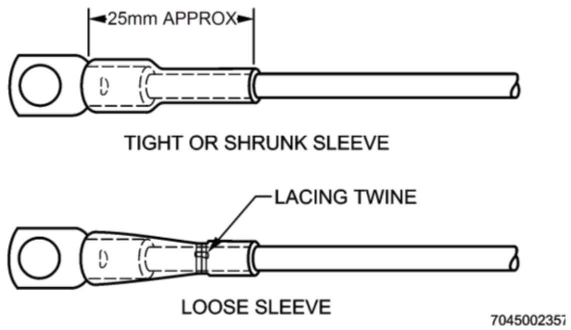


Figure 6–5 Insulating Sleeves

Insulating Sleeves

16. Uninsulated straight flag terminal lugs are insulated (after assembly to wire) with heat shrinkable tubing (see Section 2, Chapter 4) or with lengths of transparent tubing. These methods of insulation provide electrical and mechanical protection at the connection. When the size of sleeving used is such that it will fit tightly over the terminal lug, the sleeving need not be tied; otherwise, it is to be tied with lacing cord. (See Figure 6–5.)

Crimping Tools for Sizes 8 through 4/0 Terminals

17. Manual and/or power crimping tools are available for crimping M7928/4 and MS25036 insulated terminals, MS20659 uninsulated terminals and MS25189 flag type terminals. The tools are the MS25441-5 hydraulic pedal pump and the MS25441-4 electric hydraulic pump used with the MS25441-1 hydraulic head and the MS25441-3 hose (or an adaption - without the control cable), and the proper dies.

MS25441 Tool Adjustment

18. The MS25441 tools can be checked for proper adjustment. For good crimping results, this must be done before each series of crimping operations. When tool is adjustable, proper correction must be made; otherwise, the tool must be returned to manufacturer for repair. Gauge the dies of the MS25441 tool in the closed position with the appropriate GO/NO GO gauges listed in Table 6–5.

Millivolt Drop and Tensile Strength Test

19. When gauging tools are unavailable, testing can be accomplished by carrying out a millivolt drop and tensile strength test on a completed crimp (Refer to Annex D).

CRIMPING PROCEDURE FOR MS25441 TOOLS

20. Crimp large Military Standard copper terminals as follows:

a. Select proper die for terminal and wire size from Table 6–5 and install die in tool.

> **WARNING**
>
> ALWAYS disconnect power tool from its pressure source BEFORE installing or removing dies.

> NOTE
>
> Do not use any crimping tool beyond its rated capacity.

b. Strip wire insulation, using recommended practices described in Section 2, Chapter 3. Stripping lengths for copper wire shall be conductor barrel length plus 1.6mm.

c. Insert stripped wire into terminal barrel until wire insulation butts flush against end of barrel.

d. Insert wire and terminal lug assembly into die.

e. Actuate the crimp tool. Press button on handle for electrically operated tool. Do not release the button until the dies open automatically. Actuate handle for manual hydraulically operated tool.

f. Remove the crimped assembly, and examine it for proper crimp, in accordance with paragraph 36.

TERMINATING ALUMINIUM WIRE

21. Aluminium wire is used in aircraft because of its weight advantage over copper. Aluminium, however, has the disadvantage of being softer than copper. Further, bending aluminium wire will cause “work hardening” of the metal that makes it more brittle. This will result in failure or breakage of strands much sooner than in copper wire. Aluminium also forms a high resistance oxide film immediately upon exposure to air. To compensate for these disadvantages it is important to follow carefully the recommended installation procedures.

> **CAUTION**
>
> Do not use any aluminium wire which has nicked or broken strands. Damaged strands will fail in service.

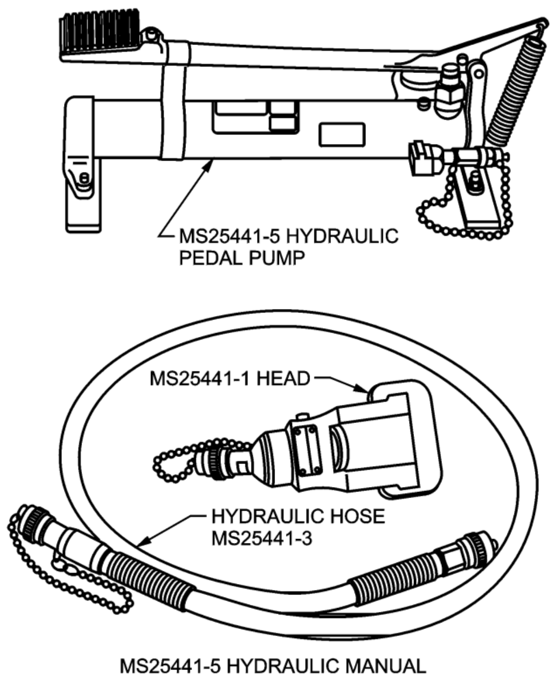


Figure 6–6 Power Crimping Tools – Large Copper Terminal Lugs

Aluminium Terminal Lugs

22. Only aluminium terminal lugs conforming to SAE AS 70991 are used to terminate aluminium wires. See Figure 6–1 for typical connections. Aluminium terminal lugs are available in four types; straight (MS25435), 90 degrees upright (MS25436), left angle (MS25437), and right angle (MS25438). The barrels of aluminium terminal lugs are filled with a petroleum-base abrasive compound. This compound, by a grinding process during the crimping operation, removes the oxide film from the aluminium. The compound also prevents oxide from reforming in the completed connection. All aluminium terminals have an inspection hole to allow checking the depth of wire insertion (see Figure 6–1). This inspection hole is sealed with a removable plastic plug, which also serves to retain the oxide-inhibiting compound. Each aluminium terminal lug is marked with the letters “AL” indicating it is for use with aluminium wire, and also with the wire size it will accommodate.

> **CAUTION**
>
> Do not remove the inspection plug until the crimp has been completed and the wire insertion is to be inspected. Replace plug after inspection.

Insulating Sleeves

23. Aluminium terminal lugs are not pre-insulated; therefore, it is necessary to insulate them, after assembly, with lengths of transparent flexible tubing or heatshrink sleeves. The sleeve provides mechanical and electrical protection at the connection. (See Figure 6–5).

Crimping Tools

24. Use the MS25441 tool to install MS aluminium terminal lugs. See paragraph 18 for tool adjustment.

Crimping Procedure for Aluminium Terminal Lugs

25. Crimp MS aluminium terminal lugs as follows:

- **a.** Using MS25441 tool, select proper die for wire size. Die is stamped with the wire size on both upper and lower faces and with the letters AL. Install die in tool head.

CAUTION

Use care when stripping wire insulation. do not nick or damage aluminium wire strands.

- **b.** Strip wire insulation carefully, using recommended stripping practices for aluminium wire described in Section 2, Chapter 3. Stripping lengths are listed in Table 6–6.
- **c.** Install insulating sleeve over wire insulation, well back from crimping area.
- **d.** Inspect to see that inner barrel is well coated with compound.

CAUTION

Do not remove the inspection plug as this keeps the compound in the barrel. When the wire is inserted to the full depth of the barrel, the compound is forced between and around the conductor strands.

- **e.** Insert wire into terminal barrel.
- **f.** Wipe off any excess compound squeezed out of terminal lug barrel with a clean soft cloth.
- **g.** Insert assembly into the die and position as shown in Figure 6–7.
- **h.** Actuate the crimp tool. On electrically operated tool, press the button on the control handle. Do not release the button until the dies open automatically. Actuate handle for manual hydraulically operated tool.

NOTE

Wire sizes No. 8 thru No. 2/0 require only one crimp. Wire sizes No. 3/0 and No. 4/0 require two crimps. Locate the second crimp centrally on the portion of the barrel remaining after the first crimp. See Figure 6–8.

- **i.** Check visually to see that the correct wire size is imprinted on the barrel.
- **j.** Remove the inspection plug and check visually or with the aid of a probe to see that wire is fully inserted. Replace the plug after inspection.
- **k.** Slide insulating sleeve over the terminal lug barrel and secure in accordance with paragraph 16 and Figure 6–5.

Table 6–6 Stripping Lengths for Aluminium Wire

Wire Size	MS25435, MS25436, MS25437, MS25438
8	17.5
6	20.6
4	21.5
2	2.6.0
1	26.0
1/0	25.0
2/0	31.0
3/0	32.5
4/0	36.5

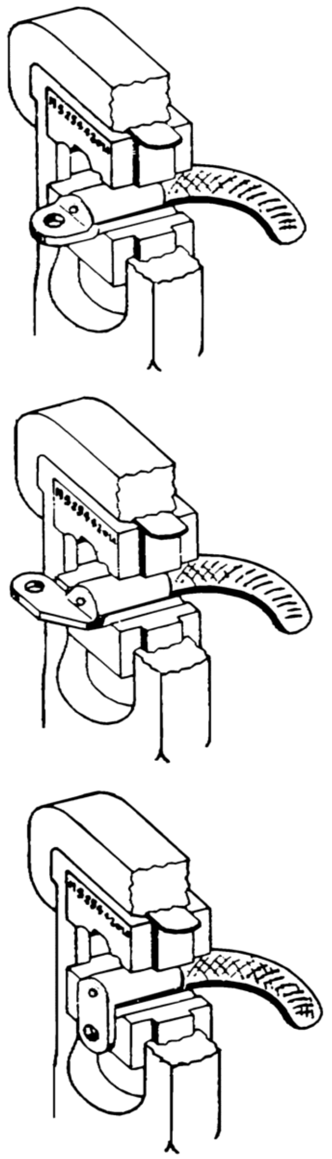


Figure 6–7 Positioning Aluminium Terminal Lugs in Die Nests

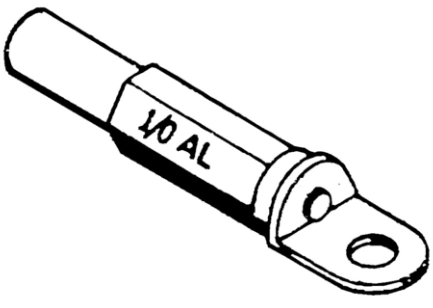


Figure 6–8 Single Crimp on Aluminium Terminal Lugs

SPLICING SMALL COPPER WIRES

26. Environmental permanent splices conforming to MIL-S-81824 are used to join small copper wire sizes No. 26 through No. 10. Typical splices are shown in Figure 6–1. The splice insulation extends over the wire insulation. Each splice size can be used for more than one wire size. Splices are colour coded in the same manner as insulated copper terminal lugs; refer to paragraph 8 and Table 6–1 for details.

27. Permanent wire splices may be used to assemble sub-assemblies, to incorporate changes or to facilitate repairs. The use of permanent splices shall be subject to the following restrictions:

- **a.** There shall not be more than one splice in any one wire segment between any two connectors or other disconnect points, except as allowed by sub-paras e, g and h below.
- **b.** Installation of splices in bundles shall not increase the size of the bundle so as to prevent the bundle from fitting in its designated space or cause congestion that will adversely affect maintenance.
- **c.** Splices shall not be used to salvage scrap lengths of wire.
- **d.** Splices shall not be used within 30cm of a termination device, except for sub-para e, below.
- **e.** Splices may be used within 30cm of a termination device when attaching to the pigtail spare lead of a potted termination device, or to splice multiple wires to a single wire, or to adjust the wire sizes so that they are compatible with the contact crimp barrel sizes.
- **f.** The application of splices shall be under design control and shall be authorised by engineering drawings.
- **g.** Splices may be used to repair manufactured harnesses or installed wiring when approved by an appropriate engineering authority.
- **h.** Splices shall not be used on firing or control circuits associated with ordnance or explosive sub-systems.
- **i.** Splices shall not be used on fire resistant wire.

28. When practicality conflicts with the intent of these restrictions refer to local engineering authority.

Crimping Tools

29. The M22520/5 and M22520/10 crimp tools with appropriate dies are the approved tools for crimping sizes 26 through 10 splices.

Single Conductor Wire Splicing And Repair

30. The following text is the repair procedure for a single conductor, non-shielded copper wire of 6 to 26 AWG.

31. To carry out the repair on a single conductor, a MIL-S-81824 splice is used. The splice is a two piece; environmentally resistant, copper crimp type splice used on 12 to 26 AWG copper wire. They may be used with tin plated and silver plated conductors, where the total temperature of the wire insulation does not exceed 150°C.

Restrictions

32. The following restrictions apply when carrying out a repair of a single conductor, non-shielded copper wire of 6 to 26 AWG:

- **a.** Repairs requiring multiple splices must be staggered. Splices should not increase the size of the bundle enough to prevent it from fitting into its designated place or cause congestion that will adversely affect maintenance.
- **b.** Splices should not to be used within 300 mm of a termination device except as follows:
  - **(1)** When attaching to the pigtail spare lead of a potted termination device;
  - **(2)** To splice multiple wires to a single wire; or

(3) To adjust wire sizes so they are compatible with contact crimp barrel sizes.

Procedure

33. If a wire is damaged at a single point and there is sufficient slack in the wire, as shown in Figure 6-9, the damaged wire can be repaired with a single splice.

34. If a wire is damaged along its entire length, as shown at the bottom of Figure 6-10, the damaged segment must be cut out and replaced with a jumper wire installed using two splices

35. To perform a single conductor wire splicing and repair:

- **a.** Cut ties and remove support clamps as required to access wire damage.
- **b.** Work damaged wires to outside of wire bundle. Carefully pull slack in wire toward damaged area to prevent strain on the splice.
- **c.** If more than one wire is to be spliced, and the wires are not colour coded or otherwise identified, tag the wires to be spliced with an identification before proceeding.
- **d.** Cut out any wire with damaged conductor or insulation. If a jumper is required, proceed as follows:

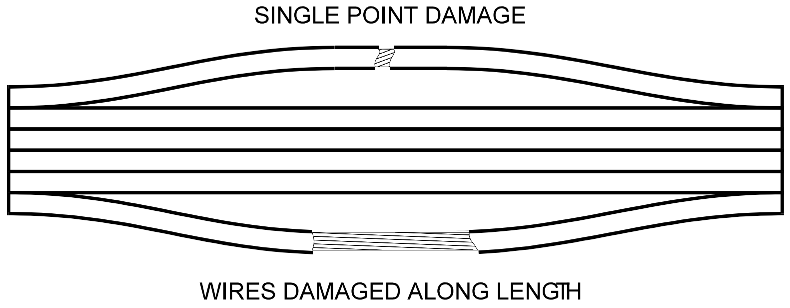


Figure 6-9 - Wire Damaged Along Its Entire Length

36. Figure 6-10 illustrates, that at least 130 mm of the damaged wire must be removed to allow room for splicing.

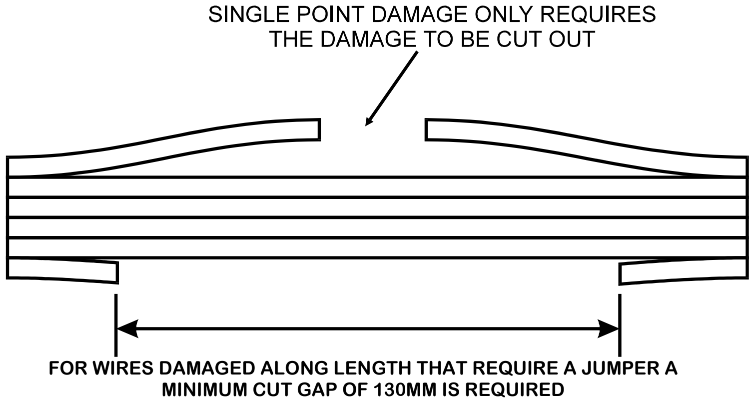


Figure 6-10 Removal of the Damaged Section

37. If more than one jumper is to be installed, stagger splice positions by varying lengths of sections that are cut out of damaged wires. This prevents bunching of the splices, keeping the diameter of the loom to a minimum. Then:

a. Determine type and gauge of wire being repaired from applicable aircraft wiring data manual.

b. Select a jumper wire of the same type and gauge, cutting a 12.5mm longer section than removed.

c. Select applicable splice for gauge of wire being repaired from the Table 6-6.

Wire Gauge	Splice Part No.	Colour Band
20 - 26	M81824/1-1	RED
16 - 18	M81824/1-2	BLUE
12 - 14	M81824/1-3	YELLOW
8	D-436-0081	N/A

Table 6-6

Warning

Dry cleaning solvent P-D-680, Type 2 is flammable. Avoid eye and skin contact or breathing of vapours. Protective equipment consisting of goggles and gloves is required.

d. Clean the last 5 cm of both ends of the wire's insulation, to be spliced, with dry cleaning solvent.

e. Strip wire insulation to dimensions specified in the table shown below.

Splice Part No.	Strip Dimension (mm) 1.5, -0
M81824/1-1	6.0
M81824/1-2	8.0
M81824/1-3	8.0
D-436-0081	11.0

Table 6-7

f. Slide sealing sleeve over one end of the stripped wire, as shown in Figure 6-11.

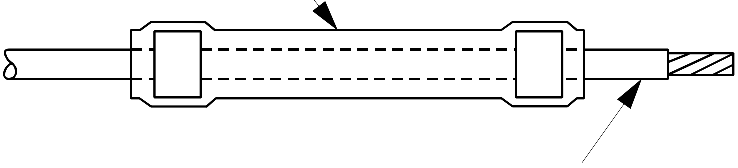


Figure 6-11 Procedure for Installing Sealing Sleeve

g. Choose the corresponding crimping tool, die set, and inspection gauge specified in the table below for the splice selected. Insert die set into the crimping tool and ensure correct die closure using the specified inspection gauge.

Splice Part No.	Strip Dimension (mm) 1.5, -0	Crimp Tool
M81824/1-1	6.0	AD-1377
M81824/1-2	8.0	AD-1377
M81824/1-3	8.0	AD-1377
D-436-0081	11.0	H20

Table 6-8

h. Insert crimp barrel into correct cavity of crimping tool as shown in Figure 6-12. For wire gages 12 through 26, the cavity colour code will match the colour of the stripe on the crimp barrel. Ensure that the end of the crimp barrel is against the of the tool and the inspection hole is visible.

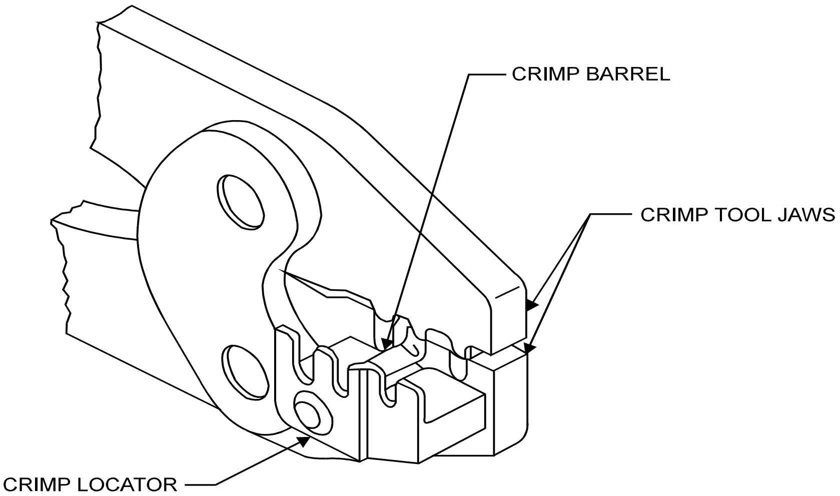


Figure 6-12 Insert Crimp Barrel into Correct Cavity of Crimping Tool

i. Insert end of wire into end of crimp barrel opposite stop. The wire must be visible through inspection hole. A gap of 0.8 to 1.5 mm for wire gages 10 through 26, or 1.5 to 3.0 mm for wire gages six and eight, must exist between wire insulation and crimp barrel as illustrated in Figure 6-13. Trim conductor or insulation as required.

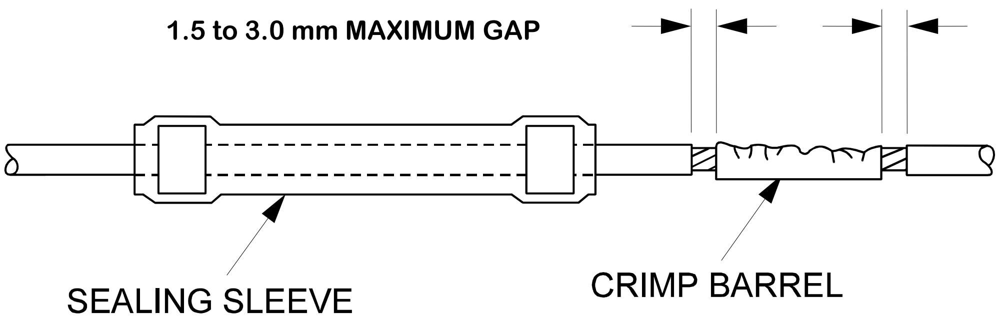


Figure 6-13 Crimping the Wire

j. Squeeze handles of the crimping tool through complete crimp cycle.

k. Reverse crimp barrel in cavity. The attached wire will fit in the slot of the stop. Ensure end of crimp barrel is against stop of tool and inspection hole is visible.

l. Repeat the two steps above.

m. Examine crimped connection for the following:

(1) Indent centred on splice barrel,

(2) Indent in line with barrel,

(3) Barrel not cracked,

(4) Wire cannot be pulled out of splice, and

(5) A gap of 0.8 to 1.5 mm for wire gages 10 through 26, or 1.5 to 3.0 mm for wire gages 6 and 8, should exist between wire insulation and crimp barrel.

n. Centre the sealing sleeve over crimp barrel as shown in Figure 6-14.

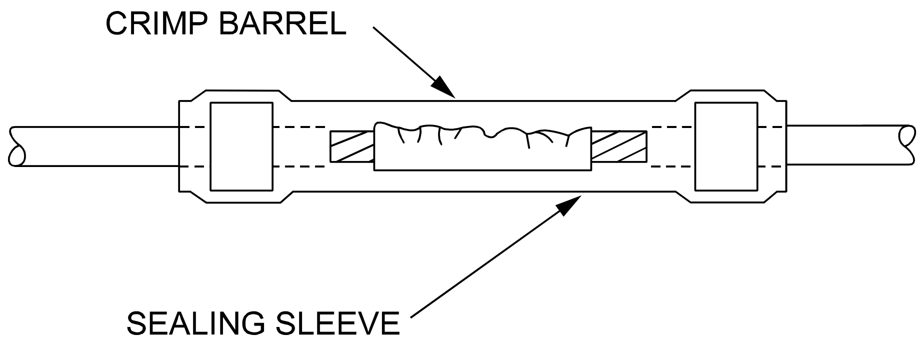


Figure 6-14 Positioning the Sealing Sleeve

o. Shrink sealing sleeve using a heat gun with a small termination sleeve reflector as shown in Figure 6-15. Start by shrinking the middle then heat towards each end until sealant melts and begins to flow out of both ends. Allow time for sleeve to cool before handling.

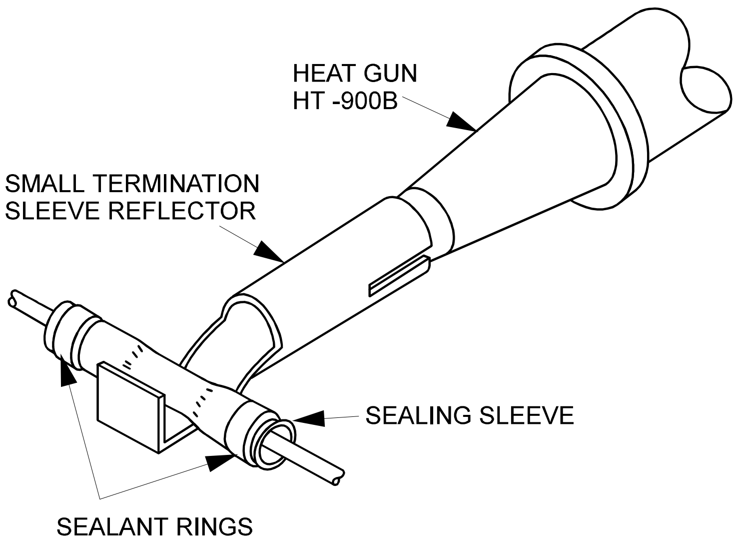


Figure 6-15
Shrinking the Sealing Sleeve

p. If installing a jumper, repeat steps six to 17 for the other end.

q. If wire identification is no longer within 75 mm of a termination the wire will require remarking.

r. As illustrated by Figure 6-16, position repaired wires into a bundle ensuring the splices remain staggered.

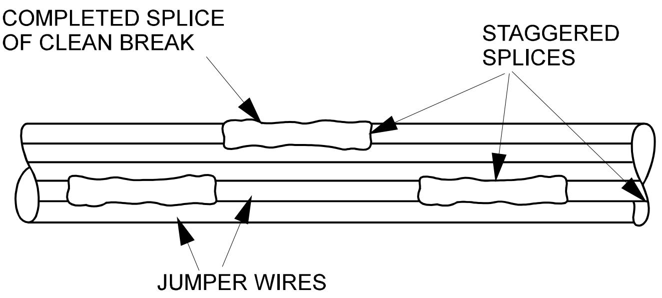


Figure 6-16
Re-Positioning the Wires within the Loom

s. 21. Reinstall any support clamps removed for access.

SPLICING PROCEDURE FOR M81824 ENVIRONMENTAL SPLICES

38. Splice in accordance with the following:

a. Check the M22520/5 or /10 crimp tool for wear in accordance with paragraph 12. If the tool is worn out of tolerance, it must be replaced.

b. Identify the correct size splice

c. Identify the correct size die that will accommodate the wire(s) to be crimped and install in M22520/5 or /10 crimp tool.

d. Strip 0.79mm to 0.86mm of insulation from wires, following one of the procedures in Section 2, Chapter 3.

e. Position the crimp barrel in the die of the M22520/5 or /10 crimp tool, so that one end of the crimp barrel butts against the crimp locator. Lock in place by partially closing the handles without denting the crimp barrel.

f. Insert the wire fully into the crimp barrel, and crimp by closing the handles until the ratchet releases.

g. Before completing the splice, slide the sealing sleeve, which will be shrunk later, back over one of the wires.

h. Reverse the position of the crimp barrel in the crimp tool die. The attached wire will extend through the slot in the crimp locator.

i. Lock the crimp barrel in place by partially closing the handles. Insert the other wire(s) and crimp as before.

WARNING

Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft.

WARNING

Use of nitrogen with hot air gun M83521/5-01 in an enclosed area can be hazardous. Ensure area is well ventilated.

j. Slide the sealing sleeve over the crimp barrel, centre it and heat with hot air to shrink the sleeve. Heat the middle first to lock the sleeve in place, then heat the ends until the sealing rings melt and ooze out around the wire. To ensure a good seal; allow to cool before handling.

CAUTION

Fire resistant wire shall not be spliced. When fire resistant wire is damaged or deteriorated replace the entire length of wire from one permanent termination to the next.

CAUTION

Fusing tin plated splices on nickel plated wire may not achieve appropriate voltage drop and tensile strength requirements. Refer to SAE AIR 1263.

SPLICING HIGH TEMPERATURE WIRES

39. Splices for high temperature applications are available in the same wire size ranges as terminal lugs. The tools and crimping procedures are the same for splices as for terminal lugs. Crimp splice at both ends. Appropriately rated high temperature splices shall be used on high temperature wire where the splice is located in a high temperature area. Where wire splice is in a low temperature area, standard splices may be used. See Table 6–9 for details of splices suitable for use on high temperature wire.

Table 6–9 Splices and Tooling – High Temperature Wire

Nickel Plated Splices Rated to 343°C (650°F) Uninsulated with Insulation Support		
Splice Pt No	**AWG**	**Tool Pt No.**
322823	22-16	46673
322825	16-14	46988
Nickel Splices Rated to 649°C (1200°F) Uninsulated with Insulation Support		
322325	22-16	46673
322346	16-14	46988

Table 6–10 Circular Mil Area (CMA) of Wires and Splices

Wire AWG	Circular Mils (Nominal)	Splice Part Number	Circular Mils (Nominal)
26	304	M81824/1-1	2025
24	475	M81824/1-2	3969
22	754	M81824/1-3	9025
20	1216		
18	1900		
16	2426		
14	3831		
12	5874		

SPLICING ALUMINIUM WIRES

40. Splice large aluminium wires sizes No. 8 through No. 4/0 with splice MS25439. Use the MS25441 power tool with the correct dies from MS25442. Follow the same procedure as for aluminium terminal lugs outlined in paragraph 25, positioning the splice in the tool. Crimp splice at both ends.

> NOTE
>
> The sealing properties of environmental splices may be compromised when multi-splicing.

MULTI-SPLICING

41. Multi-splicing is the crimping together of three or more wires in a single splice. This is a special application and may be used only when called for on the applicable engineering drawing or otherwise authorised by an appropriate authority. Where more than one wire is to be crimped into one end of a splice the technician must ensure that the combined size (circular mil area) of the conductors is compatible with the selected splice. Additionally, the wires must fit into the splice insulation support without altering their insulation. Refer to Table 6–10 for circular mil area (CMA) of common wires and splices.

ENVIRONMENT RESISTANT WIRE DISCONNECT SPLICES

42. When splices are used for inline connections of two or more wires, where disconnection is required, disconnect splices complying to SAE AS81714/11 and SAE AS81714/12 are approved for use. Sealing plugs complying with MS27488 shall be installed in unused grommet holes. Annex C contains details of SAE AS81714/11 and SAE AS81714/12 environment proof, disconnect, wire splices and associated tooling.

SPLICING TO REDUCE WIRE SIZE

43. Splices may be used to reduce wire sizes. This is a special application and may be used only when called for on the applicable engineering drawing or otherwise authorised by an appropriate authority.

> **CAUTION**
>
> Do not use any connection which is found defective as a result of the visual inspection. Cut off defective connection and remake using a new terminal lug or splice.

INSPECTION OF CRIMPED CONNECTIONS

44. Examine the crimped connection carefully for the following:

- **a.** Crimp indent centred on terminal lug barrel or splice barrels
- **b.** Crimp indent in line with barrel.
- **c.** Terminal lug or splice barrel not cracked.
- **d.** Terminal lug or splice insulation not cracked.
- **e.** Insulation support on lugs crimped.
- **f.** Spliced wires are butted against the stop.
- **g.** Splices for correct environmental sealing.
- **h.** Splices for evidence of overheating.

TERMINAL JUNCTION SYSTEMS

45. See Section 2, Chapter 4, Electrical Wiring Installation, for terminal junction systems.

Annexes:

A. Terminations and Tooling

B. Stud Size and Corresponding Terminal Lug Dimension Reference Chart

C. Disconnect Splices and Tooling

D. Crimp Tool Testing

TERMINATIONS AND TOOLING

1. The following is a list of tables contained in this annex:

a. Table 6–A–1. MS25036 - Terminal Lug, Crimp Style, Copper, Insulated, Ring Tongue, Bell Mouthed, Type II, Class 1, For 105°C Total Conductor Temperature.

b. Table 6–A–2. SAE AS7928/1 - Terminal Lug, Crimp Style, Copper, Insulated, Ring Tongue, For Thin Wall Wire, Type II, Class 1, For 105°C Total Conductor Temperature.

c. Table 6–A–3. SAE AS7928/4 - Terminal Lug, Crimp Style, Copper, Insulated, Ring Tongue, Bell Mouthed, Type II, Class 1, For 150°C Total Conductor Temperature.

d. Table 6–A–4. SAE AS81824/1 - Splice, Electric, Permanent, Crimp Style, Copper, Insulated, Environment Resistant, Class 1, For 150°C Total Conductor Temperature.

e. Table 6–A–5. MS25274 - Cap, Electrical, Wire End, Crimp Style, Type II, Class 1, For 105°C Total Conductor Temperature.

2. Appropriate crimping tool details are provided in each table.

Table 6–A–1 MS25036 – Terminal Lug, Crimp Style, Copper, Insulated, Ring Tongue, Bell Mouthed, Type II, Class 1, For 105°C Total Conductor Temperature

Stud Size	MS25036 Dash Number	Tooling
Wire Gauge 26-24 AWG (Lug Colour Yellow)		
2 4 6 8 10	143 144 145 146 147	Tool M22520/5-01 with Die M22520/5-100 or Tool M22520/10-01 with Die M22520/10-101
Wire Gauge 22-18 AWG (Lug Colour Red)		
2 4 6 6 8 10 0.250 inch 0.312 inch 0.375 inch 0.500 inch	159 148 101 102 149 103 150 104 105 151	Tool M22520/5-01 with Die M22520/5-100 or Tool M22520/10-01 with Die M22520/10-101
Wire Gauge 16-14 AWG (Lug Colour Blue)		
4 6 6 8 10 0.250 inch 0.312 inch 0.375 inch 0.500 inch	152 106 107 153 108 154 109 110 155	Tool M22520/5-01 with Die M22520/5-100 or Tool M22520/10-01 with Die M22520/10-101
Wire Gauge 12-10 AWG (Lug Colour Yellow)		
6 8 10 0.250 inch 0.312 inch 0.375 inch 0.500 inch	111 156 112 157 113 114 158	Tool M22520/5-01 with Die M22520/5-100 or Tool M22520/10-01 with Die M22520/10-100
Wire Gauge 8 AWG (Lug Colour Red)		
10 0.250 inch 0.312 inch 0.375 inch	115 116 117 118	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-8
Wire Gauge 6 AWG (Lug Colour Blue)		
10 0.250 inch 0.312 inch 0.375 inch	119 120 121 122	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-6

Stud Size	MS25036 Dash Number	Tooling
Wire Gauge 4 AWG (Lug Colour Yellow)		
0.250 inch 0.312 inch 0.375 inch	123 124 125	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-4
Wire Gauge 2 AWG (Lug Colour Red)		
0.250 inch 0.375 inch 0.500 inch	126 127 128	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-2
Wire Gauge 1 AWG (Lug Colour Clear to White)		
0.250 inch 0.375 inch 0.500 inch	129 130 131	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-1
Wire Gauge 0 AWG (Lug Colour Blue)		
0.250 inch 0.375 inch 0.500 inch	132 133 134	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-01
Wire Gauge 00 (2/0) AWG (Lug Colour Yellow)		
0.312 inch 0.375 inch 0.500 inch	135 136 137	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-02
Wire Gauge 000 (3/0) AWG (Lug Colour Red)		
0.375 inch 0.500 inch	138 139	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-03
Wire Gauge 0000 (4/0) AWG (Lug Colour Yellow)		
0.375 inch 0.500 inch	140 141	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-04
Example: MS25036-119 is a terminal lug for wire size 6 AWG suitable for stud size 10		

Table 6–A–2 SAE AS7928/1 Terminal Lug, Crimp Style, Copper, Insulated, Ring Tongue, Type II, Class 1, For Thin Wall Wire For 105°C Total Conductor Temperature

Stud Size	M7928/1 Dash Number	Tooling
Wire Gauge 26 AWG (Lug Colour Yellow with Black Stripe)		
2 4 6 8 10	1 2 3 4 5	Tool M22520/10-01 with Die M22520/10-101
Wire Gauge 24 AWG (Lug Colour Yellow with Blue Stripe)		
2 4 6 8 10	6 7 8 9 10	Tool M2520/10-01 with Die M22520/10-101
Wire Gauge 22 AWG (Lug Colour Red with Green Stripe)		
2 4 6 6 8 10 0.250 inch 0.312 inch 0.375 inch 0.500 inch	70 11 12 13 14 15 16 17 18 19	Tool M22520/5-01 with Die M22520/5-100 or Tool M22520/10-01 with Die M22520/10-101
Wire Gauge 20 AWG (Lug Colour Red)		
2 4 6 6 8 10 0.250 inch 0.312 inch 0.375 inch 0.500 inch	71 20 21 22 23 24 25 26 27 28	Tool M22520/5-01 with Die M22520/5-100 or Tool M22520/10-01 with Die M22520/10-101
Wire Gauge 18 AWG (Lug Colour Red with White Stripe)		
4 6 6 8 10 0.250 inch 0.312 inch 0.375 inch 0.500 inch	72 29 30 31 32 33 34 35 36 37	Tool M22520/5-01 with Die M22520/5-100 or Tool M22520/10-01 with Die M22520/10-101

Stud Size	M7928/4 Dash Number	Tooling
Wire Gauge 16 AWG (Lug Colour Blue)		
4 6 6 8 10 0.250 inch 0.312 inch 0.375 inch 0.500 inch	38 39 40 41 42 43 44 45 46	Tool M22520/5-01 with Die M22520/5-100 or Tool M22520/10-01 with Die M22520/10-101
Wire Gauge 14 AWG (Lug Colour Blue with Green Stripe)		
4 6 6 8 10 0.250 inch 0.312 inch 0.375 inch 0.500 inch	47 48 49 50 51 52 53 54 55	Tool M22520/5-01 with Die M22520/5-100 or Tool M22520/10-01 with Die M22520/10-101
Wire Gauge 12 AWG (Lug Colour Yellow)		
6 8 10 0.250 inch 0.312 inch 0.375 inch 0.500 inch	56 57 58 59 60 61 62	Tool M22520/5-01 with Die M22520/5-100 or Tool M22520/10-01 with Die M22520/10-100
Wire Gauge 10 AWG (Lug Colour Yellow with Brown Stripe)		
6 8 10 0.250 inch 0.312 inch 0.375 inch 0.500 inch	63 64 65 66 67 68 69	Tool M22520/5-01 with Die M22520/5-100 or Tool M22520/10-01 with Die M22520/10-100
Example: M7928/1-30 is a terminal lug for wire size 18 AWG suitable for stud size 6		

Table 6–A–3 SAE AS7928/4 Terminal Lug, Crimp Style, Copper, Insulated, Ring Tongue, Bell Mouthed, Type II, Class 1, For 150°C Total Conductor Temperature

Stud Size	M7928/4 Dash Number	Tooling
Wire Gauge 26-24 AWG (Lug Colour Transparent with Yellow Stripe)		
2 4 6 8 10	143 144 145 146 147	Tool M22520/10-01 with Die M22520/10-101
Wire Gauge 22-18 AWG (Lug Colour Transparent with Red Stripe)		
2 4 6 6 8 10 0.250 inch 0.312 inch 0.375 inch 0.500 inch	159 148 101 102 149 103 150 104 105 151	Tool M22520/5-01 with Die M22520/5-100 or Tool M2520/10-01 with Die M22520/10-101
Wire Gauge 16-14 AWG (Lug Colour Transparent with Blue Stripe)		
4 6 6 8 10 0.250 inch 0.312 inch 0.375 inch 0.500 inch	152 106 107 153 108 154 109 110 155	Tool M22520/5-01 with Die M22520/5-100 or Tool M22520/10-01 with Die M22520/10-101
Wire Gauge 12-10 AWG (Lug Colour Transparent with Yellow Stripe)		
6 8 10 0.250 inch 0.312 inch 0.375 inch 0.500 inch	111 156 112 157 113 114 158	Tool M22520/5-01 with Die M22520/5-100 or Tool M22520/10-01 with Die M22520/10-101
Wire Gauge 8 AWG (Lug Colour Transparent with Red Stripe)		
10 0.250 inch 0.312 inch 0.375 inch	115 116 117 118	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-8
Wire Gauge 6 AWG (Lug Colour Transparent with Blue Stripe)		
10 0.250 inch 0.312 inch 0.375 inch	119 120 121 122	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-6

Stud Size	M7928/4 Dash Number	Tooling
Wire Gauge 4 AWG (Lug Colour Transparent with Yellow Stripe)		
0.250 inch 0.312 inch 0.375 inch	123 124 125	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-4
Wire Gauge 2 AWG (Lug Colour Transparent with Red Stripe)		
0.250 inch 0.312 inch 0.375 inch	126 127 128	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-2
Wire Gauge 1 AWG (Lug Colour Transparent with White Stripe)		
0.250 inch 0.312 inch 0.375 inch	129 130 131	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-1
Wire Gauge 0 (1/0) AWG (Lug Colour Transparent with Blue Stripe)		
0.250 inch 0.312 inch 0.375 inch	132 133 134	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-01
Wire Gauge 00 (2/0) AWG (Lug Colour Transparent with Yellow Stripe)		
0.312 inch 0.375 inch 0.500 inch	135 136 137	Hydraulic Tooling MS25441 Head MS25441-1 Die MS23002-02
Example: M7928/4-149 is a terminal lug for wire size 22-18 AWG suitable for stud size 8		

Table 6–A–4 SAE AS81824/1 Splice, Electric, Permanent Crimp Style, Copper, Insulated, Environment Resistant, Class 1, For 150°C Total Conductor Temperature

M81824/1 Dash Number	Tool Die
Wire Gauge 26-20 AWG (Splice Colour Code Red)	
-1	M22520/5-01 and M22520/5-103 or M22520/10-01 and M22520/10-104
Wire Gauge 20-16 AWG (Splice Colour Code Blue)	
-2	M22520/5-01 and M22520/5-103 or M22520/10-01 and M22520/10-104
Wire Gauge 16-12 AWG (Splice Colour Code Yellow)	
-3	M22520/5-01 and M22520/5-102 or M22520/10-01 and M22520/10-103
Example: M81824/1-3 is a splice for wire size 16-12 AWG	
Note Following the crimping procedure, use suitable heat source to shrink the insulation sleeve on the splice for environmental sealing	

Table 6–A–5 MS25274 Cap, Electrical, Wire End, Crimp Style, Class 1, For 105°C Total Conductor Temperature

MS25274 Dash Number	Tool Die
Wire Gauge 26-24 AWG (Cap Colour Yellow)	
-1	M22520/5-01 and M22520/5-100 or M22520/10-01 and M22520/10-101
Wire Gauge 22-18 AWG (Cap Colour Red)	
-2	M22520/5-01 and M22520/5-100 or M22520/10-01 and M22520/10-101
Wire Gauge 16-14 AWG (Cap Colour Blue)	
-3	M22520/5-01 and M22520/5-100 or M22520/10-01 and M22520/10-101
Wire Gauge 12-10 AWG (Cap Colour Yellow)	
-4	M22520/5-01 and M22520/5-100 or M22520/10-01 and M22520/10-100
Example: M25274-3 is an end cap for wire size 16-14 AWG	

STUD SIZE AND CORRESPONDING TERMINAL LUG DIMENSIONS

The table below provides information on various terminal studs and the corresponding terminal lug ‘stud hole’ size. Terminal lugs may be selected by comparing with the silhouettes provided. (Approximate size only).

Stud Size Code		Stud Dia (in)	Terminal Minimum Hole Dia (in)
US Cust	Metric		
0		0.060	0.064
1		0.073	0.077
2	M2	0.086	0.090
3		0.099	0.103
4		0.112	0.116
5	M3	0.125	0.129
6	M3.5	0.138	0.142
8	M4	0.164	0.168
10		0.190	0.194
12		0.216	0.220
14		0.242	0.247
1/4	M6	0.250	0.260
5/16	M8	0.312	0.323
3/8		0.375	0.385
7/16		0.437	0.448
1/2	M12	0.500	0.510
5/8	M16	0.625	0.651
3/4		0.750	0.776
7/8		0.875	0.901
1		1.000	1.026

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DISCONNECT SPLICES AND TOOLING

SAE AS81714/11 DISCONNECT SPLICE AND TOOLING

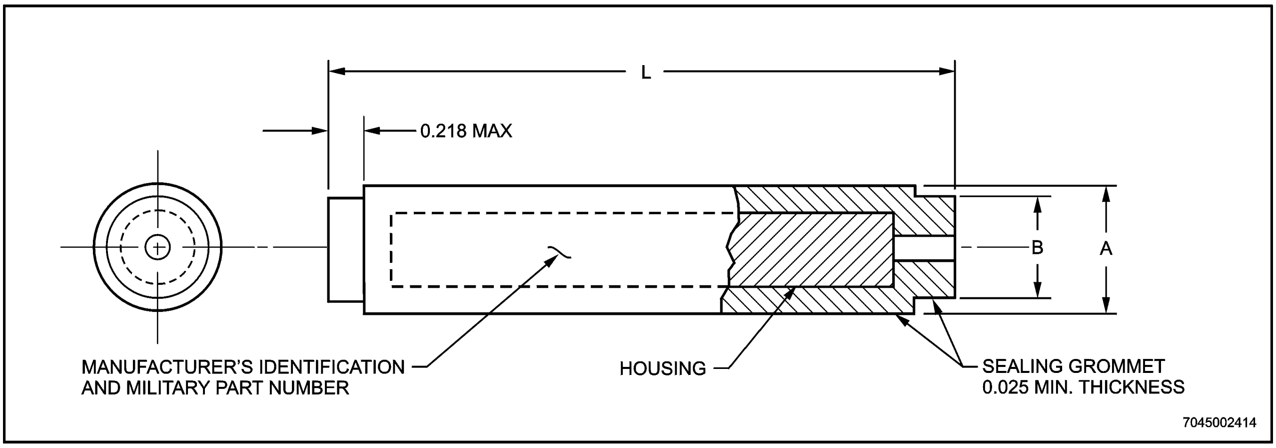

Figure 6–C–1 Single Wire In-Line Junction Body

Table 6–C–1 Single Wire In-Line Junctions

In-Line Junction							
Splice (Note 1)	**Body** (Note 2)			**Contacts**	**Crimping Tool**	**Positioner**	**Installing/Removal Tool** (Note 3)
Part Number	**A Dia ± .025**	**B Dia Max**	**L Max**	**Part Number**	**Part Number**	**Part Number**	**Part Number**
M81714/11-22D	.250	.225	1.552	M39029/1-100	M22520/2-01	M22520/2-11	M81969/14-02
M81714/11-20D	.250	.225	1.552	M39029/1-101	M22520/1-01	M22520/1-02	M81969/14-02
M81714/11-16D	.281	.256	1.922	M39029/1-102	M22520/1-01	M22520/1-02	M81969/14-03
M81714/11-12D	.344	.319	1.922	M39029/1-103	M22520/1-01	M22520/1-02	M81969/14-04

Notes:

1. Only Class D splices are approved for use.
2. Dimensions are in inches.
3. Tools for contact insertion/removal shall be ordered separately.

SAE AS81714/12 - DOUBLE DISCONNECT SPLICE AND TOOLING

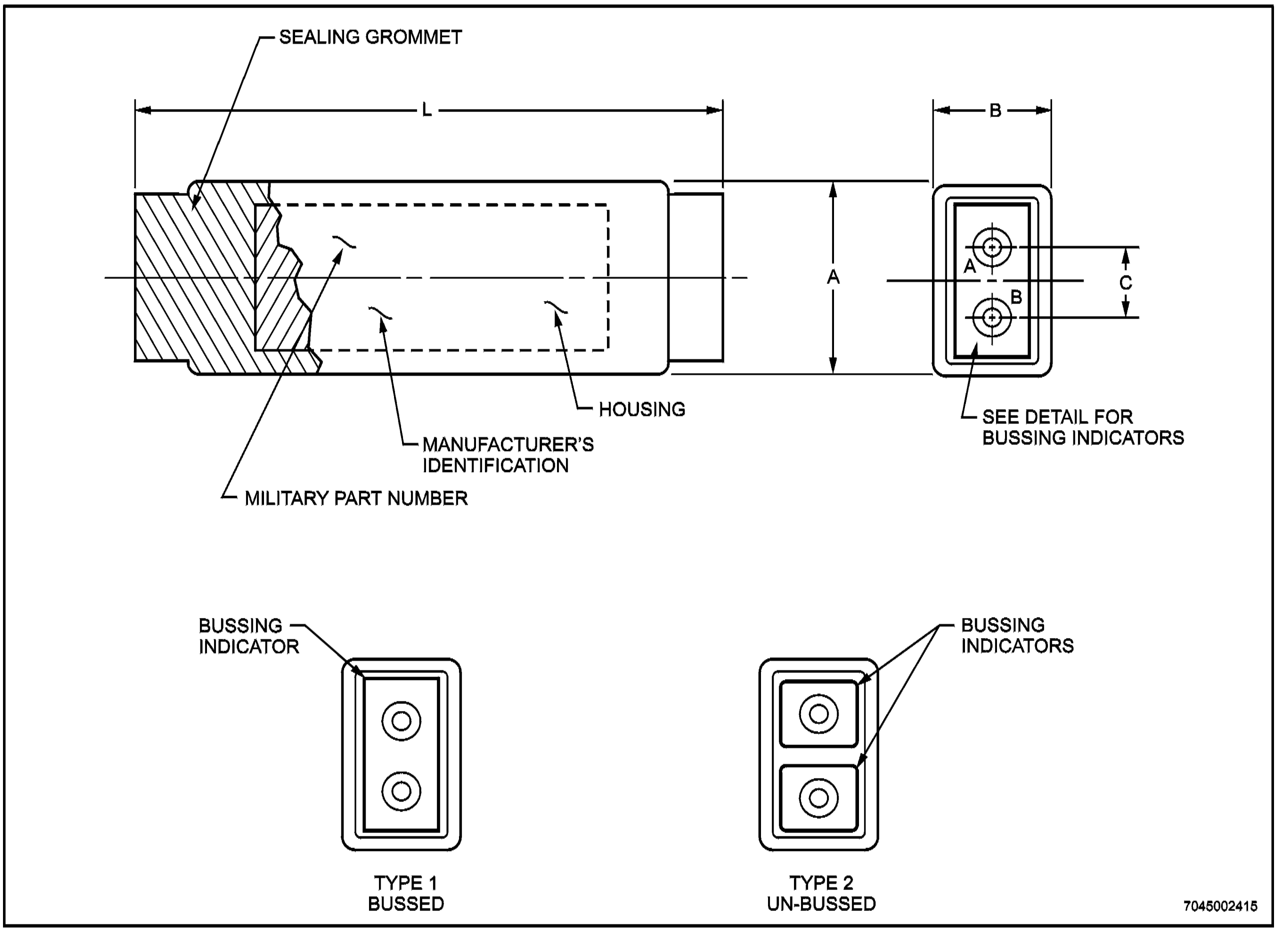

Figure 6–C–2 Double Wire In-Line Junction Body

Table 6–C–2 Double Wire In-Line Junctions

In-Line Junction								
Splice	**Body** (Note 3)				**Contacts**	**Crimping Tool**	**Positioner**	**Installing/ Removal Tool**
Part Number (Note 1) (Note 2)	**A Max**	**B Max**	**C ± .01**	**L Max**	**Part Number**	**Part Number**	**Part Number**	**Part Number** (Note 4)
M81714/12-22D-*	.400	.275	.13	1.552	M39029/1-100	M22520/2-01	M22520/2-11	M81969/14-02
M81714/12-20D-*	.400	.275	.13	1.552	M39029/1-101	M22520/1-01	M22520/1-02	M81969/14-02
M81714/12-16D-*	.500	.300	.18	1.922	M39029/1-102	M22520/1-01	M22520/1-02	M81969/14-03
M81714/12-12D-*	.620	.370	.25	1.922	M39029/1-103	M22520/1-01	M22520/1-02	M81969/14-04

Notes:

1. Only Class D splices are approved for use.
2. Insert 1 or 2 at * to indicate Type 1 or Type 2 splice.
3. Dimensions are in inches.
4. Tools for contact insertion/removal shall be ordered separately.

CRIMP TOOL TESTING

Introduction

1. Dies and other working parts of crimping tools used for electrical terminations become worn in service and this can result in unsatisfactory terminations. An effective means to ensure a serviceable termination is to monitor the condition of the tool by regular testing.

Description

2. ***General Use.*** Before a tool is used, it should be checked for completeness and signs of wear or corrosion. Check also for correct operation of the ratchet mechanism. After crimping, check the terminal for:

a. correct location of the jaw indentation on the terminal wire barrel;

b. damage to insulation or conductors;

c. all conductor strands fully inserted and secure in the wire barrel of the terminal.

Testing

3. In-service testing of crimping tools should be carried out:

a. at 12 month intervals, and

b. at any time the serviceability of a tool is suspect.

4. The test is to be performed using either:

a. the appropriate GO, NO-GO gauge which will determine the correct closure distance of the crimping jaws; or

b. a millivolt drop and tensile strength test of a completed 'test piece' termination, if a gauging tool is not available.

NOTE

Testing of the crimping tool barrel (wire) die and braid die (if applicable) is mandatory and testing of the crimping tool insulation die is advisable to ensure complete serviceability of the crimping tool.

5. ***Gauging Test.*** Prior to performing the gauging test ensure that both the crimping tool jaws and the shafts of the gauge are clean and undamaged, then carry out the following:

a. Select gauges as follows:

(1) ***Military Specification (Mil Spec) Tools.*** Gauges for Mil Spec (Class 1) tools are specified in Section 2 Chapter 6.

(2) ***Proprietary Tools.*** Units are encouraged to locally manufacture gauges for use with propriety tools.

WARNING

DO NOT INSERT THE GAUGE PRIOR TO FULLY CLOSING THE TOOL

NOTE

The tool is fully closed when the ratchet releases and the handles are able to return to the fully open position.

b. Actuate the crimping tool to the fully closed position and hold.

c. Insert the GO end of the gauge into the die cavity - no restriction should be felt.

d. Attempt to insert the NO-GO end of the gauge into the die cavity - the gauge may enter partially but must not pass completely through the die cavity.

e. The crimping tool is unserviceable if it fails either of the above tests and should be repaired or replaced as appropriate.

Millivolt Drop Testing

6. Perform the millivolt drop test of Terminal Lugs, Splices and Connector Contacts as follows:

a. Prepare one sample of the largest and smallest termination for the crimping tool. Sample crimps are to be prepared as detailed in Figure 6-D-1, 6-D-2 or 6-D-3.

b. Connect the test sample across a 28 VDC variable power supply. Adjust the current to attain the specified test current detailed in Table 6-D-1 for copper splices and terminal lugs, Table 6-D-2 for aluminium splices and terminal lugs, and Table 6-D-3 for electrical connector pins and sockets.

7. Terminal lugs, conductor splices and connector contacts shall be tested as follows:

a. Terminal lug millivolt drop measurements shall be made by puncturing the insulation of the current carrying conductor 0.062 in (1.6 mm) from the wire receiving end of the terminal, for one test point and using the intersection of the tongue and barrel for the other test point. The distance between the two tested points shall be noted. See Fig 6-D-1.

b. Conductor splice millivolt drop measurements shall be made by puncturing the insulation of the current carrying conductor 0.062 in (1.6 mm) from each wire receiving end of the splice. The distance between the two tested points shall be noted. See Fig 6-D-2.

c. Connector contact millivolt drop measurements shall be made across the entire mated length of the two contacts. Connect the voltmeter probes to the conductors approximately 6 inches (150mm) apart and equidistant from the end of each contact. See Fig 6-D-3.

d. Measure the millivolt drop across the crimped terminations while the specified test current is being applied and after the temperature of the termination has stabilised.

8. ***Tensile Strength Test.*** If the millivolt drop across the crimped joint/s is within limits, attach the test pieces to a static test rig using a suitable adaptor. Add weights to ensure the minimum tensile strength figure in Tables 6-D-1, 6-D-2 or 6-D-3 is reached without failure of the crimp joint. Alternatively, a spring balance may be used for this test.

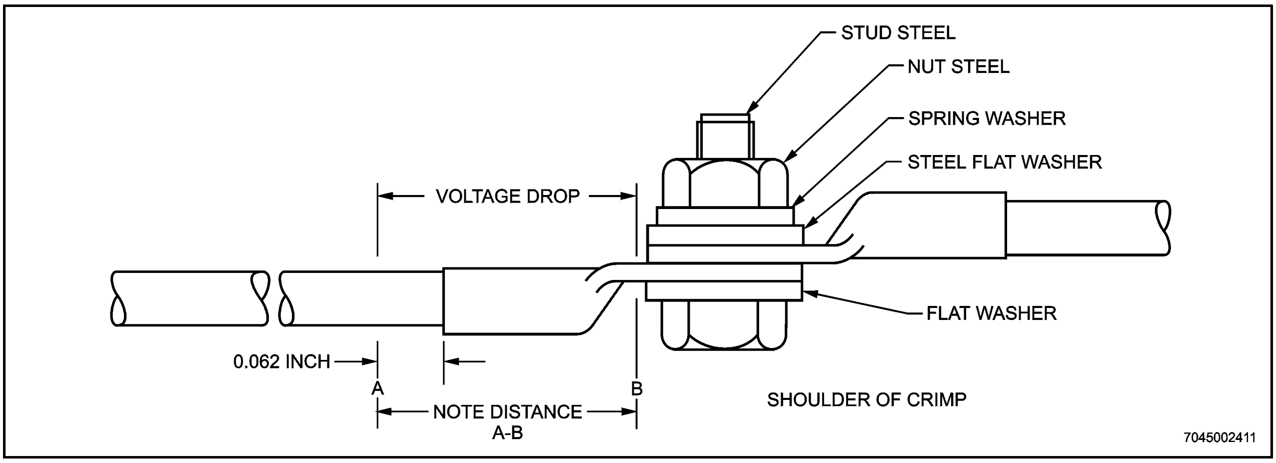

Figure 6–D–1 Terminal Lug

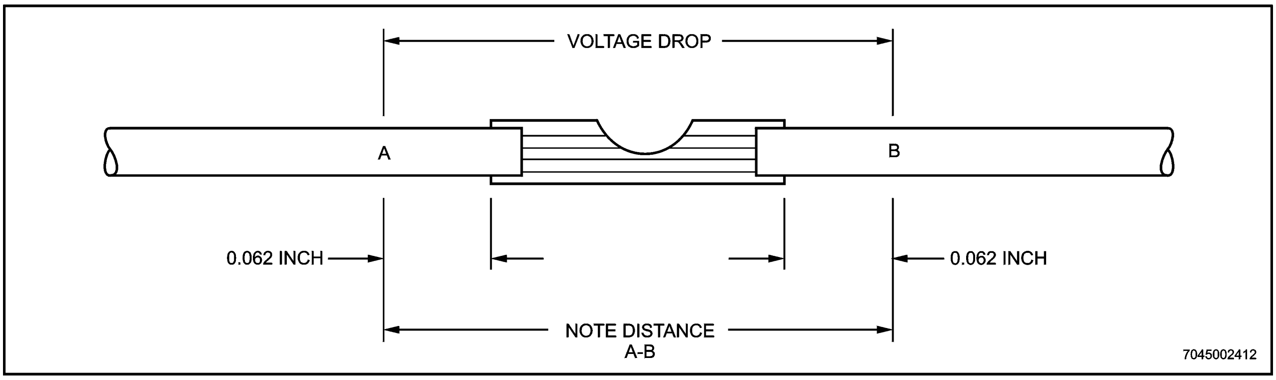

Figure 6–D–2 Splice

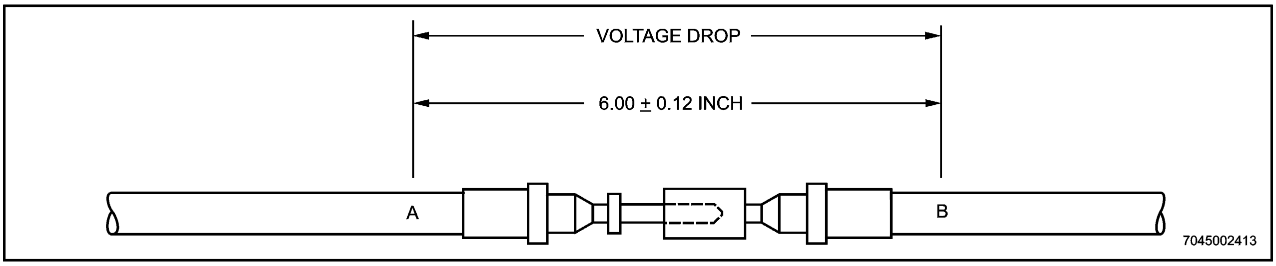

Figure 6–D–3 Connector Contacts

Table 6–D–1 Copper Terminal Lugs and Splices (SAE AS7928 and SAE AS81824)

Wire Size (AWG)	Test Current (Amps)	Maximum Voltage Drop (mV) in **Addition** to the Voltage Drop of an Equivalent Length of Wire		Minimum Tensile Strength lb (kg)
		Terminal Lug (SAE AS7928)	Splice (SAE AS81824)	
26	3	5	10	7 (3.18)
24	4.5	4	8	10 (4.53)
22	9	3	4	15 (6.80)
20	11	3	4	19 (8.62)
18	16	3	4	38 (17.24)
16	22	3	4	50 (22.68)
14	32	3	4	70 (31.75)
12	41	3	4	110 (49.90)
10	55	3	–	150 (68.04)
8	73	3	–	225 (102.06)
6	101	3	–	300 (136.08)
4	135	3	–	400 (181.44)
2	181	3	–	550 (249.48)
1	211	3	–	650 (294.83)
0	245	4	–	700 (317.51)
00	283	4	–	750 (340.19)
000	328	4	–	825 (374.21)
0000	380	4	–	875 (396.89)

Table 6–D–2 Aluminium Terminal Lugs and Splices (SAE AS70991)

Wire Size (AWG)	Test Current (Amps)	Maximum Voltage Drop (mV) in **Addition** to the Voltage Drop of an Equivalent Length of Wire		Minimum Tensile Strength lb (kg)
		Terminal Lug (SAE AS70991)	Splice (SAE AS70991)	
8	60	11	22	130 (58.97)
6	83	11	22	200 (90.72)
4	108	8	16	300 (136.08)
2	152	8	16	500 (226.80)
1	174	7	14	700 (317.52)
0	202	7	14	900 (408.23)
00	235	7	14	1100 (498.96)
000	266	7	14	1300 (589.67)
0000	303	7	14	1500 (680.40)
Note: MS25441 crimping tool with MS25442 dies are to be used with aluminium lugs and splices				

Table 6–D–3 Electrical Connector Contacts (MIL-C-39029)

Wire Size (AWG)	Test Current (Amps)	Maximum Voltage Drop (mV) (Across Mated Contacts)	Minimum Tensile Strength lb (kg)
26	2	52	5 (2.27)
24	3	45	8 (3.63)
22	5	73	12 (5.44)
20	7.5	55	20 (9.07)
16	13	49	50 (22.68)
14	17	40	70 (31.75)
12	23	42	110 (49.89)
10	33	33	150 (68.04)
8	46	26	225 (102.06)
6	60	25	300 (136.08)
4	80	23	400 (181.44)
2	100	17	550 (249.48)
1	125	19	650 (294.83)
0	150	21	700 (317.51)
00	185	19	750 (340.19)
0000	225	21	875 (396.89)

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SECTION 2

CHAPTER 7

SOLDERING

INTRODUCTION

1. Soldered connections are used in aircraft electrical wiring to form a continuous and permanent metallic connection having a constant electrical value. The importance of establishing and maintaining a high standard of workmanship for soldering operations cannot be overemphasised.

2. This section describes the materials and equipment used in soldering aircraft interconnecting wiring. It also describes and illustrates preparation and care of equipment, procedures to be followed, and the soldering techniques necessary to make a good soldered joint.

3. In addition, special materials, equipment, and techniques used in soldering printed circuit assemblies are mentioned where they differ from those used in general electrical soldering. In the repair of printed circuit assemblies, soldering is closely associated with repairs to the insulating base and conductor pattern, and with replacement of components. These repairs are usually accomplished at the intermediate or depot level where other component or "black box" repairs are made. For detailed information on printed circuit repairs to a particular system, the handbook of maintenance instructions for the particular equipment involved should be consulted.

REFERENCE SPECIFICATIONS AND STANDARDS

4. The following specifications and standards are applicable to soldering:

ANSI/J-STD-004	Requirements for Soldering Fluxes
ANSI/J-STD-006	Requirements for Electronic Grade Solder Alloys
MIL-HDBK-454	General Guidelines for Electronic Equipment
0-F-499	Flux, Brazing, Silver Alloy, Low Melting Point
QQ-B-654	Brazing Alloy, Silver
TT-I-735	Isopropyl Alcohol

DEFINITIONS AND DESCRIPTIONS

Soldering

5. Soldering is the process of joining two or more metals together at a temperature lower than the melting points of the metals. In its molten state, solder chemically dissolves part of the metal surfaces to be joined. However, most metals exposed to the atmosphere acquire a thin film of tarnish or oxide; the longer the exposure the thicker the film will become. This film is present even though it is not visible, and solder alone cannot dissolve it. A soldering flux with a melting point lower than the solder must be used to "wet" the metal and allow the solder to penetrate it and remove the film. The flux melts first, removing the tarnish or metallic oxide, and also preventing further oxide from forming while the metal is being heated to soldering temperature. The solder then melts, floating the lighter flux and the impurities suspended in it to the outer surface and edges of the molten fillet. The solder cools and forms an alloy with the metal. Most of the flux is burned away during the soldering process; any residue is removed by appropriate cleaning methods.

6. The soldering methods used for general aircraft wiring are essentially the same for both production soldering and repair work. For printed circuit assemblies, production methods and repair methods are different. In production, a dip soldering method is used, where several connections are made at the same time. Soldering repairs, however, are made individually, using techniques similar to those used for soldering general wiring - with special precautions to prevent thermal damage to the heat-sensitive, closely packed circuit elements.

Soft Solder

7. Soft solder is an alloy consisting of various combinations of tin and lead, with silver and other additives, which melts at temperatures below 370ºC. It may be in bar form to be melted for tinning or in the form of rosin cored wire for use with a soldering iron.

8. The following soft solders may be used on ADF aircraft electrical systems:

a. For general applications at temperatures up to 120°C use:

(1) non-activated flux cored solder, 60% tin, 40% lead, 1.2mm diameter, qualified to BS441.

(2) non-activated flux cored solder, 60% tin, 40% lead, 0.7mm diameter, qualified to BS441.

b. For applications with silver plated components use:

(1) non-activated flux cored solder, 62% tin, 2% silver remainder lead, 0.9mm diameter, qualified to Federal Specification QQ-S-571.

c. For high temperature applications (190°C) use:

(1) solid wire solder, 97.5% lead, 1% tin, 1.5% silver 16 SWG, qualified to SAE AMS 4756.

Hard Solder

9. Hard solders should not be confused with high temperature soft solders. Hard solder is a silver alloy and is used when greater mechanical strength or exposure to higher temperatures, such as thermocouple connections, is required. When silver soldering electrical equipment or fittings, use, Brazing Alloy-Silver which is a cadmium free, flux coated brazing rod qualified to Federal Specification QQ-B-654.

WARNING

Liquid solder flux, ANSI/J-STD-004, may generate a flammable vapour. Keep away from open flames and other sources of ignition.

WARNING

Avoid breathing fumes generated by soldering. Eye protection is required.

CAUTION

Use RMA type flux only in those cases where use of a mildly activated flux is required to obtain a good solder joint. ensure no flux remains on the solder joint by Cleaning using the procedure outlined in paragraph 37. The activating agents in the flux may cause corrosion if not adequately removed after soldering.

Flux

10. Flux is a chemical reducer used for surface conditioning before and during the soldering process. With soft solder, use only rosin fluxes conforming to Types R (non-activated) or type RMA (mildly activated) of ANSI/J-STD-004. With hard solder, use 0-F-499 fluxes, Borax or similar material mixed to a paste with water. A special solder flux sometimes used in thermocouple connections is described in Section 2, Chapter 16.

Typical Soldering Operations

11. Following are examples of typical soft-soldering operations used in aircraft electrical wiring:

NOTE

Hard-soldering procedures are described in Section 2, Chapter 16.

a. **Tinning** - wires or cables preparatory to joint soldering and to fuse ends; contact pins and inside surfaces of solder cups; shielded wire braid, after twisting, to fuse, terminate, and connect.

b. **Soldering** - wires and cables, previously tinned, inserted into solder cups of terminals, or mechanically wrapped on shaped lugs and post or hooked terminals; twisted connections, or broken wire for emergency repair; printed circuit conductor pattern defects, or component leads and lugs to conductor pattern terminal areas.

c. **De-soldering** - soldered joints prior to re-making; printed circuit component connections to remove component for replacement.

WARNING

Soldering may result in the emission of hazardous metallic fumes and vapours from fluxes used. personnel should position themselves so as to not directly inhale the fumes/vapours.

HEAT APPLICATION METHODS

Soldering Iron

12. The most commonly used method of' heat application for soldering joints in aircraft electrical wiring is by means of an electrically heated, hand held soldering iron. In addition to the conventional iron, a pencil iron is frequently used. Pencil irons, except for their smaller size, are identical to conventional irons and are used for precision soldering of small units and miniature assemblies.

Resistance Soldering

13. Resistance soldering is frequently used in large volume production where the operation is standardised. In this method, a low voltage transformer is used and the metal to be soldered is heated by the resistance to a flow of electric current. The work is gripped between two electrodes, completing the circuit and heating the metal for soldering. In another application, a carbon pencil is used as one electrode and the metal to be soldered forms the other electrode. When contact is established through the carbon pencil, intense heat is generated at the point of contact. Resistance soldering is well adapted to the soldering of small parts or for congested assemblies where it is desired to restrict heat to a small part of the assembly.

Torch Soldering

14. Torch soldering is used where a high heat is required - as in silver soldering. This process is also suitable for soft-soldering large work which is not part of an assembly or when the part to be soldered can be removed for soldering. For example, wires may be torch-soldered to large contacts that have been removed from MS connectors. Torch soldering is not suitable for soldering small parts.

Dip Soldering

15. Dip soldering is the process of immersing connections in molten solder; one or more connections can be made in a single operation. This process is used on printed circuits, where the conductor pattern is on one side of the board and the components on the opposite side. Joints are mechanically secured, dipped first into liquid flux, then into molten solder.

PREPARATION AND MAINTENANCE OF THE SOLDERING IRON

General

16. For successful, effective soldering, the soldering iron tip must be tinned to provide a completely metallic surface through which the heat may flow readily from the iron to the metal being soldered. If no tinning is present, the iron will oxidise and the heat cannot flow through. Copper has a very high rate of heat conductivity, but copper tips oxidise quickly and must be frequently cleaned and re-tinned. If a tip has become badly burned and pitted as a result of overheating, replace it.

Preparing the Soldering Iron

17. Before using the soldering iron prepare it as follows:

a. With the iron shut off, file each working surface of the soldering iron tip with a double-cut mill file until it is smooth and a bright copper colour. (See Figure 7–1.) Remove copper fuzz from dressed edges with a file card.

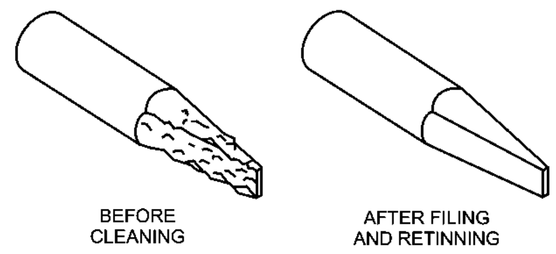


Figure 7–1 Soldering Iron Tip Before and After Cleaning

b. Plug in the iron and apply cored solder just as the bright dressed copper colour is turning to a pigeon-blue, bronze, oxide colour. This will allow the flux to “wet” and clean the working area when the solder melts to form an even, bright silver coating on the tip. (See Figure 7–2.)

CAUTION

Do not allow the iron to reach full temperature before starting the tinning operation.

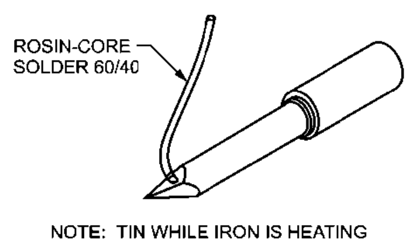


Figure 7–2 Tinning Soldering Iron Tip

c. Wipe off excess solder with a damp sponge or cloth.

> NOTE
>
> Do not file soldering iron tips coated with pure iron. Filing will ruin the protective coating. If the tip is pitted, replace it.

18. Some copper soldering iron tips used in production soldering are coated with pure iron to help prevent oxidation. Follow manufacturer's instructions for cleaning such irons. A clean damp cloth may be used to wipe the iron.

Soldering Iron Maintenance

19. Prior to use, remove the tip from the iron and clean out the black scale from the inside of the iron and from the tip with fine steel wool. When the iron or tip is new, coat the inside of the shank with dry flake graphite or anti-seize material to prevent freezing, and to ensure maximum heat transfer. When replacing the tip, make sure it is inserted to the full depth of the casing and seated firmly against the heating element.

> **WARNING**
>
> Never shake or "whip" an iron to get rid of dross or excess solder droplets.

20. During use and just before each application, pass the soldering iron tip (with a rotary motion) through the folds of a damp cleaning sponge or wipe on a wiping pad. This will remove the surface dross and excess solder from the working surface.

SOLDERING OPERATION

General Precautions and Procedures

21. Regardless of the heating method used in the soldering process, a good connection will result only if the proper soldering techniques are followed and certain precautions observed. The following instructions apply generally to soldering operations. Detailed procedures are given for soldering wires to MS connectors in Section 2, Chapter 10, to coaxial connectors in Chapter 12, and for thermocouple connections in Chapter 16.

> NOTE
>
> A quality soldered joint can be accomplished only on a mechanical connection of approved geometry, dress, and dimensions.

Cleanliness

22. Cleanliness is of the utmost .importance in the soldering operation. If possible, soldering should be done in clean dust free environment. Drafty areas should be avoided so that the soldering iron will not cool. Parts contaminated with dirt, oil, grime, grease, etc, cannot be successfully soldered. Ensure that the parts are mechanically "bright-clean" before soldering. Clean the parts with a cloth or brush dipped in alcohol, or other approved solvent. Badly corroded parts may be cleaned carefully by mechanical means, such as fine abrasive paper or a wire brush.

> **WARNING**
>
> Avoid breathing fumes generated by soldering. Eye protection is required.

Pre-Tinning

23. Wires to be attached to most electrical connectors must be pre-tinned. Follow the instructions given in Section 2, Chapter 3.

Selection of Flux and Solder

24. Use the solder and fluxes described in paragraphs 7 through 10.

> **WARNING**
>
> Liquid solder flux, ANSI-J-STD-004, may generate a flammable VAPOUR WHEN heated. Keep away from open flames and other sources of ignition.

> **CAUTION**
>
> Do not use any corrosive flux on aircraft electrical wiring.

Heating Capacity

25. Use a soldering iron or other heating method of sufficient capacity to heat the metal being soldered to solder-melting temperature.

Selection of Soldering Iron

26. The sole purpose of the soldering iron is to heat the joint to a temperature high enough to melt the solder. Select a soldering iron with a thermal capacity high enough so that the heat transfer is fast and effective. An iron with excessive heat capacity will burn or melt wire insulation; an iron with too little heat capacity will make a cold joint in which the solder does not alloy with the work. Soldering irons are available in wattage ranges from 20 to 500 watts. Irons with wattage rating of 60, 100, and 200 watts are recommended for general use in aircraft electrical wiring. Pencil irons with a rating of 20 to 60 watts are recommended for soldering small parts. The soldering iron recommended for printed circuit soldering is a lightweight 55 watt iron with a 315°C Curies point tip control. This iron has a three-wire cord to eliminate leakage currents that could damage the printed circuits.

27. A soldering iron should also be suited to the production rate. Do not select a small pencil iron where a high steady heat flow is required.

Choice of Soldering Tip

28. Select the tip best suited for the size and shape of the work being soldered. Some common tip shapes are shown in Figure 7–3. Soldering iron tips are available in sizes from 1.6mm to 50mm in diameter. For general use, a tip of 6mm to 9mm diameter is recommended. For printed circuit soldering, use a long shank tip of 1.6mm, 2.4mm, 3mm or 4.8mm diameter. Screwdriver, chisel, and pyramid shapes are recommended.

Soldering Iron

29. Before starting the soldering operation, make sure that the iron tip is clean, smooth, and well tinned. See paragraphs 15 through 19 for instructions on preparation and maintenance of soldering iron. When resistance soldering equipment is to be used, make sure that probes are clean.

Securing the Joint

30. Whenever possible, make sure that the joint is mechanically secure before soldering. When this is not possible (as with MS connector contacts), make sure that the joint is held rigid during the cooling period.

Application of Heat and Solder

31. Apply flux-core solder at the exact point between the metal and the soldering iron (as shown in Figure 7–4) and hold the iron directly against the assembly. Melt the solder on the joint, not the iron. Place the soldering iron firmly against the junction. If heavy "rocking" pressure is necessary, either the iron does not have sufficient heat capacity for the job, or it has not been properly prepared, or both.

Heat Application Time

32. Do not apply heat to the work any longer than the time necessary to melt the solder on all parts of the joint.

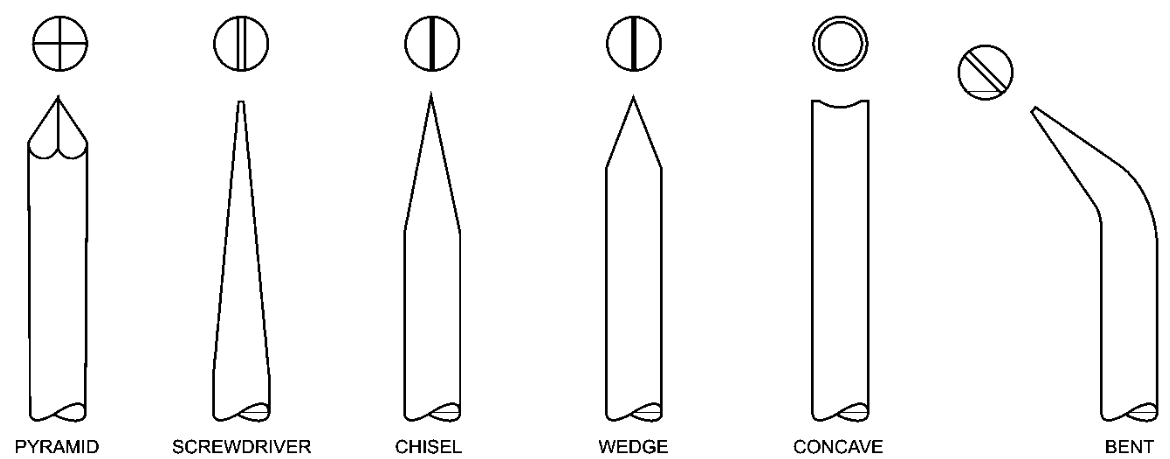


Figure 7–3 Soldering Iron Tip Shapes

Amount of Solder

33. Do not use any more solder than necessary. Do not pile up solder around the joint; this is wasteful and results in joints difficult to inspect. Care should be exercised with silver-coated wire to prevent wicking during solder application.

Soldering Iron Holder

34. When the soldering iron is not in actual use during operations, keep it in a holder. This will protect the operator against burns and the iron against damage.

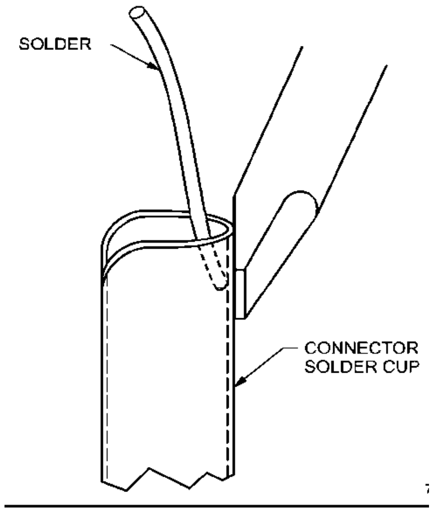


Figure 7–4 Correct Solder Application

Protection Against Overheating

35. Do not allow the iron to overheat. Disconnect the iron when it is not in use (between operations), or use a heat-dissipating stand that will keep the iron at a constant temperature.

Cooling the Solder Joint

36. When the solder joint has been made, hold the work firmly in place until the joint has set. Disturbing the finished work will result in a mechanically weak joint, with high electrical resistance. Allow solder joints to cool naturally. Do not use liquids or air blasts.

Cleaning

37. If the correct amount of solder is used and procedure instructions followed carefully, there should be little or no excess flux remaining on the finished joint. If cleaning is necessary, remove excess flux by brushing the joint with a stiff brush dipped in methyl alcohol, or a similar approved solvent. Use alcohol sparingly and avoid contact between alcohol and wire insulation. For cleaning printed circuit connections, use a cotton swab-stick for small areas and a lint-free clean cloth for large areas and board edges.

INSPECTING A FINISHED SOLDER JOINT

Acceptable Solder Joint

38. A good soldered joint will have a bright silvery appearance, with smooth fillets and feathered non-sharp, edges. The entire joint will be covered with a smooth even coat of solder, and the contour of the joint will be visible. (See Figure 7–5.)

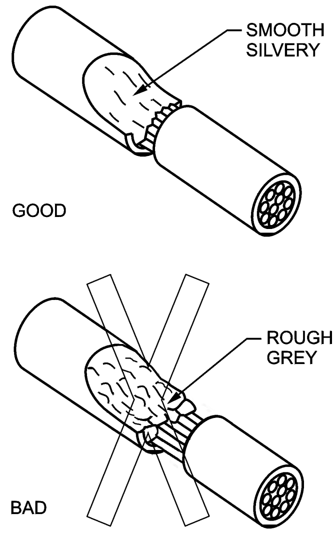


Figure 7–5 Good and Bad Soldered Connections

Unacceptable Solder Joint

39. Any of the following indicate a poor solder joint and are cause for rejection:

- **a.** Dull grey, chalky, or granular appearance - evidence of a cold joint.
- **b.** Hair cracks or irregular surface - evidence of a disturbed joint.
- **c.** Greyish, wrinkled appearance - evidence of excessive heat.
- **d.** Partially exposed joint - evidence of insufficient solder.
- **e.** Scorched wire insulation or burned connector inserts.
- **f.** Globules, drips, or tails of solder.

40. If any of the above are present in a finished solder joint, the joint should be taken apart, parts cleaned, and the entire soldering operation repeated, using fresh solder and flux.

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 Meal 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

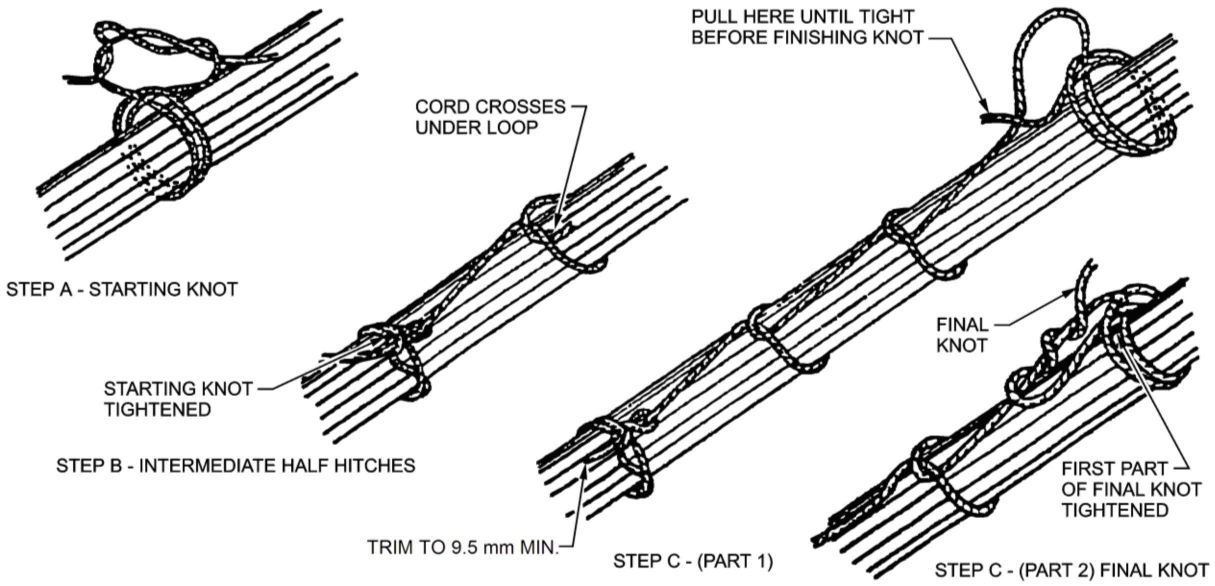


Figure 8–1 Single Cord Lacing

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 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.

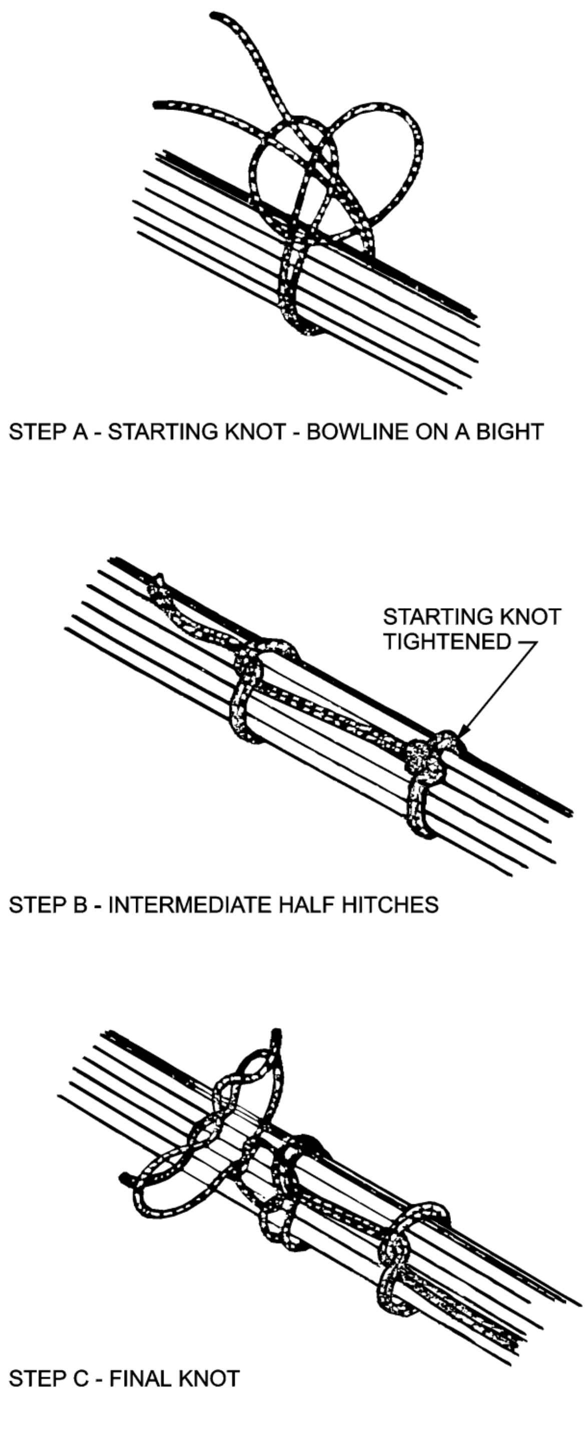


Figure 8–2 Double Cord Lacing

Lacing Branch-Offs

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

a. 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.

b. 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.

c. 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.

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

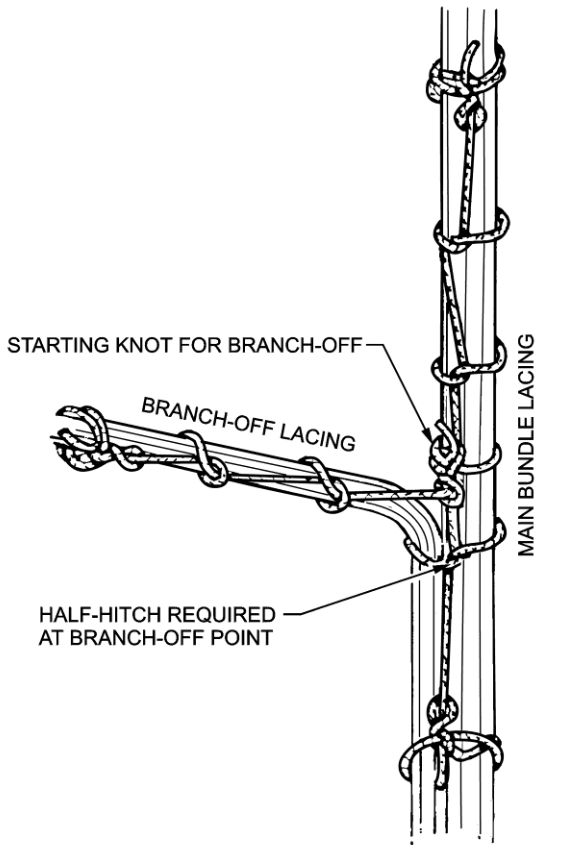


Figure 8–3 Lacing a Brach-Off

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:

a. Wrap cord around wire group or bundle, as shown in Figure 8–4.

b. Make a clove hitch, followed by a square knot with an extra loop.

c. Trim free ends of cord to 9.5mm minimum.

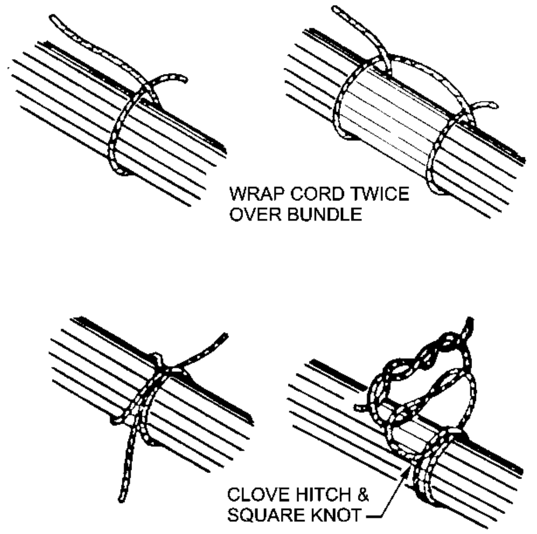


Figure 8–4 Making Ties

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:

a. MS3367 cable securing strap shown by the bold lines in Fig 8–5 and;

b. 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:

a. Where total temperature (ambient plus rise) exceeds 85° C.

b. Where failure of the strap would permit movement of the wiring against parts which could damage the insulation or foul mechanical linkages.

c. Where failure would permit the strap to fall into moving mechanical parts.

d. In high vibration areas.

e. Outside the fuselage.

f. In wheel wells.

g. Where exposure to ultraviolet light might exist, unless the straps are resistant to such exposure ie. black coloured straps.

h. To tie wire groups or harnesses within bundles.

i. 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.

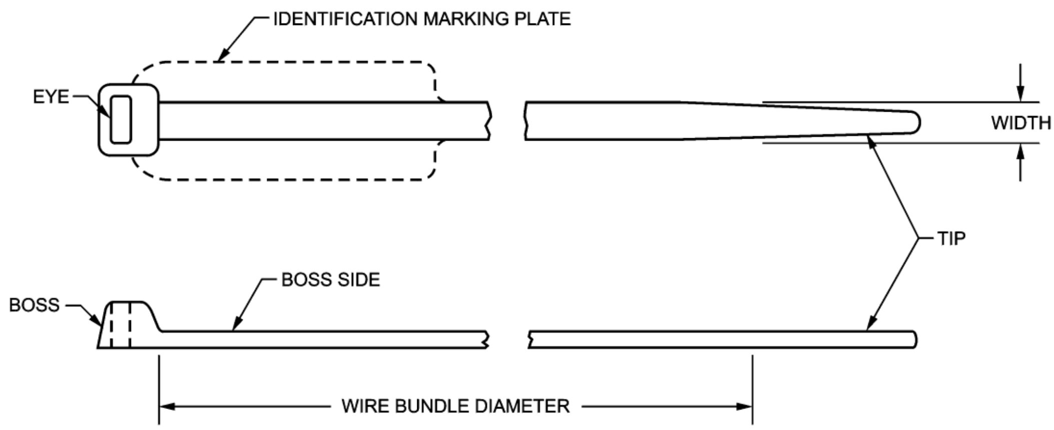


Figure 8–5 Strap Configuration

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.

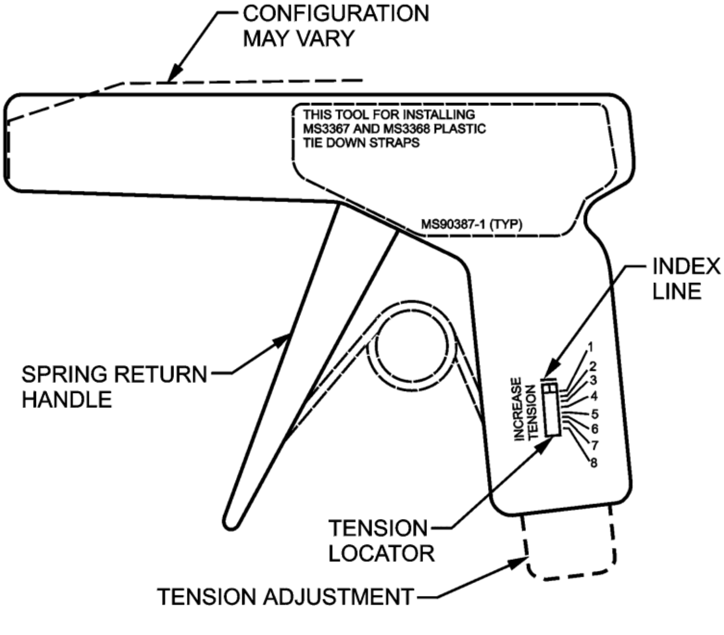


Figure 8–6 MS90387 Adjustable Hand Tools for Installing Self-Clinching Plastic Tiedown Straps

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)

SECTION 2

CHAPTER 9

WIRING: LOCK, SHEAR AND SEAL

INTRODUCTION

1. Electric connectors, emergency devices, and other pieces of electrical equipment in aircraft are secured with wire when specified on engineering drawings or specified in the applicable aircraft maintenance handbook in order to prevent accidental loosening.

2. This chapter outlines the recommended procedures for wiring MS electric connectors and emergency devices such as switches, switch guards, and handles which operate ejection seats, emergency bomb releases, fire extinguishers, etc. General practices for safety wiring are specified in Military Standard Drawing MS33540 and wire identification is provided in Table 9-1.

REFERENCE SPECIFICATIONS

3. The following specifications are applicable to Lock Wire, Shear Wire and Seal Wire:

SAE AS 50881	Wiring Aerospace Vehicle
NASM20995	Wire, Safety or Lock
NASM33540	Safety Wiring and Cotter Pinning, General Practices for

DEFINITIONS

Lock Wire

4. Lock wire is normally a single strand steel wire installed by twisting to double strand. It is used to secure parts against inadvertent opening or loosening in areas of high vibration such as the engine compartment. Electrical connectors are lockwired or safety wired in such high vibration areas. (Refer SAE AS 50881)

NOTE

Use 0.032 inch lockwire for general purpose lockwiring. 0.020 inch lockwire may be used on parts having a nominal hole diameter of less than 0.045 inch or on closely spaced screws and bolts of 0.250 inch (6.35mm) diameter or less.

NOTE

Connector plugs with self-locking coupling rings are designed for high vibration environments and do not have lock wire provisions.

Shear Wire

5. Shear wire is used where it is necessary to purposely break or shear the wire to permit operation or actuation of emergency devices. Shear wire is a thin, single strand, easily breakable wire used to secure emergency devices.

NOTE

General purpose shear wire shall be 0.020 inch diameter.

Seal Wire

6. Seal wire is the same as shear wire except that the ends of the wire are sealed with a lead seal. Seal wire is used to secure emergency devices such as fire extinguishers, oxygen regulators, etc., to prevent tampering with or use of these devices without indication.

Metallic Seals

7. Metallic seals are not to be used on airborne components, equipment or systems. When anti-tampering seals are required for lock wire, a bright gloss paint system is to be used. The paint is to be applied in such a manner that will provide a visible indication that the lock wire has been tampered with.

GENERAL PROCEDURES FOR LOCK, SHEAR AND SEAL WIRING

WARNING

Eye protection is required when using pliers that cut or trim and shall be worn while installing or removing safety wire. Keep fingers away from jaws and cutting edge.

WARNING

Lockwire ends must be bent under to prevent injury. Care should be taken not to confuse steel with aluminium wire.

CAUTION

Use only new wire when replacing wired electrical connectors or emergency devices.

Length

8. Use wire of the shortest length that will allow accomplishment of the procedures outlined in Paras 14 through 22.Double Twist Lock Wiring

9. Use the double twist method of lock wiring as illustrated in Figure 9–1 for all equipment in areas of high vibration and for electrical connectors in areas which are inaccessible.

Single Wire Method

10. Use the single wire method shown in Figure 9–2 in all conditions specified for shear and seal wire as described in Paragraphs 5 and 6. In addition, the single wire method may be used with locking wire in areas hard to reach and small screws in a closely spaced or closed geometrical pattern such as triangles, squares, rectangles, circles, etc.

NOTE

All plugs and sockets that are required to be lock wired, as specified on an engineering drawing or in the applicable aircraft maintenance manual, are to be lock wired using the twisted wire method.

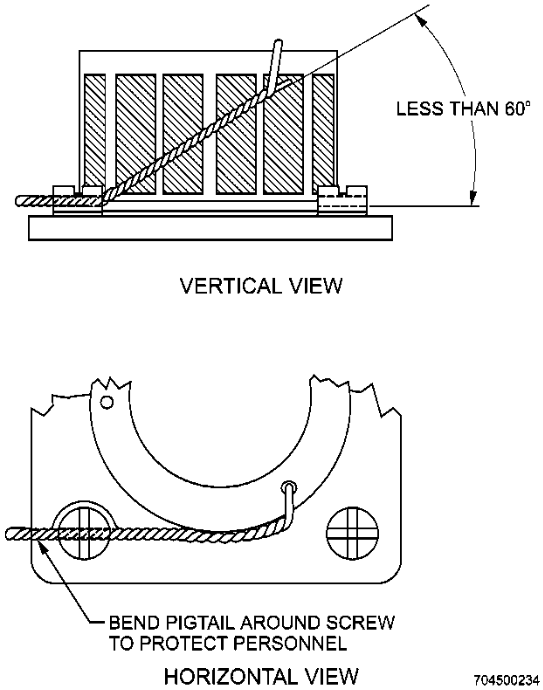


Figure 9–1 Double Twist Lock Wiring

Table 9–1 Safety Wire – Identification

Wire Type	Material	Colour	Size	Identification
Lock Wire	Steel (Corrosion Resistant)	Silver	0.020 inch	MS20995C20 9505-00-221-2650
			0.032 inch	MS20995C32 9505-00-293-4208 or 9505-00-847-1663
Lock Wire (Above 370°C)	Inconel	Natural	0.020 inch	MS20995N20 9505-00-529-9195
			0.032 inch	MS20995N32 9505-00-529-0442
Shear or Seal Wire	Annealed Copper (Cadmium Plated)	Golden Yellow	0.015 inch	MS20995CY15 9525-01-082-1008
			0.020 inch	MS20995CY20 9525-01-047-6455
Lock, Shear or Seal Wire for Magnesium Parts	Aluminium Alloy (Anodized)	Blue	0.032 inch	MS20995AB32 9525-01-031-1086

Twisting with Pliers

11. When wire is twisted by hand, use pliers for the final twists to apply tension and to secure ends of wire. Cut off part of wire gripped by pliers to remove rough edges.

> NOTE
> Make sure wire does not become kinked or nicked during twisting operation. If wire is damaged, replace with new wire.

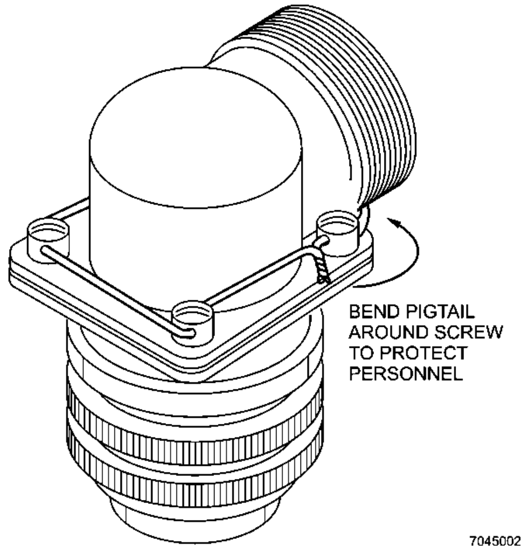


Figure 9–2 Single Wire Method

Twisting With Special Tools

12. Twist wire with a wire twister as follows (see Figure 9–3):

> **WARNING**
> Eye protection shall be worn while installing or removing safety wire. Keep fingers away from jaws and cutting edge.

> **WARNING**
> When using wire twisters and wire extends 3 inches (75mm) beyond jaws of twisters, loosely wrap wire around pliers to prevent whipping and possible injury.

a. Grip wire in jaws of wire twister and slide outer sleeve down with thumb to lock handles.

b. Pull knob; spiral rod spins pliers and twists the wire.

c. Squeeze handles together to release wire.

Tightness of Wire

13. Install wire so that the wire will be in tension if the part loosens. Twist wire together so that it is tight, but do not overstress wire as it may break under load or vibration.

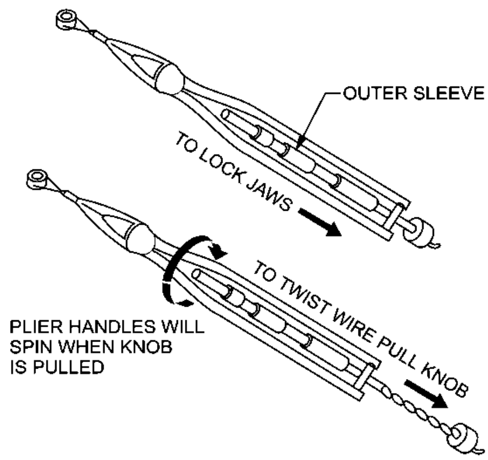


Figure 9–3 Use of Lock Wire Pliers

SPECIFIC PROCEDURES FOR LOCK, SHEAR AND SEAL WIRING

Lock Wiring Electrical Connectors and Backshells

> NOTE
> Do not install lock wire under the head of a screw or bolt. Use predrilled fillister head screws or safety tabs.

14. Secure electrical connectors and back-shells with lock wire when specified on engineering drawings or specified in the applicable aircraft maintenance handbook. Electrical and RF connectors and backshells, unless of the self-locking type, shall be lock-wired in engine nacelles, areas of high vibration, locations not readily accessible for periodic maintenance and external electronic compartments. Connectors and backshells in these locations are identified by a painted/affixed red dot 0.50 inch (12.7mm) in diameter on adjacent aircraft structure.

15. Do not lock wire electric or RF connectors and backshells which have a mechanical lock, as lock wiring will act against the locking feature. Backshells on bayonet coupled connectors shall not be safety wired to connector coupling ring. Backshells with safety wire holes shall be safety wired to aircraft structure or to connector mounting flange when required (see Figure 9–9).

Lock Wiring Connectors with Threaded Coupling Rings

16. When specified on engineering drawings or specified in the applicable aircraft maintenance handbook, lock wire connectors as follows (see Figure 9–4):

a. Thread lock wire through wire hole in coupling ring.

CAUTION

When installing new lock wire or replacing unserviceable existing lock wire, use MS20995, 0.020 inch lock wire only. Larger lock wire can break out the hole in the coupling ring.

NOTE

If connector plug to be lock wired does not have a wire hole, remove coupling nut and drill a #56 (0.046 inch) diameter hole diagonally through the edge of nut, as shown in Figure 9–6.

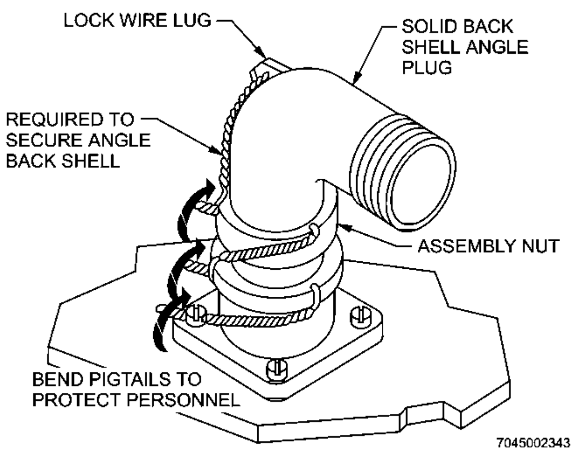


Figure 9–4 Lock Wiring Thread Coupled Connector

b. Twist wire, under slight tension, approximately 9 to 11 turns per inch, (see Figure 9–5), by hand or by special tool, as described in Paras 11 and 12. Twist wire right handed so it will have a tightening effect. Twist to within approximately 0.125 inch (3mm) of each unit.

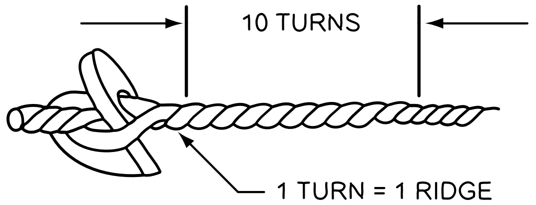


Figure 9–5 Twisting Method

c. Pull one end of twisted wire through hole in drilled fillister head screw on mounting flange of connector. Use a fillister head screw so located as to allow a 60° or smaller angle of the wire, as shown in Figure 9–1.

CAUTION

Do not back off or over-torque mounting fillister head screws, in order to align holes for lock wiring.

d. Form pigtail approximately 0.5 inch (12.7mm) or 3-7 turns.

NOTE

Individual sections of connectors may be lockwired with a continuous piece of lock wire if appropriate authorisation is obtained.

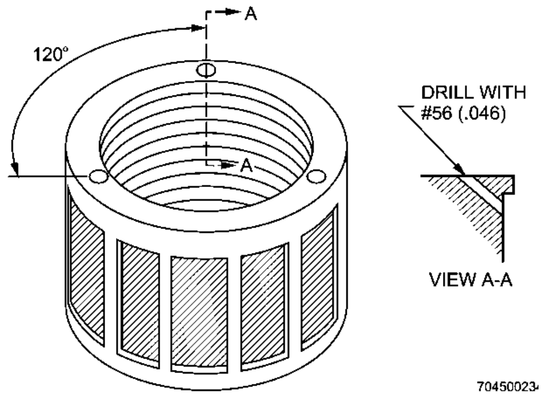


Figure 9–6 Drilling Hole in Coupling Nut

e. Bend pigtail back towards body of connector to prevent it from injuring personnel.

f. Safety wire attached cable clamps/coupling ring to connector coupling ring if provisions exist. (See Figure 9–4.) If necessary, safety wire these parts to structure (see Figure 9–8) or to mounting flange (see Figure 9–9). Use same procedure as described in steps a through e.

> **CAUTION**
>
> Electrical connectors shall not be lockwired to any part of fuel, oil, hydraulic or oxygen systems (lines, tubes, elbows, flanges, jam nuts etc).

> NOTE
>
> Connectors should be lock wired to fillister head screws, through safety wire tabs or drilled holes in structure provided for that purpose. If no holes are provided, connectors may be lockwired to each other, however, the maximum number of connectors that can be lock-wired in series is three (3). In those applications where RF connectors require safety wiring and physical dimensions preclude drilling safety wire holes, a cable clamp can be attached t o the connector for securing the safety wire. Attach the cable clamp as illustrated in Figure 9–7.

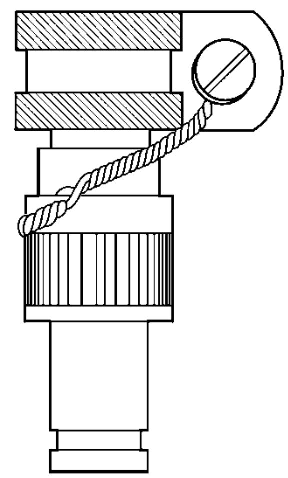


Figure 9–7 Lock Wiring Connector Using Adel Clamp

Lock Wiring Connector to Structure

17. If no fillister head screw or safety wire tab is available for attaching lock wire, secure wire to drilled hole in structure not more than 6 inches (15cm) from connector, as shown in Figure 9–8. Use same procedure as described in Para 14.

Lock Wiring Split Shell Assemblies

18. Split shell connectors are held together by two fillister head screws. Secure these screws as follows (see Figure 9–9):

a. Draw wire through hole in one screw.

b. Cross wire from left to right between screws, and draw through second screw.

c. Twist wires together with pliers and bend back.

Wiring Solid Shell Angle Plugs

19. Angle plugs with solid black shells are in two parts, held together by four screws through mating flanges. Wire these screws with a single lock wire as shown in Figure 9–2. Solid shell angle plugs made by Bendix and Cannon have back shells held in place by assembly nuts. Install a double twisted lock wire between hole in assembly nut and lug on backshell as shown in Figure 9–4. If necessary to lock wire the plug itself install a second double twisted wire between the assembly nut and the coupling nut or between the coupling nut and one of the receptacle mounting screws, as shown in Figure 9–4.

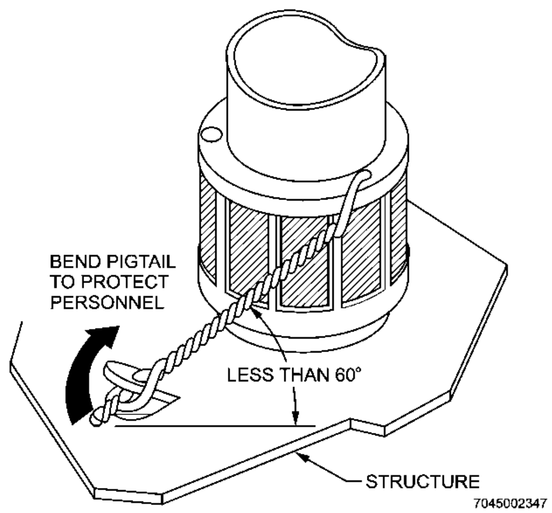


Figure 9–8 Lock Wiring Connector to Structure

Shear Wiring of Electrical Components

20. The purpose of shear wiring is as follows:

a. Prevent inadvertent operation of a switch, and

b. To highlight the selection or operation of a particular service or function.

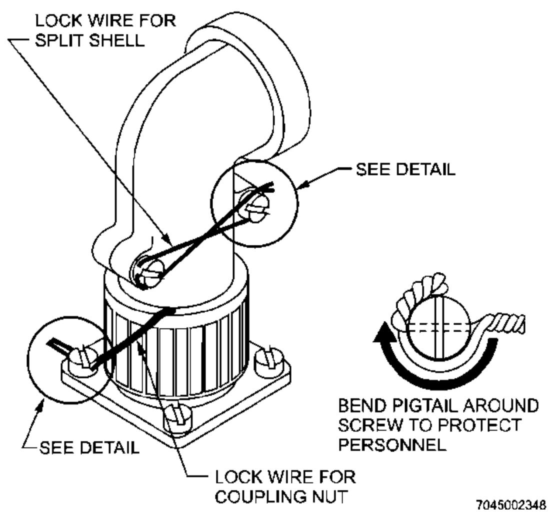


Figure 9–9 Wiring Split Shell Assembly Screws

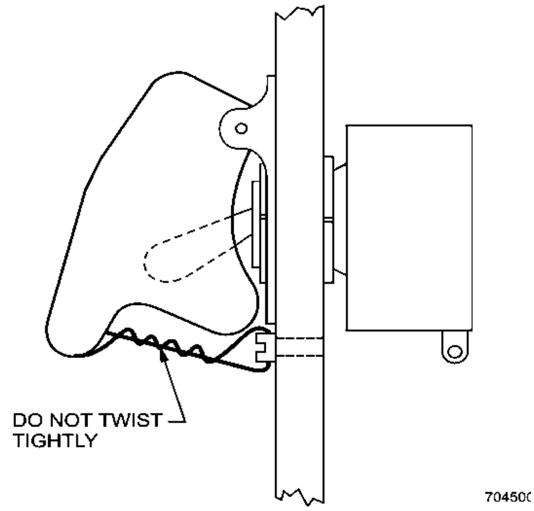


Figure 9–10 Shear Wiring Switch Guard

Shear Wiring Emergency Devices

21. Use single wire method to secure emergency devices. (See Figure 9–10.) Make sure that wire is so installed that it can easily be broken when required in an emergency situation.

NOTE

Several sizes of shear wire may be used within aircraft, however, for applications such as shear wiring of electrical switches and switch covers Annealed Copper Wire PN MS20995CY20 (NSN 9525-01-047-6455) is to be used.

SECTION 2

CHAPTER 10

GENERAL PURPOSE CONNECTORS

INTRODUCTION

1. Connectors provide a means of quickly connecting and disconnecting wires to simplify installation and maintenance of electric and electronic equipment. Connectors should be inspected and cleaned, repaired or replaced as warranted, for any condition that will impair connector performance, such as those listed below.

a. Dirty and/or contaminated with fluids.

a. Corroded, worn, bent, recessed, broken or splayed pin or socket contacts.

b. Damaged (torn, burned, etc) interfacial grommet seals, rear wire grommet seals and o-rings or peripheral seals.

c. Damaged (corroded, broken, bent, worn, missing bayonet pin, etc) shell or coupling ring.

d. Cracked, chipped or distorted dielectric connector inserts.

2. A connector with irreparable damage that could degrade its sealing capability, electrical performance or mechanical integrity should be replaced.

3. This chapter describes and illustrates the types and classes of Military Standard connectors and the recommended procedures for attaching wires to connector contacts. AN type connectors were formerly designated with the prefix “AN”, and older connectors may still be found with this prefix. The superseding connector has the same part number except that the “AN” has been replaced by “MS”. Other connectors commonly used in aircraft, similar to MS connectors, are also described and illustrated in this section. RF connectors are treated separately in Section 2, Chapter 12.

REFERENCE SPECIFICATIONS

4. The following specifications are applicable to general purpose connectors:

AN3111	Ring-Bonding, Electrical Connector
J-STD-004	Requirements for Soldering Fluxes
J-STD-005	Requirements for Soldering Pastes
J-STD-006	Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications
MIL-C-26482	Connectors, Electric, Circular, Miniature, Quick Disconnect
MIL-C-26500	Connectors, General Purpose; Electrical, Miniature, Circular, Environment Resisting
MIL-C-39029	Contacts, Electric, General Specification For
MIL-C-81511	Connectors, Electrical, Circular, High Density, Quick Disconnect, Environment Resisting
MIL-C-81659	Connectors, Electrical, Rectangular, Environment Resistant, Crimp Contacts
MIL-C-81703	Connectors, Electric, Circular, Miniature, Rack and Panel or Push-pull Coupling, Environment Resisting
MIL-DTL-22520	Crimping Tools, Contact, Electric, Hand, General Specification For
MIL-DTL-24308	Connector, Electric Rectangular, Miniature Polarized Shell, Rack and Panel General Specification For
MIL-DTL-28748	Connector, Electrical, Rectangular, Rack and Panel, Solder Type and Crimp Type Contacts General Specification For
MIL-DTL-38999	Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect, Environmental Resisting, Removable Crimp Type Contact, Reliability Assurance Program
MIL-DTL-83723	Connectors, Electrical, Circular, Environment Resisting

MIL-DTL-83733	Connector Electrical, Miniature, Rectangular Type, Rack to Panel, Environment Resisting 200°C Total Continuous Operating Temperature, General Specification For
MIL-DTL-5015	Connectors, Electrical, Circular, Threaded, AN Type
MIL-I-3190	Insulation Sleeving, Electrical, Flexible, Coated
MIL-I-631	Insulation, Electrical, Synthetic-Resin Composition, Non-Rigid
MIL-I-7444	Insulation Sleeving, Electrical, Flexible
MIL-PRF-46846	Rubber, Synthetic, Heat Shrinkable
MIL-T-83507	Tool Kit, Electrical Connectors, Contacts, and Connector and Cable Accessories General Specification For
MIL-W-22759	Wire, Electric, Fluoropolymer, Insulated, Copper or Copper Alloy
MS25274	Cap, Electrical Wire End, Crimp Style, Type II, Class I
MS3101	Connector, Plug Electric, Cable Connecting, Solder Contacts
MS3190	Contact Wire Barrel, Crimp Type
SAE AMS-DTL-23053	Insulation Sleeving, Electrical, Heat Shrinkable, General Specification For

DESCRIPTION

General Description of AN, D, M and MS Connectors

5. A connector set consists of two parts: a plug assembly and a receptacle assembly. The receptacle is usually the "fixed" part of the connector, attached to a wall, bulkhead, or equipment case. The plug is the removable part of the connector usually attached to a cable. When the two parts are joined, the electric circuit is made by pin-and-socket contacts inside the connector. The "live" or "hot" side of the circuit should have socket (female) contacts. The contacts are held in place and insulated from each other and from the shell by a dielectric insert. Insert and contacts are housed in a metal shell. Connectors may be grouped into types, classes, and series depending on their manufacture, assembly, and application.

6. The class is determined by the environment or application of the connector. Connectors manufactured in accordance with military specifications are designated in one of two ways. In some specifications such as MIL-DTL-5015, MIL-C-26482, MIL-C-26500 and MIL-DTL-38999 series I and II, the connector is designated by and "MS" number, such as MS3101. In specifications MIL-DTL-38999 series III and IV, MIL-C-81511, MIL-DTL-83723, and later specifications, the connector is designated by a D or M preceding the specification number followed by a slash and the connector number, such as D38999/21 or M83723/65.

General Description of Circular Connectors

7. Military Specifications cover the circular connectors most commonly used in aircraft: MIL-DTL-5015, MIL-C-26482, MIL-C-26500, MIL-DTL-38999, MIL-C-81511, MIL-C-81703, and MIL-DTL-83723. Connectors manufactured to these specifications have either solder type or crimp type contacts and cover a range of contact sizes from 0 to 22.

Military Connector Marking

8. Each connector is marked on the shell or coupling ring with a code of letters and numbers giving all the information necessary to identify the connector (see Figure 10-1).

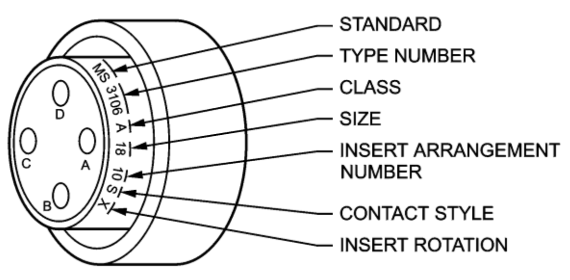


Figure 10–1 MS Connector Marking

- **a.** The letters "MS" indicate that the connector has been made according to government standards.
- **b.** Numbers such as 3106 indicate type of shell, and whether plug or receptacle. (Refer to Figure 10-3).
- **c.** Class letter indicates design of shell, and for what purpose connector is normally used.
- **d.** Numbers following class letter indicate shell size by outside diameter of mating part of receptacle in 1.6mm increments, or by the diameter of the coupling thread in 1.6mm. For example, size 12 has an outside diameter or a coupling thread of 1.9mm.

e. Numbers following a hyphen indicate the insert arrangement. This number does not indicate the number of contacts. Military Standard drawings cover contact arrangements approved for service use.

f. First letter following the number indicates style of contact. Contact style letters will normally be “P” for pin contacts and “S” for socket contacts, however, some connector specifications call out “A” and “B” to replace the “P” and “S” in the marking (part numbering) system. The “A” and “B” indicate a connector supplied without contacts. “A” indicates a connector without pin contacts. “B” indicates a connector without socket contacts. The “A” and “B” designators are used only when other than a standard power contacts are to be used (example: shielded, coaxial, thermocouple and wrappost contacts). The required contacts must be ordered separately when “A” or “B” is shown in the connector part number.

g. Last letter indicates alternative insert position. Insert position letters W, X, Y, or Z indicate that the connector insert has been rotated with respect to the shell a specified number of degrees from the normal position. Alternative positions are specified to prevent mismating when connectors of identical size and contact arrangement are installed adjacent to each other. These alternative positions are shown on military standard drawings. If no letter appears, the insert is in the normal position. On connectors with multiple keyways, the degree of rotation is measured from the widest keyway. See Figure 10-2 for typical alternative position arrangements.

NOTE

MIL-C-26500 connectors have an additional letter to indicate type of coupling between shell size and insert arrangement code numbers. These letters are “T” for threaded coupling and “B” for bayonet coupling; for example, MS24266R18B30P6, where B indicates the type of coupling. On MIL-C-26500 connectors, alternate positions are indicated by numbers 6, 7, 8, 9, 10 instead of by letters.

Solders

9. Solders and other fastening means are matched to the wire type and to the installation as follows:

a. Soft solder per standard J-STD-006 is used for tin or silver plated copper conductors and coaxial cable.

b. Soft solder per standard J-STD-006 is used for silver coated copper wire.

c. Crimp connections are used for nickel-clad copper wire, and tin, silver, or nickel plated copper wire.

d. Thermocouple wires require special procedures that are detailed in Section 2, Chapter 16.

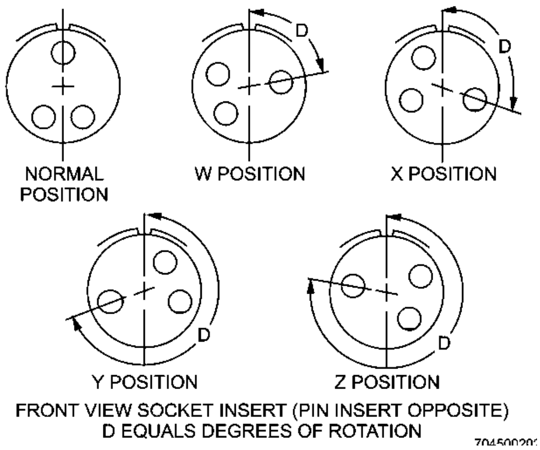


Figure 10–2 Alternative Positions of Connector Inserts

Solder Contacts

10. Solder cup contacts are silver, tin, or gold plated to provide low contact resistance. Silver-plated contacts have pre-tinned solder cups. Gold-plated contacts are not pre-tinned because the gold prevents oxidation and is therefore always easy to solder.

Preparation of Wires Prior to Assembly

11. The preparation of wires before assembly is as follows:

a. Cut wire to prescribed length.

b. Identify wire with proper coding.

c. Strip ends to the dimensions shown in Table 10–1.

d. Tin wires that are to be soldered to contacts.

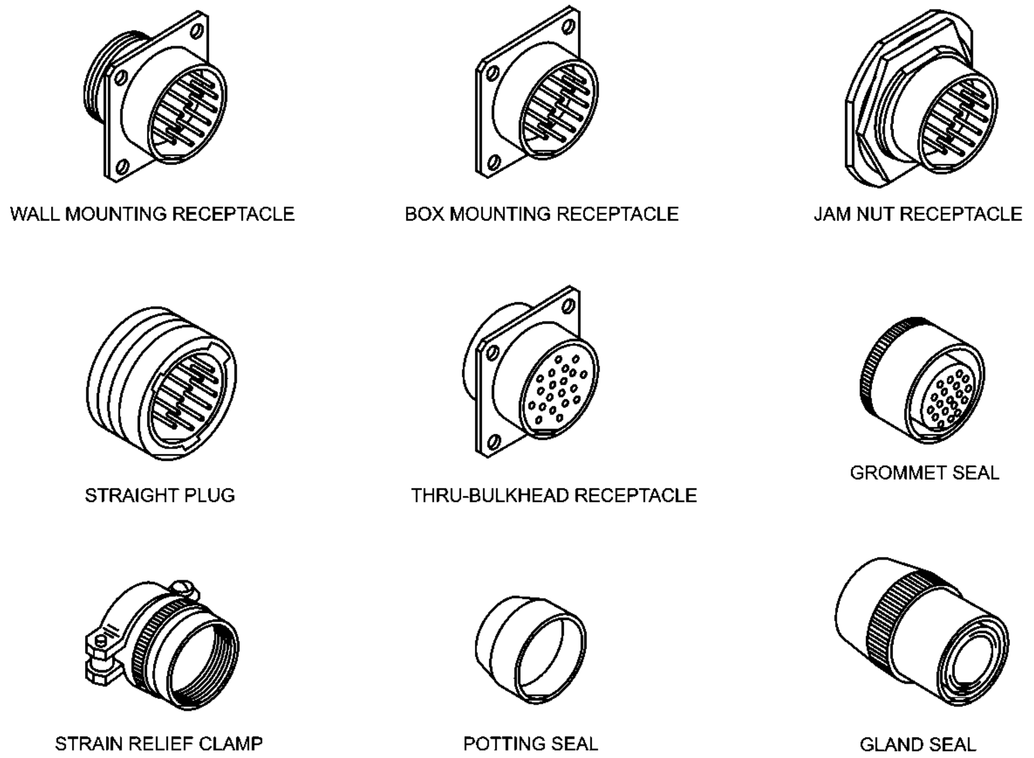


Figure 10–3 Typical Circular Connectors

0	19.0

INSULATING SLEEVES AND HEAT-SHRINKABLE TUBING

12. Insulating sleeves or heat-shrinkable tubing is used over soldered connections to help protect the connection against vibration and to lengthen the arc-over path between contacts. Insulating sleeves and heat shrinkable tubing are not used under the following conditions:

a. when connectors are to be moisture-proofed by potting; and,

b. when connectors have rear environmental wire sealing grommets that cover the soldered connection.

Table 10–1 Stripping Lengths for Solder Connections

Contact Size	Stripped Length (mm)
20	3.0
16	6.0
12	8.0
8	16.0
4	16.0

Selection of Insulating Sleeves and Heat-Shrinkable Tubing

13. Select insulating sleeving or heat-shrinkable tubing from the materials listed in Table 10–2 or Table 10–3 to suit the temperature conditions in the area where the connector will be installed. Select the proper size from Table 10–4 so that the inside diameter of the sleeving or recovered heat-shrinkable tubing will fit snugly over the solder cup.

WARNING

Temperatures above 315°C used to heatshrink tubing on Polyurethane insulated wire or cables will cause Polyurethane to release irritating gases.

Installation of Insulating Sleeves and Heat-Shrinkable Tubing

14. Cut the sleeving into lengths, as given in Table 10–4, to extend from the insert and overlap the wire insulation, covering the soldered connection completely. (See Figure 10–4.) Slip insulating sleeve or tubing of correct size, material, and length over each prepared wire, far enough back from the stripped end to avoid heat from the soldering operation (about 25mm).

Table 10–2 Insulating Sleeving Material

Temperature Range	Material	MIL Spec.

Up to 70°C	Synthetic resin composition transparent	MIL-I-631*
Up to 205°C	Silicone impregnated fiberglass	MIL-I-3190
Up to 275°C	TFE Resin, Non-rigid	MIL-I-22129
* MIL-I-631, Types E & F are not to be used.		

Table 10–3 Heat Shrinkable Tubing Material

Temperature Range	Material	MIL Spec.
-55 to 135ºC	Polyolefin	SAE AMS-DTL-23053/5
-55 to 175ºC	PVF	SAE AMS-DTL-23053/8
-67 to 250ºC	PTFE	SAE AMS-DTL-23053/12

Table 10–4 Insulating Sleeving/Heat Shrinkable Tubing Sizes

	Heat Shrinkable Tubing		Insulating Sleeving	
Wire Size	**Size**	**Type**	**Number**	**I.D. (mm)**
16-14	6.4	CRN	7	3.8
12	6.4	CRN	5	4.7
10	9.5	CRN	3	5.9
8	12.7	CRN	1	7.5
6	12.7	CRN	0	8.4
4	19.0	RNF-100	0.437	11.1
2	25.4	RNF-100	0.500	12.7
0	25.4	RNF-100	0.625	15.9

SOLDERING PROCEDURE

15. Wires are soldered to contacts in electrical connectors by means of a soldering iron, resistance heating, or a torch. Safe connections are the result of clean parts carefully soldered together. See Section 2, Chapter 7 for a description of soldering methods and procedures. When soldering wires to electrical connectors, observe the following precautions:

a. Make sure that the wire and the contact are clean and properly tinned.

NOTE

Solder type contacts size 8 and smaller are usually not removed for assembly purposes. Large solder contacts (size 4 and larger) are removed from connectors with hard inserts to protect the insert against the greater amount of heat necessary to properly solder wires to the larger contacts. Large solder contacts may be removed from connectors with resilient inserts provided the connector is not a pressurised assembly with the contacts bonded into the insert.

b. Use a soldering iron, or other heating method, with a heat capacity sufficient for the work to be soldered. Resistance soldering is recommended for sizes 8 through 0. A soldering iron is recommended for sizes 12 through 20; resistance soldering may also be used.

c. Make sure that the iron has a smooth, well tinned tip. See Section 2, Chapter 7 for detailed instructions on the care and maintenance of the soldering iron.

d. Keep electric resistance pliers clean and free from flux and solder splatter. Use a brass wire hand brush to clean contact surfaces.

e. Select a soldering iron tip of a shape to provide good heat transfer. A large area touching the contact will help to produce a good connection quickly. See Figure 10–5 for suitable soldering iron tips.

f. Use only rosin or rosin-alcohol as flux for soldering wires to connector contacts.

CAUTION

Do not use any corrosive flux for soldering an electric connector.

g. Do not hold the hot iron against the solder cup longer than necessary; this will force solder up into the conductor and stiffen the wire. Stiff wires will break under vibration.

h. Avoid having solder run on the outside of solder cup of drip into insert face. Do not move the soldered connection until the solder has hardened.

i. Solder has little mechanical strength. Do not depend on solder to keep a wire from pulling out of a contact. Use a cable clamp, grommet seal, or potting to give mechanical strength.

Electrical Resistance Soldering

16. Resistance soldering will yield excellent results for both very large and very small contacts. Large contacts are soldered to wires by the use of resistance soldering pliers, (See Figure 10–6.) The contact, removed from insert, is held in the jaws of the pliers and current is applied until the solder in the solder well has melted:

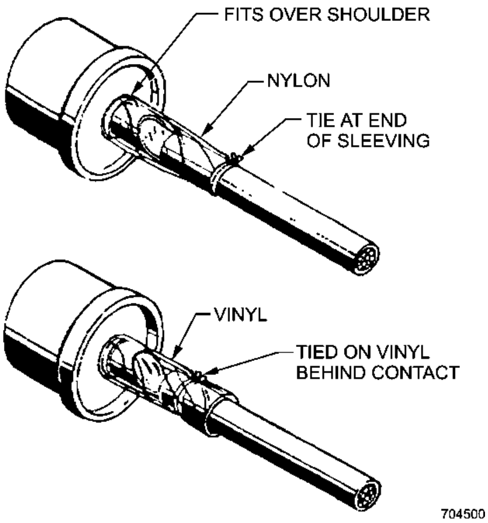


Figure 10–4 Insulating Sleeving Installed Over Solder Cup

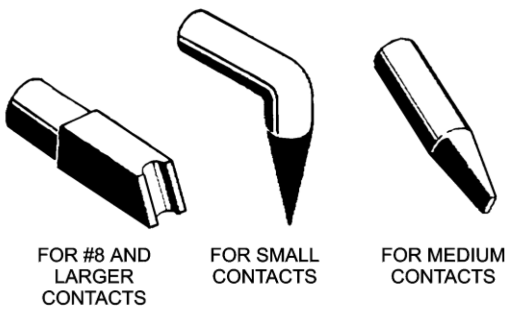


Figure 10–5 Soldering Iron Tip Shapes

a. Then the pre-tinned wire is inserted slowly into the solder cup while current is still being applied. After the wire is fully inserted, continue heating until the solder flows to form smooth fillet. Allow joint to cool and harden without movement.

b. Small contacts are heated for soldering by use of pencil type resistance soldering tool shown in Figure 10–7. The two electrodes of the tool are placed in contact with the side of the solder cup so that the heating current will pass through the wall of the cup. When the solder in the cup flows, insert the pre-tinned wire. Continue to apply heat to connection until solder flows to form smooth fillet, then stop current and allow joint to cool without movement.

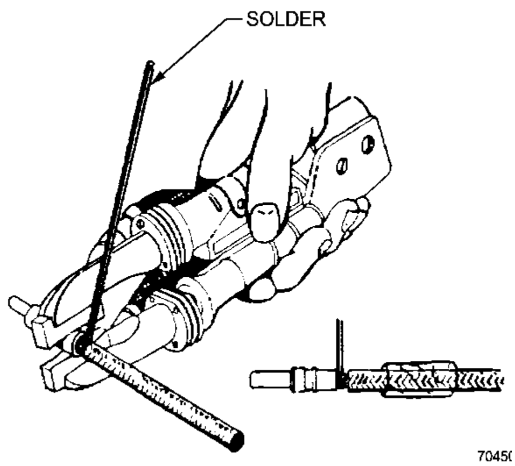


Figure 10–6 Resistance Soldering Pliers For Large Contacts

Torch Soldering

17. A torch can be used to solder wire into a large contact that has been removed from its insert (See Figure 10–8.) The contact is held in a non-metallic block to avoid heat loss, and the torch is played over the solder cup area until the solder melts.

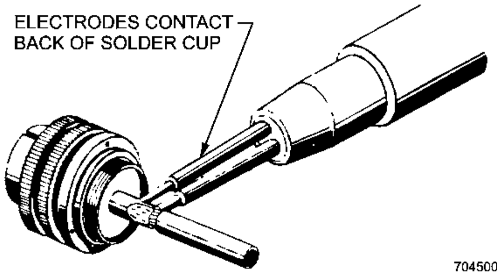


Figure 10–7 Resistance Soldering Pencil For Small Contacts

> **CAUTION**
>
> Do not overheat. Excessive heat will destroy the plating and soften the contact

18. When the solder in the cup has melted, insert the wire slowly into the cup and add more solder if necessary. Continue to heat the connection until the solder flows into a smooth fillet, then remove the flame. Allow the joint to cool without movement.

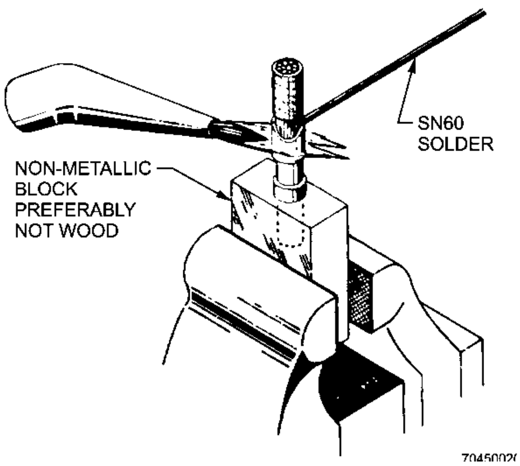


Figure 10–8 Torch Soldering Large Contact

Soldering Iron Procedure

19. Soldering with an electrically heated iron is the most common procedure. For convenience, either the iron or the connector is fastened to the bench as described in paragraph 20. Soldering is accomplished as follows:

- **a.** Large contacts which have been removed from inserts are held in a non-metallic block and soldered by first heating the solder cup with the specially shaped tip as shown in Figure 10–9. Then, while heat is still applied, the pre-tinned wire is slowly inserted into the solder cup until it bottoms. Extra solder is added to the solder cup if necessary. Hold the hot iron to the solder cup until the solder has flowed into a smooth fillet, and then allow to cool.

- **b.** Contacts that have not been removed from inserts are soldered as shown in Figure 10–10 and Figure 10–11. The solder is flowed by placing the iron alongside the solder cup as the wire-is being inserted into it. Medium size contacts such as No. 8 and No. 12 will solder more easily if the iron is held at the point where the wire touches the cutaway of the solder cup as shown in Figure 10–11. Adding a small quantity of solder at this point will aid in carrying the heat into the joint.

> **CAUTION**
>
> Do not allow solder to collect outside of the solder cup. This will reduce the arc-over distance between contacts and can result in connector failure.

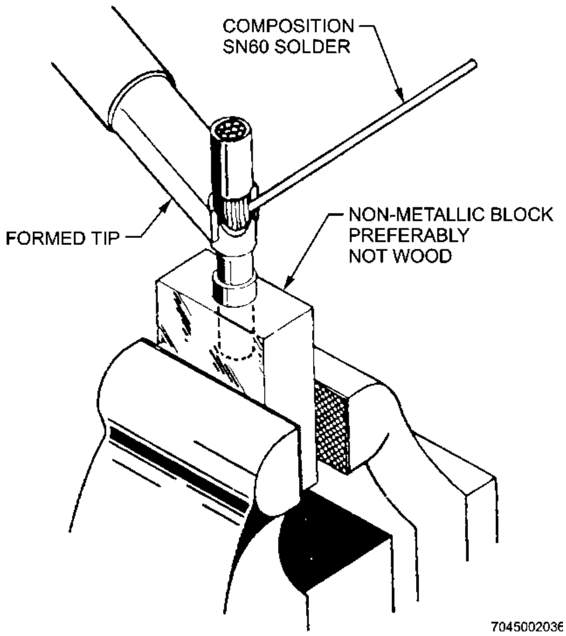


Figure 10–9 Soldering Large Size Contacts

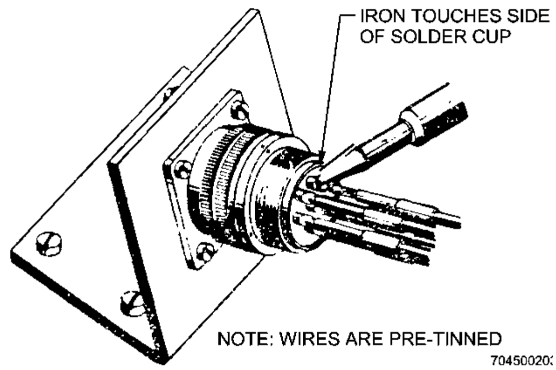


Figure 10–10 Soldering Small Size Contacts

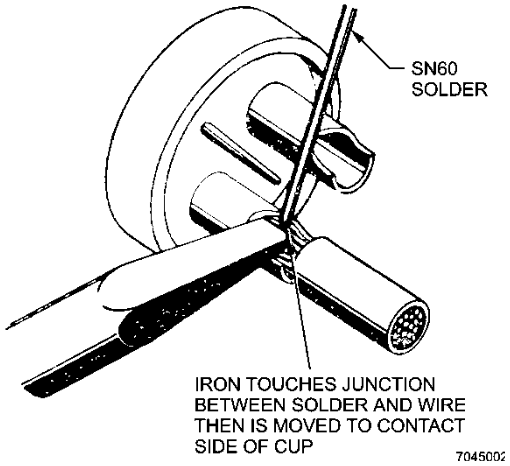


Figure 10–11 Soldering Medium Size Contacts

Holding Connectors for Soldering

20. To facilitate soldering wires to contacts that have not been removed from connectors, it is helpful to either work to a fixed soldering iron or to fasten the connector into a holding fixture. To solder connectors with a fixed iron, it is necessary to hand-hold the connector. If the connector is to be fastened to the bench, a steel bracket bent to a 60° to 75° angle is very useful.

Soldering Sequence

21. Follow a rigid sequence in soldering wires to a connector. This helps avoid errors in wiring and also prevents burning or scorching the insulation of wires already soldered. Two useful sequences are shown in Figure 10–12.

- **a.** The soldering of the connector in Figure 10–12 detail “A” is started at the right or left lower edge, depending on whether the technician is left or right-handed, and follows the bottom row across. The row above is next and is done in the same direction as the bottom row. This will permit the insert to cool between soldering operation. The operation is repeated for each row in sequence until all contacts are soldered.

> NOTE
>
> If wires are being soldered to a connector with a large number of contacts, plan the work to allow a cooling off period after each series of twenty contacts in order to prevent heat build-up.

- **b.** The sequence for the connector shown in Figure 10–12 detail “B” also starts with the bottom row from the right or left. The next step is to solder to the centre contacts working out to each edge. The final operation is to solder wires to the top row of contacts.

> NOTE
>
> The above two sequences are suggested procedures that work well. They are not mandatory, but have proved to be successful.

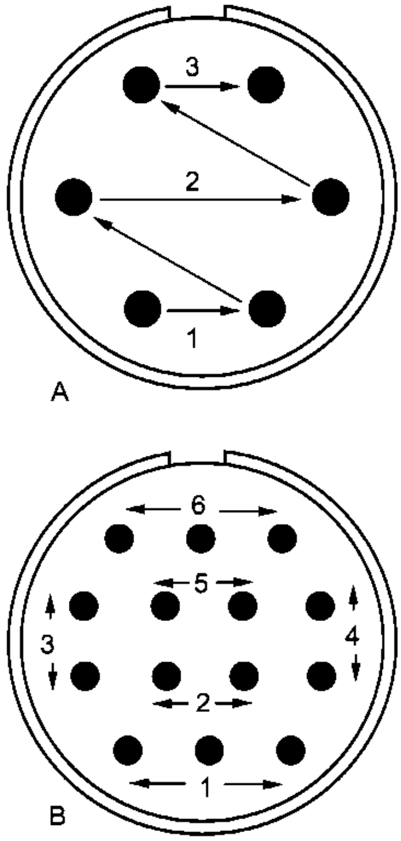


Figure 10–12 Connector Soldering Sequence

Cleaning Soldered Connections

22. After all connections have been made, examine the connector for excess solder, cold joints, and flux residues. If any of the above are found, take following corrective measures:

- **a.** Remove excess solder by using a soldering iron that has been wiped clean with a heavy, clean cloth.

- **b.** Disassemble cold joints by removing all solder with a de-soldering tool or solder removal tool and remake the connection using new 60/40 rosin-core solder.

> **WARNING**
>
> Use personnel protective equipment (eye goggles and face shield) when using compressed air.

c. Remove flux residues with denatured ethyl alcohol or other approved solutions applied with a bristle brush. Blow the connector dry with compressed air.

> **WARNING**
>
> Use correct cleaning compounds and approved procedures to clean aircraft electric components.

> **WARNING**
>
> On fuelled aircraft use only a heat source such as Compressed air/nitrogen hot air gun M83521/5-01 or equivalent.

Insulating Sleeving/Heat-Shrinkable Tubing Positioning

23. Install sleeves or heat-shrinkable tubing over the individual wires prior to assembly to solder cups. After the connections are cleaned, push the insulating sleeves or sections of heat-shrinkable tubing down over the contact until they bottom against the inserts as shown in Figure 10–13. Shrink heat-shrinkable tubing around the solder cups and terminated wire ends with hot-air gun.

24. Rotate the connector so that the pieces of tubing are fully and evenly shrunk. Where insulation sleeves are not a firm fit on the contact and wire, tie in position with nylon braid to prevent sliding back on the wires. Ensure that the ties will not interfere with the cable clamp.

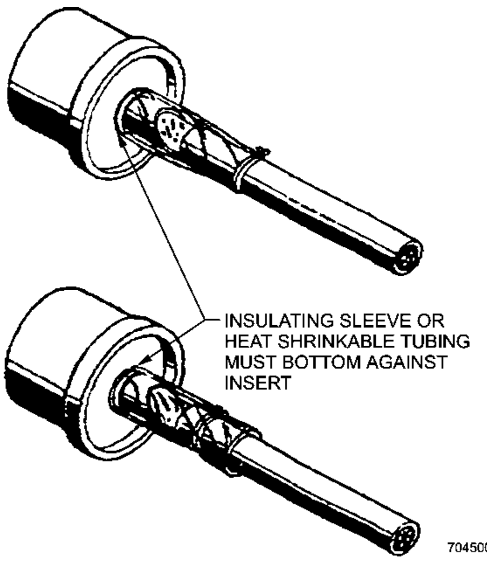


Figure 10–13 Insulation Sleeve or Heat Shrinkable Tubing Bottomed Against Insert

Preshaping Wires

25. Preshape large diameter wires (No. 14 and larger) before soldering to contacts. This will avoid strain on soldered connection when cable clamp is installed. See Figure 10–14.

> **CAUTION**
>
> Preshaping is a necessity for connectors using resilient inserts. Side strain on the contacts will cause contact splaying and prevent proper mating of pin and socket contacts.

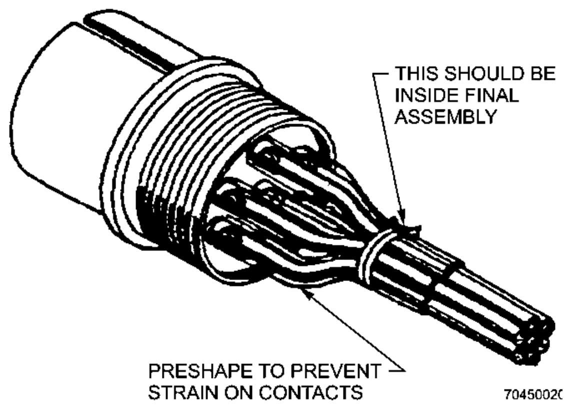


Figure 10–14 Preshaping and Tying Wires

Removable Solder Type Shielded Contacts

26. Damaged removable solder-type shielded contacts should be replaced with equivalent crimp type shielded contacts. Procedures for installing shielded contacts are packaged with the contacts.

CRIMP CONTACTS

27. Removable crimp-type contacts conforming to specification MIL-C-39029 are used with the connector types indicated in paragraph 5. The method of crimping wires to these contacts is essentially the same throughout the entire group of connectors. Standard crimping tools conforming to MIL-DTL-22520 are used to crimp the contacts. Contacts manufactured after April 1978 will be identified with BIN (basic identification on number) code colour bands (see Figure 10–15). Each digit of the BIN code will be designated on the contact by a colour band in accordance with the following:

0 – Black	5 – Green
1 – Brown	6 – Blue
2 – Red	7 – Violet
3 – Orange	8 – Grey
4 – Yellow	9 – White

28. See Table 10–5 for contact to BIN code cross reference.

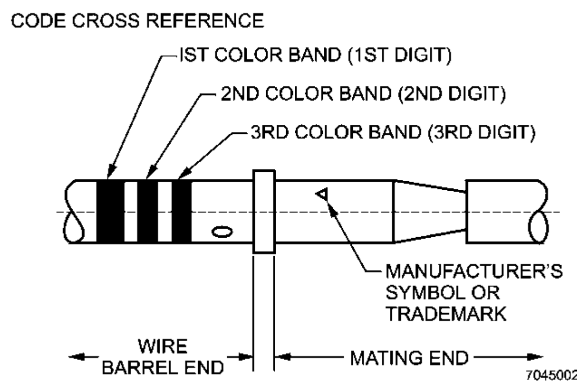


Figure 10–15 Contact Marking

HAND CRIMPING TOOLS FOR CONNECTOR CONTACTS

29. Crimping tools used for crimping removable contacts to wire conductors for use in electrical connectors, terminal junction systems, and other electrical or electronic components, should conform to MIL-DTL-22520 and one of its associated specification sheets. These tools are capable of crimping a range of contact wire barrel sizes 12 to 28, to a range of wire sizes 12 to 32. All MIL-DTL-22520 hand operated tools are cycle controlled by means of a ratchet mechanism that will not release until the crimping cycle has been completed. A brief description of each of these tools follows:

CAUTION

Do not disassemble any crimping tools. Do not tighten or loosen nuts or otherwise attempt to adjust. Required adjustments SHOULD be made only by the manufacturer, or by a calibration laboratory.

MIL-DTL-22520/1 Crimping Tool

30. The basic crimping tool, M22520/l-0l, accommodates contacts with wire barrel sizes 12 through 20 and has a provision for selecting the proper depth of crimp depending on the contact/wire combination being used. The contact is crimped by the creation of four sets of double impressions caused by the closure of the four indenters. Appropriate turret or positioner heads are installed depending on the application.

MIL-DTL-22520/2 Crimping Tool

31. The basic crimping tool, M22520/2-01, accommodates contacts with wire barrel sizes 20 through 28, and has a provision for selecting the proper depth of crimp depending on the contact/wire combination being used. The contact is crimped by the creation of four sets of double impressions caused by the closure of the four indenters. Appropriate positioners are installed depending on the application.

MIL-DTL-22520/4 Crimping Tool

32. The basic tool, MS22520/4-01, is used only with the M22520/4-02 single positioner head. This tool head combination is used to crimp outer pin and socket coaxial contacts to the shielded cables specified for them. The tool, which is not operator adjustable, creates a circular crimp around the contact. For specific tool application, see MIL-DTL-22520/4.

MIL-DTL-22520/7 Crimping Tool

33. The basic crimping tool, M22520/7-01, accommodates contacts with wire barrel sizes 16 through 22, and has a provision for selecting the proper depth of crimp depending on the contact/wire combination being used. It is similar to the M22520/2-01 in that it is smaller than the M22520/1-01 and is therefore easier to handle. It is also similar in appearance and has the same method of operation.

TOOL INSPECTION GAUGING

34. Prior to use, the crimp tool must be carefully inspected to determine correct operation. The indenters should be checked for equal travel and simultaneous movement, as the handles are closed. The indenter closing selector should also be checked to ensure a positive detent at each selector setting.

35. To ensure proper crimp dimensions during operation, a suitable 'Go/No Go' gauge is to be used for tool verification. The inspection gauge, illustrated in Figure 10-16 should be used prior to commencing any crimp operation.

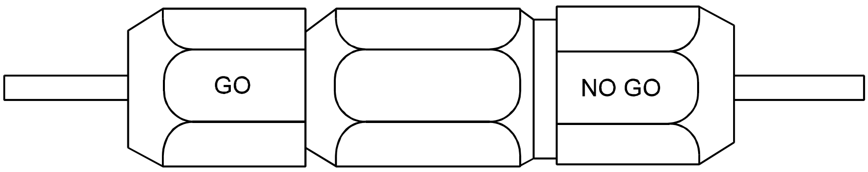


Figure 10 -16 - 'Go/No Go' Gauge

> **CAUTION**
>
> Do not crimp down on the gauge pins as this will prevent the tool from full cycling to the ratchet release position.

36. The gauge ends are colour coded green for ‘Go’ and red for ‘No Go’. The ‘Go’ end of the gauge should freely pass through indenters when the tool is in the fully closed position. Conversely, the ‘No Go’ gauge should not pass through indenters when the tool is in the fully closed position. When either gauging fails, reject the tool and have it sent for repair or calibration. The following sequence details the gauging procedure:

- **a.** Remove the safety pin from the position selector knob located on the tool frame. Pull the wire size selector knob upwards and rotate knob to setting ‘4’. Reinstall the safety pin.
- **b.** Close the handles completely and hold in fully closed position.
- **c.** Axially align the ‘Go’ end of the gauge (Green) with the indenter opening, as depicted in Figure 10-17.
- **d.** Slide the gauge into the indenter opening and through the indenters. The gauge should pass freely through the indenters, as shown in Figure 10-18. If not, the tool should no longer be used until it has been repaired.

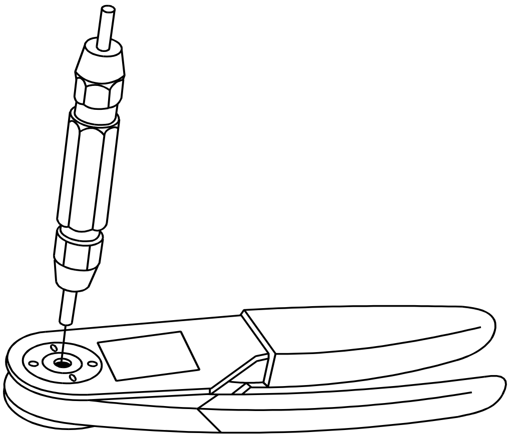


Figure 10-17 Testing the Crimp Tool

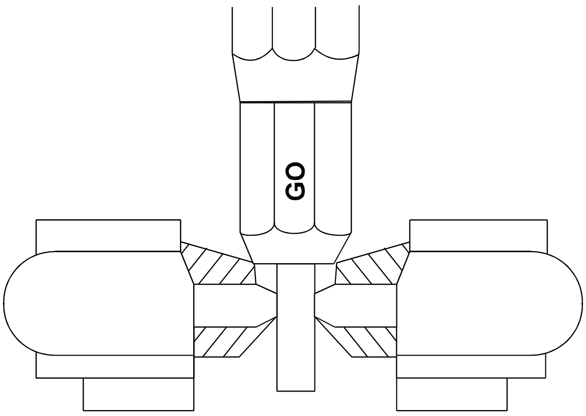


Figure 10-18 Testing a Crimp Tool

- **e.** Invert the inspection gauge while continuing to hold the handles in the fully closed position. Insert the ‘No Go’ gauge (Red) into the indenter opening, as shown in Figure 10-19. The gauge should not pass between the indenters. If the ‘No Go’ gauge does pass through the indenters, have the tool repaired.

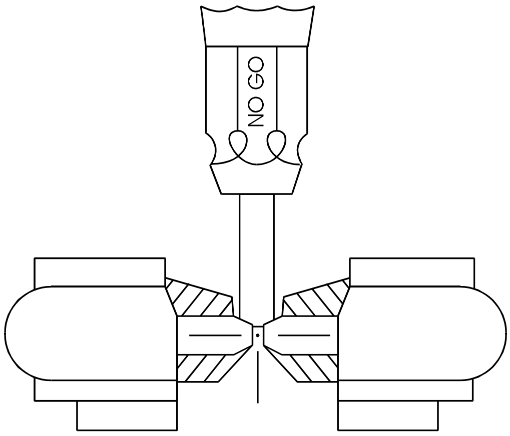


Figure 10-19 Testing a Crimp Tool

CRIMP TOOL BUILD UP AND ADJUSTMENT

37. To achieve a mechanically and electrically sound crimp contact, the proper combination of locater and selector setting is necessary. The selection of an appropriate turret head and fitment to the crimping tool is referred to as 'tool build up'. Tool build up and adjustment is performed using the following procedure and table:

Contact Size	Wire Size	Selector Setting	Turret Bushing
20	24	2	Red
20	22	3	Red
20	20	4	Red
16	20	4	Blue
16	18	5	Blue
16	16	6	Blue
12	14	7	Yellow
12	12	8	Yellow

a. Remove the safety pin from the position selector knob and rotate the knob to the required setting. Reinstall the safety pin.

b. Select the turret to suit the connector pin or socket. Each connector has a complete breakdown of information such as pin and contactor size, and the crimping tool required. Press the trigger on the turret head to release the positioner into the extended or indexing position, as illustrated in Figure 10-20.

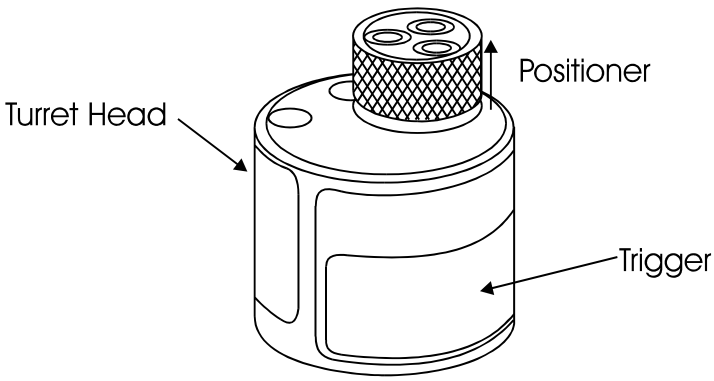


Figure 10-20 Crimp Tool Build Up and Adjustment

c. Seat the turret head onto the retainer ring on the back of the tool. Align the screws with the tapped holes ensuring correct orientation of the turret. Tighten the cap screws with an appropriately sized Allen key as shown in Figure 10-21.

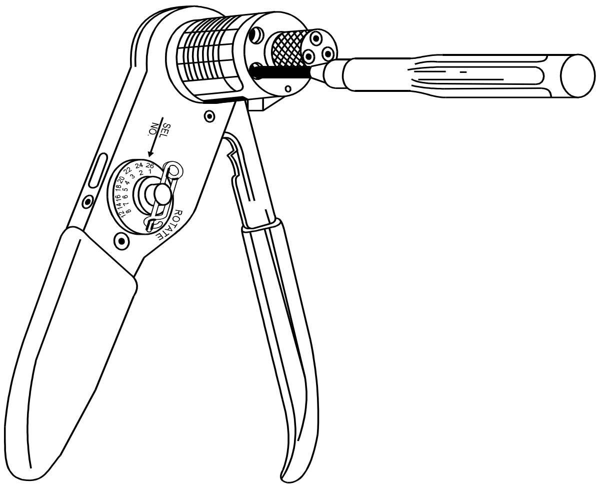


Figure 10-21 Crimp Tool Build Up and Adjustment

d. With the positioner extended, rotate, as shown in Figure 10-22 to select the matching colour index mark.

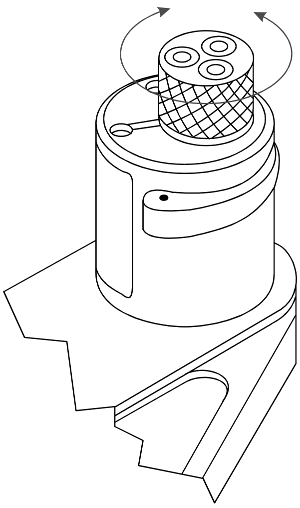


Figure 10-22 Crimp Tool Build Up and Adjustment

e. Push the positioner back in until an audible click is heard. The tool is now ready to use.

Table 10–5 Electrical Contact BIN Code Listing

Bin Code	Current Part Number	Superseded Part Number	Pin or Socket
100	M39029/1-100	M39029/1-16-22	P
101	M39029/1-101	M39029/1-16-20	P
102	M39029/1-102	M39029/1-14-16	P
103	M39029/1-103	M39029/1-12-12	P
104	M39029/2-104	M39029/2-22-22	P
105	M39029/2-105	M39029/2-20-20	P
106	M39029/2-106	M39029/2-16-16	P
107	M39029/3-107	M39029/3-22-22	S
108	M39029/3-108	M39029/3-20-20	S
109	M39029/3-109	M39029/3-16-16	S
110	M39029/4-110	M39029/4-20-20	P
		M83723-33B20	P
111	M39029/4-111	M39029/4-16-16	P
		M83723-33B16	P
112	M39029/4-112	M39029/4-16-20	P
113	M39029/4-113	M39029/4-12-12	P
		M83723-33B12	P
114	M39029/4-114	M39029/4-12-16	P
115	M39029/5-115	M39029/5-20-20	S
		M83723-34B20	S
116	M39029/5-116	M39029/5-16-16	S
		M83723-34B16	S
117	M39029/5-117	M39029/5-16-20	S
118	M39029/5-118	M39029/5-12-12	S
		M83723-34B12	S
119	M39029/5-119	M39029/5-12-16	S
120	M39029/6-120	M39029/6-01	P
121	M39029/6-121	M39029/6-02	P
122	M39029/6-122	M39029/6-03	P
123	M39029/6-123	M39029/6-04	P
124	M39029/6-124	M39029/6-05	P
125	M39029/6-125	M39029/6-06	P
126	M39029/7-126	M39029/7-001	P
127	M39029/7-127	M39029/7-002	P
128	M39029/7-128	M39029/7-003	P
129	M39029/8-129	M39029/8-001	S
130	M39029/8-130	M39029/8-002	S
131	M39029/8-131	M39029/8-003	S
132	M39029/9-132	M39029/9-20-20-C1	P
133	M39029/9-133	M39029/9-20-20-C2	P
134	M39029/9-134	M39029/9-20-20-C3	P
135	M39029/9-135	M39029/9-20-20-C4	P
136	M39029/9-136	M39029/9-20-20-C5	P
138	M39029/10-138	M39029/10-20-20-C1	S
139	M39029/10-139	M39029/10-20-20-C2	S
140	M39029/10-140	M39029/10-20-20-C3	S

Table 10–5 Electrical Contact BIN Code Listing (Continued)

Bin Code	Current Part Number	Superseded Part Number	Pin or Socket
141	M39029/10-141	M39029/10-20-20-C4	S
142	M39029/10-142	M39029/10-20-20-C5	S
144	M39029/11-144	M39029/11-22-22	P
145	M39029/11-145	M39029/11-20-20	P
146	M39029/11-146	M39029/11-16-16	P
147	M39029/11-147	M39029/11-12-12	P
148	M39029/12-148	M39029/12-22-22	S
149	M39029/12-149	M39029/12-20-20	S
150	M39029/12-150	M39029/12-16-16	S
151	M39029/12-151	M39029/12-12-12	S
152	M39029/13-152	M39029/13-01	S
153	M39029/13-153	M39029/13-02	S
154	M39029/13-154	M39029/13-03	S
155	M39029/13-155	M39029/13-04	S
156	M39029/13-156	M39029/13-05	S
157	M39029/13-157	M39029/13-06	S
158	M39029/14-158	M39029/14-01	S
159	M39029/14-159	M39029/14-02	S
160	M39029/14-160	M39029/14-03	S
161	M39029/14-161	M39029/14-04	S
162	M39029/14-162	M39029/14-05	S
163	M39029/14-163	M39029/14-06	S
166	M39029/16-166	M39029/16-23-28	S
167	M39029/16-167	M39029/16-23-22	S
168	M39029/16-168	M39029/16-20-20	S
169	M39029/16-169	M39029/16-16-16	S
170	M39029/16-170	M39029/16-12-12	S
171	M39029/17-171	M39029/17-23-28	S
172	M39029/17-172	M39029/17-23-22	S
173	M39029/17-173	M39029/17-20-20	S
174	M39029/17-174	M39029/17-16-16	S
175	M39029/17-175	M39029/17-12-12	S
176	M39029/18-176	M39029/18-23-28	P
177	M39029/18-177	M39029/18-23-22	P
178	M39029/18-178	M39029/18-20-20	P
179	M39029/18-179	M39029/18-16-16	P
180	M39029/18-180	M39029/18-12-12	P
181	M39029/19-181	M39029/19-01	P
182	M39029/19-182	M39029/19-02	P
183	M39029/19-183	M39029/19-03	P
184	M39029/20-184	M39029/20-01	P
185	M39029/20-185	M39029/20-02	P
186	M39029/20-186	M39029/20-03	P
187	M39029/21-187	M39029/21-01	S
188	M39029/21-188	M39029/21-02	S

Table 10–5 Electrical Contact BIN Code Listing (Continued)

Bin Code	Current Part Number	Superseded Part Number	Pin or Socket
189	M39029/21-189	M39029/21-03	S
190	M39029/22-190	M39029/22-22-28	S
		M39029/15-22-28	S
191	M39029/22-191	M39029/22-22-22	S
		M39029/15-22-22	S
192	M39029/22-192	M39029/22-20-20	S
193	M39029/22-193	M39029/22-16-16	S
194	M39029/23-194	M39029/23-01	P
195	M39029/23-195	M39029/23-02	P
196	M39029/23-196	M39029/23-02	P
197	M39029/23-197	M39029/23-04	P
198	M39029/23-198	M39029/23-05	P
199	M39029/24-199	M39029/24-01	S
200	M39029/24-200	M39029/24-02	S
201	M39029/24-201	M39029/24-03	S
202	M39029/24-202	M39029/24-04	S
203	M39029/24-203	M39029/24-05	S
204	M39029/25-204	M39029/25-01	P
205	M39029/25-205	M39029/25-02	P
206	M39029/25-206	M39029/25-03	P
207	M39029/26-207	M39029/26-01	S
208	M39029/26-208	M39029/26-02	S
209	M39029/26-209	M39029/26-03	S
210	M39029/27-210	M39029/27-12A	S
211	M39029/28-211	M39029/28-12A	P
212	M39029/29-212	M39029/29-16-16	P
		M83723-29T16	P
		M53162-16-16	P
213	M39029/29-213	M39029/29-12-12	P
		M83723-29T12	P
		M53162-12-12	P
214	M39029/29-214	M39029/29-8-8	P
		M83723-29T8	P
		M53162-8-8	P
215	M39029/29-215	M39029/29-4-4	P
		M83723-29T4	P
		M53162-4-4	P
216	M39029/29-216	M39029/29-0-0	P
		M83723-29T0	P
		M53162-0-0	P
217	M39029/30-217	M39029/30-16S-16	S
		M83723-30T16	S
		M53163-16S-16	S
218	M39029/30-218	M39029/30-16-16	S
		M83723-30T16	S
		M53163-16-16	S

Table 10–5 Electrical Contact BIN Code Listing (Continued)

Bin Code	Current Part Number	Superseded Part Number	Pin or Socket
219	M39029/30-219	M39029/30-12-12	S
		M83723-30T12	S
		M53163-12-12	S
220	M39029/30-220	M39029/30-8-8	S
		M83723-30T8	S
		M53163-8-8	S
221	M39029/30-221	M39029/30-4-4	S
		M83723-30T4	S
		M53163-4-4	S
222	M39029/30-222	M39029/30-0-0	S
		M83723-30T0	S
		M53163-0-0	S
223	M39029/31-223	MS3192-20-20A	P
224	M39029/31-224	MS3192-20-20C4	P
225	M39029/31-225	MS3192-20-20C1	P
226	M39029/31-226	MS3192-20-20C2	P
227	M39029/31-227	MS3192-20-20C3	P
228	M39029/31-228	MS3192-16-16A	P
229	M39029/31-229	MS24254-16P	P
230	M39029/31-230	MS3192-16-16C4	P
231	M39029/31-231	MS3192-16-16C1	P
232	M39029/31-232	MS3192-16-16C2	P
233	M39029/31-233	MS3192-16-16C3	P
234	M39029/31-234	MS3192-12-12A	P
235	M39029/31-235	MS24254-12P	P
236	M39029/31-236	MS3192-12-12C4	P
237	M39029/31-237	MS3192-12-12C1	P
238	M39029/31-238	MS3192-12-12C2	P
239	M39029/31-239	MS3192-12-12C3	P
240	M39029/31-240	MS3192-A20-20A	P
241	M39029/31-241	MS24254-20P	P
242	M39029/32-242	MS3193-20-20A	S
243	M39029/32-243	MS3193-20-20C4	S
244	M39029/32-244	MS3193-20-20C1	S
245	M39029/32-245	MS3193-20-20C2	S
246	M39029/32-246	MS3193-20-20C3	S
247	M39029/32-247	MS3193-16-16A	S
248	M39029/32-248	MS24255-16S	S
249	M39029/32-249	MS3193-16-16C4	S
250	M39029/32-250	MS3193-16-16C1	S
251	M39029/32-251	MS3193-16-16C2	S
252	M39029/32-252	MS3193-16-16C3	S
253	M39029/32-253	MS3193-12-12A	S
254	M39029/32-254	MS24255-12S	S
255	M39029/32-255	MS3193-12-12C4	S
256	M39029/32-256	MS3193-12-12C1	S

Table 10–5 Electrical Contact BIN Code Listing (Continued)

Bin Code	Current Part Number	Superseded Part Number	Pin or Socket
257	M39029/32-257	MS3193-12-12C2	S
258	M39029/32-258	MS3193-12-12C3	S
259	M39029/32-259	MS3193-A20-20A	S
260	M39029/32-260	MS24255-20S	S
261	M39029/33-261	MS3343A23-28	S
262	M39029/33-262	MS3343B23-28	S
263	M39029/33-263	MS3343A23-22	S
264	M39029/33-264	MS3343B23-22	S
265	M39029/33-265	MS3343A20-20	S
266	M39029/33-266	MS3343B20-20	S
267	M39029/33-267	MS3343A16-16	S
268	M39029/33-268	MS3343B16-16	S
269	M39029/33-269	MS3343A12-12	S
270	M39029/33-270	MS3343B12-12	S
271	M39029/34-271	MS17803-20-20	P
272	M39029/34-272	MS17803-16-20	P
273	M39029/34-273	MS17803-16-16	P
274	M39029/35-274	MS17804-20-20	S
275	M39029/35-275	MS17804-16-20	S
276	M39029/35-276	MS17804-16-16	S
277	MS39029/36-277	MS17807-16-20	P
278	MS39029/36-278	MS17807-16-16	P
279	MS39029/36-279	MS17808-16-20	S
280	MS39029/37-280	MS17808-16-16	S
287	MS39029/44-287	MS90453-16-22	P
288	MS39029/44-288	MS90453-16-16	P
289	MS39029/44-289	MS90453-12-16	P
290	MS39029/44-290	MS90453-12-12	P
291	MS39029/44-291	MS90453-8-8	P
292	MS39029/44-292	MS90453-4-4	P
293	MS39029/44-293	MS90453-0-0	P
294	MS39029/45-294	MS90454-16-22	S
295	MS39029/45-295	MS90454-16-16	S
296	MS39029/45-296	MS90454-12-16	S
297	MS39029/45-297	MS90454-12-12	S
298	MS39029/45-298	MS90454-8-8	S
299	MS39029/45-299	MS90454-4-4	S
300	MS39029/45-300	MS90454-0-0	S
301	M39029/46-301	MS90460A23-28	S
302	M39029/46-302	MS90460B23-28	S
303	M39029/46-303	MS90460A23-22	S
304	M39029/46-304	MS90460B23-22	S
305	M39029/46-305	MS90460A20-20	S
306	M39029/46-306	MS90460B20-20	S
307	M39029/46-307	MS90460A16-16	S
308	M39029/46-308	MS90460B16-16	S
309	M39029/46-309	MS90460A12-12	S

Table 10–5 Electrical Contact BIN Code Listing (Continued)

Bin Code	Current Part Number	Superseded Part Number	Pin or Socket
310	M39029/46-310	MS90460B12-12	S
311	M39029/47-311	MS90461-A23-28	P
312	M39029/47-312	MS90461-B23-28	P
313	M39029/47-313	MS90461-A23-22	P
314	M39029/47-314	MS90461-B23-22	P
315	M39029/47-315	MS90461-A20-20	P
316	M39029/47-316	MS90461-B20-20	P
317	M39029/48-317	MS90559-11	P
318	M39029/48-318	MS90559-12	P
319	M39029/48-319	MS90559-14	P
320	M39029/48-320	MS90559-8	P
321	M39029/48-321	MS90559-9	P
322	M39029/48-322	MS90559-13	P
323	M39029/48-323	MS90559-5	P
324	M39029/48-324	MS90559-6	P
325	M39029/48-325	MS90559-3	P
326	M39029/48-326	MS90559-4	P
327	M39029/48-327	MS90559-1	P
328	M39029/48-328	MS90559-2	P
329	M39029/49-329	MS90560-7	S
330	M39029/49-330	MS90560-8	S
331	M39029/49-331	MS90560-5	S
332	M39029/49-332	MS90560-9	S
333	M39029/49-333	MS90560-3	S
334	M39029/49-334	MS90560-2	S
335	M39029/49-335	MS90560-1	S
336	M39029/47-336	MS90461-A16-16	P
337	M39029/47-337	MS90461-B16-16	P
338	M39029/47-338	MS90461-A12-12	P
339	M39029/47-339	MS90461-B12-12	P
340	M39029/50-340	N83733/13-12	P
341	M39029/51-341	N83733/14-12	S
342	M39029/54-342	MS27184-22P	P
343	M39029/54-343	MS27184-20P	P
344	M39029/55-344	MS27185-22S	S
345	M39029/55-345	MS27185-20S	S
348	M39029/56-348	MS27490-22D	S
349	M39029/56-349	MS27490-22M	S
350	M39029/56-350	MS27490-22	S
351	M39029/56-351	MS27490-20	S
352	M39029/56-352	MS27490-16	S
353	M39029/56-353	MS27490-12	S
354	M39029/57-354	MS27491-22D	S
355	M39029/57-355	MS27491-22M	S
356	M39029/57-356	MS27491-22	S
357	M39029/57-357	MS27491-20	S
358	M39029/57-358	MS27491-16	S

Table 10–5 Electrical Contact BIN Code Listing (Continued)

Bin Code	Current Part Number	Superseded Part Number	Pin or Socket
359	M39029/57-359	MS27491-12	S
360	M39029/58-360	MS27493-22D	P
361	M39029/58-361	MS27493-22M	S
362	M39029/58-362	MS27493-22	S
363	M39029/58-363	MS27493-20	S
364	M39029/58-364	MS27493-16	P
365	M39029/58-365	MS27493-12	P
366	M39029/59-366	MS27535	P
367	M39029/60-367	MS27536	P
368	M39029/63-368	MS24308/10-1	P
369	M39029/64-369	MS24308/11-1	P
384	M39029/69-384	M39029/69-1	P
385	M39029/69-385	M39029/69-2	P
386	M39029/69-386	M39029/69-3	P
387	M39029/70-387	M39029/70-1	P
388	M39029/70-388	M39029/70-2	P
389	M39029/70-389	M39029/70-3	P
390	M39029/71-390	M39029/71-1	P
391	M39029/71-391	M39029/71-2	P
392	M39029/71-392	M39029/71-3	P
393	M39029/72-393	M39029/72-1	S
394	M39029/72-394	M39029/72-2	S
395	M39029/72-395	M39029/72-3	S
396	M39029/73-396	M39029/73-12A	S
397	M39029/73-397	M39029/73-12B	S
398	M39029/73-398	M39029/73-12C	S
399	M39029/74-399	M39029/74-12A	P
400	M39029/74-400	M39029/74-12B	P
401	M39029/74-401	M39029/74-12C	P
402	M39029/27-402	M39029/27-12B	S
403	M39029/27-403	M39029/27-12C	S
404	M39029/27-404	M39029/27-12D	S
405	M39029/27-405	M39029/27-12E	S
406	M39029/27-406	M39029/27-12F	S
407	M39029/27-407	M39029/27-12G	S
408	M39029/27-408	M39029/27-12H	S
409	M39029/28-409	M39029/28-12B	P
410	M39029/28-410	M39029/28-12C	P
411	M39029/28-411	M39029/28-12D	P
412	M39029/28-412	M39029/28-12E	P
413	M39029/28-413	M39029/28-12F	P
414	M39029/28-414	M39029/28-12G	P
415	M39029/28-415	M39029/28-12H	P
416	M39029/75-416	M39029/75-12A	S
417	M39029/75-417	M39029/75-12B	S
418	M39029/75-418	M39029/75-12C	S
419	M39029/75-419	M39029/75-12D	S

Table 10–5 Electrical Contact BIN Code Listing (Continued)

Bin Code	Current Part Number	Superseded Part Number	Pin or Socket
420	M39029/75-420	M39029/75-12E	S
421	M39029/75-421	M39029/75-12F	S
422	M39029/75-422	M39029/75-12G	S
423	M39029/75-423	M39029/75-12H	S
424	M39029/76-424	M39029/76-16A	P
425	M39029/76-425	M39029/76-16B	P
426	M39029/76-426	M39029/76-16C	P
427	M39029/76-427	M39029/76-16D	P
428	M39029/77-428	M39029/77-16A	S
429	M39029/77-429	M39029/77-16B	S
430	M39029/77-430	M39029/77-16C	S
431	M39029/77-431	M39029/77-16D	S
432	M39029/78-432	M39029/78-16A	S
433	M39029/78-433	M39029/78-16B	S
434	M39029/78-434	M39029/78-16C	S
435	M39029/78-435	M39029/78-16D	S
436	M39029/79-436	M39029/79-16A	P
437	M39029/79-437	M39029/79-16B	P
438	M39029/80-438	M39029/80-16A	S
439	M39029/80-439	M39029/80-16B	S
440	M39029/34-440	M39029/34-22-22	P
441	M39029/35-441	M39029/35-22-22	S
448	M39029/31-448	M39029/31-20-20	P
449	M39029/32-449	M39029/32-20-20	S
450	M39029/83-450	M39029/83-20-22	P
451	M39029/83-451	M39029/83-20-28	P
452	M39029/84-452	M39029/84-20-22	S
453	M39029/84-453	M39029/84-20-28	S
454	M39029/85-454	M39029/85-16-16-C1	P
455	M39029/85-455	M39029/85-16-16-C2	P
456	M39029/85-456	M39029/85-16-16-C3	P
457	M39029/85-457	M39029/85-16-16-C4	P
458	M39029/85-458	M39029/85-12-12-C1	P
459	M39029/85-459	M39029/85-12-12-C2	P
460	M39029/85-460	M39029/85-12-12-C3	P
461	M39029/85-461	M39029/85-12-12-C4	P
462	M39029/86-462	M39029/86-16-16-C1	S
463	M39029/86-463	M39029/86-16-16-C2	S
464	M39029/86-464	M39029/86-16-16-C3	S
465	M39029/86-465	M39029/86-16-16-C4	S
466	M39029/86-466	M39029/86-12-12-C1	S
467	M39029/86-467	M39029/86-12-12-C2	S
468	M39029/86-468	M39029/86-12-12-C3	S
469	M39029/86-469	M39029/86-12-12-C4	S
470	M39029/87-470	M39029/87-22-22-C1	P
471	M39029/87-471	M39029/87-22-22-C2	P
472	M39029/87-472	M39029/87-22-22-C3	P

Table 10–5 Electrical Contact BIN Code Listing (Continued)

Bin Code	Current Part Number	Superseded Part Number	Pin or Socket
473	M39029/87-473	M39029/87-22-22-C4	P
474	M39029/87-474	M39029/87-20-20-C1	P
475	M39029/87-475	M39029/87-20-20-C2	P
476	M39029/87-476	M39029/87-20-20-C3	P
477	M39029/87-477	M39029/87-20-20-C4	P
478	M39029/87-478	M39029/87-16-16-C1	P
479	M39029/87-479	M39029/87-16-16-C2	P
480	M39029/87-480	M39029/87-16-16-C3	P
481	M39029/87-481	M39029/87-16-16-C4	P
482	M39029/88-482	M39029/88-22-22-C1	S
483	M39029/88-483	M39029/88-22-22-C2	S
484	M39029/88-484	M39029/88-22-22-C3	S
485	M39029/88-485	M39029/88-22-22-C4	S
486	M39029/88-486	M39029/88-20-20-C1	S
487	M39029/88-487	M39029/88-20-20-C2	S
488	M39029/88-488	M39029/88-20-20-C3	S
489	M39029/88-489	M39029/88-20-20-C4	S
490	M39029/88-490	M39029/88-16-16-C1	S
491	M39029/88-491	M39029/88-16-16-C2	S
492	M39029/88-492	M39029/88-16-16-C3	S
493	M39029/88-493	M39029/88-16-16-C4	S
494	M39029/89-494	M39029/89-22-22-C1	S
495	M39029/89-495	M39029/89-22-22-C2	S
496	M39029/89-496	M39029/89-22-22-C3	S
497	M39029/89-497	M39029/89-22-22-C4	S
498	M39029/89-498	M39029/89-20-20-C1	S
499	M39029/89-499	M39029/89-20-20-C2	S
500	M39029/89-500	M39029/89-20-20-C3	S
501	M39029/89-501	M39029/89-20-20-C4	S
502	M39029/89-502	M39029/89-16-16-C1	S
503	M39029/89-503	M39029/89-16-16-C2	S
504	M39029/89-504	M39029/89-16-16-C3	S
505	M39029/89-505	M39029/89-16-16-C4	S
506	M39029/89-506	------	S
507	M39029/89-507	M39029//-20-22D	S
508	M39029/83-508	------	P
509	M39029/84-509	------	S
528	M39029/58-528	------	P
529	M39029/90-529	------	S

Table 10–6 Specification Replacements

MIL-DTL-83723, Series I are replaced by MIL-C-26482 as shown below	
MIL-DTL-83723 Specification Sheet	**Superseded By**
1 and 2	MS3470
3 and 4	MS3472
5 and 6	MS3474
7 and 8	MS3471
9 and 10	MS3440
11 and 12	MS3443
13 and 14	MS3476
33	MIL-C-39029/4
34	MIL-C-39029/4
36, 37, 38, 39, 40 and 41	No superseding document
42 and 43	MS3475
44	MS3181
45	MS3115
46	MS3180
48 and 49	No superseding document
MIL-DTL-83723, Series II are replaced by MIL-DTL-5015 as shown below	
MIL-DTL-83723 Specification Sheet	**Superseded By**
17 and 18	MS3451
19 and 20	MS3450
21 and 22	MS3452
23 and 24	MS3456
25	MS3141
26	MS3143
27	MS3109 or MS3117 and MS3158 or MS3416
29	MIL-C-29029/29
30	MIL-C-29029/30
35	No superseding document
50	No superseding document
52 and 53	MS3459

Table 10–7 Crimping Tool Inspection Gauges and Selector Settings

Crimping Tool Part Number	Inspection Gauge Part Number	Selector Setting
M22520/1-01	M22520/3-1	4
M22520/2-01	M22520/3-1	8
M22520/4-01	M22520/3-2	Not applicable
M22520/7-01	M22520/3-3	8

Inspection of M22520/1-01, M22520/2-01, M22520/4-01, M22520/7-01 Basic Tools

38. Inspection gauging is performed on the basic tool only. However, the tools may be gauged with a positioning device installed as long as it does not interfere with the gauging operation. If the presence of the positioning device makes gauging difficult, remove it before inspecting. The inspection procedure is as follows:

- **a.** Select the proper inspection gauge to be used from Table 10–7.
- **b.** Set the selector at the proper selector number as specified in Table 10–7.
- **c.** Close the handles completely and hold.
- **d.** The GO gauge (green end) should pass freely through the indenter tips.
- **e.** The NO GO gauge (red end) should not enter through the indenter tips.

TYPES OF CONTACT POSITIONING DEVICES

39. All crimping tools have positioning devices available that are used for locating contacts in the proper relation to the tool indenters. The following is a brief description of the types of positioners used for the various types of tools:

M22520/1-01 Basic Tools

40. These tools use turret heads, single positioner heads and universal heads.

- **a.** **Turret Heads.** These heads have a turret that has three separate positioners that are colour coded and marked with the applicable contact size accommodated by each individual positioner within the head. The colour and contact size correspond to the information on the foil label (data plate) attached to the side of the head. The proper positioner is selected for the contact type and size to be crimped by referring to the data plate.
- **b.** **Single Position Heads.** These heads have only one positioner and are not adjustable. They also have data plates which provide crimping information.
- **c.** **Universal Heads.** These heads are used for locating contacts which are not military standard or for which no positioning heads are available. They are adjusted for each application while attached to the tool as described below, but have no data plate with crimping information.

M22520/2-01and M22520/7-01 Basic Tools

41. These tools use locating devices known as positioners. They are individual locators with a data plate attached to the top that specifies the contact part numbers(s) accommodated, and correlates the wire sizes.

M22520/4-01 Basic Tool

42. This is a single purpose tool that only uses the M22520/4-02 single positioner head that is not operator adjustable.

CRIMPING PROCEDURES

M22520/1-01 Crimping Tools with Turret Heads and Single Position Heads

43. The procedure for crimping contacts to wire conductors is as follows:

- **a.** Select the proper positioning head to be used for the contacts being crimped.
- **b.** If the head to be used is a turret head, first depress the turret trigger to release the turret portion to the indexing or extended position as shown in Figure 10–23.
- **c.** Place the head over the retaining ring on the back of too1 (selector side) and seat against the tool body; secure the 3.5mm socket head screws with Allen wrench (see Figure 10–23). If the positioning head is the single positioner type, omit steps d. and e.
- **d.** If the positioning head is the turret type, it has three separate positioners that are colour coded and marked with the applicable contact size accommodated by each individual positioner. The colour code and contact size correspond to the information contained on the data plate. Refer to the data plate to select the proper positioner to be used for the contact being crimped.
- **e.** Rotate the turret until the correct positioner is lined up with the index mark on the turret head and push the turret in until it snaps into the locked position (see Figure 10–23).

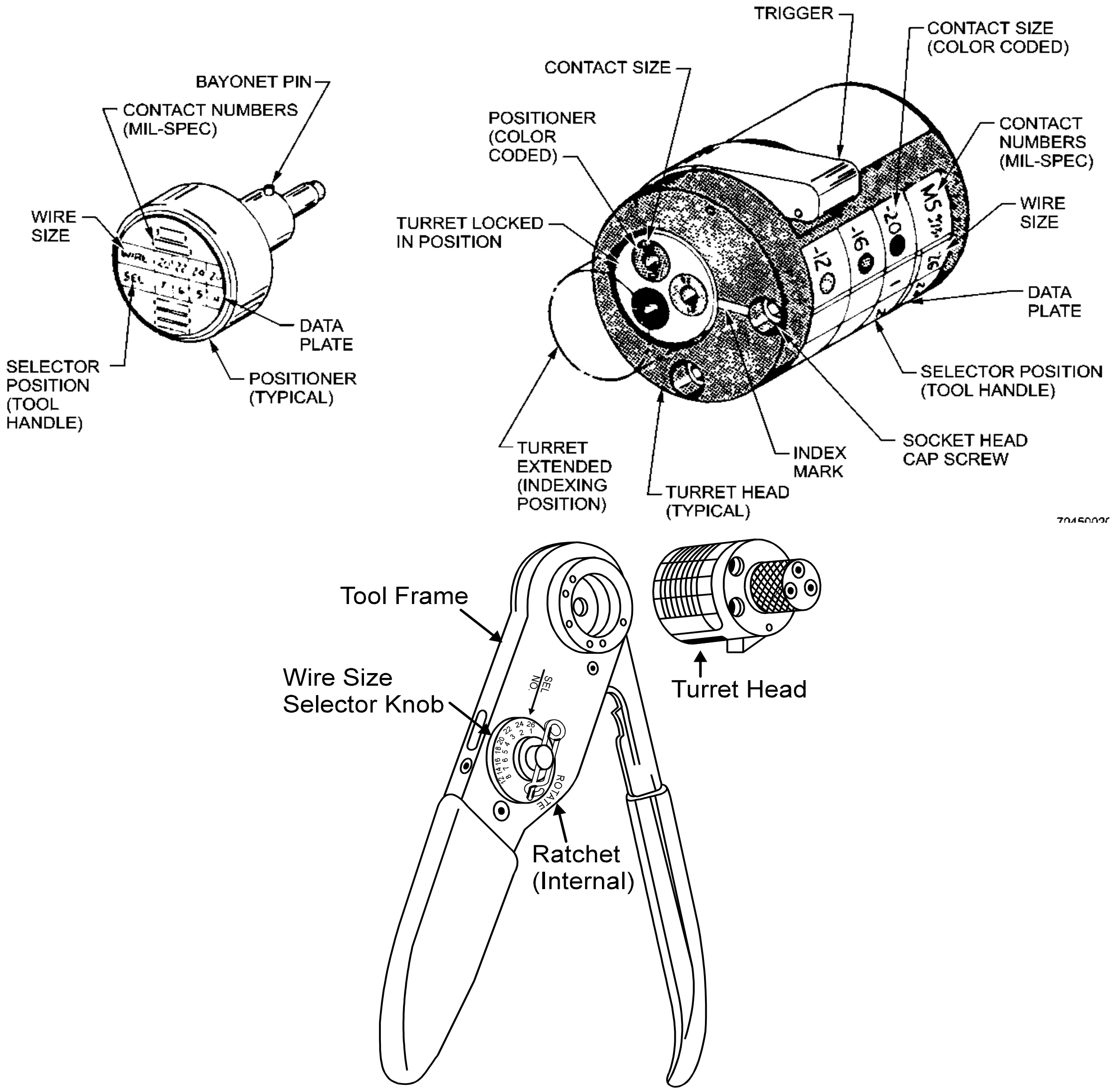


Figure 10–23 Typical M22520 Positioner and Turret Head

f. Refer again to the data plate for the correct selector setting for the wire size being used. With the handles fully open, remove spring clip lock wire from selector knob, lift and rotate the selector knob (or slide the thumb button) to the correct setting and release and reinstall spring clip lock wire.

g. Determine the proper length of insulation to be removed. Wire must be visible in inspection hole, insulation must be between 0.4mm and 0.8mm from end of contact. Strip the insulation from the conductor by using any of the methods described in Section 2, Chapter 3.

h. Insert the stripped wire into the wire barrel of the contact until the end of the wire can be seen through the inspection hole. Insert the wire and contact through the indenters on the front side of tool (opposite from selector side) until it bottoms and fully seats in the positioner.

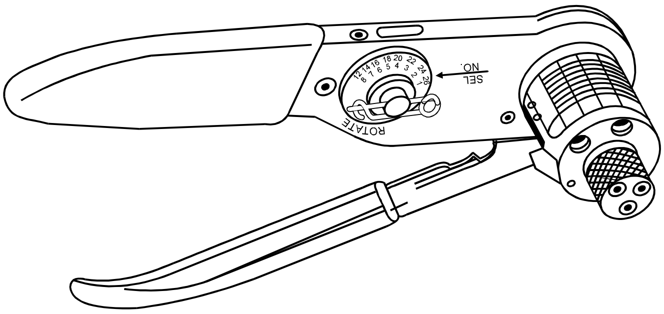
NOTE

When crimping contacts with an insulation support cup, make sure the insulation extends into it (0.4 to 0.8 mm from bottom of cup).)

i. Hold the wire and contact in place and squeeze the tool handles until they fully bottom and the ratchet releases, allowing the handles to automatically return the open position.

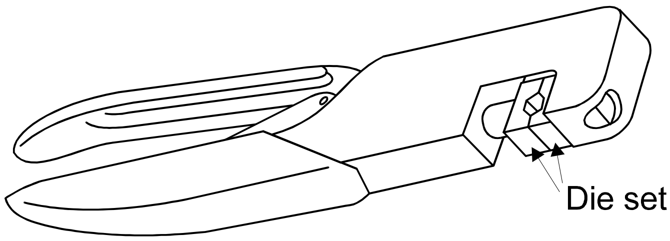
j. Remove the crimped contact and inspect, making sure the wire strands are visible through the inspection hole in the contact wire barrel (see Figure 10–25).

Type 1 crimp tools are those which produce an indent crimp.



Type 1 Crimping Tool (Indent Crimp)

Type 2 crimp tools are used to produce a formed crimp.



Type 2 Crimping Tool (Formed Crimp)

Figure 10–24 M22520 Crimping Tools

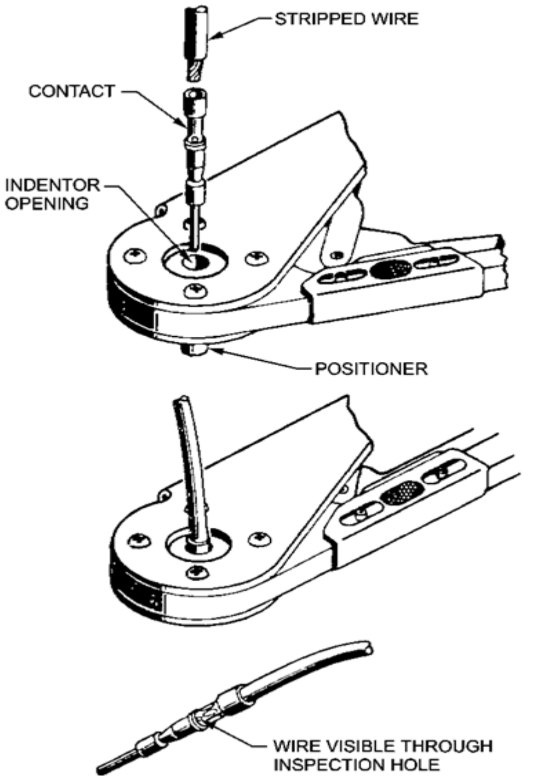


Figure 10–25 Assembling Wires to Crimp Type Contacts

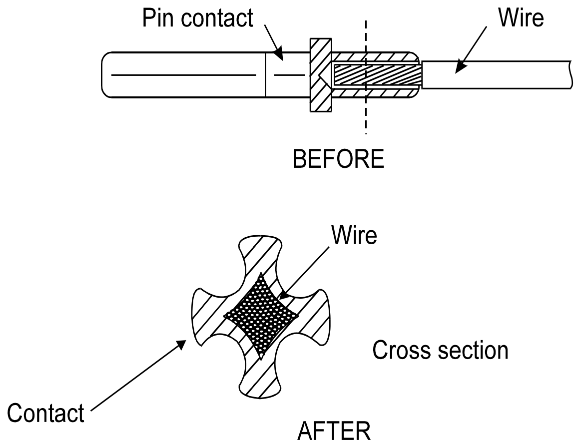


Figure 10-26

44. Type 2 crimp tools, are used to produce a formed crimp. The tool can be fitted with a number of different die sets used to compress the barrel of a crimp into a variety of shapes. Figure 10-27 shows a cross sectional view of various formed crimps.

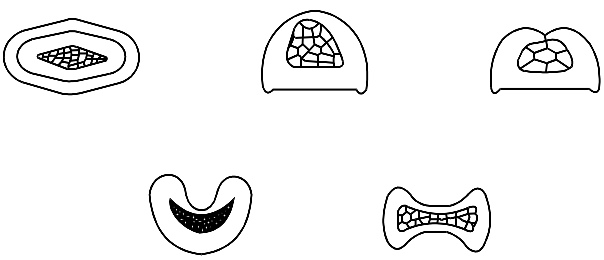


Figure 10-27 Cross Sectional Views Of Type 2 Crimps

M22520/1-01 Crimping Tools with Universal Heads

45. The universal head may be used when a turret or single position head is not available. The procedure is as follows:

- **a.** Rotate the lock nut counter clockwise to the released position and turn adjustment nut counter-clockwise until head can be seated on tool.
- **b.** Place the head over the retaining ring on the back of the tool (selector side) and seat against the tool body; secure the 3.5mm socket head screws with an Allen wrench. With the tool handles fully open, remove spring clip lock wire from selector knob, raise and rotate the selector knob (or slide the thumb button) until the arrow is in line with the wire size being crimped, release selector knob and reinstall spring clip lock wire.

CAUTION

The wire sizes are for reference only. They are based on the use of MIL-W-22759 silver plated wire crimped in MS3190 wire barrels. Settings must be established when using other contact/wire combinations.

- **c.** Turn adjustment screw on head clockwise until it stops. With the tool opening facing up, insert contact through indenter opening into positioner until it bottoms. Begin turning adjustment screw out until indenters are cantered between inspection hole and end of wire barrel. If contact has insulation support cup, centre the indenters between inspection hole and bottom of cup.
- **d.** Without turning the adjustment screw, tighten lock nut against head.
- **e.** Strip wire, insert wire and contact, crimp and inspect.

M22520/2-01 and M22520/7-01 Crimping Tools with Positioners

46. The procedure for the crimping contacts with these tools is as follows:

- **a.** Select the proper positioner to be used for the contact being crimped.
- **b.** Insert the positioner into the retaining ring on the back of the tool (selector side). The positioner is spring-loaded and must be pushed in and then rotated 90° clock-wise until it locks into position. Insert the spring clip lock wire (if present) through the retaining ring.
- **c.** Refer to the data plate for the correct selector setting for the wire size being used. With the handles fully open, remove spring clip lock wire from selector knob, lift and rotate the selector knob to the correct setting and release and reinstall spring clip lock wire.
- **d.** Strip wire. Insert wire and contact, crimp and inspect.

CRIMPING TOOL KITS

47. There are several crimping tool kits available for maintenance use.

INSTALLING AND REMOVING CRIMP TYPE CONTACTS

Insertion Tools for Front Release Crimp Type Contacts

48. Type tools for inserting contacts into front release connector inserts are shown in Figure 10–28. There is a separate tool for each contact size. Contact sizes are listed in Table 10–8. An indicating band on the working end of the tool determines the correct depth of tool insertion. Use these tools to insert contacts in front release connectors with removable contacts.

Table 10–8 Contacts and Their Wire Size Range

Contact Size	Wire Size Range
20	24-20
16	22-16
12	14-12
8	10-8
4	6-4
0	2-0

Assembling Wired Contacts into Front Release Connector

49. Insert the crimped contact into the connector as follows:

a. Slide rear accessories back onto wire bundle.

> NOTE
>
> Before attempting any insertion of contacts into MIL-C-81511 series 1 or 2 connectors, determine that the rear nut assembly is in the unlocked position. A coloured stripe will appear when the rear nut assembly is rotated counter clockwise. At this point, the connector is in position for both insertion and removal of contacts.

b. Select the correct insertion tool. Insert the crimped end of the contact into the hollow end of the insertion tool, and lay along handle (see Figure 10–28).

c. Guide the contact into the correctly numbered grommet hole in the rear face of the insert and feed the contact carefully into the hole.

d. Push the tool straight in at right angles to the grommet surface, until the contact is fully seated.

e. Withdraw the tool, keeping it perpendicular to the grommet face.

f. Gently pull on wire to make sure contact is held in place.

g. Fill all unused holes with unwired contacts and sealing plugs of appropriate size.

> NOTE
>
> After all contacts and sealing plugs have been inserted into MIL-C-81511 series 1 and 2 connectors, tighten the rear nut by turning clockwise until the locking nut is tight.

> **CAUTION**
>
> Do not attempt to reseat a contact once the insertion tool has been removed. Remove contact and start again with contact barrel properly located in tool. Failure to follow this precaution will cause insertion tool to shear barrel while inside grommet. Sharp edge of sheared material will cut through grommet web and cause short circuit.

Alternative Front Release Contact Assembly Procedure

50. If desired, the following procedure may be used to insert wired contacts into the connector:

a. Push the wired contact carefully into the correct grommet hole. Do not push all the way in.

b. Slide the insertion tool over the contact barrel. (See Figure 10–21).

c. Complete the procedure by following steps d, e, f and g of paragraph 45. Observe caution and note in paragraph 45.

Extraction Tools for Front Release Crimp Type Contacts

51. Typical tools for extracting contacts from front-release connector inserts are shown in Figure 10–28. The sizes for each contact are listed in Table 10–8. This tool has a hollow cylindrical probe which fits snugly over the pin or socket end of the contact and releases the insert retention clip when pushed over the contact. Two indicating bands determine correct depth; the band nearest the working end of the tool is for pin contacts, the other for socket contacts. The extraction tool has a thrust assist collar (or slide) which is pushed forward to eject the contact from the insert retention clip by means of an internal plunger. Use these tools to remove contacts from front release connectors with removable contacts.

Removing Contacts from Front Release Connectors

52. Remove contacts from the connector as follows:

a. Select the correct extraction tool for the contact to be removed.

b. Slide rear accessories back on the wire bundle.

> NOTE
>
> On MIL-C-81511 series 1 and 2 connectors, loosen the rear nut assembly by turning it counter clockwise when viewed from the wire end. Approximately 1.5mm of axial movement unlocks the contacts. The coloured stripe will fully appear. The connector is now in position for removal of contacts.

Broken Wire Contact Removal

53. The removal of a contact from a plug when the wire is broken is as follows:

a. Using the insertion removal tool, insert the white tip 3.0 mm into rear of connector as shown in Figure 10-28.

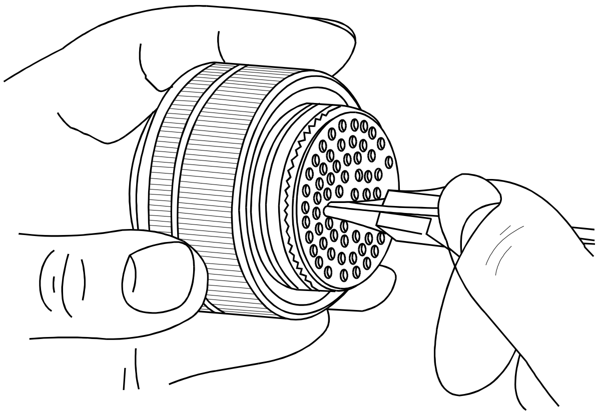


Figure 10-28 Broken Wire Contact Removal

b. If resistance is felt, withdraw tool slightly and rotate tool 1/6 of a turn and reinsert. Repeat this step until tool passes the resistance area. Continue until a positive stop is felt.

c. Exert pressure on the mating end of the contact (from the front of the connector as shown in Figure 10-29 with pin or socket.

d. Use pressure on the mating end of the contact to push the broken contact out of the connector before disengaging the tool from the connector.

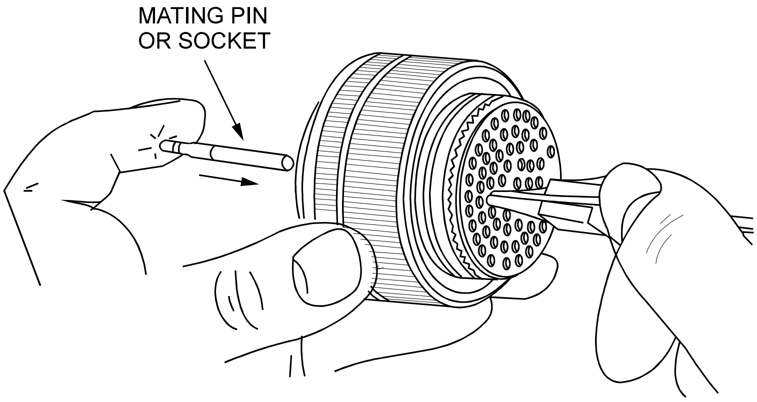


Figure 10-29 Broken Wire Contact Removal

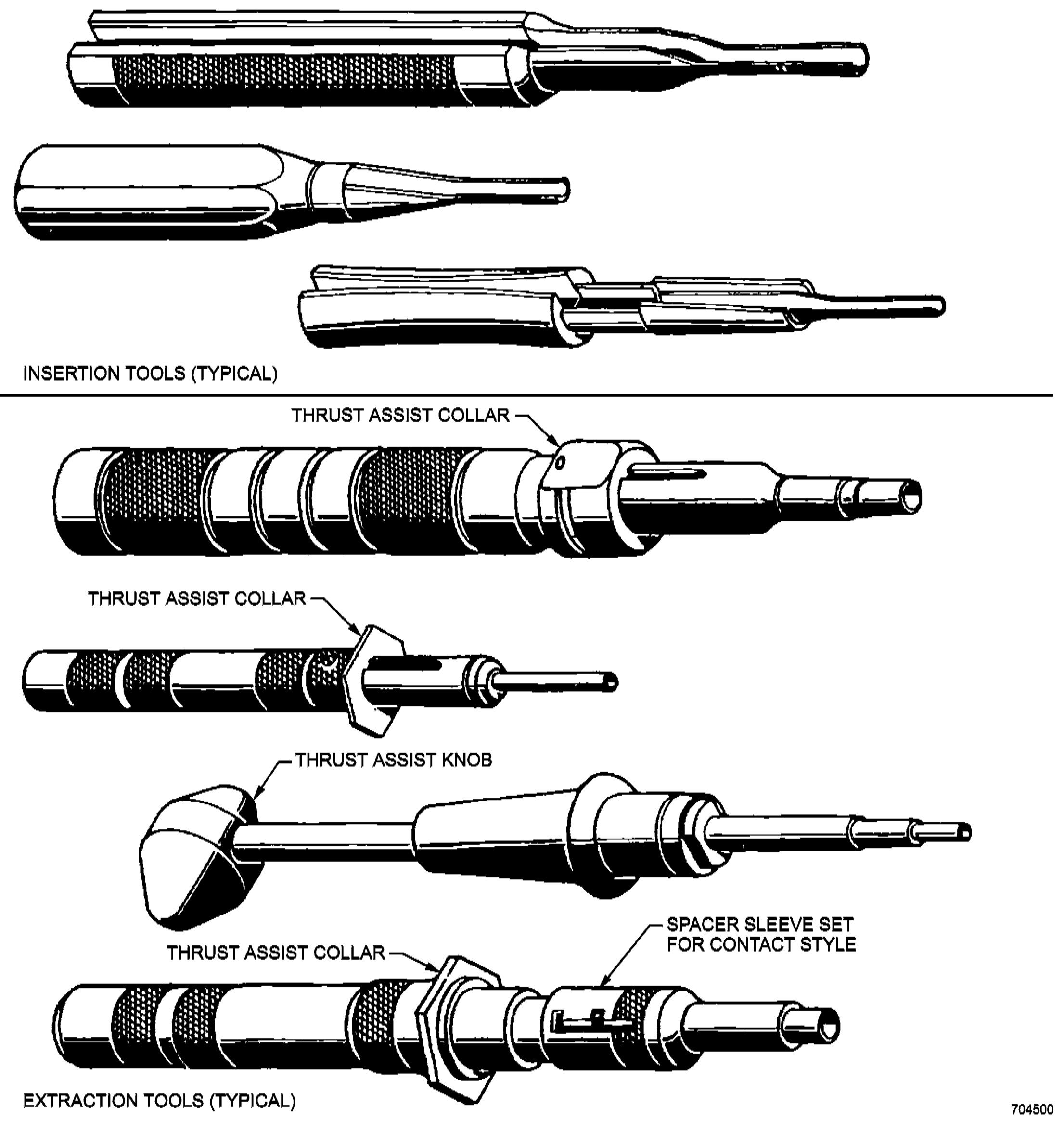
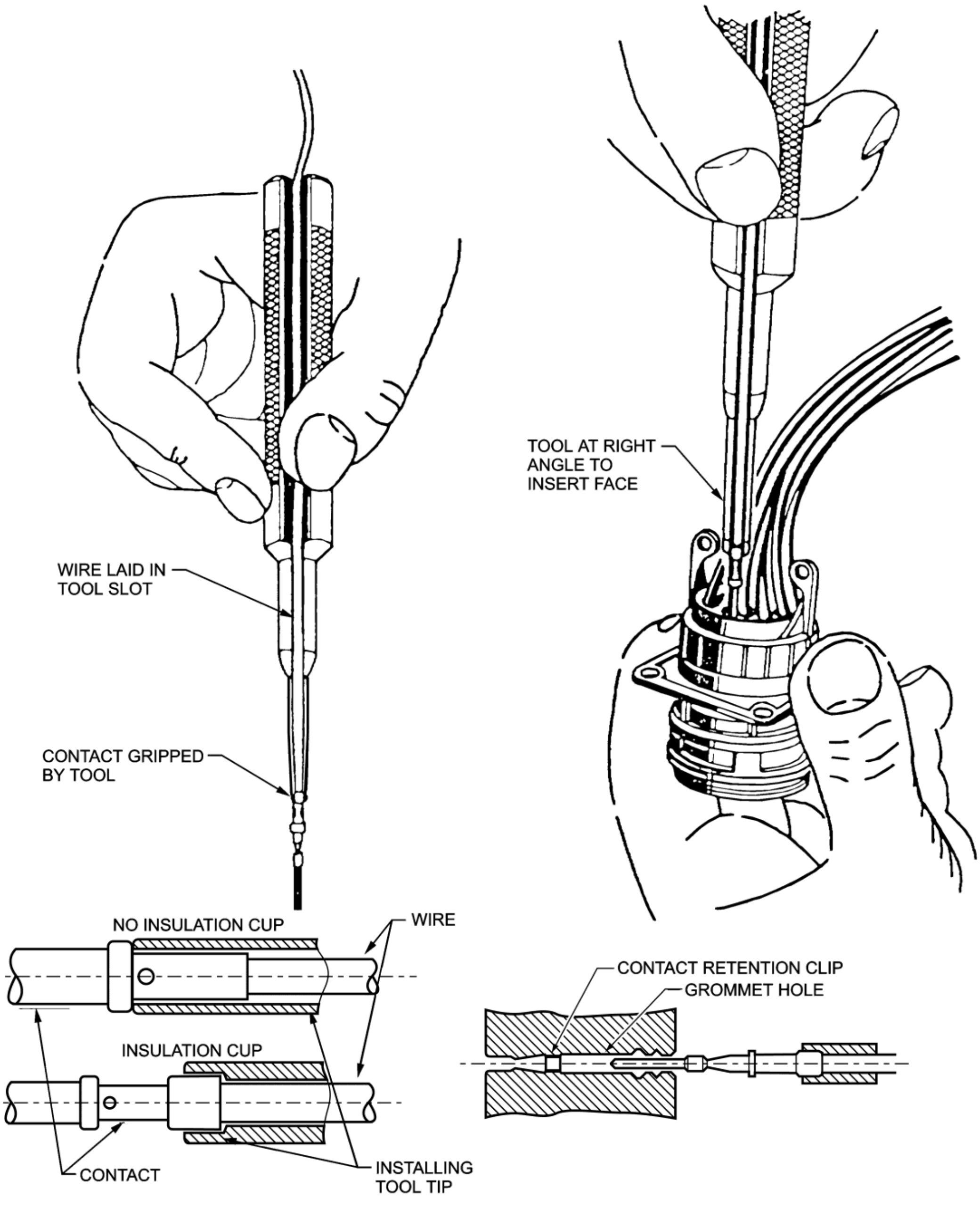
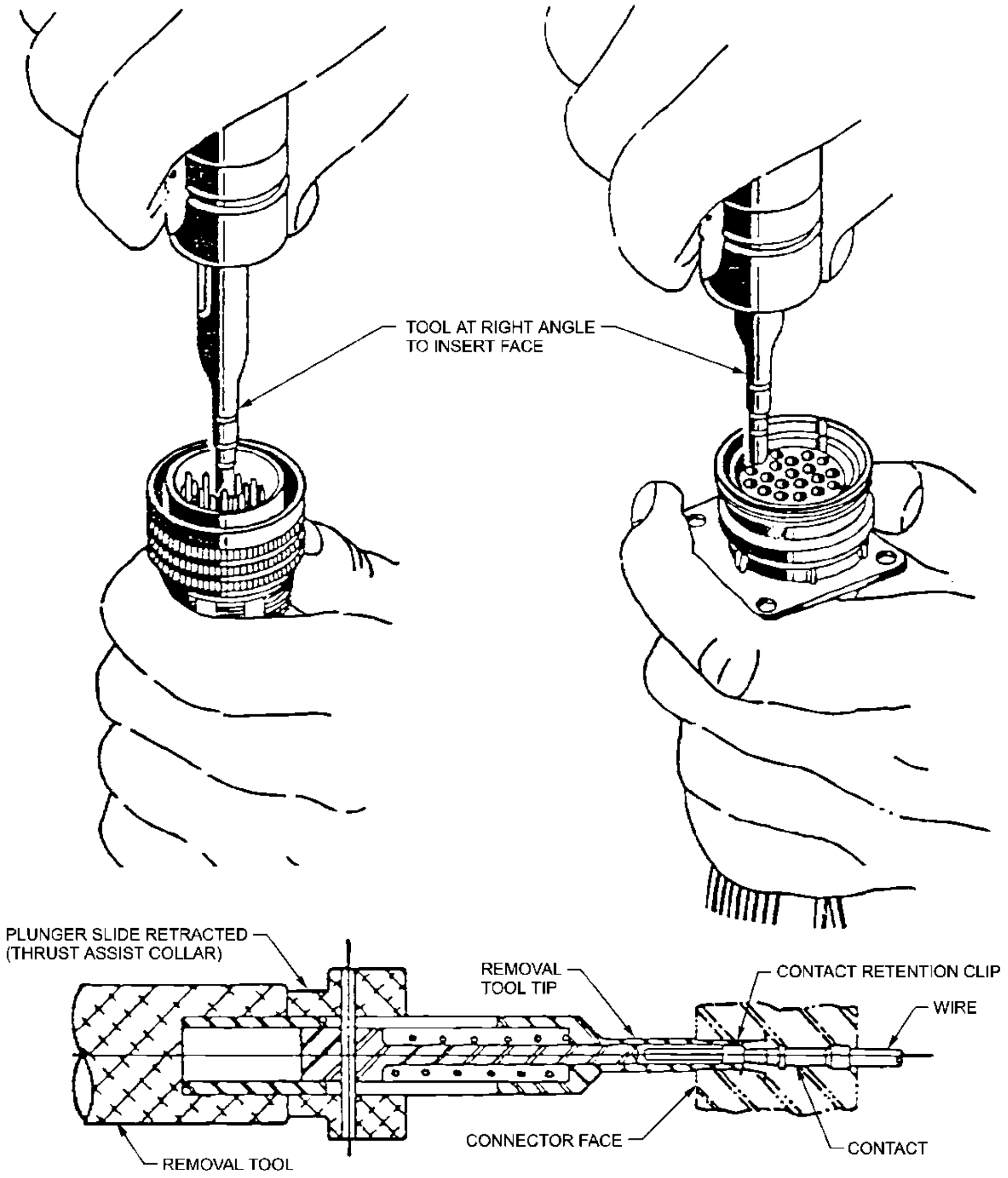


Figure 10–30 Insertion and Extraction Tools for Front Release Crimp Type Contacts



1. SELECT CORRECT INSTALLING TOOL AND PLACE CONTACT/WIRE ASSEMBLY IN TOOL.
   (a) #20 CONTACTS WITH INSULATION CUPS ARE INSERTED BY SLIDING CUP INTO FRONT END OF INSTALLING TIP UNTIL END OF CUP BUTTS AGAINST SHOULDER IN INSTALLING TIP.
   (b) CONTACTS WITHOUT INSULATION CUPS ARE INSERTED BY SLIDING WIRE BARREL INTO FRONT END OF INSTALLING TIP UNTIL CONTACT SHOULDER BUTTS AGAINST INSTALLING TIP.
2. ALIGN TOOL AND CONTACT AXIALLY WITH GROMMET HOLE AND CAREFULLY GUIDE CONTACT THROUGH GROMMET INTO LOCK POSITION.

Figure 10–31 Assembling Wired Contacts Into Connector



1. SELECT CORRECT CONTACT REMOVAL TOOL.
2. TOOL MUST BE HELD IN STRAIGHT LINE; PARALLEL TO CONTACT AND SQUARE TO CONNECTOR FACE.
3. FOR PIN CONTACTS, INSERT REMOVAL TOOL TIP INTO CONNECTOR TO FIRST MARK ON BARREL WHICH WILL RELEASE RETENTION CLIP. PUSH PLUNGER SLIDE FORWARD TO EJECT CONTACT.
4. FOR SOCKET CONTACTS, INSERT REMOVAL TOOL TIP INTO CONNECTOR TO SECOND MARK ON BARREL WHICH WILL RELEASE RETENTION CLIP. PUSH PLUNGER SLIDE FORWARD TO EJECT CONTACT.

NOTE: PLUNGER SLIDE MUST REMAIN IN RETRACTED POSITION AS REMOVAL TOOL TIP IS INSERTED INTO CONNECTOR.

Figure 10–32 Removing Crimp Type Contacts From Front Release Connectors

e. Series 1 and 2 (gauge release) contacts are removed from the front of the connector as follows:

(1) The pin contact removal tool has a hole to accept the pin contact. The socket removal tool has a pin tip to insert in the socket.

(2) Grasp the tool by the handle. Locate the contact to be removed by numbers on the insert face. (See Figure 10–32)

(3) Mate the tool with the contact and, holding the tool at right angles with the insert face, push axially against the tip of the contact until the contact appears at the grommet (rear) end of the connector. The removal tools are designed to bottom against the insert face when the contact is completely released and pushed out.

(4) The wire and contact can now be removed from the connector.

f. Working from the front or mating end of the connector, slip the hollow end of the extraction tool over the contact, with the tool parallel to the contact, and squarely perpendicular to the insert face. (See Figure 10–32)

NOTE

Some extraction tools have a spacer sleeve with positions for either pin or socket contacts. Set to correct position before installing tool on contact.

g. Push the tool toward the rear of the connector with a firm steady push until the tool comes to a positive stop and bottoms in the insert hole. A slight rotation of the tool may aid the tool insertion.

h. Push the thrust assist collar or slide forward as far as it will go.

i. Withdraw the tool from the contact, keeping the tool perpendicular to the insert face.

j. Remove the contact from the back of the connector.

CAUTION

Ensure the extraction tool is always exactly aligned with the contact to avoid damage to the contact or insert.

Insertion and Extraction Tools for Rear-Release Crimp Type Contacts

54. There is a separate tool for each contact size, The tools may be plastic or metal, single or double ended tools (see Figure 10–33) or metal tweezer type tools (see Figure 10–34). See Figure 10–35 and Figure 10–36 for contact installation instructions. See Figure 10–37 and Figure 10–38 for contact removal instructions.

NOTE

Connector rear accessory (cable clamp, etc) must be removed prior to installation or removal of contacts.

NOTE

Insertion/extraction tools are colour coded according to contact size; the insertion tool being coloured and the extraction tool white. For unwired contacts, an additional tool may have to be used in conjunction with the extraction tool to push the unwired contact from the front after the locking tines have been released by the extraction tool in the rear.

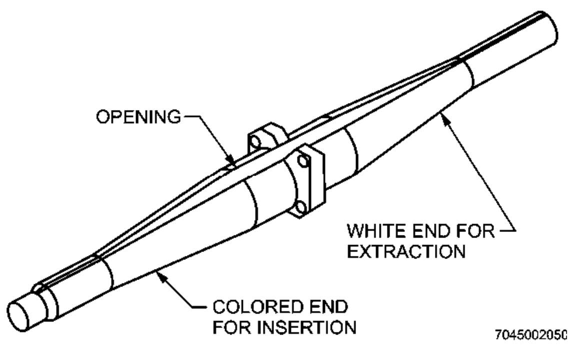


Figure 10–33 Insertion and Extraction Tool For Rear Release Crimp Contacts

REAR RELEASE CONNECTORS
INSTRUCTIONS FOR TWEEZER TYPE INSTALLING TOOLS

USE ONLY WHEN PLASTIC TOOL IS NOT AVAILABLE OR
WHEN SPACE DOES NOT PERMIT USE OF PLASTIC TOOL

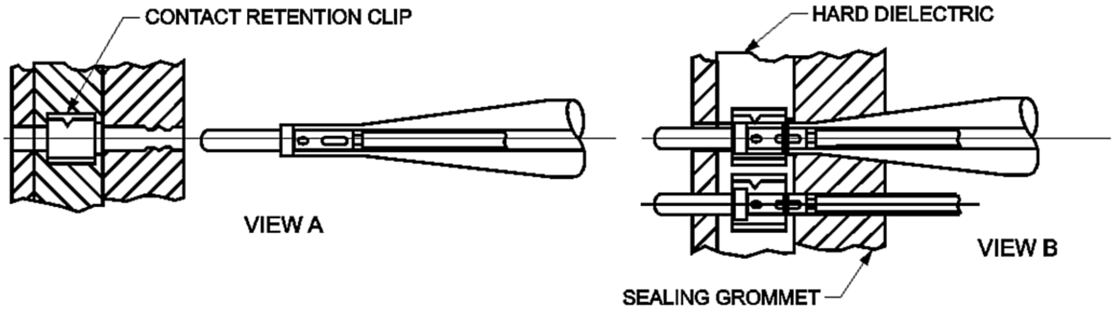
1. SELECT CORRECT INSTALLING TOOL.
   (INSTALLING TOOLS HAVE A SINGLE COLOR CODE BAND).
2. COMPRESS TWEEZER HANDLES TO OPEN TIPS. STRADDLE CONTACT WIRE BARREL WITH TIPS BUTTING AGAINST CONTACT SHOULDER (SEE VIEW "A" UNDER PLASTIC TOOLS). REDUCE PRESSURE ON HANDLES ALLOWING TIPS TO CLOSE.
3. CAREFULLY GUIDE CONTACT INTO CONNECTOR THRU SEALING GROMMET AND HARD DIELECTRIC UNTIL CONTACT SNAPS FIRMLY IN PLACE. (SEE VIEW "B' UNDER PLASTIC TOOLS).
4. WITHDRAW TOOL FROM CONNECTOR.
5. GENTLY PULL ON WIRE TO MAKE SURE CONTACT IS HELD IN PLACE.

CAUTION: CONTACT MUST BE INSERTED PERPENDICULAR TO FACE OF CONNECTOR.
DO NOT TIP SPREAD OR ROTATE TOOL WHILE IN CONNECTOR.

Figure 10–34 Tweezers Type Installing Tools

REAR RELEASE CONNECTORS

INSTRUCTIONS FOR SINGLE OR DOUBLE ENDED CONTACT INSTALLING TOOLS



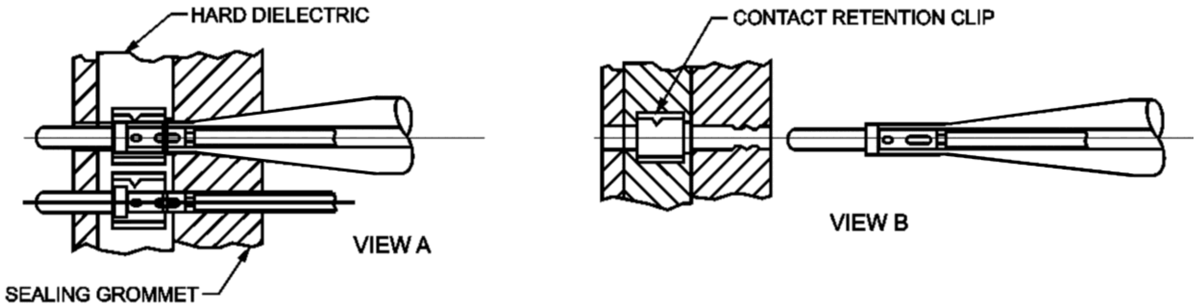
1. **SELECT CORRECT INSTALLING TOOL.**
   AND PLACE TOOL AROUND WIRE ATTACHED TO BE INSERTED.
2. **SLIDE TOOL DOWN WIRE ON TO CONTACT CRIMP BARREL UNTIL IT BUTTS AGAINST THE CONTACT SHOULDER. (SEE VIEW A).**
3. **GRIP TOOL, WIRE AND CONTACT AS A UNIT AND GUIDE CONTACT INTO CONNECTOR THRU SEALING GROMMET AND HARD DIELECTRIC UNTIL CONTACT IS FIRMLY SEATED. (SEE VIEW B).**
4. **RELEASE GRIP ON WIRE AND WITHDRAW TOOL FROM CONNECTOR UNTIL IT CLEARS THE GROMMET. HOLD WIRE FORWARD WHILE TOOL IS BEING REMOVED FROM WIRE.**
5. **GENTLY PULL ON WIRE TO MAKE SURE CONTACT IS HELD IN PLACE.**

CAUTION: ASSEMBLED CONTACT MUST BE HELD PERPENDICULAR TO FACE OF CONNECTOR DURING INSTALLATION. WHEN SEATING BOOT DO NOT ALLOW EXCESSIVE BENDING OR TWISTING OF THE CABLE.

Figure 10–35 Single or Double Ended Contact Installing Tools

REAR RELEASE CONNECTORS

INSTRUCTIONS FOR SINGLE OR DOUBLE ENDED CONTACT REMOVAL TOOLS



1. SELECT CORRECT REMOVAL TOOL AND PLACE TOOL AROUND WIRE ATTACHED TO CONTACT TO BE REMOVED.
2. SLIDE TOOL DOWN WIRE INTO THE CONNECTOR THRU THE SEALING GROMMET AND INTO THE HARD DIELECTRIC UNTIL TOOL STOPS AGAINST CONTACT SHOULDER. (SEE VIEW A).
3. AT THIS STAGE OF REMOVAL, TOOL WILL COLLAPSE CONTACT RETENTION CLIPS TO THE POINT WHERE THEY NO LONGER RETAIN CONTROL.
4. GRIP WIRE AND TOOL AS A UNIT AND WITHDRAW WIRE, TOOL AND CONTACT FROM CONNECTOR SIMULTANEOUSLY. (SEE VIEW B.)

CAUTION: TO AVOID DAMAGE TO TOOL AND/OR CONNECTOR, DO NOT TIP, SPREAD OR ROTATE TOOL WHILE IN CONNECTOR.

70

Figure 10–36 Single or Double Ended Contact Removal Tools

REAR RELEASE CONNECTORS
INSTRUCTIONS FOR TWEEZER TYPE REMOVAL TOOLS

USE ONLY WHEN PLASTIC TOOL IS NOT AVAILABLE OR
WHEN SPACE DOES NOT PERMIT USE OF PLASTIC TOOL

1. SELECT CORRECT REMOVAL TOOL. .
   (REMOVAL TOOLS HAVE A WHITE BAND AND A COLOR CODE BAND).
2. COMPRESS IWEEZER HANDLES TO OPEN TIPS. STRADDLE WIRE, REDUCE PRESSURE ON HANDLES, ALLOWING TIPS TO CLOSE WITHOUT NICKING OR CUTTING THE INSULATION. SLIDE TOOL DOWN WIRE INTO CONNECTOR UNTIL IT BOTTOMS TO RELEASE SPRING CLIP.
3. TO REMOVE CONTACT, PULL LIGHTLY ON WIRE WHILE WITHDRAWING TOOL.

CAUTION: DO NOT EXERT EXCESSIVE FORCE ON WIRE. IF CONTACT IS NOT EASILY EXTRACT, REMOVE TOOL AND REPEAT ABOVE PROCEDURES.

Figure 10–37 Tweezer Type Removal Tools

SHIELD CONNECTIONS

Connecting Single Shielded Wire to Connector

55. Terminate shielded wire as described in Section 2, Chapter 3. For connection to non-environmental resistant connectors, shield must end inside back shell as shown in Figure 10–38. For connection to environmental resistant connectors with rear wire seal or potted connectors, shield must end outside seal. Splice pigtail to short length of wire that is then terminated inside connector to a contact in the regular manner, as shown in Figure 10–39.

> NOTE
>
> Connector accessories (backshells) should not be used to terminate ground wires or shields unless they were specifically designed for that purpose.

> NOTE
>
> Shield connections currently installed under cable clamp screws should not be disturbed unless maintenance is being performed on the connector, and then shield connections must be installed in accordance with current requirements.

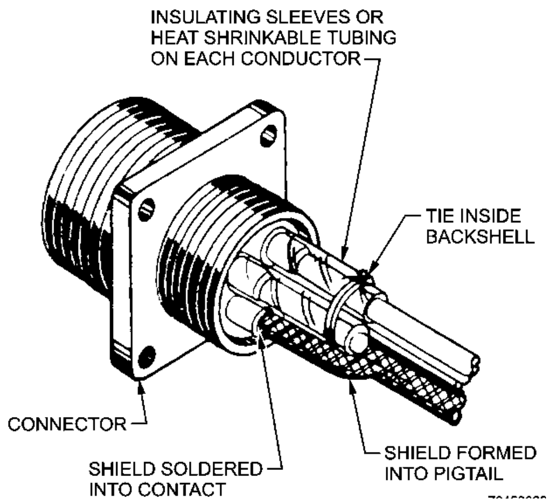


Figure 10–38 Terminating Shielded Wire at MS Connector

Multiple Shield Connections

56. Potted connectors that contain shielded wires and all other connectors that have many shields should terminate shields outside the connector. The procedure is as follows:

- **a.** Form pigtail from shield outside connector area (see Figure 10–39).
  - **(1)** For potted connector, pigtail should start 1 inch (25mm) from end of wire.
  - **(2)** For other connectors, pigtail should start far enough back to remain outside cable clamp.
- **b.** Solder or crimp each wire to its contact.
- **c.** Crimp pigtails together into one end of permanent splice (see Figure 10–39).
- **d.** Crimp single wire, doubled if necessary; into other end of permanent splice (see Figure 10–40).
- **e.** Slide sleeve over splice and tie or heat shrink as appropriate.
- **f.** Solder or crimp single wire to proper contact in connector as shown in Figure 10–39.
- **g.** Complete connector assembly in normal manner.

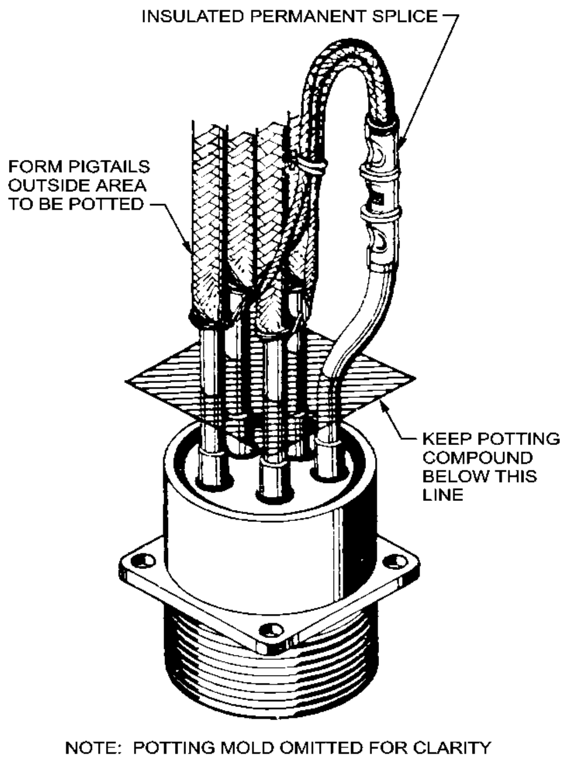


Figure 10–39 Terminating Shielded Wires at Potted Connector

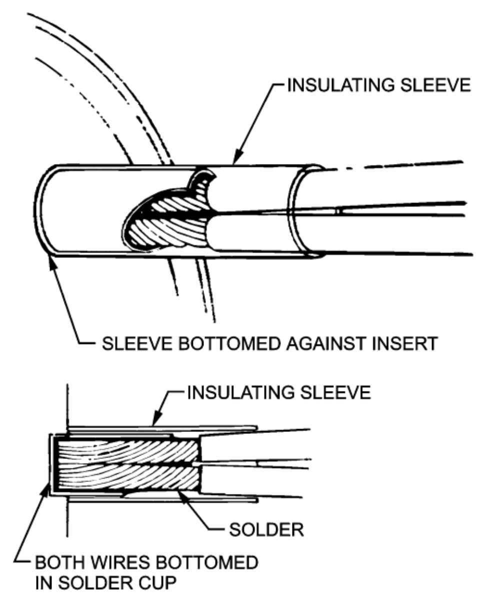


Figure 10–40 Terminating Two Wires at One Contact on Non-environmental Resistant Connector

Multiple Connections

CAUTION

Do not connect two wires to one contact in environmental type connectors; this will cause loss of environmental sealing.

57. Connect two wires to one contact by using one of the following methods:

a. If both wires can be fitted into contact solder cup, proceed as with single wire. Slide insulating sleeve over both wires together and insert them into solder cup. Make sure all strands are inside cup before soldering. When solder has cooled, push insulating sleeve down until it butts against insert. (See Figure 10–40).

b. If both wires cannot fit into solder cup, use permanent splice to join both wires to a third wire that can fit into solder cup or crimp barrel. See Section 2, Chapter 6 for splicing procedure and Figure 10–41 and Figure 10–43 for illustration of this connection.

Grounding Shields with Bonding Ring

58. When specified on the applicable engineering drawing, an AN3111 bonding ring may be used to ground shields on certain solder type MIL-DTL-5015 connectors.

a. Remove washers from the connector cable clamp and slide clamp back on wire bundle.

b. Install the AN3111 bonding ring on the wire bundle between the connector back shell and the cable clamp, with the bonding ring lug toward the solder contacts.

c. Make a hole in one shield and expand it to hold up to three other shields as shown in Figure 10–42. Tighten the expanded shield around the others and seat solder together. Repeat as necessary for number of shields to be grounded.

d. Pull one of the shields through to form a jumper. Install a length of insulating sleeving over the jumper shield.

e. Clamp the ears of the bonding ring lug around the jumper(s) and solder. Pull the insulating sleeve over the soldered connection.

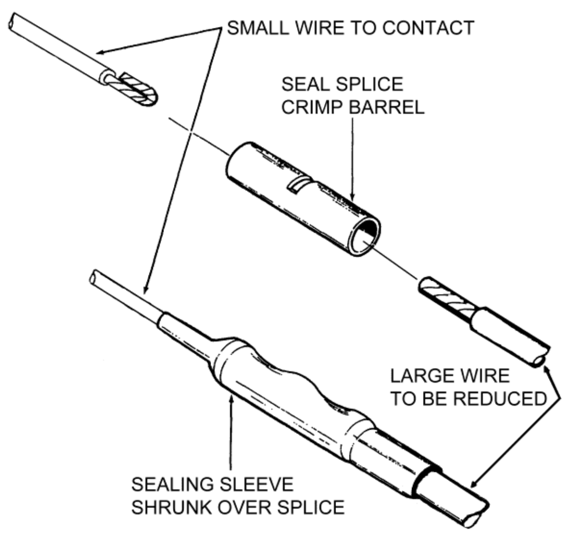


Figure 10–41 Reducing Wire Size at Connector Using Permanent Environmental Splice

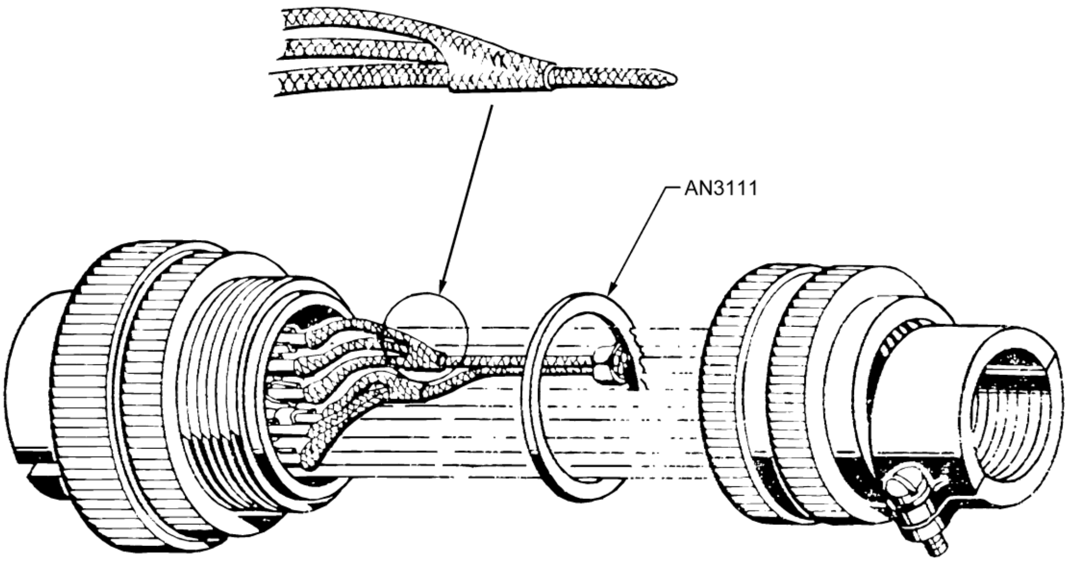


Figure 10–42 Installing AN3111 Bonding Ring

Reducing Wire Size at MS Connector

> **CAUTION**
> Reduction of wire size needs approval by an engineering design approval. Current carrying capacity of smaller wire and contact must not be exceeded.

59. Reduction of wire size to enable a larger diameter wire to be soldered or crimped to a smaller diameter contact is sometimes required. A safe method of making the reduction is as follows:

- **a.** Select a permanent splice or sealed splice that will accommodate the larger wire. Crimp this splice to the stripped wire as described in Section 2, Chapter 6.
- **b.** Select a 15cm length of wire that will fit the wire barrel of the contact. Strip one end sufficiently long to be able to double the stripped portion back on itself as shown in Figure 10–43.

Assembly and Disassembly Instructions for Connectors and Wire Terminations not Covered by Military Specifications or Standards

60. Assembly instructions and tool calibration procedures recommended by the connector and/or tool manufacturer(s) should be followed in assembling electrical connectors and wire terminations not covered by military specifications or standards.

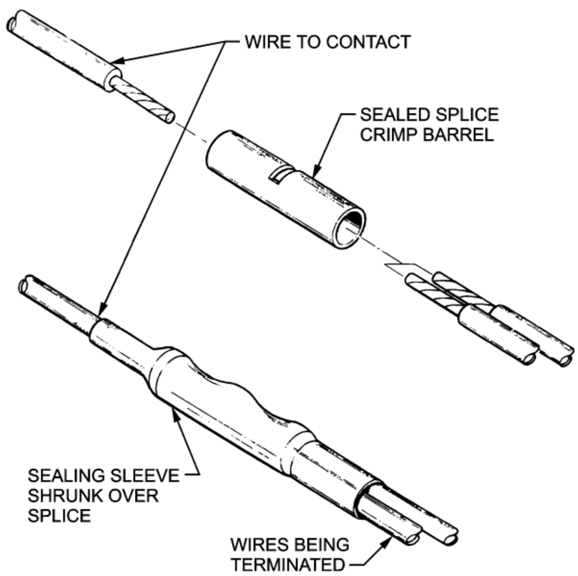


Figure 10–43 Terminating Two Wires to One Contact Using Permanent Environmental Splice

CONTINUITY TEST

61. Test all wires and wire groups as fabricated, with terminations attached, for short circuits as well as for continuity between the termination points specified on the applicable schematic. Continuity test on unshielded wires and wires less than 15 meters can be accomplished by using a light or buzzer connected to a nine volt battery.

CAUTION

Do not use lead pencils to count pins in connectors. points can break off and lodge in the connector, leading to arcing, shorting, and system malfunction. Do not use oversize prods in connector sockets during testing; this may result in splayed or damaged sockets. Do not puncture wire insulation with a probe, or attach clamps to wire insulation while continuity testing or trouble shooting.

62. Use the ohmmeter section of an approved multimeter to determine circuit continuity. Continuity for short runs, where conductor resistance is not a factor, is defined as "zero" resistance. The procedure for determining continuity, using a multimeter is as follows:

a. Set the function control to OHMS, and the range control to Rx1. Zero the instrument as directed in the operating manual for the instrument used.

b. Attach the test leads to the terminations of the wire run.

c. Note reading on the ohms scale. A reading of 0.25 ohms, +0.25 ohms, is considered verification of circuit continuity.

NOTE

The test lead extremities contacting the terminations under test must provide adequate constant contact, and must not damage the termination.

TEST LEADS

63. For ground points and terminal lugs, use test leads with alligator clips. For connector pins and sockets, use a special lead ending in a sleeve-insulated pin or socket of the same size as that being tested.

PROTECTION OF ELECTRICAL CONNECTORS

64. Protect all unmated connector plugs and/or receptacles with protective covers. (See Figure 10–44) Standard protective covers for connectors are listed in the applicable connector specification. Protective covers are available with or without an attaching chain. Plastic dust caps to fit MS plugs and receptacles are also available. Electrostatic free dust caps for electrical connectors are listed in Table 10–10.

WARNING

Ensure both the plug and receptacle are covered while not in use. foreign objects can present a hazard that may damage equipment and harm personnel.

Table 10–9 Test Leads

Item Name	**Part No**
Test Leads (Black)	Model B-36-0
Test Leads (Red)	Model B-36-2
22 Gauge Sockets (Black)	4690-0
22 Gauge Sockets (Red)	4690-2
22 Gauge Pins (Black)	4691-0
22 Gauge Pins (Red)	4691-2
20 Gauge Sockets (Black)	3560-0
20 Gauge Sockets (Red)	3560-2
20 Gauge Pins (Black)	3561-0
20 Gauge Pins (Red)	3561-2
18 Gauge Sockets (Black)	3562-0
18 Gauge Sockets (Red)	3562-2
18 Gauge Pins (Black)	3563-0
18 Gauge Pins (Red)	3563-2
16 Gauge Sockets (Black)	3564-0
16 Gauge Sockets (Red)	3564-2
16 Gauge Pins (Black)	3565-0
16 Gauge Pins (Red)	3565-2

CAUTION

Protect ESD susceptible items. Failure to adequately protect ESD could cause damage to equipment.

65. All unmated connector plugs and/or receptacles should be protected. All loose wires/cables should be secured as detailed in Section 2, Chapter 4.

66. Unmated connectors can be wrapped with MIL-I-46852, silicone rubber tapes. Both materials can be secured with waxed or nylon cord. These are alternative methods used to protect unmated connectors exposed to contaminants during repairs or storage when standard protective covers and plastic caps are not available. Silicone rubber tapes should not be used where they will be exposed to fluids, such as jet fuels, hydraulic fluids, engine oils, silicone damping fluid (DC-200), etc. These fluids may cause silicone tapes to swell and/or lose adhesive properties.

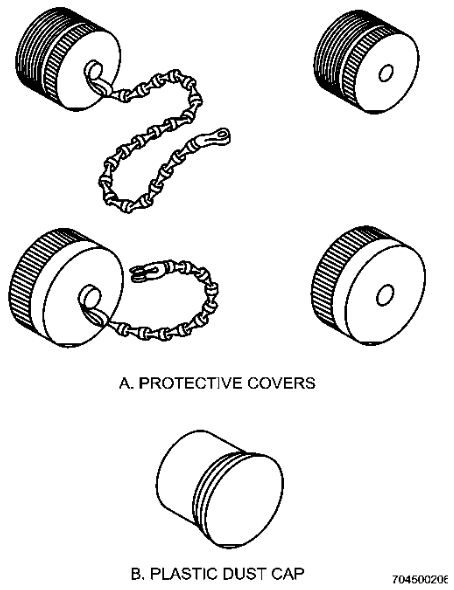


Figure 10–44 Typical Protective Connector Caps

Table 10–10 Electrostatic Free Dust Caps

Dust Cap Internal Diameter (mm ± 0.25)	Part Number	Nomenclature
15.5	MS90376-10RF	Cap Protective Antistatic
16.3	MS90376-12YF	
18.3	MS90376-12RF	
19.9	MS90376-14YF	
21.6	MS90376-14RF	
22.7	MS90376-16YF	
24.7	MS90376-16RF	
26.1	MS90376-18YF	
27.8	MS90376-18RF	
29.2	MS90376-20YF	
31.3	MS90376-20RF	
32.3	MS90376-22YF	
34.0	MS90376-22RF	
35.3	MS90376-24YF	
37.2	MS90376-24RF	
41.9	MS90376-28YF	
43.6	MS90376-28RF	
48.0	MS90376-32YF	
49.9	MS90376-32RF	

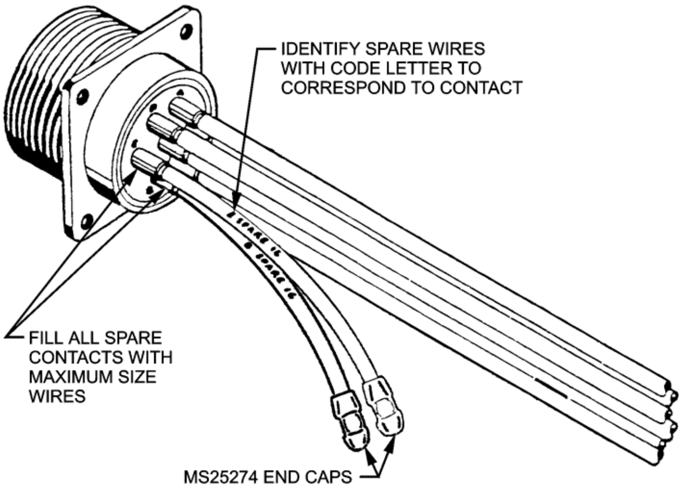


Figure 10–45 Spare Wires for Potting Connector

CAUTION

Do not use pressure sensitive tape on connectors as The residue left after the tape is removed will cause contaminants to stick to the connectors.

POTTING CONNECTORS

67. These connectors are used only where potting is required. They are similar to other standard types, except that they have a shorter body shell and include a potting mould. Potting connectors are supplied with a plastic potting mould. Installation is as follows:

a. Slide the plastic mould over the wire bundle.

CAUTION

Polytetrafluoroethylene (TFE) and fluorinated polyethylene propylene (FEP) insulated wires require special preparation prior to potting (see section 2, chapter 11).

b. Identify and install wires into contacts.

NOTE

Spare wires should be installed in all unused contacts. Use the largest gauge wire suitable for each contact. Spare wires should be approximately 23cm long. (See Figure 10–47.)

c. Insulate the ends of all spare wires. (See Figure 10–45). The preferred method of insulating a spare wire is to crimp it into an MS25274 wire end cap (Table 10–11) with tool as detailed in Section 2, Chapter 6. The procedure for crimping wire end caps with standard tool is as follows:

(1) Select an end cap of the correct size for the wire to be insulated

(2) Make sure the locator is properly positioned behind the lower nest. Position the wire end cap in the correct die nest with the closed end of the cap resting against the locator.

(3) Insert the stripped wire so that the end of the stripped wire is seated against the closed end of the cap, and the insulation is against the metal sleeve of the cap.

(4) Close tool handles until ratchet releases and the tool opens. Remove the crimped assembly.

WARNING

Skin, eye, and respiratory protection is required. Do not breathe fumes, maintain good ventilation.

d. Clean the complete connector assembly by scraping off rosin and then brush vigorously with suitable cleaning solvent, such as Isopropyl Alcohol.

e. Rinse area to be potted with suitable cleaning solvent, such as Isopropyl Alcohol.

NOTE

Complete potting within two hours after cleaning.

f. Slide plastic mould into position on rear of connector.

WARNING

The accelerator contains toxic compounds. Use in a well ventilated area. Avoid eye and skin contact. Use personal protective equipment, rubber or polyethylene gloves and approved eye protection. Clean hands thoroughly after use.

CAUTION

Mate connectors before potting either part to avoid splaying contacts during the potting operations.

g. Apply potting compound prepared in accordance with directions in Section 2, Chapter 11. Fill back of connectors by inserting nozzle down between wires until it almost touches back of insert (see Figure 10–46). Fill slowly while moving nozzle back from insert and ensure no air bubbles are trapped. Fill to top of mould. Tamp down the compound, if necessary, with a wooden or metal 3mm dowel. Tap connector assembly on a resilient surface or vibrate mechanically to help flow the compound into all spaces and to release trapped air.

h. Immediately after filling each connector, tie the wires together loosely about 15cm away from the connector. Ensure that wires are centrally located in the connector so that each wire is completely surrounded by potting compound. Suspend the assembly so that the potting material remains level, as shown in Figure 10–46, and allow to air cure for at least 1.5 hours at 24°C without any movement. Make sure that the tie is applied after potting.

i. Carefully place assembly, still suspended, into drying oven for 3 to 4 hours at 38°C or air cure at 24°C for 24 hours.

NOTE

Full cure with maximum electrical characteristics is not achieved until 24 hours after potting. Do not perform any electrical insulation resistance tests until this period has passed.

j. Apply a light film of lubricating oil to all exterior metal surfaces after potting compound is completely cured.

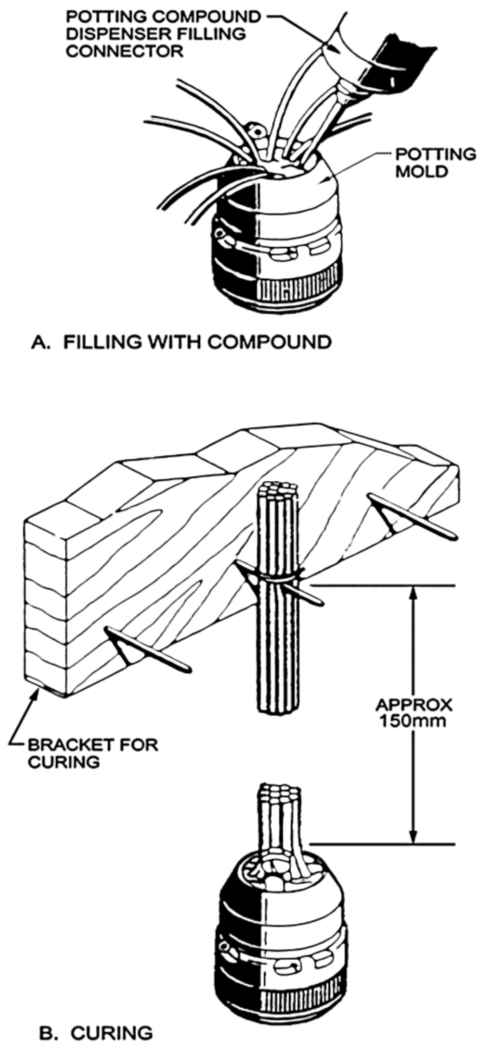


Figure 10–44 Filling and Curing Potting Connector

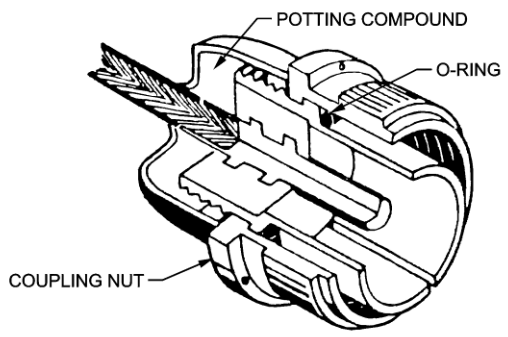


Figure 10–45 Installation of O-Ring on AN Type Potted Connector Plug

Table 10–11 Wire End Caps

Wire Gauge	Wire Strip Length (mm)	Cap Colour	Cap Part Number	Crimp Tool	Positioner
26-24	7.6	Yellow	MS25274-1	M22520/5-01 M22520/10-01	M22520/5-100 M22520/10-101
22-18	7.6	Red	MS25274-2	M22520/5-01 M22520/10-01	M22520/5-100 M22520/10-101
16-14	7.6	Blue	MS25274-3	M22520/5-01 M22520/10-01	M22520/5-100 M22520/10-101
12-10	8.9	Yellow	MS25274-4	M22520/5-01 M22520/10-01	M22520/5-100 M22520/10-101

Table 10–12 O-Ring Sizes For AN Type Connectors

Plug Size	O-Ring Size (mm)	O-Ring ID (mm)	MS29513 Dash Nos.
8S	1.8	7.9	-10
10 & 10S	1.8	9.2	-12
12 & 12S	1.8	12.4	-14
14 & 14S	1.8	12.4	-14
16 & 16S	1.8	15.6	-16
18	1.8	18.8	-18
20	1.8	21.9	-20
22	1.8	25.1	-22
24	1.8	28.3	-24
28	1.8	34.6	-28
32	1.8	34.6	-28
36	2.6	44.1	-132
40	2.6	50.5	-136
44	2.6	56.8	-140
48	2.6	63.2	-144

CONNECTOR ACCESSORIES

68. Circular electrical connectors should be provided with accessories. Connector accessories for all new design and retrofit wiring systems should be in accordance with SAE AS50881 and this publication.

Installation of Cable Clamp

69. The cable clamp, is installed as follows (see Figures 10–50, and 10–51):

a. Slide cable clamp without saddles on wire bundle before wires are connected.

b. Slide bushing (if needed) on wire bundle before wires are connected.

> NOTE
>
> A wrap of teflon, silicone rubber or glass fibre tape can be used instead of a bushing. Only teflon tapes, silicone rubber tapes and glass fibre tapes should be used to build-up under saddle clamps. MIL-I-23594 teflon, tape, teflon tape part number P440-4IN, A-A-59163, Type 1, silicone rubber tapes and MIL-I-19166 glass fibre tapes work satisfactorily as build-up tapes under saddle clamps. Silicone rubber tapes should not be used where they will be exposed to fluids, such as jet fuels, hydraulic fluids, engine oils, silicone damping fluid (DC-200), etc. These fluids may cause silicone rubber tapes to swell and/or lose adhesive properties. Neoprene rubber tapes and vinyl tapes should be not be used for build-up under the saddle clamp because of their shrinkage and out-gassing properties. If tape wrap is used, secure with nylon braid behind saddle. A bushing or tape build-up is required where the wire bundle diameter is too small to be effectively gripped by the saddle bar.

c. Assemble wires to connector.

d. Install bushing into cable clamp and attach clamp to connector. Padded jaw connector pliers may be used to tighten or loosen a cable clamp or other backshell accessory if necessary.

> **CAUTION**
>
> Care should be taken not to bend the coupling ring or backshell when a strap wrench or padded jaw pliers are used.

e. Attach saddle bars with supplied screws and lockwashers.

> **CAUTION**
>
> Ensure bushings are not pinched between saddles and centre bar. Ensure that there is no flexing of the cable within the tightened saddle bars. Flexing will cause damage to the connector wiring. Cable assemblies with connector clamps should not be disturbed regardless of backshell screw positions unless authorised repair work is warranted.

> NOTE
>
> Ensure that the saddle clamp screw heads are placed so that pushing on screw heads will tighten cable clamp to backshell. (Some saddle bars have both screw heads on same side).

f. Attach saddles with both screws and lockwashers and tighten until cable is secured within the saddle clamp. There should be no flexing of the cable within the saddle clamp. Use extra bushings in original assembly if saddle is not tight.

Installation of MS3057 Series Connector Cable Clamps

70. There are three types of MS3057 connector cable clamps. (See Figure 10–49 and Table 10-14).

a. MS3057 has a single saddle held by two screws. It contains a metal or plastic washer and a flat rubber bushing. For shipping, to prevent loss of the metal or plastic washer, it is placed inside the clamp and held in place by the rubber bushing. Before use, reverse the position to that shown in Figure 10–49 so that the metal or plastic washer will contact the back shell of the connector.

b. MS3057A has two saddles separated by a centring bar. This cable clamp is supplied with MS3420 bushing to protect the wire bundle under the clamp. Add extra bushings if necessary.

c. MS3057B has a gland and tapered sleeve. The gland is squeezed around the wire bundle when the cable clamp is screwed to the connector back shell.

d. Before installing MS3057 cable clamps onto connectors, screw the mating part onto the connector with the coupling nut. This will help to prevent contacts splaying when the cable clamp is tightened.

Installation of MS3057 Cable Clamp

71. The MS3057 cable clamp is installed as follows (see Figure 10–50):

a. Slide the MS3420A telescoping bushings on the wire bundle if the bundle diameter is too small to be effectively gripped by the saddle.

b. Slide the MS3057 cable clamp without saddle on the wire bundle followed by the rubber bushing and the metal or plastic washer.

c. Assemble wires to the connector and tighten the backshell.

d. Push the MS3057 cable clamp toward the backshell and hand tighten. Use a strap wrench to tighten fully.

e. Push the MS3420A bushings, if required, into the cable clamp until it is past the saddle.

f. Attach saddle with both screws and tighten until 1.6mm space is left between the saddle and the body as shown in Figure 10–50. MS3420A bushing, if used, should bulge slightly when the saddle is tight.

NOTE

Ensure that the saddle clamp screw heads are placed so that pushing on the screw heads will tighten the cable clamp to backshell. (Some saddle bars have both screw heads on same side).

CAUTION

Ensure bushings are not pinched between saddles and centre bar. Ensure that there is no flexing of the cable within the tightened saddle bars. Flexing will cause damage to the connector wiring.

Installation of MS3057A Cable Clamp

72. The MS3057A cable clamp is installed as follows (see Figure 10–53):

a. Slide MS3057A cable clamp, without saddles, on to the wire bundle before wires are connected.

b. Slide MS3420 telescoping bushing on wire bundle before wires are connected.

c. Assemble wires to connector and tighten back shell.

d. Push MS3057A cable clamp together with inserted MS3420 bushing toward back shell and hand tighten. Use plug pliers or a strap wrench to tighten fully.

e. Attach both saddles with supplied screws and lockwashers.

NOTE

Ensure that the saddle clamp screw heads are placed so that pushing on screw heads will tighten cable clamp to backshell. (Some saddle bars have both screw heads on same side).

CAUTION

Ensure bushings are not pinched between saddles and centre bar. Ensure that there is no flexing of the cable within the tightened saddle bars, Flexing will cause damage to the connector wiring.

f. Tighten saddles until firm against cable, making sure that the cable is not pinched within the clamping assembly. If saddles do not prevent cable from flexing inside the connector, use extra MS 3420 telescoping bushings in the connector assembly. See Table 10–13 for telescoping bushing dimensions. The saddle clamps may be tight against the centring bar as long as the cable is not pinched within the assembly.

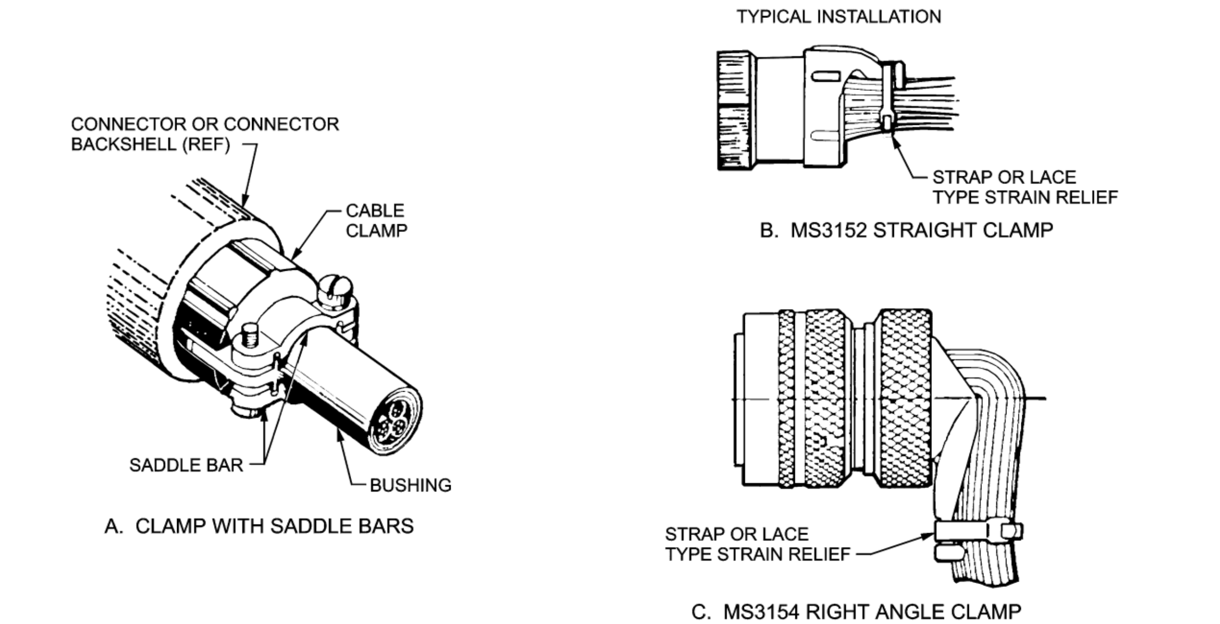


Figure 10–48 Cable Clamps

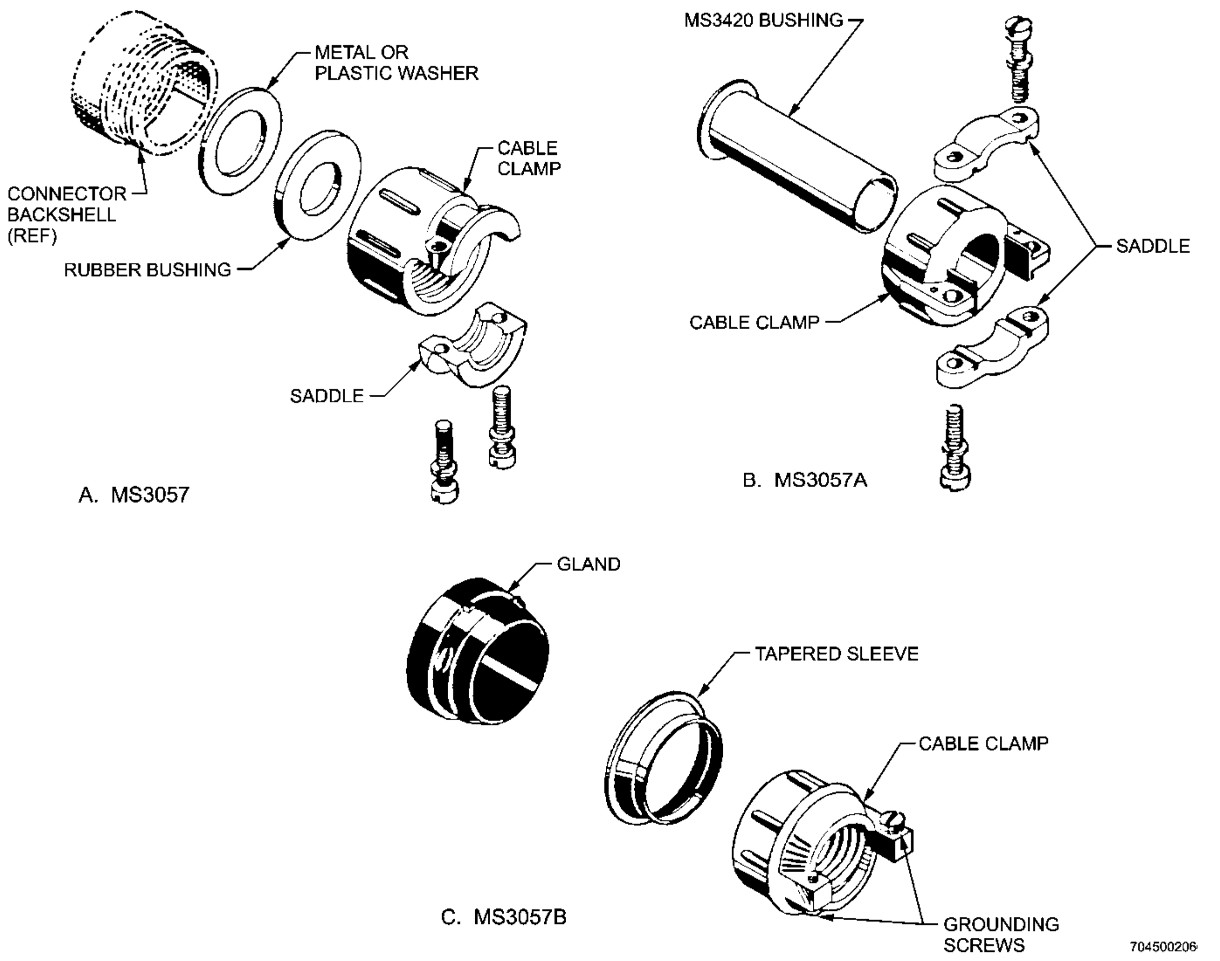


Figure 10–49 MS3057 Connector Cable Clamp Types – Exploded View

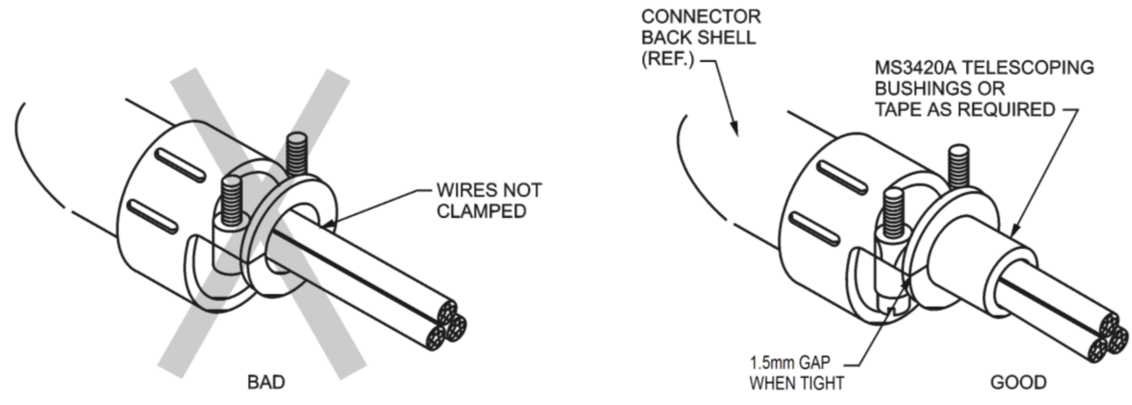
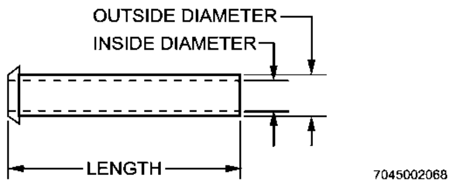


Figure 10–50 Installation of MS3057 Cable Clamp

Table 10–13 Telescoping Bushings



Connector Size	Bushing Part No.	Bushing		
		Inside Diameter (mm)	**Outside Diameter (mm)**	**Length (mm)**
8S, 10S	MS3420-3A	3.3	5.3	73.0
10SL, 12S, 12	MS3420-4A	5.6	7.7	69.8
14, 14S	MS3420-6A	7.9	10.8	66.7
16, 16S	MS3420-8A	11.0	14.0	63.5
18	MS3420-10A	14.2	15.6	60.3
20, 22	MS3420-12A	15.9	18.8	57.1
24, 28	MS3420-16A	19.0	23.5	53.9
32	MS3420-20A	23.8	31.5	50.8
36	MS3420-24A	31.7	34.7	47.6
40	MS3420-28A	34.9	41.0	44.5
44	MS3420-32A	41.2	47.3	41.3
48	MS3420-40A	47.6	60.0	38.1

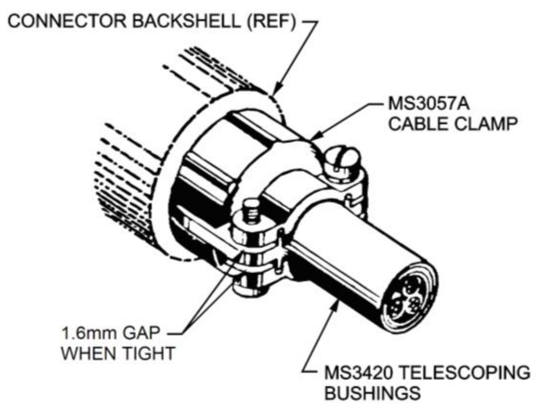


Figure 10–51 Installation of MS3057A Cable Clamp

Table 10–14 Selecting MS3057 Cable Clamp

Cable Clamp	MS Connector Shell Size
MS3057-3	8S, 10S
MS3057-4	10SL, 12S, 12
MS3057-6	14, 14S
MS3057-8	16, 16S
MS3057-10	18
MS3057-12	20, 22
MS3057-16	24, 28
MS3057-20	32
MS3057-24	36
MS3057-28	40
MS3057-32	44
MS3057-40	48
MS connector shell sizes are the same for type MS3057 A or B cable clamps	

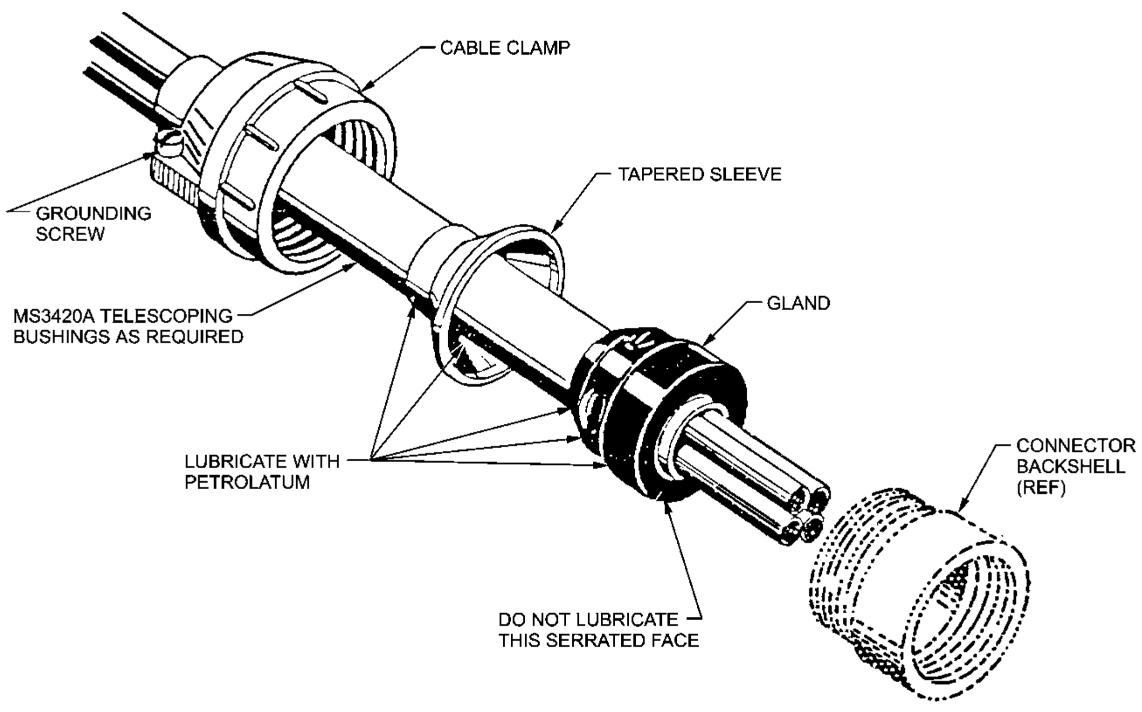


Figure 10–52 Installation of MS3057B Cable Clamp

Installation of MS3057B Cable Clamp

73. The MS3057B cable clamp is installed as follows (see Figure 10–52):

a. Slide MS3420A telescoping bushings, if required, on wire bundle before wires are connected. See Table 10–13 for telescoping dimensions.

b. Slide MS3057B cable clamp assembly on wire bundle before wires are connected.

> **CAUTION**
>
> Proper lubrication of gland and tapered sleeve is important for this assembly. In handling parts, keep them clean and free of dirt. Wash away dirt with clean denatured ethyl alcohol and relubricate with petrolatum (Federal Specification VV-P-236) as shown in Figure 10–52. Do not apply petrolatum to inside of gland or to serrated face of gland.

> **WARNING**
>
> Perform all solvent cleaning operations in a well ventilated area. Avoid prolonged breathing of vapours. Avoid eye and repeated skin contact. Keep solvents away from sparks and flames.

c. Assemble wires to connector and tighten backshell.

d. Push MS3420A bushings, if used, through gland of MS3057B so that end of bushing is flush with serrated face of gland.

e. Slide entire assembly toward back shell and hand tighten. Use strap wrench or padded jaw connector pliers to fully tighten until MS3057B bottoms onto backshell. While tightening, hold wire bundle and telescoping sleeving until gland seats on backshell.

> NOTE
>
> Shield braid (and jacket, if present) should end outside of MS3057B cable clamp to retain moisture resistant qualities of clamp. Ground braid in accordance with standard procedures.

> NOTE
>
> Protect all unmated connectors with protective covers.

Installation of MS3152 and MS3154 Cable Clamp

74. The MS3152 and MS3154 cable clamps are installed as follows (see Figure 10–48):

a. Slide cable clamp on wire bundle before wires are connected.

b. Assemble wires to connector and tighten back shell.

c. Wrap cable using teflon, silicone rubber, or glass fibre tape at the point where wire will have contact with saddle bar.

d. Tie cable wrap at both ends with lacing cord or self clinching cable straps.

> NOTE
>
> Plastic cable straps will not be used on coaxial cables or bundles containing coaxial cables that do not have hard dielectrics.

e. Secure cable to saddle bar with lacing cord or self clinching cable straps (see Figure 10–48).

Removal of Cable Clamp

75. The cable clamp is removed as follows:

a. Remove screws from saddle bars and remove saddle bars from clamp.

b. Unscrew cable clamp from connector. The strap wrench or padded jaw pliers listed previously may be used if necessary.

Instructions for Assembly and Disassembly of Plug Connector

76. Instructions for assembly and disassembly of Plug Connector to and from Receptacle Connector are given in Section 2, Chapter 10.

Heat Shrinkable Strain Relief Boots for Connectors

77. Heat shrinkable strain relief boots are used at the rear of connectors to support wiring and to prevent twisting or pulling on crimped or soldered connections. They are available for a variety of connectors.

BOOT REPAIR PROCEDURES

Rebonding Boot

78. The following steps should be followed in rebonding a boot to a connector or harness assembly:

a. Clean visible bonding surfaces with lint free cloth dampened with Standard Oil Company 265 cleaning solvent (aliphatic petroleum hydrocarbon) or equivalent. Wipe immediately with clean lint free cloth.

b. Prepare Raychem Corporation S-1009 adhesive by thoroughly mixing equal amounts by weight of components A and B.

NOTE

Pot life of mixed epoxy is 1 hour at 21°C ± 6°C.

c. Apply a thin continuous coat of mixed adhesive on bonding surfaces. Reassemble boot to connector and/or cable harness.

d. Allow adhesive to cure at room temperature for 24 hours.

CAUTION

Do not bend or stress bonded cable joints during adhesive cure. Improper bond(s) could result if bonded joints are bent or stressed during adhesive cure.

Boot Removal

79. Remove a boot from a cable assembly as follows:

a. Loosen the connector backshell adapter to gain access to the connector backside.

WARNING

Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft.

WARNING

Use of nitrogen with hot air gun M83521/5-01 in an enclosed area can be hazardous. Ensure area is well ventilated.

b. **Convoluted Boots.** Heat the boot with heat gun until warm to touch, and pull the loosened adapter away from the connector exposing the wire conductors where they enter the connector. Hold in the retracted position until cool and the boot remains retracted.

c. **Standard Boots.** Heat the boot with heat gun until warm to touch, then pull the adapter and boot back exposing the connector backside with enough clearance to allow repair.

80. In some cases the boot may have to be cut off. When a boot has to be cut off the following procedure should be used:

a. Score (cut) the boot lengthwise, taking care not to cut through the boot into the cable jacket.

b. Heat the boot with a heat gun until warm to touch.

c. Peel the boot from the cable jacket and connector with pliers.

Reinstalling Convoluted and Standard Boots

81. Heat the boot with a heat gun until warm to touch, slide backshell and boot up to rear of connector and tighten backshell coupling ring.

New Boot Installation

82. The following steps should be followed when installing a new boot on a connector harness assembly:

a. Abrade outer jacket on jacketed cable with 320 emery cloth. Clean loose particles from surface with a clean, dry cloth or paper tissue.

b. Degrease connector backshell or adapter with suitable cleaning solvent, such as Isopropyl Alcohol.

c. Apply adhesive to cable and connector bonding areas if required (some boots are pre-coated with an adhesive in the bonding areas).

d. Install new boot over end of cable.

NOTE

Boots can be installed over connectors in most cases. Occasionally, it may be necessary to disassemble a connector to install the repair boot.

e. Shrink the boot starting at the connector end and proceeding to the cable end with a heat gun.

f. Cure the adhesive according to recommended curing instructions.

RECTANGULAR CONNECTORS

83. Environmental resistant and non-environmental resistant rectangular connectors are used in electrical and electronic rack and panel applications. These connectors are available with front release crimp contacts, rear-release crimp contacts and solder contacts. Rectangular connectors most commonly used in aircraft are covered by military specifications such as MIL-DTL-24308, MIL-DTL-28748, MIL-C-81659 and MIL-DTL-83733.

Assembly and Disassembly of Rectangular Connectors

84. Assembly and disassembly procedures are the same as those used for circular connectors. Refer to the appropriate paragraph in the circular connector instructions for assembly and disassembly procedures.

MIL-DTL-83723 CIRCULAR CONNECTORS

Description

85. The connectors provided by this specification are miniature environment resisting types with either bayonet or threaded couplings (See Table 10–15). MIL-DTL-83723, Series I (bayonet coupling) are replaced by MIL-C-26482, Series II, and MIL-DTL-83723. Series II (threaded coupling) are replaced by MIL-DTL-5015. (See Table 10–6)

> NOTE
>
> These connectors will be supplied without backshell hardware (See paragraph 81).

> **CAUTION**
>
> Installation and removal of MIL-DTL-83723 contacts is from the rear of the connectors.

Identification of Connectors and Component Parts

86. For purposes of ordering MIL-DTL-83723 connectors, the part numbers are constructed as follows:

a. Connectors.

MM83723 01 R 22 55 N

- Military designator — MM83723
- Specification sheet — 01
- Class (Table 4-14) — R
- Shell size in 0.0625 inch — 22
- Insert arrangement — 55
- Insert position — N

b. Backshell hardware for Series I (bayonet) and Series III (bayonet and threaded) is shown in Figure 10–54.

MS3417 22 A

- Basic part number — MS3417
- Shell size — 22
- Finish — A

MS34l5 - 45° clamp	Finish
MS34l6E - No clamp	A - Cadmium
MS34l7 - Straight clamp	G - Black anodize (non-conductive)
MS341S - 90° clamp	N - Electroless nickel

c. Backshell hardware for Series II (threaded).

M83723 35 A 22 R

- Military designator — M83723
- Specification sheet — 35
- Backshell type — A
  - A - 90° clamp
  - S - Straight
  - N - No clamp
- Shell size — 22
- Finish — R
  - R - 200° conductive
  - G - Stainless steel
  - A - Black anodized (non-conductive)

d. Series II (threaded) saddle clamp backshell hardware.

M83723 50 R 22 N

- Military designator (M83723)
- Specification sheet (50)
- Backshell type (R)
  - R - Straight strain relief rotatable arm
  - A - 90° strain relief
  - B - 45° strain relief
- Shell size (22)
- Finish (N)
  - N - Electroless nickel
  - A - Anodic coating

e. For shrink hardware (bayonet and threaded connector series).

M83723 16 S 22 A

- Military designator (M83723)
- Base specification and specification sheet (16)
  - (-16 Series I & III)
  - (-37 Series II)
- Type shrink boot (S)
  - (A: 90° angle)
  - (S: Straight)
- Shell size (0.0625 inch) (22)
- (A)
  - (A: 150°C 1000 hr)
  - (B: 200°C shrink hardware)

f. Contacts and service tools, Series I and Series III (rear release contacts).

M39029 /4 - 110

- Military designator (M39029)
- Specification sheet (/4)
  - /5 socket contact
  - /4 pin contact
- Bin code (110)

Bin Codes	Contact Size	Contact Insertion/ Extraction Tool
/4-110, /5-115	20-20	M81969/14-02
/4-111, /5-116	16-16	M81969/14-03
/4-112, /5-117	16-20	M81969/14-03
/4-113, /5-118	12-12	M81969/14-04
/4-114, /5-119	12-16	M81969/14-04

Table 10–15 MIL-DTL-83723 Connectors

Specification M83723/XX	Plug or Receptacle	Mounting Type	Coupling	Class (See Note)	Contacts
Series I (Bayonet)					
/1	Receptacle	Narrow Flange	Bayonet	G, R	Crimp Socket
/2	Receptacle	Narrow Flange	Bayonet	G, R	Crimp Pin
/3	Receptacle	Wide Flange	Bayonet	G, R	Crimp Socket
/4	Receptacle	Wide Flange	Bayonet	G, R	Crimp Pin
/5	Receptacle	Single Hole	Bayonet	G, R	Crimp Socket
/6	Receptacle	Single Hole	Bayonet	G, R	Crimp Pin
/7	Receptacle	Cable	Bayonet	G, R	Crimp Socket
/8	Receptacle	Cable	Bayonet	G, R	Crimp Pin
/9	Receptacle	Narrow Flange	Bayonet	H	Solder Pin
/10	Receptacle	Wide Flange	Bayonet	H	Solder Pin
/11	Receptacle	Solder Flange	Bayonet	H	Solder Pin
/12	Receptacle	Single Hole	Bayonet	H	Solder Pin
/13	Plug	Cable	Bayonet	G, R	Crimp Socket
/14	Plug	Cable	Bayonet	G, R	Crimp Pin
/36	Plug	Cable	Bayonet	G, R	Crimp Pin
/37	Plug	Cable	Bayonet	G, R	Crimp Socket
/38	Receptacle	Narrow Flange	Bayonet	G, R	Crimp Pin
/39	Receptacle	Narrow Flange	Bayonet	G, R	Crimp Socket
/40	Receptacle	Wide Flange	Bayonet	G, R	Crimp Pin
/41	Receptacle	Wide Flange	Bayonet	G, R	Crimp Socket
/42	Plug (R.F.I.)	Cable	Bayonet	G, R, A	Crimp Pin
/43	Plug (R.F.I.)	Cable	Bayonet	G, R, A	Crimp Socket
/48	Plug (R.F.I.)	Cable	Bayonet	G, R, A	Crimp Pin
/49	Plug (R.F.I.)	Cable	Bayonet	G, R, A	Crimp Socket
Series II (Threaded)					
/17	Receptacle	Cable	Threaded	G, R	Crimp Socket
/18	Receptacle	Cable	Threaded	G, R	Crimp Pin
/19	Receptacle	Wall Mount	Threaded	G, R	Crimp Socket
/20	Receptacle	Wall Mount	Threaded	G, R	Crimp Pin
/21	Receptacle	Box Mount	Threaded	G, R	Crimp Socket
/22	Receptacle	Box Mount	Threaded	G, R	Crimp Pin
/23	Plug	Cable	Threaded	G, R	Crimp Socket
/24	Plug	Cable	Threaded	G, R	Crimp Pin
/25	Receptacle	Square Flange	Threaded	H	Solder Pin
/26	Receptacle	Solder Flange	Threaded	H	Solder Pin
/52	Plug	Cable	Threaded Self-lock	K	Crimp Pin
/53	Plug	Cable	Threaded Self-lock	K	Crimp Socket
Series III					
/71	Receptacle	Flange	Bayonet	G, R, A	Crimp Socket
/72	Receptacle	Flange	Bayonet	G, R, A	Crimp Pin
/73	Receptacle	Single Hole	Bayonet	G, R, A	Crimp Socket
/74	Receptacle	Single Hole	Bayonet	G, R, A	Crimp Pin
/75	Plug	Cable	Bayonet	G, R, A	Crimp Socket
/76	Plug	Cable	Bayonet	G, R, A	Crimp Pin
/77	Plug (R.F.I.)	Cable	Bayonet	R	Crimp Socket
/78	Plug (R.F.I.)	Cable	Bayonet	R	Crimp Pin
/79	Receptacle	Flange	Bayonet	H	Crimp Pin
/80	Receptacle	Solder Flange	Bayonet	H	Crimp Pin
/81	Receptacle	Single Hole	Bayonet	H	Crimp Pin
/82	Receptacle	Flange	Threaded	G, K, R, A	Crimp Socket
/83	Receptacle	Flange	Threaded	G, K, R, A	Crimp Pin

MIL-DTL-83723 Connectors (Continued)

Specification M83723/XX	Plug or Receptacle	Mounting Type	Coupling	Class (See Note)	Contacts
/84	Receptacle	Single Hole	Bayonet	G, K, R, A	Crimp Socket
/85	Receptacle	Single Hole	Bayonet	G, K, R, A	Crimp Pin
/86	Plug	Cable	Bayonet	G, K, R, A	Crimp Socket
/87	Plug	Cable	Bayonet	G, K, R, A	Crimp Pin
/88	Receptacle	Flange	Bayonet	H	Solder Pin
/89	Receptacle	Single Hole	Threaded	H	Solder Pin
/90	Receptacle	Solder Flange	Threaded	H	Solder Pin
/93	Receptacle	Solder Flange	Bayonet	H	Straight Pin
/94	Receptacle	Single Hole	Bayonet	H	Straight Pin
/95	Plug	Cable	Threaded Self-lock	K, R, A	Crimp Socket
/96	Plug	Cable	Threaded Self-lock	K, R, A	Crimp Pin

Note

Classes

R	200°C	Aluminium Shell, Conductive Finish
H	200°C	Steel Shell, Hermetic, Fluid Resistant Insert
G	200°C	Stainless Steel Shell, Passivated, Fluid Resistant Insert
A	200°C	Black Anodize (non-conductive)
K	200°C	Stainless Steel, Passivated, Fluid Resistant Insert (firewall type)
W	175°C	Aluminium Shell, Cadmium Plated Conductive Finish

g. Contacts and service tools, Series II (rear release contacts).

M39029 /29 - 212

Military designator

Specification sheet
/30 socket contact
/29 pin contact

Bin code
(see paragraph 28)

Bin Codes	Contact Size	Contact Insertion/ Extraction Tool
/30-217	16S-16	M81969/14-03
/29-212, /30-218	16-16	M81969/14-03
/29-213, /30-219	12-12	M81969/14-04
/29-214, /30-220	8-8	M81969/29-02*
/29-215, /30-221	4-4	M81969/29-03*
/29-216, /30-222	0-0	M81969/29-04*
*Extraction Tool only – sizes 8, 4 and 0 contacts can be installed without the use of an insertion tool.		

Disassembly of Connectors

87. Disassembly of MIL-DTL-83723 connectors is accomplished as follows:

a. **Plugs.** Remove backshell, ferrule, and coupling nut.

b. **Receptacles.** Remove backshell and ferrule. Since these are environmentally sealed connectors, the inserts cannot be removed from the connector shell.

Crimping of Contacts for MIL-DTL-83723 Connectors

88. Wires may be crimped in sizes 12, 16 and 20 contacts with M22520/1-01 crimp tool with M22520/1-02 crimp tool turret head assembly. The detail procedures are given in paragraph 40. To crimp size 0, 4 and 8 contacts, a power crimping tool, M22520/23-01, with appropriate die set and locator is required. Die set M22520/23-02 and locator M22520/23-09 are required for size 8 contacts. Die set M22520/23-04 and locator M22520/23-11 are required for size 4 contacts. Die set M22520/23-05 and locator M22530/23-13 are required for size 0 contacts. Follow crimping procedures provided with tool. Wire stripping dimensions are as follows:

Contact Size	Stripping Dimensions

20	4.7mm
16	6.3mm
12	6.3mm
8	12.7mm
4	12.7mm
0	15.8mm

CAUTION

If a size 10 wire is used in a size 8-8 contact, a bushing, MS3348-8-10, must be used to ensure a good crimp joint. If a size 6 wire is used in a size 4-4 contact, a bushing, MS3348-4-6, must be used. If a size 2 wire is used in a size 0-0 contact, a bushing, MS3348-0-2, must be used.

Insertion and Removal of Contacts

89. The crimp type contacts, which are found in all but the Class H (hermetic) connectors, are removable. The procedures for insertion and removal are given below:

a. Remove backshell, ferrule, and coupling nut from plug (backshell and ferrule from receptacle) and slide back over wire loom.

b. Follow instructions given in Figures 10–22 to 10–26 as applicable.

MIL-DTL-5015 CONNECTORS

90. Description. MIL-DTL-5015 covers circular, electric connectors with solder or removable crimp contacts (both front and rear release). These connectors are for use in electronic, electrical power, and control circuits. The type designations and class availability are given in Table 10–16.

91. See Figure 10–51 for typical illustrations of AN/MS type connectors. Refer to Figure 10–52 for insert arrangement. For the purpose of ordering MIL-DTL-5015 connectors, the part numbers of connectors and component parts are given as follows:

a. Cable clamps for MIL-DTL-5015 connectors are described in paragraph 98 and Figure 10–53.

b. Crimping of Contacts: Use same crimping procedure and tools described for MIL-DTL-83723 connectors (see paragraph 83).

c. Connectors.

MS3456 W 12 - 10 P W

MS number
Class
(see Table 4-16)
Shell size
(see paragraph 8)
Insert arrangement
(see Figure 4-43)
Contact style
(see paragraph 8)
Insert position
(blank for normal position)

d. Contacts and service tools for connector series MS3450 through MS3459 (Rear Release Contacts).

M39029 /29 - 212

Military designator
Specification sheet
/30 socket contact
/29 pin contact
Bin code
(see paragraph 28)

Bin Codes	Contact Size	Contact Insertion/ Extraction Tool
/30-217	16S-16	M81969/14-03
/29-212, /30-218	16-16	M81969/14-03
/29-213, /30-219	12-12	M81969/14-04
/29-214, /30-220	8-8	M81969/29-02*
/29-215, /30-221	4-4	M81969/29-03*
/29-216, /30-222	0-0	M81969/29-04*
*Extraction Tool only – sizes 8, 4 and 0 contacts can be installed without the use of an insertion tool.		

e. Contacts and service tools for connector series MS3400 through MS3412 (Front Release Contacts).

Bin Codes	Contact Size	Contact Insertion Tool	Contact Extraction Tool
/44-287, /45-294	16-22	M81969/17-01	M81969/19-01
/44-288, /45-295	16-16	M81969/17-01	M81969/19-01
/44-289, /45-296	12-16	M81969/17-02	M81969/19-02
/44-290, /45-297	12-12	M81969/17-02	M81969/19-02
/44-291, /45-298	8-8	M81969/17-06	M81969/19-03
/44-292, /45-299	4-4	M81969/17-07	M81969/19-04
/44-293, /45-300	0-0	M81969/17-08	M81969/19-05

Table 10–16 MIL-DTL-5015 Connector Classes

Class	Feature	Solder Contacts MS3100 Series 1/	Front Release Crimp Contacts MS3400 Series	Rear Release Crimp Contacts MS3400 Series	Environ. Resistant	Fluid Resistant	Insert Material	Shell Material	Shell Finish
A	Solid shell	X	–	–	–	Limited	Neoprene	Aluminium	Cadmium, olive drab
B	Split shell	X	–	–	–	Limited	Neoprene	Aluminium	Cadmium, olive drab
C	Pressurized	X	–	–	–	Limited	Neoprene	Aluminium	Cadmium, olive drab
D	High impact shock	–	X	–	X	Partial	Silicone	Wrought aluminium	Cadmium, over nickel
E	Without clamp	X	–	–	X	Limited	Neoprene	Aluminium	Cadmium, olive drab
F	With clamp	X	–	–	X	Limited	Neoprene	Aluminium	Cadmium, olive drab
H	Hermetic seal	X	–	–	X	Complete	Silicone	Ferrous alloy	Electroless nickel
J	Gland seal for jacketed cable	X	–	–	X	Limited	Neoprene	Aluminium	Cadmium, olive drab
K	Firewall	X	X	X	X	Complete	Silicone	Ferrous alloy	Electroless nickel
L	Fluid resistant	–	X	X	X	Complete	Silicone	Aluminium	Electroless nickel
P	Potting seal	X	–	–	X	Limited	Neoprene	Aluminium	Cadmium, olive drab
R	Grommet seal without clamp	X	–	–	X	Limited	Neoprene	Aluminium	Cadmium, olive drab
U	High temperature	–	X	X	X	Partial	Silicone	Aluminium	Electroless nickel
W	Life	–	X	X	X	Complete	Silicone	Aluminium	Cadmium, olive drab
Y	Accepts large wire insulation O.D.	–	X	–	X	Partial	Silicone	Aluminium	Cadmium, olive drab

1/ MS3450 Series is the preferred replacement for MS3100 Series.

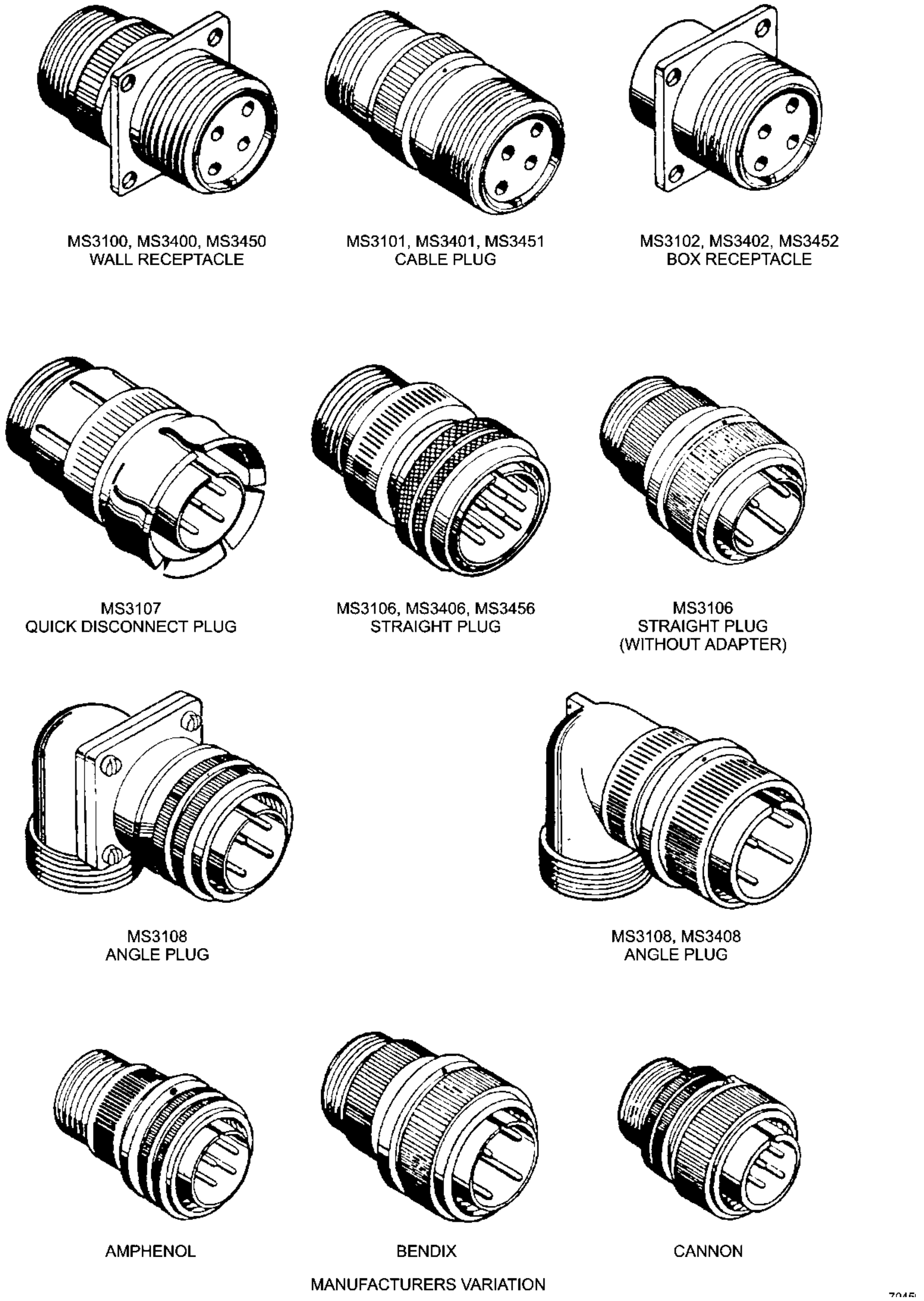


Figure 10–53 Typical AN(MS) Connectors

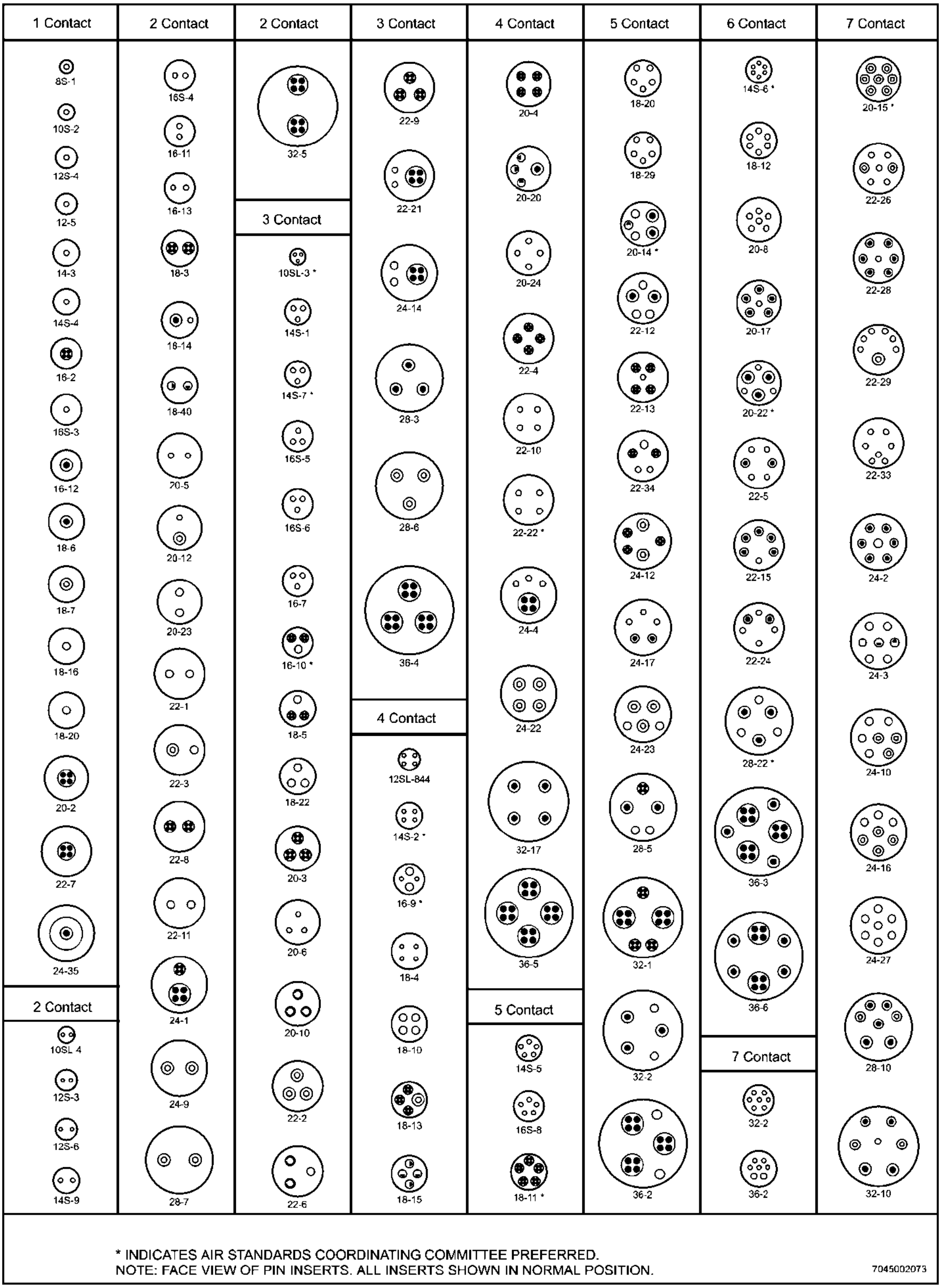
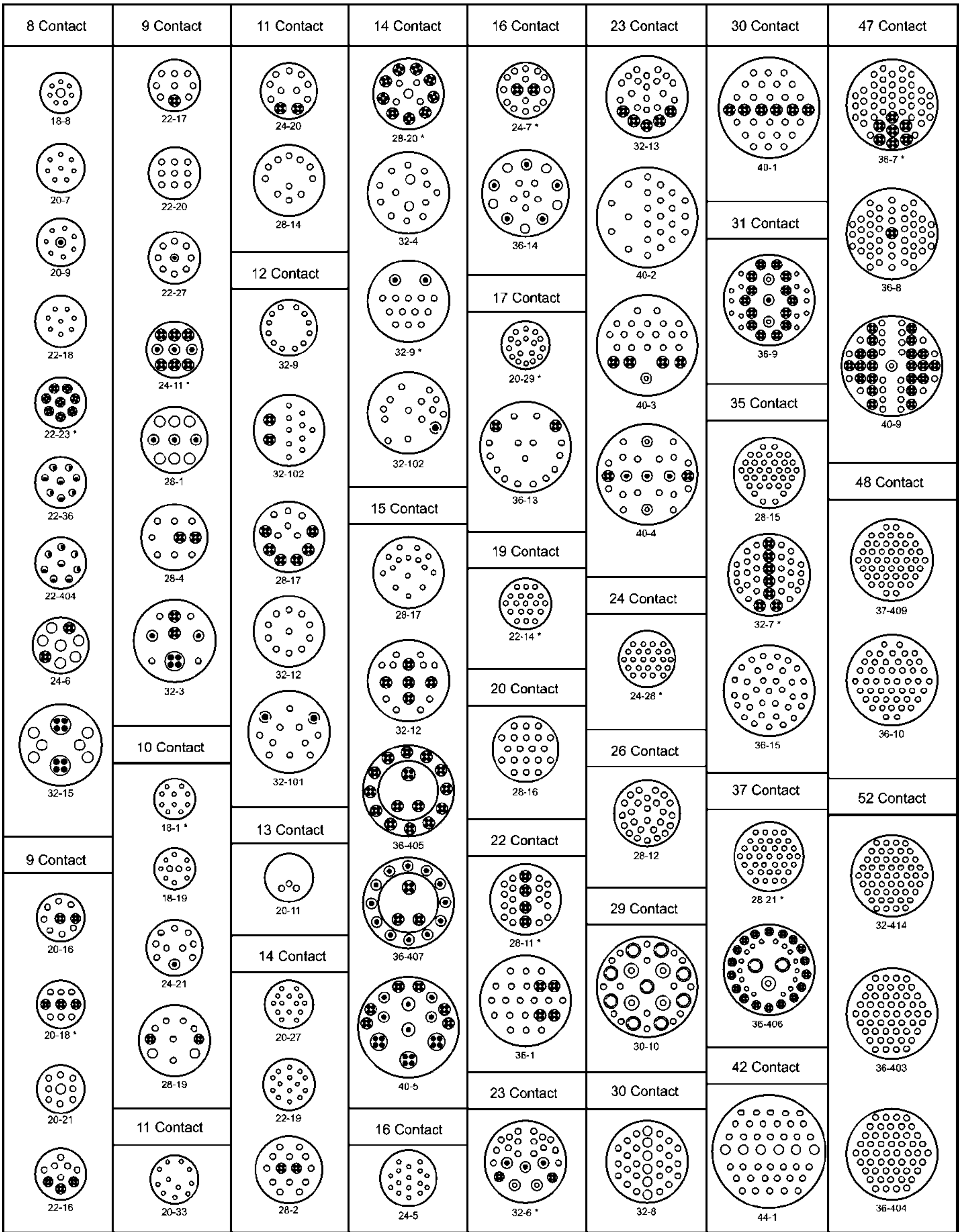


Figure 10–54 Insert Arrangements - AN Type Connectors, MIL-DTL-5015 and MIL-DTL-83723, Series II (Sheet 1 of 2)



* INDICATES AIR STANDARDS COORDINATING COMMITTEE PREFERRED.
NOTE: FACE VIEW OF PIN INSERTS. ALL INSERTS SHOWN IN NORMAL POSITION.

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Figure 10–55 Insert Arrangements - AN Type Connectors, MIL-DTL-5015 and MIL-DTL-83723, Series II (Sheet 2 of 2)

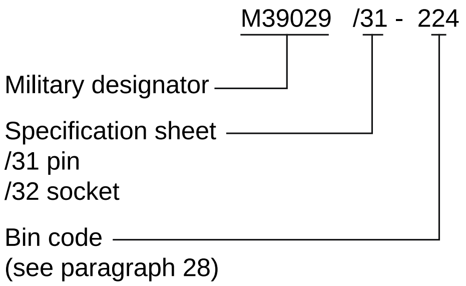
MIL-C-26482, MIL-C-26500 AND MIL-C-81703 CONNECTORS

Description

92. MIL-C-26482, MIL-C-26500 and MIL-C-81703 cover, electric connectors with solder or removable crimp contacts. The types and classes of MIL-C-26482, MIL-C-26500 and MIL-C-81703 connectors are listed in Table 10–17.

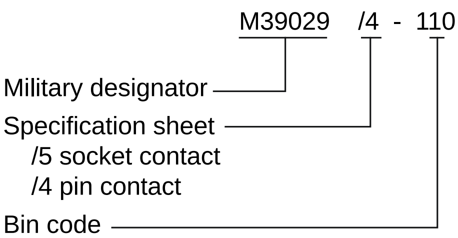
93. Typical connectors are illustrated in Figure 10–53. Refer to paragraph 8 and Figure 10–1 for typical connector identification.

a. Contacts and service tools for MIL-C-26482 Series 1, MIL-C-26500 and MIL-C-81703 Series 2 connectors.



Bin Code	Contact Size	Basic Crimp Tool	Positioner or Turret	Contact Insertion Tool	Contact Extraction Tool
/31-223, /31-240 /31-241, /31-448 /32-242, /32-250 /32-260, /32-449	20-20	M22520/1-01 or M22520/2-01 or M22520/7-01	M22520/1-02 M22520/2-02 M22520/7-02	M81969/14-02 or M81969/17-03	M81969/19-07
/31-228, /31-229 /32-247, /32-248	16-16	M22520/1-01 or M22520/7-01	M22520/1-02 M22520/7-03	M81969/14-03 or M81969/17-04	M81969/19-08
/31-243, /31-235 /32-253, /32-254	12-12	M22520/1-01	M22520/1-02	M81969/14-04 or M81969/17-05	M81969/19-09

b. Contacts and service tools for MIL-C-26482 Series 2 and MIL-C-81703 Series 3 connectors.



c. Cable clamps, for MIL-C-26482 Series 1 and MIL-C-81703 Series 2 connectors, are provided with the connectors. Cable clamps for MIL-C-26482 series 2 and MIL-C-81703 connectors are described in paragraph 98 and Figure 10–56.

Bin Code	Size	Basic Crimp Tool	Positioner or Turret	Contact Insertion/ Extraction Tool
/4-110, /5-115	20-20	M22520/1-01 or M22520/2-01 or M22520/7-01	M22520/1-02 M22520/2-02 M22520/7-02	M81969/14-02
/4-111, /5-116	16-16	M22520/1-01 or M22520/7-01	M22520/1-02 M22520/7-03	M81969/14-03
/4-112, /5-117	16-20	M22520/1-01 or M22520/7-01	M22520/1-02 or M22520/7-03	M81969/14-03
/4-113, /5-118	12-12	M22520/1-01	M22520/1-02	M81969/14-04
/4-114, /5-119	12-16	M22520/1-01	M22520/1-02	M81969/14-04

MIL-C-81511 CONNECTORS

Description

94. MIL-C-81511 connectors are general-purpose high-density, environment-resisting connectors similar to the MS series. The connectors have a quick disconnect feature, employing bayonet-type locking ring. The types available are indicated in Table 10–18.

Marking MIL-C-81511 Connectors

95. The connector part number consists of the letter “M”, the basic number of the specification sheet, and the applicable characteristics as in the following example (See Notes 2, 3, and 4 from Table 10–18):

M 81511/01 E D 01 P 1

Military part number indicator
Basic part number
Class
Shell size
Insert arrangement
Contact designator
Key positions

a. Contacts and service tools for MIL-C-81511 Series 1 and 2 connectors.

M39029 /33 - 261

Military designator
Specification sheet
/33 socket (Series I)
/46 socket (Series 2)
/47 pin (Series 1 & 2)
Bin code
(see paragraph 28)

b. Contacts and service tools for MIL-C-81511 Series 3 and 4 connectors.

M39029 /16 - 166

Military designator
Specification sheet
/16 socket (Series 4)
/17 socket (Series 3)
/18 pin (Series 3 & 4)
Bin code
(see paragraph 28)

Bin Code	Contact Size	Basic Crimp Tool	Positioner or Turret	Contact Insertion Tool	Contact Extraction Tool
/33-261, /33-262	23-28	M22520/2-01	M22520/2-03	M81969/2-01	M81969/3-01
/33-263, /33-264	23-22	M22520/2-01	M22520/2-03	M81969/2-01	M81969/3-01
/46-301, /46-302	23-28	M22520/2-01	M22520/2-03	M81969/2-01	M81969/3-01
/46-303, /46-304	23-22	M22520/2-01	M22520/2-03	M81969/2-01	M81969/3-01
/47-311, /47-312	23-28	M22520/2-01	M22520/2-03	M81969/2-01	M81969/3-05
/47-313, /47-314	23-22	M22520/2-01	M22520/2-03	M81969/2-01	M81969/3-05
/33-265, /33-266	20-20	M22520/1-01	M22520/1-08	M81969/2-02	M81969/3-02
/46-305, /46-306	20-20	M22520/1-01	M22520/1-08	M81969/2-02	M81969/3-02
/47-315, /47-316	20-20	M22520/1-01	M22520/1-08	M81969/2-02	M81969/3-06
/33-267, /33-268	16-16	M22520/1-01	M22520/1-08	M81969/2-02	M81969/3-03
/46-307, /46-308	16-16	M22520/1-01	M22520/1-08	M81969/2-02	M81969/3-03
/47-336, /47-337	16-16	M22520/1-01	M22520/1-08	M81969/2-02	M81969/3-07
/33-269, /33-270	12-12	M22520/1-01	M22520/1-08	M81969/2-02	M81969/3-04
/46-309, /46-310	12-12	M22520/1-01	M22520/1-08	M81969/2-02	M81969/3-04
/47-338, /47-339	12-12	M22520/1-01	M22520/1-08	M81969/2-02	M81969/3-08

Bin Code	Contact Size	Basic Crimp Tool	Positioner or Turret	Contact Insertion/ Extraction Tool	Extraction Tool For Unwired Contact
/16-166	23-28	M22520/2-01	M22520/2-13	M81969/16-04	M81969/30-01
/16-167	23-22	M22520/2-01	M22520/2-13	M81969/16-04	M81969/30-01
/17-171	23-28	M22520/2-01	M22520/2-16	M81969/16-04	M81969/30-01
/17-172	23-22	M22520/2-01	M22520/2-16	M81969/16-04	M81969/30-01
/18-176	23-28	M22520/2-01	M22520/2-13	M81969/16-04	M81969/30-01
/18-177	23-22	M22520/2-01	M22520/2-13	M81969/16-04	M81969/30-01
/16-168	20-20	M22520/2-01	M22520/2-14	M81969/16-01	M81969/30-02
/17-173	20-20	M22520/2-01	M22520/2-17	M81969/16-01	M81969/30-02
/18-178	20-20	M22520/2-01	M22520/2-14	M81969/16-01	M81969/30-02
/16-169	16-16	M22520/2-01	M22520/2-15	M81969/16-02	M81969/30-03
/17-174	16-16	M22520/2-01	M22520/2-18	M81969/16-02	M81969/30-03
/18-179	16-16	M22520/2-01	M22520/2-15	M81969/16-02	M81969/30-03
/16-170	12-12	M22520/1-01	M22520/1-09	M81969/16-03	M81969/30-04
/17-175	12-12	M22520/1-01	M22520/1-10	M81969/16-03	M81969/30-04
/18-180	12-12	M22520/1-01	M22520/1-09	M81969/16-03	M81969/30-04

Insertion and Removal of Contacts

96. The connector inserts in the MIL-C-81511 connectors are bonded to the connector shells and are not removable. The insertion and/or removal of contacts in these connectors is accomplished as follows:

97. Precautionary Measures. These connectors are built to withstand successfully the anticipated conditions common to the application in which they will be used. However, certain precautionary measures as listed below must be followed when working with these connectors.

- **a.** Do not attempt to remove the inserts from the shell. These components are permanently bonded to the shells and cannot be removed without destroying them. Also, do not attempt to remove the face seal from the pin insert.
- **b.** When working with these connectors, always choose a clean, dry, smooth working surface, to prevent foreign matter from collecting on the sealing surfaces and/or the electrical components. This is necessary also to prevent abrasion of sealing surfaces. It is also important to avoid sliding the resilient components along working surfaces.
- **c.** Occasionally some damage to the wire holes in the resilient grommet may occur during insertion of the contacts. This damage may be limited to small slash or knife-blade type cuts resulting in cracks that radiate between the wire holes. The grommet will seal satisfactorily in this case. On the other hand, the damage around the holes may consist of nicks or actual voids due to small portions of the rubber being removed or gouged out. Larger voids will present a serious sealing problem, and the connector will require replacement.

98. Insertion of Contacts. The insertion of contacts is as follows:

- **a.** Before attempting any insertion of contacts, determine if the rear nut assembly is in the unlocked position. A coloured stripe will appear when the rear nut assembly is rotated counter clockwise. At this point, the connector is in position for both insertion and removal of contacts. This can also be determined by checking the space between the rear nut knurled diameter and the shell. The space should be between 2.5 to 4 mm.
- **b.** Place the contact into the desired hole in the rear of the connector by hand; then, using the appropriate insertion tool (see Table 10–19), place the crimped contact in the front of the tool. The mating end should extend out of the tool and the wire into the tool. The tool is in its proper position when it grasps the rear of the contact behind the contact shoulder.
- **c.** The contact and the tool should be aligned within the desired hole as straight as possible to avoid serious damage to the connector.

Table 10–17 Miniature MS Connector Type and Class Availability

Connector Type	Description	Contact Type	Series	Class Availability
MIL-C-26482F – Bayonet Coupling				
MS3110	Wall Mounting Receptacle	Solder	1	E, F, J
MS3111	Cable Connecting Plug	Solder	1	E, F, J, P
MS3112	Box Mounting Receptacle	Solder	1	E
MS3113	Solder Mounting Receptacle	Solder	1	H
MS3114	Single Hole Mounting Receptacle	Solder	1	E, F, P, H
MS3115	Dummy Stowage Receptacle	Solder	1	
MS3116	Straight Plug	Solder	1	E, F, P, J
MS3119	Bulkhead Mounting Receptacle	Solder	1	E
MS3120	Wall Mounting Receptacle	Crimp	1	E, F
MS3121	Cable Connecting Plug	Crimp	1	E, F, P
MS3122	Box Mounting Receptacle	Crimp	1	E
MS3124	Single Hole Mounting Receptacle	Crimp	1	E, F, P
MS3126	Straight Plug	Crimp	1	E, F, P
MS3127	Box Mounting Receptacle	crimp	1	E
MS3128	Wall Mounting Receptacle	Crimp	1	E, F, P
MS3440	Narrow Flange Mounting Receptacle	Solder	2	H
MS3442	Wide Flange Mounting Receptacle	Solder	2	H
MS3443	Solder Flange Mounting Receptacle	Solder	2	H
MS3449	Single Hole Mounting Receptacle	Solder	2	H
MS3470	Narrow Flange Mounting Receptacle	Crimp	2	E, L, W, A
MS3471	Cable Connecting Receptacle	Crimp	2	E, L, W, A
MS3472	Wide Flange Mounting Receptacle	Crimp	2	E, L, W, A
MS3474	Rear Mounting Jam Nut Receptacle	Crimp	2	E, L, W, A
MS3475	RFI Shielded Plug	Crimp	2	E, L, W
MS3476	Plug	Crimp	2	E, L, W, A
MIL-C-81703 – Push-Pull Coupling				
MS3130	Wall Mounting Receptacle	Solder	1	E, P, J
MS3132	Box Mounting Receptacle	Solder	1	E, H
MS3134	Single Hole Mounting Receptacle	Solder	1	E, P, J, H
MS3135	Wall Mounting Dummy Stowage Receptacle	Solder	1,2	
MS3137	Short Plug	Solder	1	E, P, J
MS3138	Lanyard Plug	Solder	1	E, P, J
MS3139	Bulkhead Receptacle	Solder	1	E
MS3140	Wall Mounting Receptacle	Crimp	2	E, J
MS3144	Single Hole Mounting Receptacle	Crimp	2	E, J
MS3147	Straight Plug	Crimp	2	E, J
MS3148	Lanyard Plug	Crimp	2	E, J
MS3424	Wall Mounting Flange Receptacle	Crimp	3	E, L
MS3445	Rack and Panel Plug	Crimp	2	E
MS3446	Rack and Panel Plug	Crimp	3	E, L
MS3463	Hermetic Solder Mounting Receptacle	Solder	3	H
MS3464	Jam Nut Mounting Receptacle	Crimp	3	E, L
MS3466	Hermetic Box Mounting Receptacle	Solder	3	H
MS3467	Plug	Crimp	3	E, L
MS3468	Lanyard Plug	Crimp	3	E, L
MS3469	Hermetic Jam Nut Mounting Receptacle	Solder	3	H
MIL-C-26500 – Threaded and Bayonet Couplings				
MS24266	Straight Plug	Crimp		F. H, R
MS27562	Flange Mounting Receptacle	Crimp		F, H, R
MS27563	Single Hole Mounting Receptacle	Crimp		F, H, R
MS27564	Straight Plug (Hard Insert)	Crimp		F, H. R

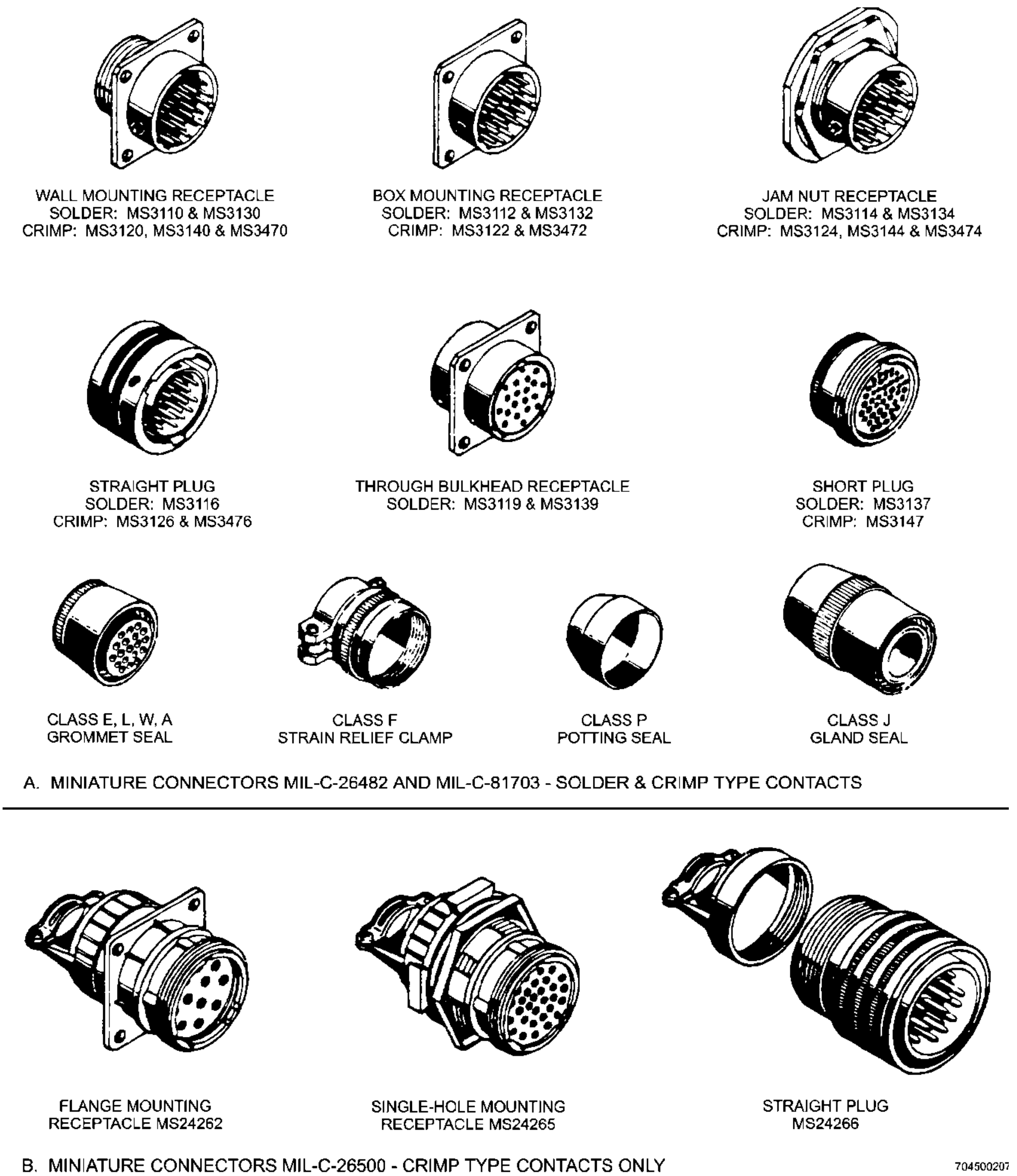


Figure 10–56 Typical MS Connectors – Miniature

d. Push the contact into the connector. The shoulder on the contact provides a positive stop. At this point, the contact is fully inserted. Slide the tool back along the wire insulation until it clears the grommet.

> NOTE
>
> For rear-release contacts (series 3 and 4 crimp-type), tines will lock into place behind the contact shoulder. A light pull should be exerted on the wire of rear-release contacts to be sure they are locked into position.

e. A contact should be inserted in all unwired holes in the receptacle to provide for proper sealing on the equipment. Sealing plugs must be placed behind all unwired contacts.

f. After all contacts and sealing plugs have been inserted into the connector, tighten the rear nut by turning clockwise until the locking nut is tight.

NOTE

To maintain seal, all holes behind unused contacts must be filled with the proper size sealing plugs.

Table 10–18 MIL-C-81511 Connectors

Specification (M81511/XX)	Plug or Receptacle	Mounting Type	Series (Note 1)	Classes (Note 2)	Contacts
/01	Receptacle	Square flange	2	A, F, E	Crimp
/02	Receptacle	Solder flange	2	B, G, H	Solder (pins only)
/03	Receptacle	Single hole	2	A, F, E	Crimp
/04	Receptacle	Single hole	2	B, G, H	Solder (pins only)
/05	Receptacle	Cable	2	A, F, E	Crimp
/06	Plug	Cable	2	A, F, E	Crimp
/21	Receptacle	Square flange	1	A, F, E	Crimp
/22	Receptacle	Solder flange	1	B, G, H	Solder (pins only)
/23	Receptacle	Single hole	1	A, F, E	Crimp
/24	Receptacle	Single hole	1	B, G, H	Solder (pins only)
/25	Receptacle	Cable	1	A, F, E	Crimp
/26	Plug	Cable	1	A, F, E	Crimp
/27	Receptacle	Single hole	1	B, G, H	Non-removable
/28	Receptacle	Single hole	2	B, G, H	Non-removable
/31	Receptacle	Square flange	2	C, T, P	Crimp
/32	Receptacle	Single hole	2	C, T, P	Crimp
/33	Plug	Cable	2	C, T, P	Crimp
/34	Plug	Cable	2	C, T, P	Crimp
/35	Receptacle	Square flange	1	C, T, P	Crimp
/36	Receptacle	Single hole	1	C, T, P	Crimp
/37	Plug	Cable	1	C, T, P	Crimp
/38	Plug	Cable	1	C, T, P	Crimp
/41	Receptacle	Square flange	3	A, E, F	Crimp
/42	Receptacle	Solder flange	3	D	Solder (pins only)
/44	Receptacle	Single hole	3	D	Solder (pins only)
/45	Receptacle	Cable	3	A, E, F	Crimp
/46	Plug		3	A, E, F	Crimp
/47	Receptacle	Solder flange	3	L	Crimp (pins only)
/48	Receptacle	Single hole	3	L	Crimp (pins only)
/49	Receptacle	Single hole	3	A, E, F	Crimp
/50	Receptacle	Single hole	4	L	Crimp (pins only)
/51	Receptacle	Square flange	4	A, E, F	Crimp
/52	Receptacle	Solder flange	4	D	Solder (pins only)
/53	Receptacle	Single hole	4	A, E, F	Crimp
/54	Receptacle	Single hole	4	D	Solder (pins only)
/55	Receptacle	Cable	4	A, E, F	Crimp
/56	Plug	Cable	4	A, E, F	Crimp
/57	Receptacle	Solder flange	4	L	Crimp (pins only)

Table 10–18 MIL-C-81511 Connectors (Continued)

NOTES

(1) Series are defined as follows:
Series 1 & 3 – Long shell
Series 2 & 4 – Light weight, short shell

(2) Series defined as follows:

Type	Operating Temperature 150°C	175°C	200°C
Grommet seal	E	F	A
Hermetic seal	H	G	B
Potting seal	P	T	C

(3) The shell size and insert arrangement are identified by a two-part code. The first part consists of a single letter indicating the shell size in accordance with the following code. The second part should be two digits indicating the insert arrangement in accordance with the applicable insert arrangement.

Shell Size Code

Shell Size	Code Letter
8	A
10	B
14	D
16	E
18	F
20	G
22	H
24	J

(4) The following designators are used to indicate a full complement of applicable power contacts:
P – Pin contacts
S – Socket contacts
C – Feedthrough contacts

The following designators are used to indicate a connector less contacts. They will be used only when other than power contacts are to be installed in the connector. Examples of this are shielded, thermocouple, and coaxial contacts:
A – Less pin contacts
B – Less socket contacts

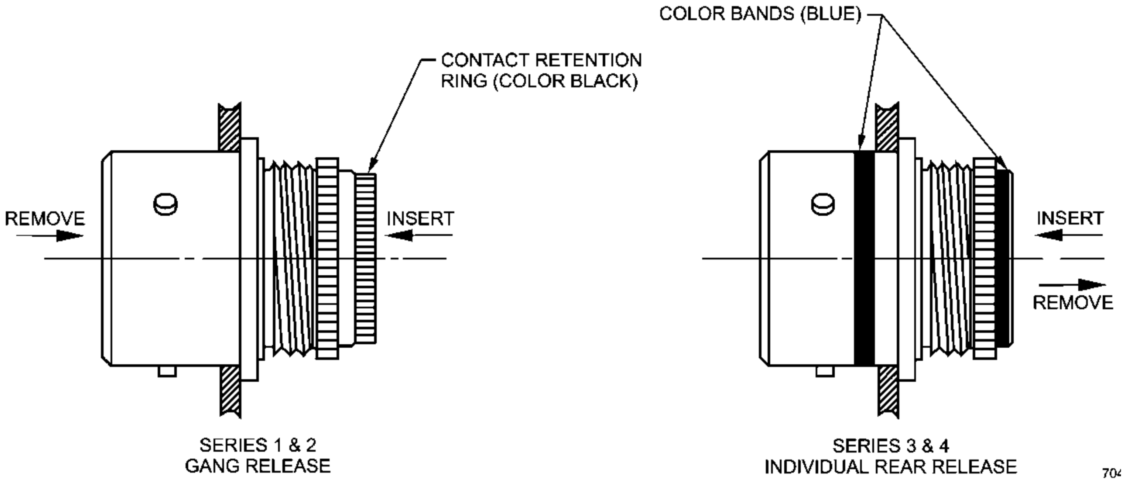


Figure 10–57 Colour Marking for Individual Release MIL-C-81511 Connectors

99. Connector Disassembly and Removal of Contacts. Carry out connector disassembly and removal of contacts as follows:

> **CAUTION**
>
> The newer type MIL-C-81511 (series 3 and 4) connectors have individual release contacts which must be removed (and installed) from the rear of the connector. These connectors are identified by a special blue band on both front and rear as shown in Figure 10–56.

a. Remove any adapters from the rear of the connector.

b. Loosen the rear nut assembly by turning it counter clockwise when viewed from the wire end. Approximately 1.5mm of axial movement unlocks the contacts. The coloured stripe will fully appear. The connector is now in position for removal of contacts.

c. Select the proper contact removal tool from Table 10–19.

d. Series 1 and 2 (gang release) contacts are removed from the front of the connector as follows:

(1) The pin contact removal tool has a hole to accept the pin contact. The socket removal tool has a pin tip to insert in the socket.

(2) Grasp the tool by the handle. Locate the contact to be removed by the numbers on the insert face.

(3) Mate the tool with the contact and, holding the tool at right angles with the insert face, push axially against the tip of the contact until the contact appears at the grommet (rear) end of the connector. The removal tools are designed to bottom against the insert face when the contact is completely released and pushed out.

(4) The wire and contact can now be removed from the connector.

> **CAUTION**
>
> Good axial alignment should be maintained during removal of series 1 and 2 contacts. Misalignment can bend the contact and damage the connector.

e. Series 3 and 4 (individual release) contacts are removed from the rear of the connector as follows:

(1) With the rear of the connector facing you, lay the wire of the contact to be removed along the slot of the tool. Squeeze the wire firmly into the tool between the thumb and forefinger about 1.2mm from the tool tip, and snap the wire into the tool. (A quick pull on the tool away from the connector may be necessary to snap the wire into place).

(2) With the wire in place in the tool, slide the tool down along the wire and into the rear cavity and slowly into the connector until a positive resistance is felt. At this time, the contact retaining mechanism is in the unlocked position.

> **CAUTION**
>
> When using minimum diameter wire, the tool may have a tendency to stop against the rear of the contact crimp barrel. If this should occur, careful manipulation of the tool will permit it to ride over the crimp barrel and into the proper position to unlock the contact.

(3) Press the wire of the contact against the serrations of the plastic tool, and pull both the tool and the wired contact out of the connector.

> **CAUTION**
>
> Individual release contacts are easily removed. The use of too much force may damage the connector insert.

f. Unwired series 3 and 4 (individual release) contacts are removed from the rear of the connector as follows:

(1) Remove sealing plug and insert appropriate size MS3159 tool into rear of cavity. Extended plunger in MS3159 tool can be used to guide tool through cavity to rear of contact crimp barrel.

(2) When plunger butts against contact barrel, release plunger and grasp tool using probe hand grip. Push probe in so that contact barrel slides into hollow centre of probe and pushes plunger back. Hollow probe diameter is slightly less than contact barrel diameter so contact will stick in probe.

(3) When probe bottoms in connector, contact locking tines will be released, and contact may be pulled out.

(4) Plunger may then be used to push removed contact from removal tool.

Table 10–19 MIL-C-81511 Contact Insertion and Removal Tools

Contact Size	Series 1 & 2 (Gang Release) Contacts			Series 3 & 4 (Individual Release) Contacts	
	Insertion Tool	**Pin Removal Tool**	**Socket Removal Tool**	**Insertion and Removal Tool**	**Unwired Contact Removal Tool**
22 & 23	MS3323-23	MS3342-23	MS3344-23	MS3160-22	MS3159-22
20	MS3323-20	MS3342-20	MS3344-20	MS3160-20	MS3159-20
16	MS3323-16	MS3342-16	MS3344-16	MS3160-16	MS3159-16
12				MS3160-12	MS3159-12

MIL-DTL-38999 CONNECTORS

General Description

100. Connectors manufactured under this specification are miniature, high-density, environment-resisting types. They are available with removable crimp type contacts, except for the hermetic sealing types which have non-removable solder contacts. The availability of MIL-DTL-38999 is indicated in Table 10–20. Typical MIL-DTL-38999 connectors are illustrated in Figure 10–57.

Classification

101. These connectors are classified as follows:

a. Series:

(1) I – Grounded, Scoop-proof; Bayonet Coupling.

(2) II – Low Silhouette; Bayonet Coupling.

(3) III – Grounded, Scoop-proof; Threaded Coupling.

(4) IV – Grounded, Scoop-proof; Breech Coupling.

NOTE

The series I, II, III and IV connectors are not interchangeable or intermatable.

b. Types:

(1) Plugs:

(a) Straight.

(b) Straight, Grounded.

(c) Lanyard Release.

(2) Receptacles:

(a) Box Mounting.

(b) Wall Mounting.

(c) Jam-nut Mounting.

(d) Solder Mounting.

c. Classes (Series I & II):

(a) E – Environment resisting.

(b) P – For potting; includes potting form.

(c) T – Environment resisting.

(d) Y – Hermetically sealed.

d. Classes (Series III & IV):

(a) C – Environment resisting nonconductive finish.

(b) F – Environment resisting conductive finish.

(c) K – Environment resisting firewall barrier.

(d) W – Environment resisting corrosion resistant plating.

(e) Y – Hermetically Sealed.

e. Finishes (Series I & II):

(a) A – Bright cadmium plate.

(b) B – Olive-drab cadmium plate.

(c) C – Anodic.

(d) D – Fused tin plate.

(e) E – Stainless steel, unplated.

(f) F – Electroless nickel.

f. Finishes (Series III & IV):

(a) C – Anodic.

(b) F – Electroless Nickel.

(c) K – Corrosion Resistant Steel Shell.

(d) W – Olive-drab cadmium plate.

(e) Y – Corrosion resistant steel shell.

g. Shell Size Code – Series III & IV only:

Shell Size	Code Letter	Shell Size	Code Letter
9	A	17	E
11	B	19	F
13	C	21	G
15	D	23	H
		25	I

h. Cable Clamps for MIL-DTL-38999 connectors are described in paragraph 98 and Figure 10–57.

i. Contact Styles:

(a) P – Pin.

(b) S – Socket.

M39029 /58 - 360

Military designator
Specification sheet
/56 socket contact
(Series I, III & IV)
/57 socket contact
(Series II)
/58 pin contact
(Series I, II, III & IV)
Bin code
(see paragraph 28)

Socket Bin Code (Series I, III & IV)	Socket Bin Code (Series II)	Pin Bin Code (Series I, II, III & IV)	Contact Size	Contact Insertion Tool*	Contact Extraction Tool*
/56-348	/57-354	/58-360	22-22D	M81969/14-01 or M81969/8-01	M81969/14-01 or M81969/8-02
/56-349	/57-355	/58-361	22-22M	M81969/14-01 or M81969/8-01	M81969/14-01 or M81969/8-02
/56-350	/57-356	/58-362	22-22	M81969/8-03	M81969/8-04
/56-351	/57-357	/58-363	20-20	M81969/14-02 or M81969/8-05	M81969/14-02 or M81969/8-06
/56-352	/57-358	/58-364	16-16	M81969/14-03 or M81969/8-07	M81969/14-03 or M81969/8-08
/56-353	/57-359	/58-365	12-12	M81969/14-04 or M81969/8-09	M81969/14-04 or M81969/8-10
/56-327	N/A	/58-528	10-10	M81969/14-05	M81969/14-05
* M81969/8-XX is a metal tool. M81969/14-XX is a double ended plastic insertion/extraction tool.					

Bin Code	Contact Size	Basic Crimp Tool	Positioner or Turret
/56-348, 56/349 and /56-350	22-22D 22-22M 22-22	M22520/2-01 or M22520/7-01	M22520/2-07 or M22520/7-05
/56-354, 56/355 and /56-356	22-22D 22-22M 22-22	M22520/2-01 or M22520/7-01	M22520/2-06 or M22520/7-06
/56-360, 56/361 and /56-362	22-22D 22-22M 22-22	M22520/2-01 or M22520/7-01	M22520/2-09 or M22520/7-07
/56-351, 56/357 and /56-363	20-20	M22520/1-01 or M22520/2-01 or M22520/7-01	M22520/1-04 or M22520/2-10 or M22520/7-08
/56-352, 56/358 and /56-364	16-16	M22520/1-01 or M22520/7-01	M22520/1-04 or M22520/7-04
/56-353, 56/359 and /56-365	12-12	M22520/1-01	M22520/1-04

Table 10–20 Availability of MIL-DTL-38999 Connectors

Spec (MSxxxxx)	Type	Mounting	Series	Class**
27466	Receptacle	Wall Flange	I	E,P,T
27467	Plug Straight		I	E,P,T
27468	Receptacle	Jam Nut	I	E,P,T
27469	Receptacle	Wall Flange	I	Y
27470	Receptacle	Jam Nut	I	Y
27471	Receptacle	Solder	I	Y
*27472	Receptacle	Wall Flange	II	E,P,T
*27473	Plug Straight		II	E,P,T
*27475	Receptacle	Wall Flange	II	Y
*27476	Receptacle	Box Flange	II	Y
*27477	Receptacle	Jam Nut	II	Y
*27478	Receptacle	Solder	II	Y
*27479	Receptacle	Wall Flange	II	E,P,T
*27480	Plug Straight		II	E,P
*27481	Receptacle	Jam Nut	II	E,P,T
*27482	Receptacle	Wall Flange	II	Y
*27483	Receptacle	Jam Nut	II	Y
*27484	Plug Straight Grounding		II	E,P,T
27496	Receptacle	Box Flange	I	E,P,T
*27497	Receptacle	Back Panel Wall	II	E,P,T
*27498	Plug 90° Elbow		I	E,P
*27499	Receptacle	Box Flange	II	E
*27500	Receptacle	Box Flange	II	E
*27503	Receptacle	Solder	II	Y
*27504	Receptacle	Box Flange	II	E,P,T
27505	Receptacle	Box Flange	I	E
*27508	Receptacle	Back Panel Box	II	E,P,T
*27513	Receptacle	Box Flange	II	E
*27515	Receptacle	Back Panel Wall	I	E,P,T
*Inactive for new design. **Class E and P inactive for new design.				
Spec (D38999/)	**Type**	**Mounting**	**Series**	**Class**
20	Receptacle	Wall Mount Flange	III	F, G, J, K, M, S, W
21	Receptacle	Box Mount Flange	III	N, Y
22	Receptacle	Dummy Stowage	III	G, J, M, W
23	Receptacle	Jam Nut	III	N, Y
24	Receptacle	Jam Nut	III	F, G, J, K, M, S, W
25	Receptacle	Solder	III	N, Y
26	Plug (EMI)	Straight	III	F, G, J, K, M, S, W
27	Receptacle	Weld	III	N, Y
28	Nut	Connector Mounting	III, IV	C, F, G, H, J, K, M, W
29	Plug (Pins)	Lanyard Release	III	F, K, S, W
30	Plug (Sockets)	Lanyard Release	III	F, K, S, W
31	Plug	Lanyard Release	III	W
32	Cover Plug	Protective	III	G, J, M, W
33	Cover Receptacle	Protective	III	G, J, M, W
34	Receptacle	Breakaway Jam Nut	III	W
35	Receptacle	Breakaway Wall Mount	III	W
40	Receptacle	Wall Mount Flange	IV	C, F, K, S, W
41	Receptacle	Box Mount Flange	IV	N, Y
42	Receptacle	Box Mount Flange	IV	C, F, W
43	Receptacle	Jam Nut	IV	N, Y
44	Receptacle	Jam Nut	IV	C, F, K, S, W
45	Receptacle	Solder	IV	N, Y
46	Plug (EMI)	Straight	IV	F, K, S, W
47	Plug	Breech Coupling	IV	C, W
48	Receptacle	Weld Mount	IV	N, Y
49	Receptacle	Breech Coupling	IV	C, F, W
50	Receptacle	Dummy Stowage	IV	W

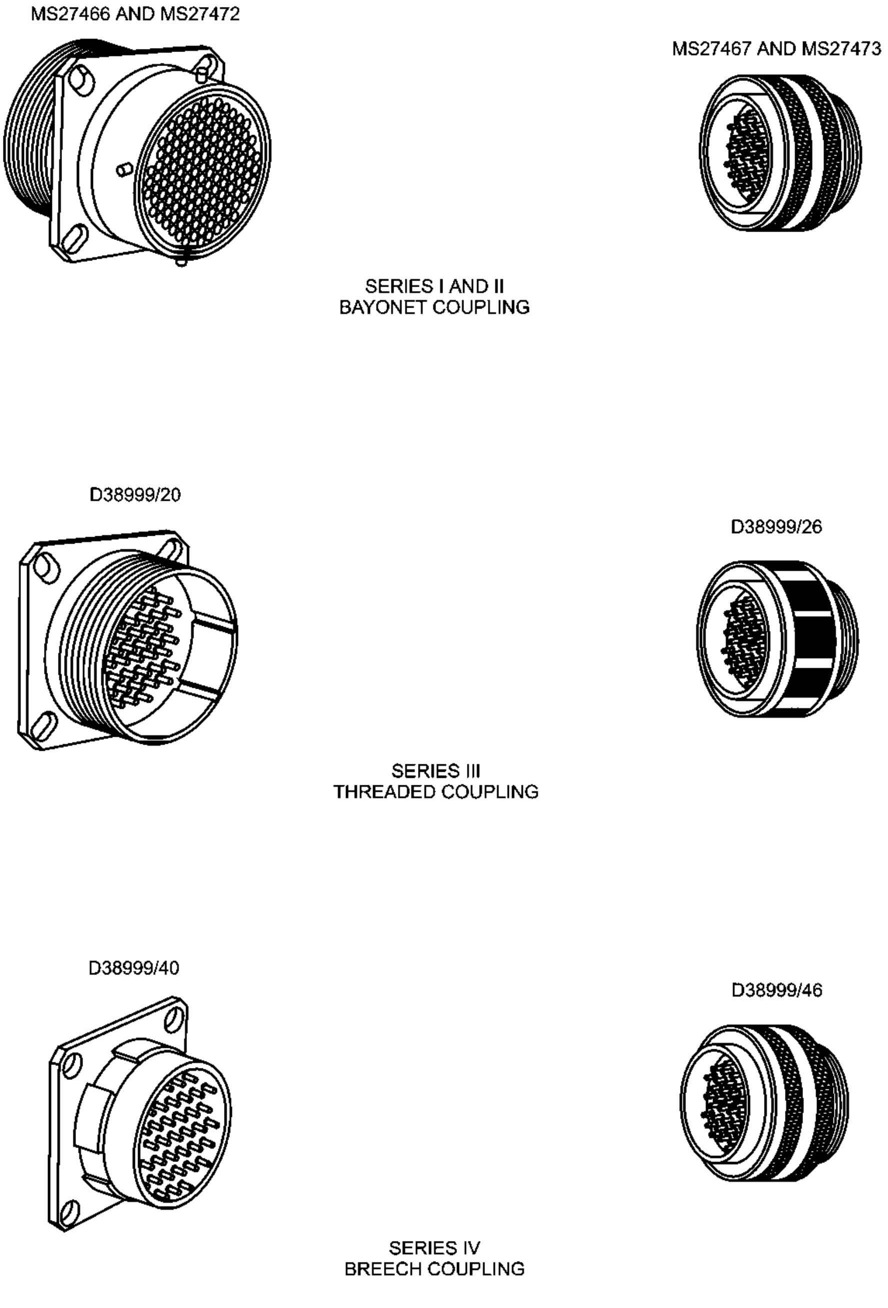


Figure 10–58 Typical MIL-DTL-38999 Connectors

Marking

102. The connectors are marked as follows:

a. Series I and II:

MS27467 B 13 B 8 P A

- MS number (see Table 4-20)
- Class (see paragraph 96 and see Table 4-22)
- Shell size
- Finish (see paragraph 96)
- Insert arrangement
- Contact style (see paragraph 96)
- Polarization (Key or Key way location) (no letter required for normal)

b. Series III and IV:

D38999/ 20 W A 35 P N

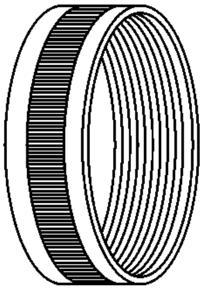
- DOD number prefix
- Specification sheet number
- Class (see paragraph 96)
- Shell size code (see paragraph 96)
- Insert arrangement
- Contact style (see paragraph 96)
- Polarization (Key or Key way location) (letter N required for normal)

M AND MS CONNECTOR CABLE CLAMPS

103. Connector cable clamps are used on the back end of M and MS connectors to support wiring and to prevent twisting or pulling on wire terminations. Standard cable clamps that fit MIL-DTL-5015 (MS3400 and MS3450 Series), MIL-C-26482 (Series 2), MIL-C-81703, (Series 3) and MIL-DTL-83723 (Series I and III) are shown in Figure 10–56. Standard cable clamps for MIL-DTL-38999 connectors are shown in Figure 10–59. See Table 10–21 for connector accessory installation torque values.

Table 10–21 Installation Torque Values For MIL-C-85049 Circular Electrical Connector Accessories

Shell Sizes	**Accessory Thread Torque ± 5 inch pounds**	
	Group 1	**Group 2**
	MIL-C-85049 Part Numbers: /17, 27, 29, 30, 32, 33, 34, 35, 36, 37, 41, 42, 45, 46, 47, 49, 56, 57, 61, 62, 63, 64, 65, 76, 77, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92	MIL-C-85049 Part Numbers: /1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 15, 16, 18, 19, 20, 21, 23, 24, 25, 26, 31, 38, 39, 43, 51, 52, 53, 54, 55, 59, 60, 66, 67, 69, 78, 79
8, 9, A	40	70
3, 10, 10SL, 11, B	40	95
7, 12, 12S, 13, C	40	135
14, 14S, 15, D	40	145
16, 16S, 17, E	40	145
18, 19, 27, F	40	145
20, 21, 37, G	80	170
22, 23, H	80	170
24, 25, 61, J	80	170
28, 29	120	185
32, 33	120	185
36	120	185
40	170	205
44	170	205
48	170	205
Note: The above values are recommended.		

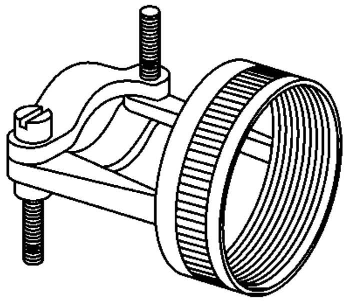


MS3416
STYLE E

EXAMPLE OF PART NUMBER

MS3416 - 22 E C

BASIC PART NO.
DASH NO.
STYLE
FINISH

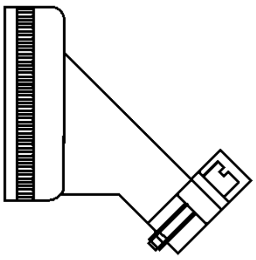


MS3417

EXAMPLE OF PART NUMBER

MS3417 - 22 C

BASIC PART NO.
DASH NO.
FINISH

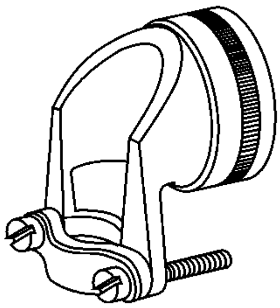


MS3415

EXAMPLE OF PART NUMBER

MS3415 - 22 C

BASIC PART NO.
DASH NO.
FINISH



MS3418

EXAMPLE OF PART NUMBER

MS3418 - 22 C

BASIC PART NO.
DASH NO.
FINISH

Dash Number	For Connector Shell Size (Ref) MIL-C-81703 Series 3	MIL-C-26482 Series 2	MIL-C-5015 MS3400, MS3450 Series	MIL-C-83723 Series I & III
-3	3			
-8		8	8S	8
-10		10	10S, 10SL	10
-12	7	12	12S & 12	12
-14	12	14	14S & 14	14
-16	19	16	16s & 16	16
-18	27	18	18	18
-20	37	20	20	20
-22		22	22	22
-24		24	24	24
-28			28	
-32			32	
-36			36	
-40			40	
-44			44	
-48			48	
-61	61			

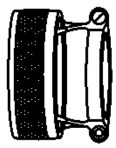
FINISH

A - CADMIUM

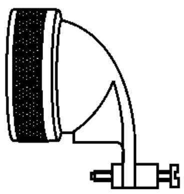
G - BLACK ANODIZE (NON-CONDUCTIVE)

N - ELECTROLESS NICKEL

Figure 10–59 Typical Cable Clamps For MIL-DTL-5015 (MS3400 & MS3450 Series), MIL-C-26482 (Series 2), MIL-C-81703 (Series 3) and MIL-DTL-83723 (Series I and Series II) Connectors



MS27506
FOR SERIES
I & II
OR
M85049/38
FOR SERIES
III & IV



MS27507
FOR SERIES
I & II
OR
M85049/39
FOR SERIES
III & IV

EXAMPLE OF PART NUMBER

MS27506 - B 16 C

BASIC PART NO.
FINISH
SHELL SIZE
ADAPTER GEOMETRY

M85049/38 - 17 A

BASIC PART NO.
SHELL SIZE
FINISH

EXAMPLE OF PART NUMBER

MS27507 - B 12

BASIC PART NO.
FINISH
SHELL SIZE

M85049/39 - 17 A

BASIC PART NO.
SHELL SIZE
FINISH

SHELL SIZE	
SERIES I, III & IV	SERIES II
9	8
11	10
13	12
15	14
17	16
19	18
21	20
23	22
25	24

FINISH (MS27506)

A - BRIGHT CADMIUM
B - OLIVE-DRAB CADMIUM
C - ANODIC (NON CONDUCTIVE)
F - ELECTROLESS NICKEL

FINISH (M85049/)

A - BLACK ANODIZE (NON-CONDUCTIVE)
S - STAINLESS STEEL (PASSIVATED)

Figure 10–60 Typical Cable Clamps For MIL-DTL-38999 Series I, II, III & IV Connectors

MIL-C-81659 CONNECTORS

Description

104. MIL-C-81659 environment-resistant, rectangular connectors are used in electrical and electronic rack and panel applications. These connectors are available with front release contacts (Series 1) or rear-release contacts (Series 2). Series 1 and Series 2 connectors are available in two types and classes. Type I has a short grommet seal and Type II has a standard grommet seal. Class 1 is built for a temperature range from -65°C to 125°C. Class 2 will operate at a higher temperature, its range being from -65°C to 200°C. The connectors are furnished with standard contacts sizes 22, 20 and 16, and coaxial contacts sizes 1, 3, 5, 7 and 9. The connectors have crimp type removable standard contacts and crimp type coaxial contacts, some of which are rear-releasable and others non-releasable. Their availability is indicated in Table 10–22.

Marking of MIL-C-81659 Connectors

105. The connector part number consists of the letter "M", the basic number of the specification sheet, and the coded numbers or letters as in the following example:

M81659/29 A 2 - 0002 12

Basic part number
Shell size designator
Series designator
Insert designator
Polarization
(no number required for 01 position)

a. Shells with size designator A have a key stone shape and a mounting flange width of 50mm. Shells with size designator B have a rectangular shape and a mounting flange width of 6.3cm.

b. The insert arrangements are described in MS3157. There are fifteen different insert arrangements shown in MS3157 Sheets 1 through 14. Table 10–23 lists the number, size, and type (standard or coaxial) of contacts in each insert arrangement. In a given insert, the contacts may be all pins, in which case they are housed in a receptacle (See Figure 10–58). The insert arrangements may be housed in single, double, triple, or quadruple plugs or receptacles. Any combination of insert arrangements may be used in the multiple plugs or receptacles. Some of the various combinations of insert arrangements are listed in Table 10–24 with their corresponding designation numbers.

c. The polarization positions and the corresponding polarization numbers are explained in Table 10–25. Normally the plugs and receptacles are furnished with 01 polarization, i.e., all plug polarizing posts up and all receptacle polarizing insert holes up. If the polarization must be changed to prevent connection of similar plugs to the wrong receptacles, the polarization number from Table 10–25 must be marked on the connector shell following the connector part number.

MIL-C-81659 Assembly and Disassembly

106. The method of assembling and disassembling MIL-C-81659 connectors with standard contacts or with rear-release coaxial contacts is shown in Figure 10–61. The method of disassembling the polarizing or keying assembly to change the polarization position is shown in Figure 10–62. The method of assembling and disassembling MIL-C-81659 connectors with non-releasable coaxial contacts is shown in Figure 10–61.

a. Installing Non-releasable Coaxial Socket Contacts. (See Figure 10–63).

(1) Select the plug shell needed for your application. A double shell is shown in Figure 10–63 to illustrate the possible combination of a C2 coaxial contact insert and a standard contact insert.

(2) Insert two socket contacts into the rear insert. Position this assembly on a horizontal support with the back of the contacts resting on the support.

(3) Slide the retention springs over the front of the contacts.

(4) Install the retaining rings by using a suitable tool to spread each ring and slide it over the front of the contact. Push the ring down until it locks behind the shoulder of the contact. Ensure the ring is properly seated behind the shoulder.

(5) Slide the retaining plate over the cables. Then slide the contact ferrules over the unstripped cables.

(6) Strip the cables and crimp the contacts.

(7) Insert the front insert into the back of the connector as indicated in Figure 10–63.

(8) Insert the contacts into the front insert by hand until the back insert is flush with the back of the plug shell.

(9) Slide the retainer plate over the cables and position it on the back of the shell. Secure the plate with the four screws and washers supplied with the connector.

b. Installing Non-releasable Coaxial Pin Contacts. (See Figure 10–63.)

(1) Select the receptacle shell that mates with the plug shell used above.

(2) Strip and crimp the coaxial cable to the contacts using the procedure described in paragraph 40. (Figure 10–63 illustrates a semi-rigid coaxial cable.)

(3) Insert the front insert into the back of the receptacle shell as shown in Figure 10–63. Make sure the recessed cavities in the front insert are facing the back of the shell.

(4) Slide the retainer plate over the crimped contacts and cable.

(5) Insert the contacts by hand into the front insert. Make sure the contacts seat in the recessed cavities.

(6) Slide the rear insert over the rear portion of the contacts. Push the rear insert in until it is flush with the back of the shell.

(7) Slide the retainer plate over the cables and position the plate on the back of the shell. Secure the plate with the four screws and washers supplied with the connector.

Table 10–22 MIL-C-81659 Connectors

Specification (MIL-C-81659/xx)	Plug or Receptacle	Type	Class	Series	Shell Size	Insert Plug Types
/1	Plug	II	1	1	A	Single
/2	Plug	II	2	1	A	Single
/3	Receptacle	II	1	1	A	Single
/4	Receptacle	II	2	1	A	Single
/5	Receptacle	I	1	1	A	Single
/6	Receptacle	I	2	1	A	Single
/7	Plug	II	1	1	A	Double
/8	Plug	II	2	1	A	Double
/9	Receptacle	II	1	1	A	Double
/10	Receptacle	II	2	1	A	Double
/11	Receptacle	I	1	1	A	Double
/12	Receptacle	I	2	1	A	Double
/21	Plug	II	1	1	B	Double
/22	Plug	II	2	1	B	Double
/23	Plug	I	1	1	B	Double
/24	Plug	I	2	1	B	Double
/25	Receptacle	II	1	1	B	Double
/26	Receptacle	II	2	1	B	Double
/27	Receptacle	I	1	1	B	Double
/28	Receptacle	I	2	1	B	Double
/29	Plug	II	1	2	A	Single
/30	Plug	II	2	2	A	Single
/31	Receptacle	II	1	2	A	Single
/32	Receptacle	II	2	2	A	Single
/33	Plug	II	1	2	A	Double
/34	Plug	II	2	2	A	Double
/35	Receptacle	II	1	2	A	Double
/36	Receptacle	II	2	2	A	Double
/37	Plug	II	1	2	A	Triple
/38	Plug	II	2	2	A	Triple
/39	Receptacle	II	1	2	A	Triple
/40	Receptacle	II	2	2	A	Triple
/41	Plug	II	1	2	A	Quadruple
/42	Plug	II	2	2	A	Quadruple
/43	Receptacle	II	1	2	A	Quadruple
/44	Receptacle	II	2	2	A	Quadruple
/45	Plug	II	1	2	B	Single
/46	Plug	II	2	2	B	Single
/47	Receptacle	II	1	2	B	Single
/48	Receptacle	II	2	2	B	Single
/49	Plug	II	1	2	B	Double
/50	Plug	II	2	2	B	Double
/51	Receptacle	II	1	2	B	Double
/52	Receptacle	II	2	2	B	Double
/53	Plug	II	1	2	B	Triple
/54	Plug	II	2	2	B	Triple
/55	Receptacle	II	1	2	B	Triple
/56	Receptacle	II	2	2	B	Triple
/57	Plug	II	1	2	B	Quadruple
/58	Plug	II	2	2	B	Quadruple
/59	Receptacle	II	1	2	B	Quadruple
/60	Receptacle	II	2	2	B	Quadruple

Table 10–23 Contact Insert Arrangements for MIL-C-81659 Connectors

Position Insert Arrangement	Total Number of Contact Positions	Number, Size and Type of Contacts	Shell Size	MS3157 Sheet Number
26	26	26 size 16	A	1
40	40	40 size 20	A	2
45	45	45 size 20	A	3
57	57	57 size 20	A	3
67	67	64 size 20, 3 size 16	A	4
106	106	106 size 20	A	5
124	124	124 size 20	B	6
C2	2	2 size 1 coaxial	A	7
C3	3	2 size 7 coaxial, 1 size 3 coaxial	A	8
C8	8	8 size 9 coaxial	A	9
D8	8	4 size 16, 4 size 12	A	10
10C3	10	7 size 20, 3 size 11 coaxial	A	11
32C2	32	30 size 20, 2 size 5 coaxial	A	12
33C4	33	25 size 20, 4 size 16, 4 size 5 coaxial	A	13
40C1	40	39 size 20, 1 size 5 coaxial	A	14

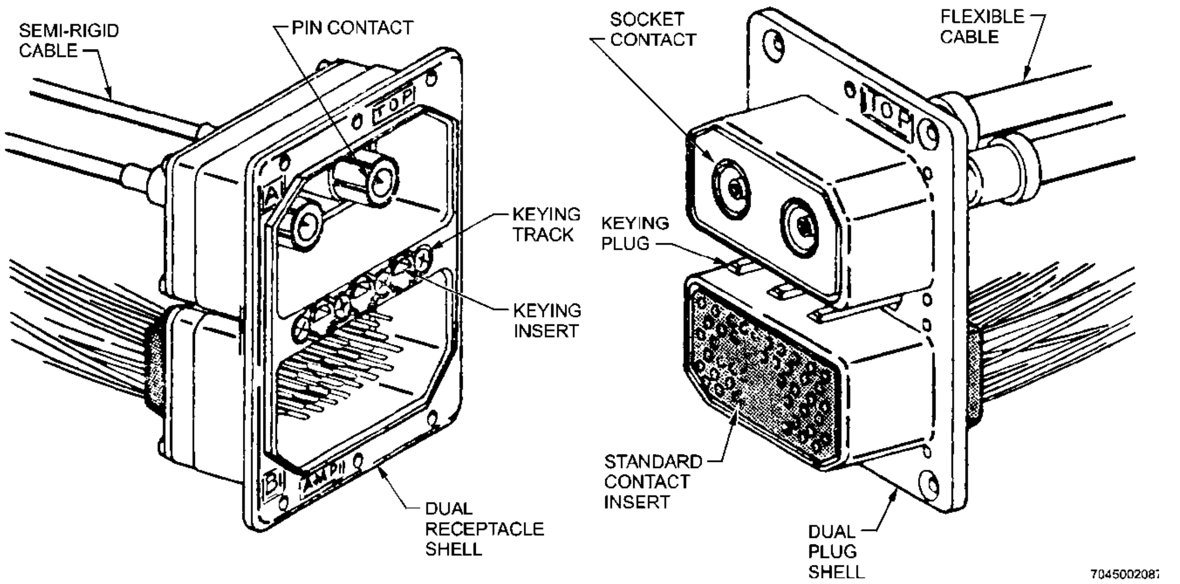


Figure 10–61 Typical MIL-C-81659 Duplex Connector

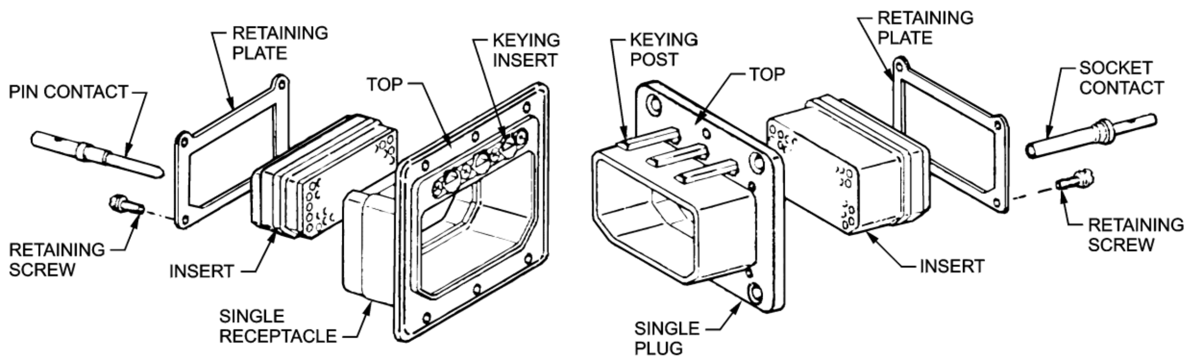


Figure 10–62 Assembly of MIL-C-81659 Connectors With Standard Contacts

Crimping and Assembly of Standard Contacts in MIL-C-81659 Connectors

107. Crimping of standard contacts and their insertion and removal in the MIL-C-81659 connectors are accomplished with the tools listed in Table 10–26.

a. Installation of Rear-Release Standard Pin or Socket Contacts.

(1) Select the insertion tool MS3156 corresponding to the size of the contact barrel (-22, -20, or -16). (See Table 10–26) Place the wire from the contact over the wire slot of the coloured insertion tip and hold it in this position with your thumb.

(2) While applying light pressure on the wire, slide your thumb toward the tip of the tool. The tip will spread, allowing the wire to enter the tip.

(3) Position the tool tip against the shoulder of the contact as shown in Figure 10–64. (Note that the bevelled tip of the insertion tool is smaller than the outside diameter of the contact shoulder. This allows the locking tines in the cavity to grip the shoulder of the contact.)

(4) Press the wire against the tool handle to hold the contact in position.

(5) Align the contact with the cavity and insert the contact straight into the cavity until it bottoms and the locking tines in the cavity click into position behind the contact shoulder.

(6) Remove the tool. Pull back lightly on the wire to make certain the contact is locked in the cavity.

CAUTION

Contacts are easily inserted. The use of too much force may damage the connector insert.

b. Removal of Rear-Release Standard Pin or Socket Contacts.

(1) Select the extraction tool MS3156 corresponding to the size of the contact barrel (-22, -20, or -16). (See Table 10–26) Place the wire from the contact over the wire slot of the white extraction tip and hold it in this position with your thumb.

(2) Apply light pressure on the wire and slide your thumb toward the tip of the tool. The tip will spread, allowing the wire to enter the tip.

(3) Insert the tool tip straight into the cavity until it bottoms. This will release the locking tines.

(4) Hold the wire against the tool handle. Pull the tool and contact straight out the back of the connector cavity. (See Figure 10–75).

CAUTION

Contacts are easily removed. The use of too much force may damage the connector insert.

NOTE

To remove unwired rear-release contacts, remove sealing plug, insert the appropriate size removal tool, MS3156, to grasp the rear of the contact and release the locking tines. Then push on the front of the contact with tool MS3344 (or the appropriate size variation of this tool). After the contact has been released from the insert, remove the extraction tool, grasp rear of contact, and pull from the connector.

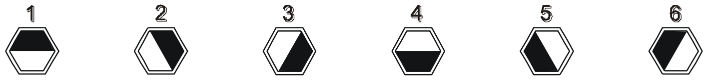
Table 10–24 Insert Arrangements, MIL-C-81659 Connector, Series 1 and 2

Insert Designation Number	Shell Insert Arrangement				Insert Designation Number	Shell Insert Arrangement			
	A	B	C	D		A	B	C	D
0001	26 P				0070	C8S	33 C4S		
0002	26 S				0071	67 P	106 S		
0003	26 P	26 P			0072	67 S	106 P		
0004	26 S	26 S			0073	67 P	67 P	C8P	
0005	26 P	26 P	26 P		0074	67 S	67 S	C8S	
0006	26 S	26 S	26 S		0075	67 P	67 P	106 S	
0007	26 P	26 P	26 P	26 P	0076	67 S	67 S	106 P	
0008	26 S	26 S	26 S	26 S	0077	67 P	106 S	33 C4P	
0009	40 P				0078	67 S	106 P	33 C4S	
0010	40 S				0079	67 P	106 S	67 P	
0011	40 P	40 P			0080	67 S	106 P	67 S	
0012	40 S	40 S			0081	67 P	67 P	33 C4P	33 C4P
0013	40 P	40 P	40 P		0082	67 S	67 S	33 C4S	33 C4S
0014	40 S	40 S	40 S		0083	D8P			
0015	40 P	40 P	40 P	40 P	0084	D8S			
0016	40 S	40 S	40 S	40 S	0085	C8P	C8P	67 P	67 P
0017	45 P				0086	C8S	C8S	67 S	67 S
0018	45 S				0087	106 S	C8P		
0019	45 P	45 P			0088	106 P	C8S		

Table 10–24 Insert Arrangements, MIL-C-81659 Connector, Series 1 and 2 (Continued)

Insert Designation Number	Shell Insert Placement				Insert Designation Number	Shell Insert Placement			
	A	B	C	D		A	B	C	D
0020	45 S	45 S			0089	106 S	67 P		
0021	45 P	45 P	45 P		0090	106 P	67 S		
0022	45 S	45 S	45 S		0091	106 S	106 S	67 P	
0023	45 P	45 P	45 P	45 P	0092	106 P	106 P	67 S	
0024	45 S	45 S	45 S	45 S	0093	106 S	106 S	33 C4P	
0025	57 P				0094	106 P	106 P	33 C4S	
0026	57 S				0095	106 S	C8P	106 S	106 S
0027	57 P	57 P			0096	106 P	C8S	106 P	106 P
0028	57 S	57 S			0097	106 S	67 P	106 S	C8P
0029	57 P	57 P	57 P		0098	106 P	67 S	106 P	C8S
0030	57 S	57 S	57 S		0099	106 S	67 P	C8P	C8P
0031	57 P	57 P	57 P	57 P	0100	106 P	67 S	C8S	C8S
0032	57 S	57 S	57 S	57 S	0101	106 S	106 S	67 P	67 P
0033	67 P				0102	106 P	106 P	67 S	67 S
0034	67 S				0103	33 C4P			
0035	67 P	67 P			0104	33 C4S			
0036	67 S	67 S			0105	33 C4P	106 S		
0037	67 P	67 P	67 P		0106	33 C4S	106 P		
0038	67 S	67 S	67 S		0107	33 C4P	C8P		
0039	67 P	67 P	67 P	67 P	0108	33 C4S	C8S		
0040	67 S	67 S	67 S	67 S	0109	C2P	40 C1P		
0041	106 S				0110	C2S	40 C1S		
0042	106 P	106 P			0111	C2P	57 P		
0043	106 S	106 S			0112	C2S	57 S		
0044	106 S	106 S			0113	C3P	67 P		
0045	106 P	106 P	106 P		0114	C3S	67 S		
0046	106 S	106 S	106 S		0115	C3P	106 S		
0047	106 P	106 P	106 P	106 P	0116	C3S	106 P		
0048	106 S	106 S	106 S	106 S	0117	C8P	106 S		
0049	124 P				0118	C8S	106 P		
0050	124 S				0119	10 C3P	32 C2P		
0051	124 P	124 P			0120	10 C3S	32 C2S		
0052	124 S	124 S			0121	32 C2P	40 C1P		
0053	124 P	124 P	124 P		0122	32 C2S	40 C1S		
0054	124 S	124 S	124 S		0123	32 C2P	45 P		
0055	124 P	124 P	124 P	124 P	0124	32 C2S	45 S		
0056	124 S	124 S	124 S	124 S	0125	32 C2P	57 P		
0057	106 S	26 P			0126	32 C2S	57 S		
0058	106 P	26 S			0127	32 C2P	67 P		
0059	26 P	106 S			0128	32 C2S	67 S		
0060	26 S	106 P			0129	32 C2P	106 S		
0061	26 P	26 P	26 P	26 S	0130	32 C2S	106 P		
0062	26 S	26 S	26 S	26 P	0131	40 C1P	40 C1P		
0063	10 C3P	10 C3P	C8P	67 P	0132	40 C1S	40 C1S		
0064	10 C3S	10 C3S	C8S	67 S	0133	57 P	106 S		
0065	C8P	C8P	C8P		0134	57 S	106 P		
0066	C8S	C8S	C8S		0135	C8P			
0067	C8P	C8P	106 S		0136	C8S			
0068	C8S	C8S	106 P		0137	10 C3P			
0069	C8P	33 C4P			0138	10 C3S			
0139	32 C2P				0144	67 C3S			
0140	32 C2S				0145	C8P	57 P		
0141	40 C1P				0146	C8S	57 S		
0142	40 C1S				0147	57 P	26 P		
0143	67 C3P				0148	57 S	26 S		

Table 10–25 Polarization (Keying) Positions



DARK PORTION INDICATES POSITION OF POST & LIGHT PORTION INDICATES POSITION OF INSERT

KEY CODE	#PLUG KEYING POST			KEY CODE	RECEPTACLE KEYING INSERT		
	L	C	R		L	C	R
00				00			
01	1	1	1	01	4	4	4
02	2	1	1	02	4	4	3
03	3	1	1	03	4	4	2
04	4	1	1	04	4	4	1
05	5	1	1	05	4	4	6
06	6	1	1	06	4	4	5
07	1	1	6	07	5	4	4
08	2	1	6	08	5	4	3
09	3	1	6	09	5	4	2
10	4	1	6	10	5	4	1
11	5	1	6	11	5	4	6
12	6	1	6	12	5	4	5
13	1	1	5	13	6	4	4
14	2	1	5	14	6	4	3
15	3	1	5	15	6	4	2
16	4	1	5	16	6	4	1
17	5	1	5	17	6	4	6
18	6	1	5	18	6	4	5
19	1	1	4	19	1	4	4
20	2	1	4	20	1	4	3
21	3	1	4	21	1	4	2
22	4	1	4	22	1	4	1
23	5	1	4	23	1	4	6
24	6	1	4	24	1	4	5
25	1	1	3	25	2	4	4
26	2	1	3	26	2	4	3
27	3	1	3	27	2	4	2
28	4	1	3	28	2	4	1
29	5	1	3	29	2	4	6
30	6	1	3	30	2	4	5
31	1	1	2	31	3	4	4
32	2	1	2	32	3	4	3
33	3	1	2	33	3	4	2
34	4	1	2	34	3	4	1
35	5	1	2	35	3	4	6
36	6	1	2	36	3	4	5
37	1	2	1	37	4	3	4
38	2	2	1	38	4	3	3
39	3	2	1	39	4	3	2
40	4	2	1	40	4	3	1
41	5	2	1	41	4	3	6
42	6	2	1	42	4	3	5
43	1	2	6	43	5	3	4
44	2	2	6	44	5	3	3
45	3	2	6	45	5	3	2
46	4	2	6	46	5	3	1
47	5	2	6	47	5	3	6
48	6	2	6	48	5	3	5
49	1	2	5	49	6	3	4

KEY CODE	# PLUG KEYING POST			KEY CODE	RECEPTACLE KEYING INSERT		
	L	C	R		L	C	R
50	2	2	5	50	6	3	3
51	3	2	5	51	6	3	2
52	4	2	5	52	6	3	1
53	5	2	5	53	6	3	6
54	6	2	5	54	6	3	5
55	1	2	4	55	1	3	4
56	2	2	4	56	1	3	3
57	3	2	4	57	1	3	2
58	4	2	4	58	1	3	1
59	5	2	4	59	1	3	6
60	6	2	4	60	1	3	5
61	1	2	3	61	2	3	4
62	2	2	3	62	2	3	3
63	3	2	3	63	2	3	2
64	4	2	3	64	2	3	1
65	5	2	3	65	2	3	6
66	6	2	3	66	2	3	5
67	1	2	2	67	3	3	4
68	2	2	2	68	3	3	3
69	3	2	2	69	3	3	2
70	4	2	2	70	3	3	1
71	5	2	2	71	3	3	6
72	6	2	2	72	3	3	5
73	1	3	1	73	4	2	4
74	2	3	1	74	4	2	3
75	3	3	1	75	4	2	2
76	4	3	1	76	4	2	1
77	5	3	1	77	4	2	6
78	6	3	1	78	4	2	5
79	1	3	6	79	5	2	4
80	2	3	6	80	5	2	3
81	3	3	6	81	5	2	2
82	4	3	6	82	5	2	1
83	5	3	6	83	5	2	6
84	6	3	6	84	5	2	5
85	1	3	5	85	6	2	4
86	2	3	5	86	6	2	3
87	3	3	5	87	6	2	2
88	4	3	5	88	6	2	6
89	5	3	5	89	6	2	6
90	6	3	5	90	6	2	5
91	1	3	4	91	1	2	4
92	2	3	4	92	1	2	3
93	3	3	4	93	1	2	2
94	4	3	4	94	1	2	1
95	5	3	4	95	1	2	6
96	6	3	4	96	1	2	5
97	1	3	3	97	2	2	4
98	2	3	3	98	2	2	3
99	3	3	3	99	2	2	3

\# L – LEFT C – CENTRE R – RIGHT

Table 10–26 Tools For MIL-C-81659 Standard Contacts

Contact Size	Crimp Tool	Insertion Tool	Removal Tool
Series 1 Front Release			
22	MIL-DTL-22520/2	AMP 91039-1	AMP 91040-1
20	MIL-DTL-22520/2 (or /1)	AMP 91039-1	AMP 91040-1
16	MIL-DTL-22520/1	MS 90455-1	MS 90456-1
Series 2 Rear Release			
22	MIL-DTL-22520/2	MS 3156-22 (Black End)	MS 3156-22 (White End)
20	MIL-DTL-22520/2 (or /1)	MS 3156-20 (Green End)	MS 3156-20 (White End)
16	MIL-DTL-22520/1	MS 3156-16 (Blue End)	MS 3156-16 (White End)

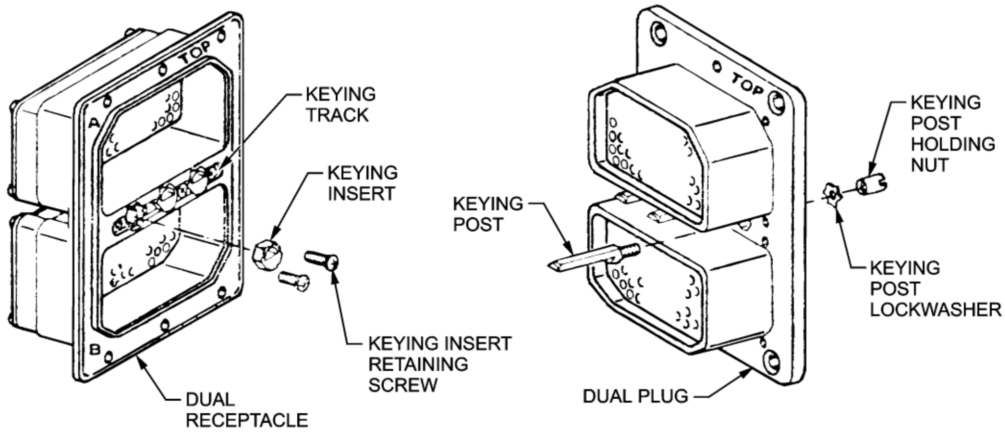


Figure 10–63 Assembly of MIL-C-81659 Connectors Polarization (Keying) Posts and Inserts

Crimping of Coaxial Contacts in MIL-C-81659 Connectors

108. Table 10–27 lists the type of contact, type of coaxial cable, crimping tools, selector position setting, and contact positioner used with inner contact crimping tool, crimping die opening used with ferrule crimping tool, and cable stripping lengths for each of the MIL-C-81659 coaxial connectors. These connectors are described in MS drawings 3168 through 3177. Sizes 1, 3 and 7 connector contacts are non-releasable. They can only be removed by disassembling the connector as shown in Figure 10–63. Size 5 and 9 connectors are equipped with rear-release contacts that may be released and removed from the rear of the connector with the use of special tool MS3178-001.

109. Centre Contact Crimping Procedure. The centre contacts of MIL-C-81659 coaxial connectors are crimped with either the MS22520/2-01 standard crimping tool or the AMP 220015-1 crimping tool as listed in Table 10–27. If the MS22520/2-01 tool is used, a special AMP contact positioner (also listed in Table 10–27) must be employed.

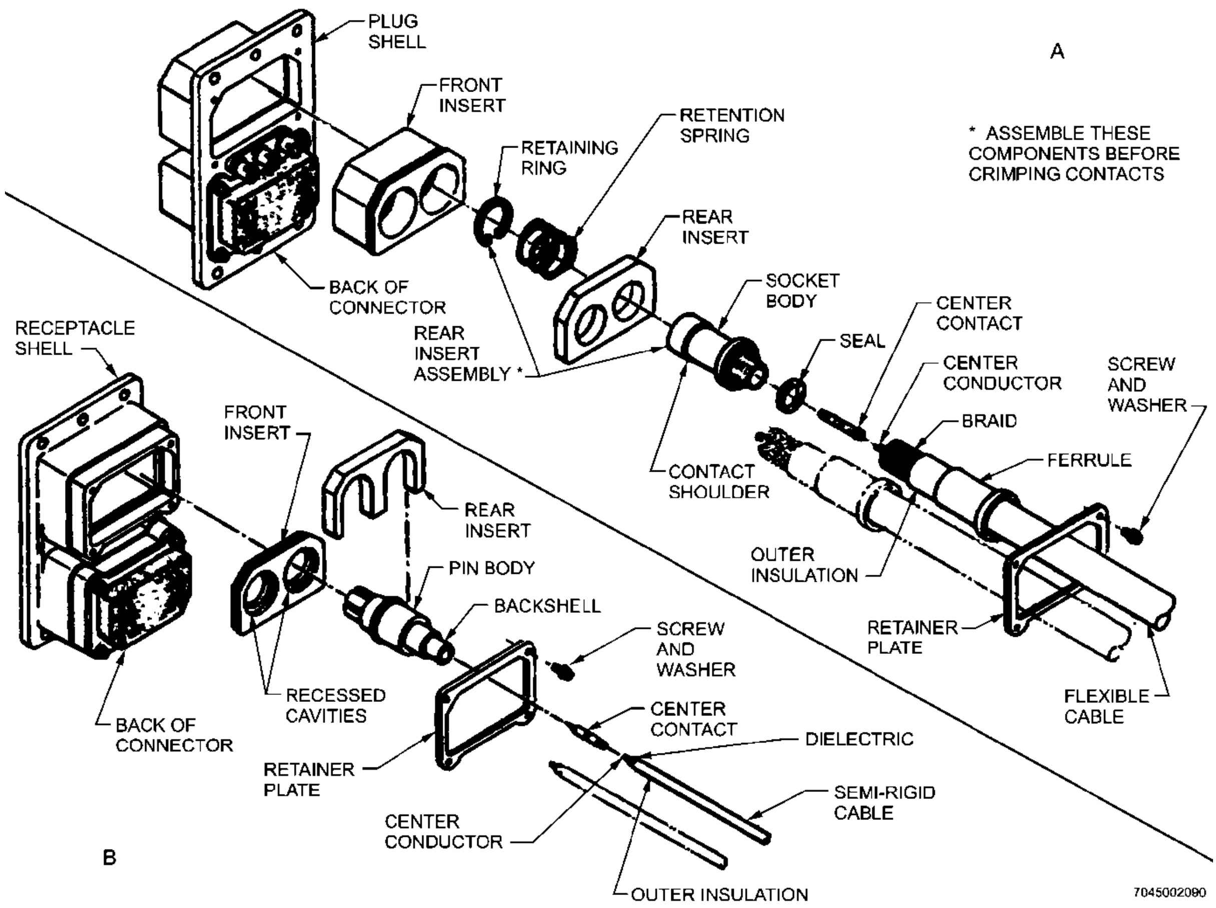


Figure 10–64 Assembly of MIL-C-81659 Connectors with Coaxial Connectors

a. The procedure to be used with the MS22520/2-01 crimping tool is as follows:

(1) Select the special AMP positioner to use from Table 10–27.

(2) Open the tool handles. (If not already open. The tool handles must be fully closed to release the ratchet).

(3) Install the positioner by inserting it into the crimping tool retainer ring and turning 90° to the right until the bayonet pin locks.

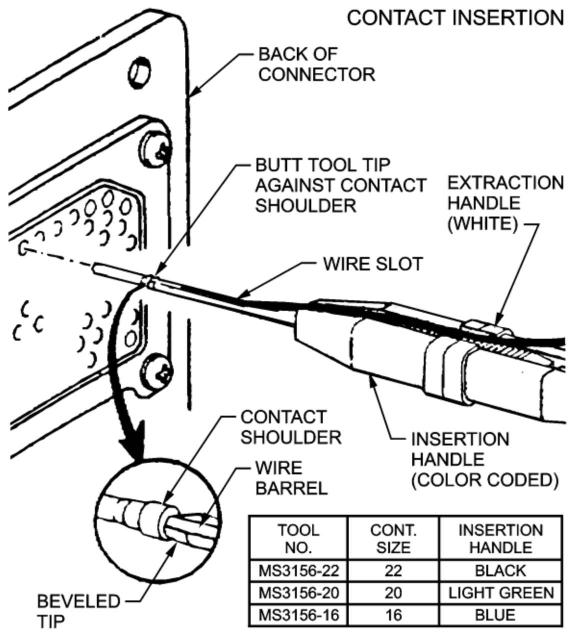
(4) Install the safety clip in retainer ring.

(5) Raise selector knob on crimping tool, and rotate it until selector position number from Table 10–27 is opposite index mark.

(6) Slip sealing boot (when used) over cable. The end of the sealing boot with the rounded lip should face the end of the cable.

NOTE

Sealing boots are needed with all size 5 and size 9 coaxial contacts. Sealing rings are needed for all size 3 and size 7 coaxial contacts and for some size 1 contacts. In general, the manufacturer will furnish the parts needed to seal the connector from the environment and to keep moisture from getting into the cable. Make sure all seals furnished with the contacts are properly installed. (See Figure 10–66)



TOOL NO.	CONT. SIZE	INSERTION HANDLE
MS3156-22	22	BLACK
MS3156-20	20	LIGHT GREEN
MS3156-16	16	BLUE

Figure 10–65 Insertion of Standard Contacts in MIL-C-81659 Connectors

(1) Slip ferrule (when used) over cable. The crimp end of the ferrule should face the end of the cable and the shoulder end of the ferrule should face away from the end of the cable. (See Figure 10–66).

NOTE

A crimping ferrule is not used with semi-rigid coaxial cable.

(2) Strip cable using stripping lengths given in Table 10–27 and illustrated in Figure 10–65. For braided cable, flare braid. (See Figure 10–66.)

(3) Insert contact into indentor opening so that contact rests in positioner and wire barrel is between indentor jaws.

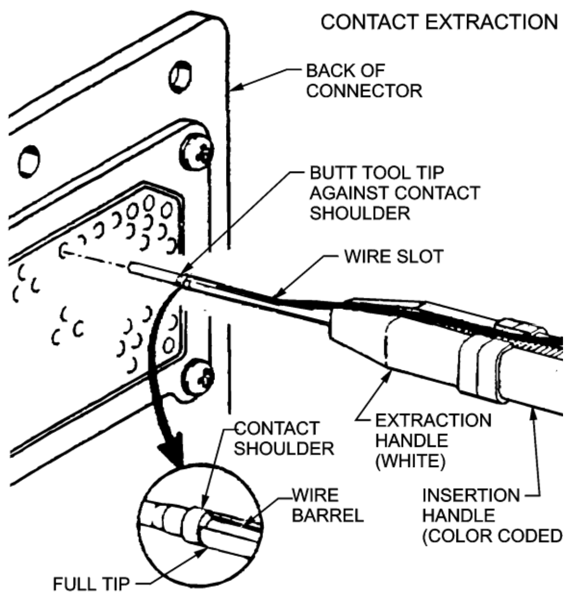


Figure 10–66 Removal of Standard Contacts in MIL-C-81659 Connectors

(4) Insert stripped centre conductor into centre contact until cable dielectric butts against rim of wire barrel. Then close crimp tool handles until ratchet releases. Handles will then return to open position, allowing crimped contact to be removed.

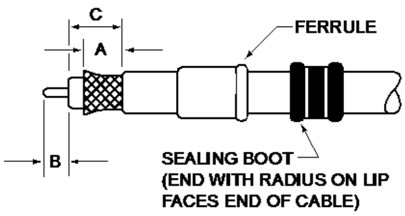


Figure 10–67 Installation of Sealing Boot and Ferrule on Coaxial Cable Before Crimping Contacts

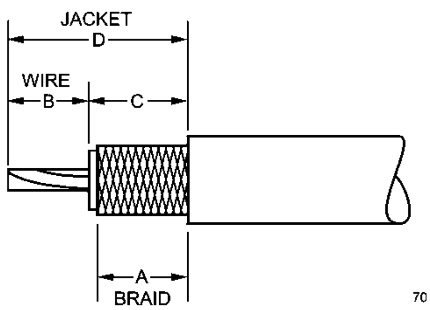


Figure 10–68 Stripping Dimensions for Coaxial Cable in Table 10–27

b. The procedure to be used with AMP 220015-1 crimping tool is as follows:

(1) Slip sealing boot (when used) over cable. The end of the sealing boot with the rounded lip should face the end of the cable. (See Figure 10–66)

NOTE

Sealing boots are needed with all size 5 and size 9 coaxial contacts. Sealing rings are needed for all size 3 and size 7 coaxial contacts and for some size 1 contacts. In general, the manufacturer will furnish the parts needed to seal the connectors against the environment and to keep moisture from getting into the cable. Make sure all seals furnished with the contacts are properly installed.

Table 10–27 Stripping Lengths, Crimping Tools, Contacts, and Cables for MIL-C-81659 Coaxial Connectors

Stripping Lengths and Crimping Tools								
Contact MS Number	Stripping Length, mm ± 0.4				Centre Contact Crimp Tool	Selector Setting	Outer Contact Crimp Tool	Die
	Braid A	Wire B	Braid + Insul. C	Total Jacket D				
3168	1.2	4.8	1.2	6.7	M22520/2-01 AMP-1-601966-9	8	220066-1	B
3169	12.7	4.8	12.7	17.5	AMP-220015-1		220015-1	
3170	5.5	3.2	5.5	11.0	M22520/2-01 AMP-1-601966-8	8	220066-1	B
3171	12.7	4.8	12.7	17.5	AMP-220015-1	5	220015-1	
3172	5.5	3.2	7.9	11.0	M22520/2-01 AMP-1-601966-6	5	220066-1	B
3173	5.5	3.2	7.9	11.0	M22520/2-01 AMP-1-601966-6	5	220066-1	B
3174	5.5	3.2	7.9	11.0	M22520/2-01 AMP-1-601966-7	4	220066-1	C
3175	5.5	3.2	7.1	10.3	M22520/2-01 AMP-1-601966-7	5	220066-1	B
3176	1.2	4.8	1.2	6.7	M22520/2-01 AMP-1-601966-6	5	220066-1	B
3177	5.5	3.2	7.9	11.0	M22520/2-01 AMP-1-601966-6	5	220066-1	B

Contacts and Cables					
Contact MS Number	Outer Contact Type	Contact Size	Cable Type	Exit Arrangement	Removal Tool
3168	Pin	1	141S.R.	Straight	Non-releasable
3169	Socket	1	RG214	Straight	Non-releasable
3170	Pin	3	RG142	Straight or 90°	Non-releasable
3171	Socket	3	RG214	Straight	Non-releasable
3172	Pin	5	RG58C RG223	Straight Straight	MS3178-001 MS3178-001
3173	Socket	5	RG58C RG223	Straight Straight	MS3178-001 MS3178-001
3174	Pin	7	RG188	Straight or 90°	Non-releasable
3175	Socket	7	RG58C	Straight	Non-releasable
3176	Pin	9	141S.R.	Straight	MS3178-001
3177	Socket	9	RG58C	Straight	MS3178-001

(2) Slip ferrule (when needed) over cable. The crimp end of the ferrule should face the end of the cable and the shoulder end of the ferrule should face away from the end of the cable. (See Figure 10–59)

NOTE

A crimping ferrule is not used with semi-rigid coaxial cable.

(3) Strip cable using stripping lengths given in Table 10–27 and illustrated in Figure 10–67. For braided cable, flare braid. (See Figure 10–57.)

(4) With crimping tool handles fully open, rotate contact locator-stop knob (on back of tool head) to open position. (See Figure 10–68)

(5) Insert centre conductor of coaxial cable into centre contact wire barrel until cable dielectric butts against rim of wire barrel. Then place contact in tool head as shown in Figure 10–68.

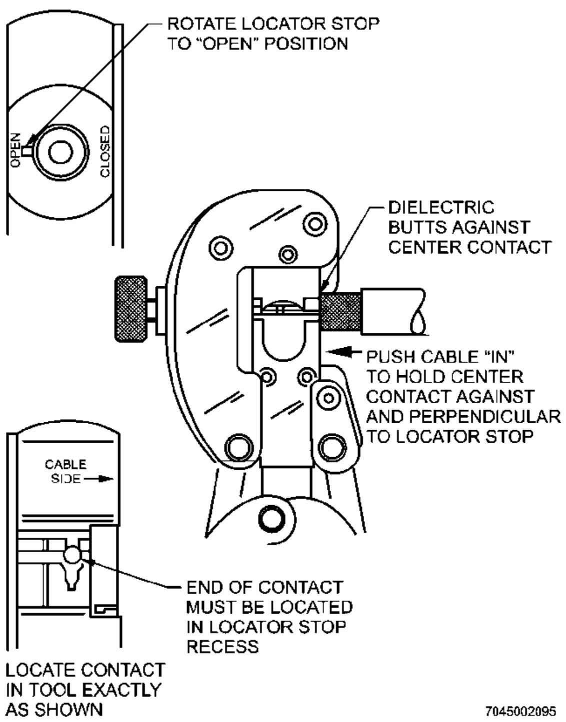


Figure 10–69 Crimping Centre Contacts with AMP 220015-1 Crimping Tool

(6) Close tool handles until ratchet releases. Tool ratchet will not release and handles will not open until full crimping cycle has been completed, assuring proper depth of crimp indent.

110. Outer Contact Crimping Procedure. The outer contacts of MIL-C-81659 coaxial connectors are crimped with either the AMP 220066-1 crimping tool or the AMP 220015-1 crimping tool as listed in Table 10–27. The 220015-1 tool has only one outer contact crimping die, but the 220066-1 tool has three. The correct die to use is given in Table 10–27.

a. The procedure for crimping braided coaxial cable to outer contacts, with the AMP 220015-1 tool is as follows:

(1) Install seal ring (if used) over braid support section of contact against shoulder on contact. (See Figure 10–69)

(2) Insert crimped centre contact into contact body until cable dielectric bottoms against dielectric inside contact body. Braid should fit over braid support section of contact. (See Figure 10–70)

NOTE

When crimped centre contact of size 1 contact is inserted into the size 1 contact body, an internal locking feature should engage and hold the centre contact captive. Pull back lightly on cable to deter mine if contact is being held captive by the internal locking feature. This locking feature is not present in the smaller size contacts.

(3) Position ferrule over braid and against shoulder on contact.

(4) Place the assembly in crimping die of tool with shoulder of contact against die. (See Figure 10–71)

(5) Close tool handles until ratchet releases to form braid crimp.

b. The procedure for crimping braided coaxial cable to outer contacts with the AMP 220066-1 tool is as follows:

(1) Install seal ring (if used) over braid support section of contact. (See Figure 10–69)

(2) Insert crimped centre contact into contact body until cable dielectric bottoms against dielectric inside contact body. Braid should fit over braid support section of contact. (See Figure 10–70)

NOTE

When crimped centre contact of size 1 contact is inserted into the size 1 contact body, an internal locking feature should engage and hold the centre contact captive. Pull back lightly on cable to determine if contact is being held captive by internal locking feature. This locking feature is not present in the smaller size contacts.

(3) Position ferrule over braid and against shoulder on contact.

(4) Place the contact-ferrule assembly in the appropriate crimping die (from Table 10–27) of the tool, with the shoulder of the contact against the tool jaw. (See Figure 10–72 and 10-73)

(5) Close tool handles until ratchet releases to from braid crimp.

c. The procedure for crimping semi-rigid coaxial cable contacts with the AMP 220066-1 ferrule crimping tool is as follows:

(1) Insert crimped centre contact into contact body until cable dielectric bottoms against dielectric inside contact body. Outer conductor of cable should slip inside contact backshell. (See Figure 10–74)

NOTE

When crimped centre contact of size 1 contact is inserted into the size 1 contact body, an internal locking feature should engage and hold the centre contact captive. Pull back lightly on cable to determine if contact is being held captive by internal locking feature. This locking feature is not present in the smaller size contacts.

(2) Place the cable-contact assembly in the appropriate crimping die (from Table 10–27) of AMP 220066-1 ferrule crimping tool so that the contact backshell is in the crimping die and the shoulder of the contact body (adjacent to the backshell) butts against the die. (See Figure 10–75)

(3) Close tool handles until ratchet releases to form backshell crimp.

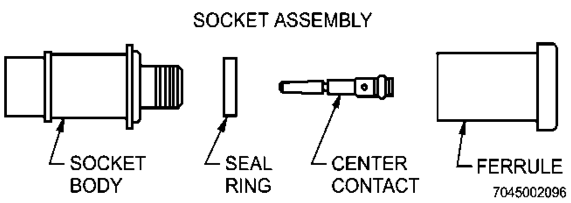


Figure 10–70 Contact Assembly Using Seal Ring

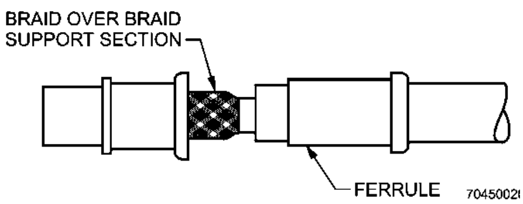


Figure 10–71 Crimped Centre Contact of Braided Coaxial Cable Inserted in Contact Body

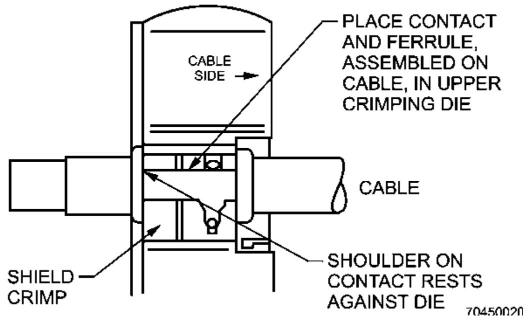


Figure 10–72 Contact-Ferrule Assembly in Ferrule Crimping Die of Crimping Tool AMP 220015-1 Ready for Crimping

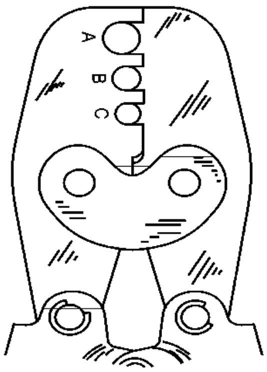


Figure 10–73 AMP 220066-1 Ferrule Crimping Tool Showing the Three Crimping Dies

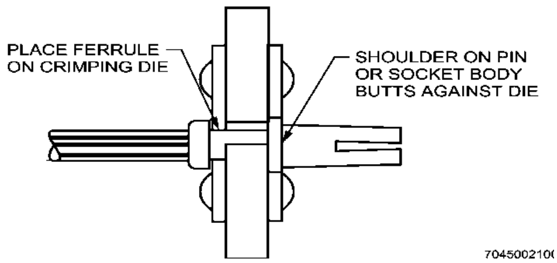


Figure 10–74 Contact-Ferrule Assembly in Crimping Die of AMP 220066-1 Ferrule Crimping Tool Ready for Crimping

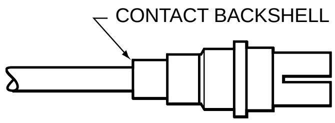


Figure 10–75 Crimped Centre Contact of Semi-Rigid Coaxial Cable Inserted in Contact Body

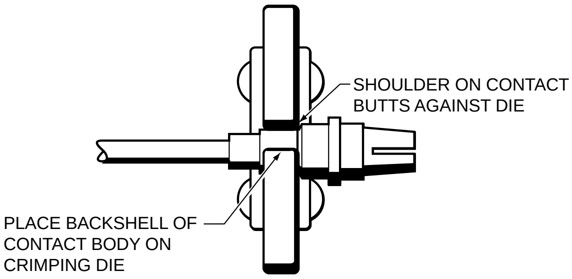


Figure 10–76 Semi-Rigid Cable-Contact Assembly in Crimping Die of AMP 220066-1 Ferrule Crimping Tool Ready for Backshell Crimping

Insertion and Removal of Rear Release Coaxial Contacts in MIL-C-81659 Connectors

111. Inserting Contacts. An insertion tool is not required for inserting these contacts. To insert a contact, align it with the back of the contact cavity and push it straight into the connector until it bottoms. Pull back lightly on the cable to make certain the contact is locked in the cavity. Slide the sealing boot over the cable and into the contact cavity until the collar of the seal butts against the insert as shown in Figure 10–76. Slight rotation of the seal will ease insertion.

112. Extracting Contacts. Removal tool MS3178-001 is designed to remove size 5 and 9 contacts from MIL-C-81659 connectors. The procedure is as follows:

- **a.** Slide the sealing boot back over the cable a minimum distance of 8.2cm before extracting the contact. Do not cut or otherwise damage the sealing boot.
- **b.** Place the cable over the “V” notch of the extraction tool handle. Then press the cable into the notch. The tool handle will spread open and allow the cable to enter. Make certain the cable is seated in the full length of the tool as shown in Figure 10–77.
- **c.** Grip the tool handle firmly and insert the tip to the contact cavity until it bottoms.
- **d.** Maintain slight inward pressure on the back of the tool handle and pull back on the cable to release the contact.
- **e.** Pull the cable and tool out of the contact cavity.

113. Sealing Plugs. All unused cavities in circular and rectangular connectors should be filled with unwired contacts and appropriate MS27488 sealing plugs (see Table 10–28). The unwired contacts and sealing plugs are required to preserve the environmental sealing characteristics of the connectors.

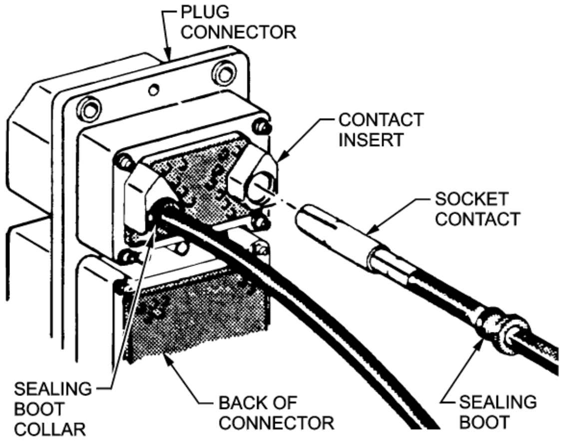


Figure 10–77 Insertion of Rear-Release Coaxial Contacts in MIL-C-81659 Connectors

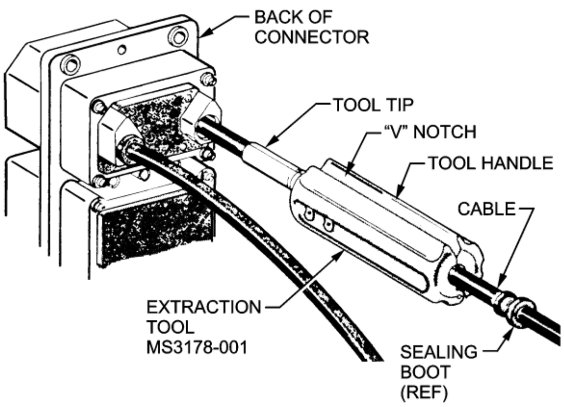


Figure 10–78 Removal of Rear-Release Coaxial Contacts From MIL-C-81659 Connectors

Table 10–28 MS27488 Sealing Plugs and Superseded Part Numbers

Connector or Module Contact Cavity Size	Superseding Part Number	Superseded Military Specification Part Number					
22 & 23	MS27488-22	M81511/39-22					
20	MS27488-20	M81511/39-20	M83723/28-20	MS25251-20	MS27186-1	MS27187-3	MS3187-20-2
16	MS27488-16	M81511/39-16	M83723/28-16	MS25251-16	MS27186-2	MS27187-1	MS3187-16-2
12	MS27488-12	M81511/39-12	M83723/28-12	MS25251-12	MS27186-3	MS27187-2	MS3187-12-2
8	MS27488-8		M83723/28-8	MS25251-8			MS3187-8-2
4	MS27488-4		M83723/28-4			MS27187-4	MS3187-4-2
0	MS27488-0		M83723/28-0				MS3187-0-2

MULTIPLE TERMINATION CONNECTORS (MTCS)

114. MTCs are rectangular, flat and high density connectors used in making environmentally protected electrical connections between round wire harnesses (see Figure 10–78).

Wire Removal Procedure

115. The wire removal procedure for MTCs is as follows:

a. Insert wafer removal tool in the rear of the MTC connector and gently pull the cable to release the wafer from the shell.

b. Clamp the appropriate wafer holding fixture in a convenient position and insert wafer into holding fixture.

c. If working on installed harnesses, attach the static grounding bus to the wafer contacts. It attaches by clipping onto the contacts of either pin or socket wafers. Do not force the grounding bus rightly onto the wafer. Very gentle insertion is sufficient for static grounding.

d. Isolate the wire and sleeve terminator with the sleeve isolator on the holding fixture.

WARNING

Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft.

WARNING

Use of nitrogen with hot air gun M83521/5-01 in an enclosed area can be hazardous. Ensure area is well ventilated.

e. Use the M83521/5-01 heater and direct hot air at the solder joint only. When the solder melts pull the wire and the sleeve material straight off with tweezers.

f. To prevent electrostatic discharge damage to sensitive electronic components when working on installed harnesses, the static grounding bus must be used whenever any solder sleeve terminators are installed, either on the wafer or anywhere on the wires.

Wire Connection Procedure

116. The wire connection procedure for MTCs is as follows:

a. Clamp appropriate wafer holding fixture in a convenient position and insert wafer into holding fixture.

b. Install a connector solder sleeve terminator back over the wire flue end first.

c. Strip wire back 3.8 – 4.3mm.

d. Position stripped wire over solder tab and slide sleeve terminator over wire and tab until it touches the wafer.

e. Isolate sleeve with the sleeve isolator in holding fixture.

WARNING

Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft.

WARNING

Use of nitrogen with hot air gun M83521/5-01 in an enclosed area can be hazardous. Ensure area is well ventilated.

f. Using a M83521/5-01 hot air gun, direct hot air at the solder until it melts and flows.

NOTE

Allow terminator to cool before disturbing.

g. Remove assembly from fixture and inspect in accordance with Figure 10–79.

h. Insert wafer into rear of MTC shell.

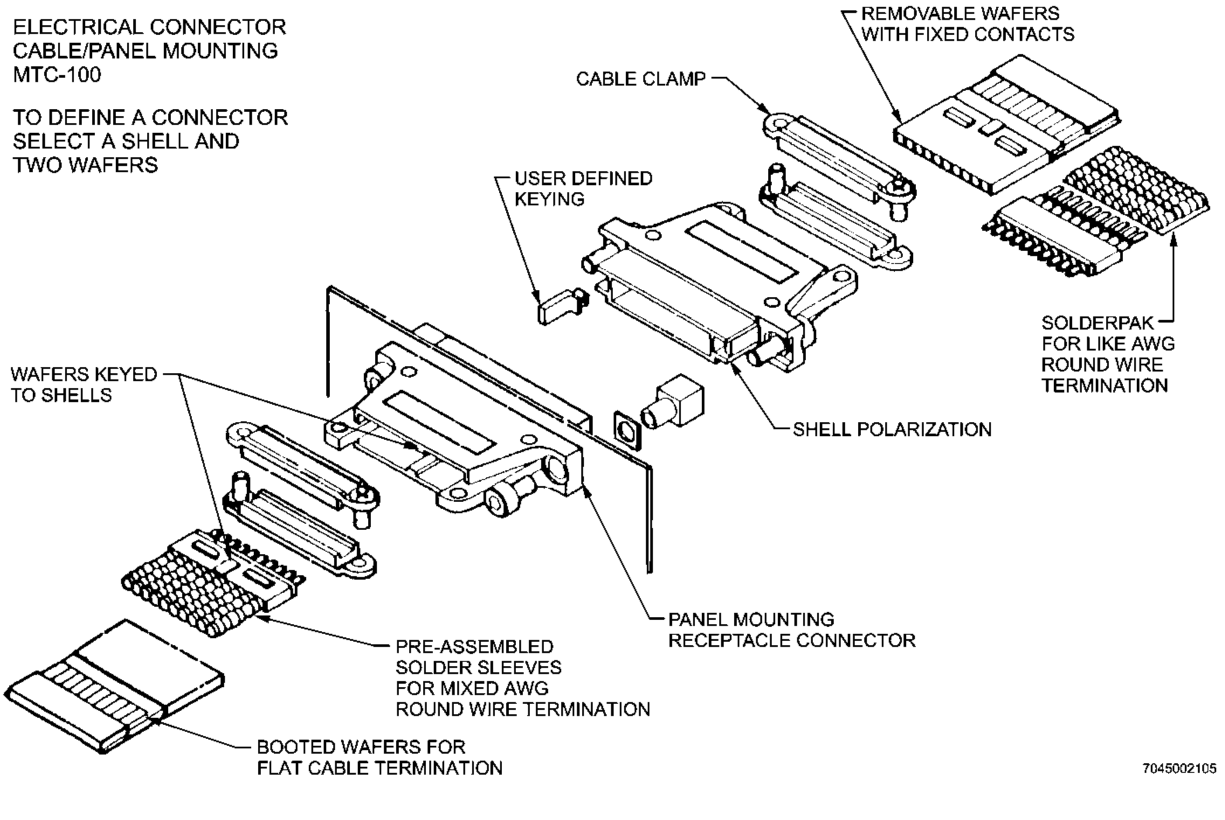


Figure 10–79 Multiple Termination Connector

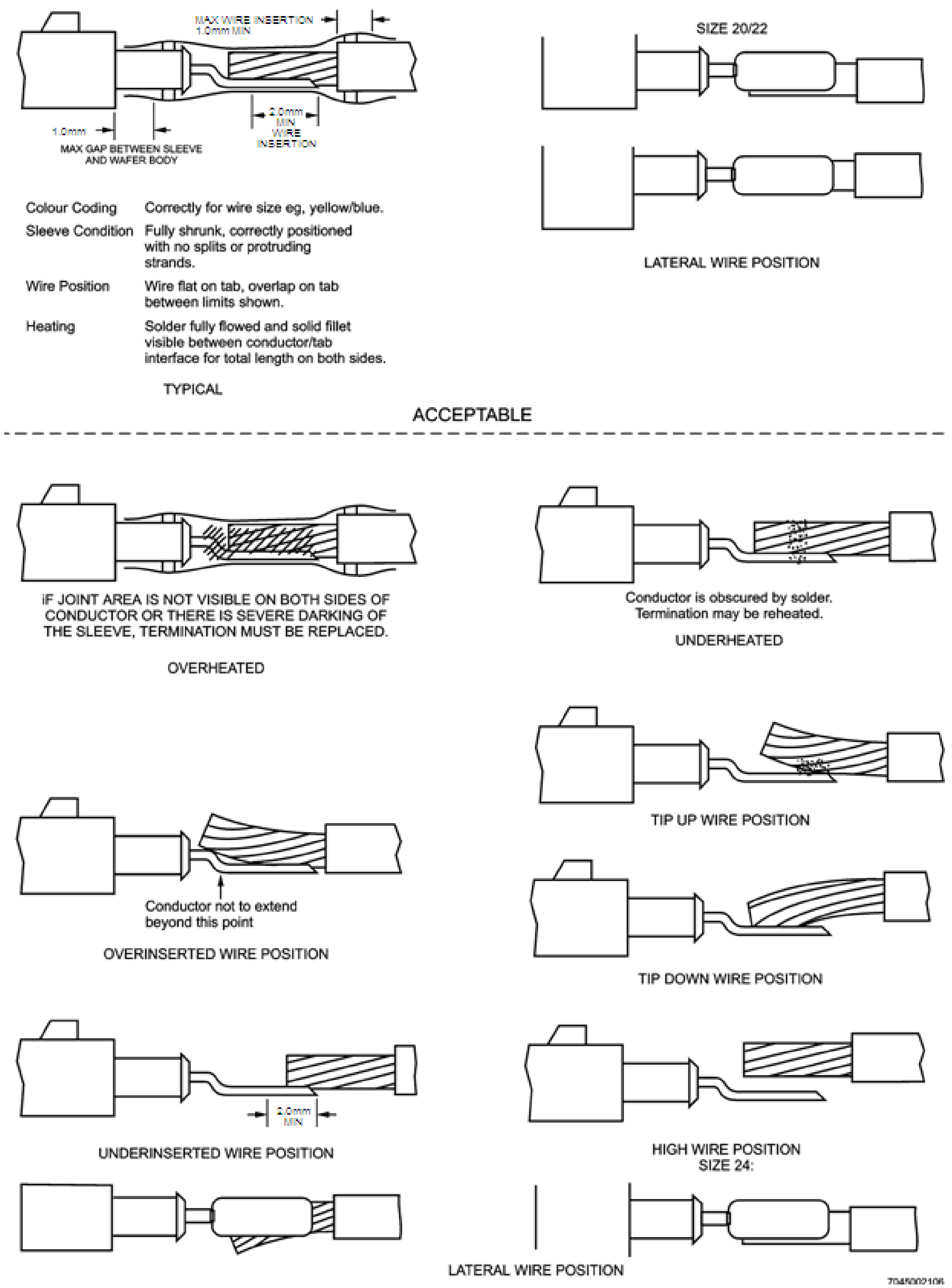


Figure 10–80 Inspection Criteria

SECTION 2

CHAPTER 11

ELECTRIC CONNECTOR SEALING COMPOUND

INTRODUCTION

1. Sealing compound is used to moisture-proof and reinforces the wiring connected to the backs of electric connectors against failure caused by vibration and lateral pressure which fatigues the wire at the solder cup. This process is commonly called potting. The sealing compound protects electric connectors from corrosion, contamination, and arcing by excluding moisture, and other contaminants.

2. This chapter describes the potting compounds used on aircraft electric connectors, and gives instructions for preparing and storing the compounds. Instructions for potting MS electric connectors are detailed in Section 2, Chapter 10.

REFERENCE SPECIFICATIONS

3. The following specifications are applicable to electric connector sealing:

MIL-PRF-8516	Sealing Compound, Synthetic Rubber, Electric Connectors and Electric Systems, Chemically Cured
MIL-PRF-23586	Sealing Compound (With Accelerator), Silicone Rubber, Electrical
MIL-M-24041	Moulding and Potting Compound, Chemically Cured, Polyurethane
SAE AMS-DTL-23053	Insulation Sleeving, Electrical, Heat Shrinkable

DESCRIPTION

4. Sealing compound in accordance with military specification MIL-PRF-8516 is a two-part polysulfide synthetic rubber compound, consisting of a base and an accelerator (curing agent), packaged together. This compound is used to seal connectors located in areas where the ambient temperature does not exceed 85°C. Sealing compound in accordance with military specification MIL-PRF-23586, silicone rubber compound, consists of a base and an accelerator (curing agent). This compound is used to seal connectors in areas where the ambient temperature exceeds 85°C, but does not exceed 230°C.

NOTE

MIL-M-24041 must be prepared under controlled conditions as described in Paras 19 to 25. The use of MIL-PRF-23586 Type II, Class II, Grade A, silicone potting compound should be restricted to small connectors used in adequately vented areas. Under all other conditions, use only the Grade B compound. Sealing compound is not generally applied to the following connectors: environment-proof “H”, “K”, “L” and “W” connectors, and coaxial connectors.

GENERAL PRECAUTIONS

5. Potting compounds may be supplied in paired containers of base compound and accelerator, pre-mixed and frozen and in bulk. Follow the manufacturer’s instructions carefully when mixing the base compound and accelerator if both are supplied in separate containers. Substitution, partial mixing or use of incorrect proportions of compound and accelerator may produce a sealant with inferior properties.

6. Ensure that the entire amount of accelerator is mixed into the entire amount of base. Any change in catalyst ratio will affect the electrical properties of the sealant and may also affect the pot life, reversion resistance, and hardness of the cured compound. Do not mix base compounds and accelerator components of different batch numbers because substandard electrical properties may result.

WARNING

The sealants may contain small quantities of flammable solvents or release flammable by-products on curing. Observe adequate ventilation and fire precautions during mixing, curing, and/or storage.

WARNING

Elastomeric sealing and potting compounds shall comply with the requirements of specifications MIL-PRF-8516 and MIL-PRF-23586. Silicone potting compound (RTV) containing acetic acid shall not be used on connectors because acetic acid causes corrosion.

PREPARATION OF SEALING COMPOUND

Preparing Frozen Pre-Mixed Sealants

7. Remove the frozen, pre-mixed sealant from the deep freeze and bring its temperature to room temperature before use by warming with compressed air on the outside of the container. Never use heat to raise the sealant temperature. Utilise frozen, pre-mixed sealant as soon as possible after removal from the deep freeze because of a significant reduction in work life (approximately 50 percent).

Hand Mixing Procedure

> **WARNING**
>
> The accelerator contains toxic compounds. Use in a well ventilated area. Avoid eye and skin contact. Use personal protective equipment, rubber or polyethylene gloves and approved eye protection. Clean hands thoroughly after use.

8. Paired containers of base compound and accelerator shall be mixed as follows:

- **a.** Remove lid from accelerator container and stir contents slowly into a smooth creamy paste with a clean spatula, wooden tongue depressor, or putty knife.
- **b.** Remove top from the base compound container and stir contents until material has a smooth texture. This is necessary to recombine material that may have settled in storage.
- **c.** Combine accelerator and base material and thoroughly agitate or mix until no accelerator streaks or traces of unmixed material are visible. Mix slowly, do not beat or whip; fast mixing may cause excessive amounts of air to become trapped in the compound. Mixing normally requires five to eight minutes. Continued scraping of the sides and corners of the bottom of the container will ensure complete mixing.
- **d.** For base compound and accelerator supplied in bulk, weigh out the desired amount of base compound and the related specified amount of accelerator in separate containers. Follow the manufacturer's instructions carefully. Combine the accelerator and the base material and thoroughly agitate or mix in such a manner as to minimise the entrapment of air until no accelerator streaks or traces of unmixed material are visible. This normally requires five to eight minutes. Continued scraping of the sides and corners of the bottom of the container will ensure complete mixing.
- **e.** Determine if mixing is complete by spreading a drop of the mixture very thinly on a piece of white paper with a knife blade or similar instrument. Close examination should not reveal any specks or streaks. Do not mix the sealant beyond the point where tests show the accelerator to be thoroughly mixed into the base compound.
- **f.** When the mixing procedure has been completed, the sealant is ready for use and may be poured directly into the connector (primed in accordance with the manufacturer's instructions) to be sealed. For details of connector sealing, see Section 2, Chapter 10.
- **g.** If the mixed compound is not to be used immediately, store it as directed in Paragraph 11.
- **h.** Sealants having an application time of one hour or less shall be hand mixed on the job. Do not freeze such material.

Mechanical Mixing

9. Mechanical mixing should be done at 15°C or lower to prolong the working life of the sealant. The procedure is as follows:

- **a.** Hand mix the accelerator as described in Para 8. A paint shaker vibrating machine may be used if available. Shake for five to seven minutes.
- **b.** If the base material is packaged in a metal container, cut off the top of the container using a mechanical can opener. This should leave a smooth wall without any burr at the top of the can.
- **c.** Clamp base material container securely to drill press geared to 50 RPM minimum to 90 RPM maximum. Insert a mixing paddle fashioned from a drill rod and wire.
- **d.** Start drill press motor and slowly lower mixing paddle into the base compound to recombine any material that may have settled.
- **e.** Scrape all accelerator from its container and place it in the base material. Start drill press motor again and mix slowly for approximately two minutes. Stop machine, raise paddle, and scrape container walls as clean as possible. Start the drill press and lower the mixing paddle again and continue mixing for an additional three minutes.
- **f.** Make thin spread of sealant on white paper as described in Paragraph 8, step e. If necessary, continue mixing in two-minute cycles followed by paper test until no traces of unmixed material are visible. The sealant is then ready for use.
- **g.** If the mixed compound is not to be used at once, store in accordance with instructions in Paragraph 11.

STORAGE OF SEALING COMPOUND

Storage of Unmixed Sealing Compound

10. Store base compound and accelerator in a cool place, preferably under refrigeration. Shelf life for MIL-PRF-8516 and MIL-PRF-23586 compounds is approximately six months when stored below 24°C and can be extended to one year when stored at 7°C or below.

CAUTION

Do not store sealing compound at temperatures above 27°C. Keep base compound and accelerator together in the carton as supplied. Note manufacturing date stamped on carton and use oldest material first.

NOTE

Do not use sealing compound which has exceeded normal shelf life unless it has been tested by an appropriate laboratory to evaluate its acceptability for further use.

Storage of Mixed Sealing Compound

11. Mixed MIL-PRF-8516 potting compound can be stored in cartridge tubes for periods of 30 to 60 days provided the filled tubes are quick-frozen immediately after mixing and are stored at -40°C. Quick-freezing and thawing of the filled tubes should be done in accordance with the manufacturer's instructions. Freezing by slow cooling in air is not recommended since it reduces the mixed storage life. Mixed MIL-PRF-23586 potting compounds usually have shorter storage life than MIL-PRF-8516 compounds after quick-freezing; the storage life of quick-frozen MIL-PRF-23586 potting compounds is usually less than three weeks at -40°C. In general, extended storage of mixed, frozen potting compound shortens pot life and cure time after thawing. The method to determine whether the frozen compound is suitable for use is to thaw the material; if it is still pourable and has sufficient pot life remaining for application purposes, it can be considered satisfactory.

CAUTION

Mixed compound in tubes should not be stored in dry ice since the material will absorb carbon dioxide and cause sponging or porosity.

Dispensers for Sealing Compound

12. Potting compound once mixed should be immediately poured into dispenser tubes made of polyethylene, TFE, or aluminium. If necessary to store mixed compound in accordance with Paragraph 11, the compound should first be poured into the final dispenser tube.

PREPARATION OF FLUOROCARBON INSULATED WIRE FOR POTTING

13. The following types of insulated wire must be specially prepared prior to potting regardless of the type of sealant to be used: polytetrafluoroethylene (PTFE) or fluorinated polyethylene propylene (FEP). The preferred method is to etch the insulation with fluorocarbon compound. (See Paragraph 16)

14. An etching compound currently available is Tetra-Etch.

15. MIL-PRF-23586 silicone rubber sealant will require a primer application to all metal surfaces in addition to the etched fluorocarbon surfaces prior to potting. When using MIL-PRF-8516 sealant, prime and/or pre-coat when recommended in the manufacturer's instructions.

Etching Method

WARNING

Personnel engaged in cleaning and etching operations should use appropriate personal protective equipment.

WARNING

Etching vapours are toxic. Ensure Adequate ventilation. if etchant solution contacts the skin, Neutralise with butyl alcohol and flush immediately with water. Avoid direct contact of the etchant solution with water, chlorinated hydrocarbons, and carbon dioxide. Any spillage of etchant solution should first be neutralised with butyl alcohol before washing with water. Etchant solution is highly flammable and should be kept away from open flames.

CAUTION

Sodium in the etchant solution reacts with oxygen, moisture, and carbon dioxide, and exposure to air affects the solution strength. Etchant that has deteriorated badly will appear as a yellow or white solution. The nominal colour of a fresh solution is dark bluish-black. etching solution loses its normal dark colour as its potency reduces.

CAUTION

Chemical etches should be applied only to TFE and FEP insulations. Contact with other types of insulation should be avoided.

16. Etching wire to provide a bondable surface shall be completed prior to attachment to the connector, as follows:

- **a.** Clean the bonding surfaces by scrubbing with clean safety solvent and immediately wipe with a clean dry cloth.
- **b.** Dip the ends of the wire, at least 3mm above the anticipated potted level, in a fresh etchant solution for ten to thirty seconds. If the wire cannot be conveniently immersed, fresh solutions may be brushed on the bonding surfaces to obtain desired etching.
- **c.** After dipping, neutralise the solution on the wire with butyl alcohol and clean off residue by wiping with a clean cloth wet with acetone.
- **d.** A properly etched surface will have a brown to deep brown colour.

17. Carry out a quality control check as follows:

- **a.** Uniform colour of etched wires is desired.
- **b.** A colour comparison may be used with samples previously etched to within the acceptable colour range. The individual wires within the typical bundle may vary in colour within this range.
- **c.** Every precaution shall be taken to ensure that etchant or water does not come in contact with a connector assembly or pin.
- **d.** Before any etchant is brought into an aircraft, cover a sufficient section below the area to be treated with heavy grade polyethylene and, in turn, cover this with cloth. Any flowing of etchant (if spilled) across the polyethylene will be eliminated.
- **e.** If etchant is dripped or spilled on material other than the polyethylene cover, wipe it up immediately with a soft lint-free cloth.

Shrink Tube Method

18. An alternate to etching is to use heat shrink tubing as follows:

- **a.** Select tubing from Table 11–1 that has an unrestricted shrinkage that is at least 20% smaller than the outside diameter of the wire being used.
- **b.** Shrink a section of the tubing to the portion of individual wire insulation that is to be encased in potting compound. Tubing should extend approximately 9.5mm beyond the anticipated potting level.

PR-1547 (MIL-M-24041) MOULDING AND POTTING COMPOUND

NOTE

PR-1547 must be prepared under controlled conditions as described below.

Description

19. PR-1547 sealing compound is a two component polyether polyurethane system consisting of a prepolymer and a curing agent, before mixing. These compounds are flexible cold-flow and cold-resistant materials with excellent electrical properties and are intended for use in a sea-water environment. This compound will adhere to metal, rubber, or polyvinylchloride, and may be used for sealing and reinforcing electrical connectors, wiring, and other electrical apparatus. This compound is used to seal connectors located in areas where the temperature range is -62°C to 150°C.

Table 11–1 Shrinkable Tubing

Military Part Number	As Supplied I.D. Min. (mm)	After Unrestricted Shrinkage	
		I.D. Max	Wall Thickness
M23053/8-001C	1.17	0.58	0.6 ± 0.05
M23053/8-002C	1.6	0.78	0.6 ± 0.05
M23053/8-003C	2.36	1.17	0.6 ± 0.05
M23053/8-004C	3.18	1.6	0.6 ± 0.05
M23053/8-005C	4.75	2.36	0.6 ± 0.05
M23053/8-006C	6.35	3.18	0.3 ± 0.08
M23053/8-007C	9.52	4.79	0.3 ± 0.08
M23053/8-008C	12.7	6.35	0.3 ± 0.08
M23053/8-009C	19.0	9.53	0.4 ± 0.08
M23053/8-010C	25.4	12.7	0.45 ± 0.08
M23053/8-011C	38.1	19.3	0.5 ± 0.08

Frozen Pre-Mixed Cartridges

CAUTION

Thawing time and temperature must be controlled closely to obtain the maximum application life. Application life will be reduced by an increase in either the thawing time or temperature. An incomplete thaw will result if thawing time or temperature is reduced.

20. Prepare as follows:

a. Remove cartridge from storage and place upright in an oven, heating block, or in a dry metal sleeve in a water bath at 55°C for 20 minutes.

b. Remove cartridge from heat and “work” the pliable cartridge with hands to distribute temperature evenly.

c. Replace cartridge at 55°C for 5 minutes.

d. Remove cartridge from heat, bleed any entrapped air from under the plunger.

e. Insert cartridge in sealant gun, attach nozzle, and apply.

Mixing Instructions

NOTE

The base compound absorbs moisture from the air. Do not open containers until ready to use.

21. For dense void-free compounds, it is recommended that the material be degassed prior to application. For small quantities, the material may be degassed in a standard laboratory dessicator connected to a vacuum pump. Larger quantities may be degassed in standard volume equipment. Instructions are as follows:

a. Prolonged storage of the base compound below 18°C will result in thickening. The base compound may be liquefied by warming to 82°C for approximately two to three hours and stirring thoroughly.

b. The accelerator thickens at ambient temperatures. Warm the accelerator to 94°C to 99°C. Stir occasionally until a homogeneous mix results.

WARNING

Avoid inhalation of vapours resulting from heating of accelerator. Conduct operation only in a well ventilated area.

c. Cool the base compound and the accelerator to 21°C to 27°C. Combine components and mix thoroughly. A wooden paddle must not be used due to the high moisture content of wood.

d. Place freshly mixed material in a container approximately two times the volume of the mixed material and degas under a vacuum of 3 millimetres of mercury or less for a period of 5 to 15 minutes or until foaming subsides. After this, the material is ready to use. If smaller quantities are desired, mix 100 parts base compound with 25 parts accelerator, using procedure outlined in the above paragraphs. It should be noted that when the base compound has been exposed to atmospheric moisture, it may chemically react and, further, foam and solidify. It is recommended that a blanket of inert gas be used on all base compound containers if small quantities are utilised.

CAUTION

After mixing the base compound and the accelerator, all subsequent operations should be expedited to minimise the reduction in application life.

Curing Time

22. PR-1547 may be cured at either room temperature or at elevated temperatures. PR-1547 cures to a firm condition in 24 hours at 25°C and in 1-1/2 to 2 hours at 82°C. PR-1547 reaches ultimate hardness after five days at 25°C or six hours at 82°C. When required, faster curing periods can be obtained by using cure temperatures of 94°C to 99°C.

Storage Life

23. When stored at temperatures below 27°C in original unopened containers, the storage life of PR-1547, supplied in two-component kit form, is six months. Pre-mixed frozen PR-1547has a storage life of at least 7 days when stored at -29°C and a minimum storage life of 28 days when stored at -68°C.

Surface Preparation

24. Before applying PR-1547 potting compound, prepare the surface as follows:

a. **Cleaning.** To obtain good adhesion, PR-1547 should be applied only to clean, dry surfaces. Surfaces may be cleaned with an oil-free solvent using a small brush or a clean, oil-free cloth.

b. **Application of Primer.** Primers should be used for optimum adhesion and moisture resistance. The following surface preparations are recommended:

(1) **Metal.** PR-420-HTC is designed for metal surfaces. A thin film of primer is applied to the clean, dry surface.

(2) **Neoprene.** PR-1523M is designed for neoprene surfaces. For some neoprene formulations, buffing with an abrasive is sufficient. Otherwise, after thoroughly buffing, apply a coat of PR-1523M to the clean, dry surface.

(3) **Polyvinyl Chloride.** PR-1543 is designed for polyvinyl chloride surfaces. When a primer is required, apply a thin coat PR-1543 to the clean, dry surface.

SECTION 2

CHAPTER 12

RF CONNECTORS AND CABLING

INTRODUCTION

1. Coaxial cable assemblies are used to carry radio frequency (RF) power from one point to another with a known rate of loss. An assembly consists of RF connectors attached to coaxial cable. The coaxial cable described in this chapter is of the flexible, solid dielectric type, relatively small to medium size. The characteristic impedance of most of the cable is 50 ohms, but several of the cables listed have a characteristic impedance of 48, 53, 75 or 93 ohms.

2. This chapter describes and illustrates the Military Standard RF connectors and coaxial cable most commonly used in aircraft and the recommended methods for assembling coaxial cable to the connectors. This section also describes and gives instructions for assembly of miniature RF connectors to coaxial cable, and for RF connectors used in fuel-quantity-indicating systems. General procedures for installation of coaxial cable assemblies into aircraft are given in Section 2, Chapter 4.

REFERENCE SPECIFICATIONS

3. The following specifications are applicable to RF connectors and cabling:

J-STD-004	Requirements for Soldering Fluxes
J-STD-005	Requirements for Soldering Pastes
J-STD-006	Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications.
MIL-C-17	Cables, Radiofrequency, Flexible and Semi-rigid, General Specification For
MIL-C-3607	Connectors, Coaxial, Radiofrequency, Series Pulse, General Specification For
MIL-C-3643	Connectors, Coaxial, Radiofrequency, Series HN, General Specification For
SAE AS 8660	Silicone Compound NATO Code Number S-736 FSC 6850
MIL-S-22473	Sealing, Locking and Retaining Compounds, Single-Component
MIL-DTL-22520	Crimping Tools, Wire Termination, General Specification For
MIL-DTL-25516	Connectors, Electrical, Miniature, Co-axial, Environment Resisting Type, General Specification For
MIL-PRF-39012	Connectors, Coaxial, Radio Frequency, General Specification for

DESCRIPTION

RF Connectors

4. RF connectors are available as pin-contact or socket-contact plugs. (See Figure 12–1.) All plugs are cabled and are for attaching to the ends of coaxial cables. Receptacles are designed for mounting to panels or chassis. Receptacles are either cabled or uncabled. The following categories of RF connectors are used for replacement purposes, with Category D being the preferred.

a. Category A - Braid clamp and solder contact.

b. Category C - Solder centre pin or socket crimp ferrule. See Figure 12–2.

c. Category D - Crimp centre pin or socket, crimp ferrule. See Figure 12–2.

5. The following series of RF connectors are used:

a. **BNC Series.** A small, lightweight, bayonet type, quick-connect/disconnect connector, used with small coaxial cables, where peak voltage is not more than 500 volts. (See Figure 12–2.)

b. **HN Series.** A high voltage (up to 5,000 volts), threaded coupling connector used with medium size coaxial cables. (See Figure 12–3.)

c. **N Series.** A general purpose, threaded coupling connector used with medium size coaxial cables. (See Figure 12–4.)

d. **C Series.** A bayonet type, quick-connect/disconnect connector used with medium size coaxial cables. It is electrically similar to the N series. (See Figure 12–5.)

e. Pulse Series. A high-voltage connector for pulse or DC applications. (See Figure 12–6.) Designed to be used with rubber dielectric pulse cables but may be used with equivalent-size cables of other constructions where high voltage is not required. With ceramic inserts, peak voltage is 15,000 volts at sea level. With rubber inserts, peak voltage is 5,000 volts at 50,000 feet, but higher voltages may be used at lower altitudes.

f. TNC Series. A small lightweight connector similar to the BNC series, but having a threaded coupling, used where a positive coupling under vibration and a low noise level is desirable. See Figure 12–7.)

g. SC Series. A connector used with medium size coaxial cables; similar to the C series, but having a threaded coupling. (See Figure 12–8.)

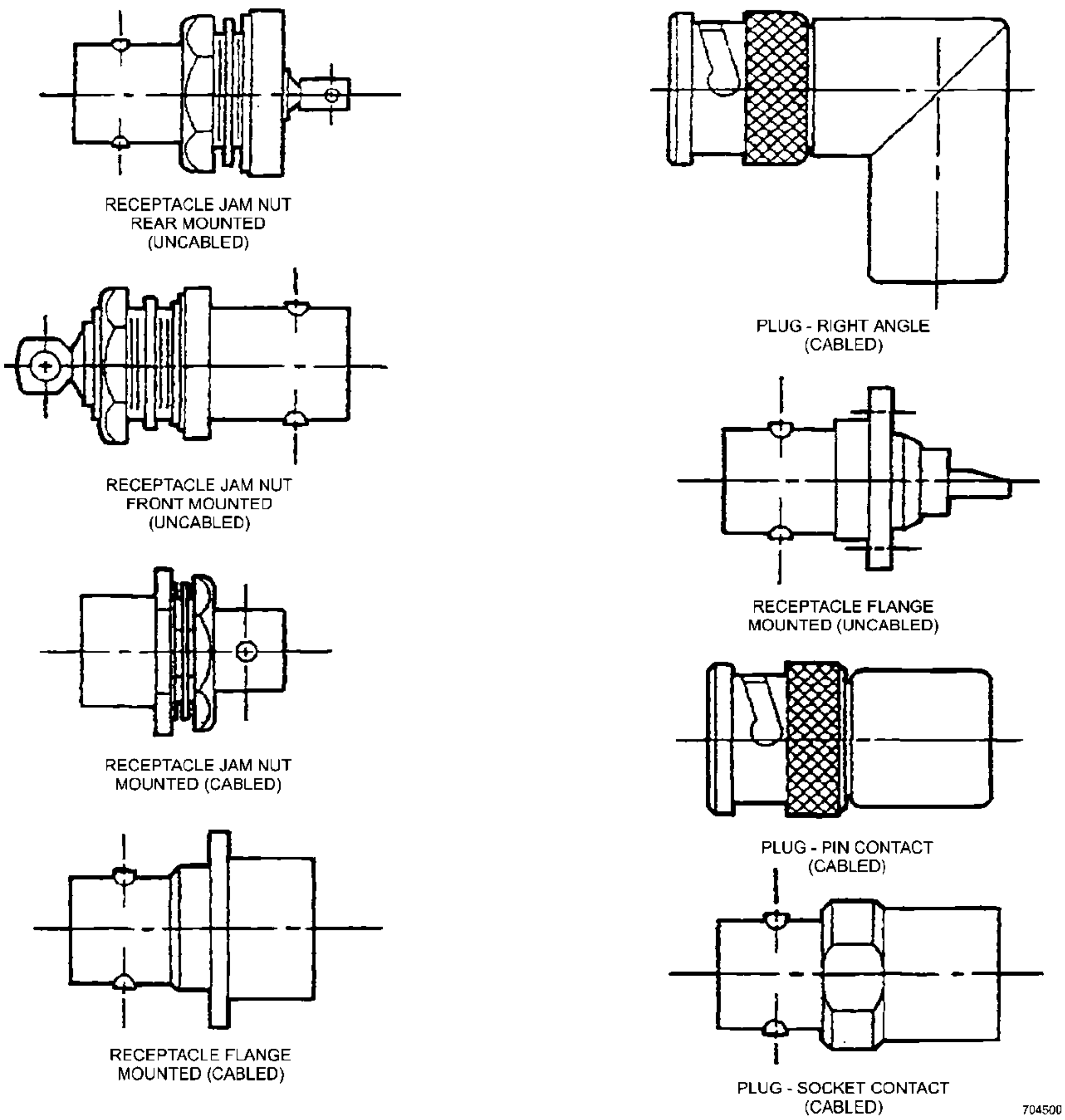


Figure 12–1 RF Connectors

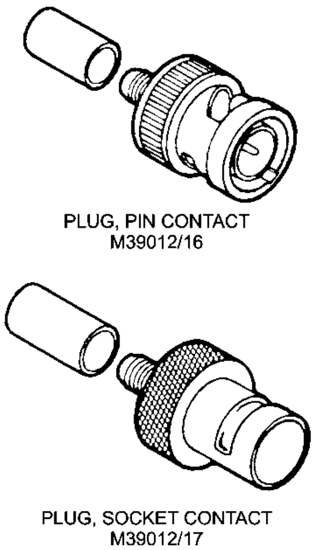


Figure 12–2 Typical BNC Connectors

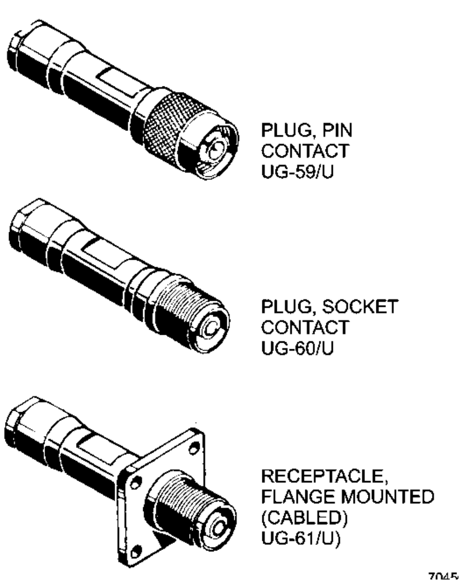


Figure 12–3 Typical HN Connectors

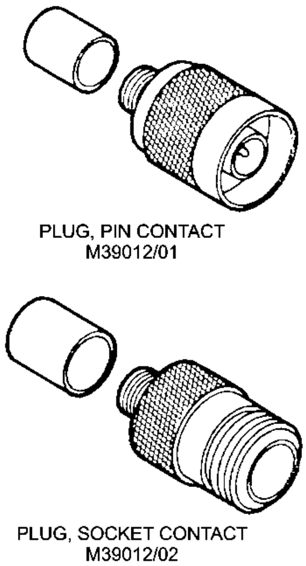


Figure 12–4 Typical N Connectors

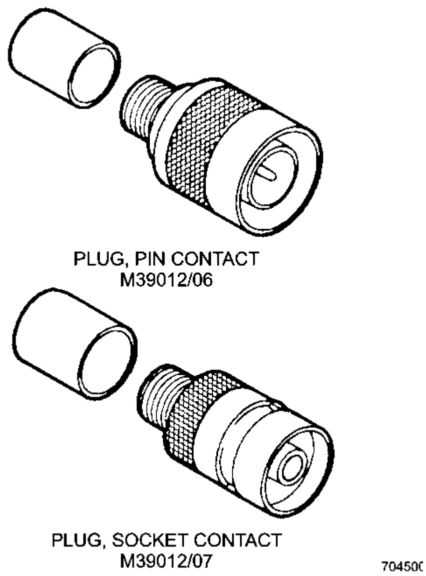


Figure 12–5 Typical C Connectors

Coaxial Cable

6. Coaxial cable consists of an inner (centre) conductor separated from the outer conductor, usually called a shield, by an insulating dielectric. The cable is protected against moisture and abrasion by a tough outer jacket (sometimes called a sheath). See Figure 12–9 for typical coaxial cables. The inner conductor is usually copper, either solid or stranded, and may be bare, tin plated, or silver plated. The outer conductor (shield) is usually a copper braid, bare, tin plated, or silver plated, woven over the dielectric. Some coaxial cables have a double outer conductor (double shield) to provide extra shielding. The dielectric has two functions: (1) it provides low loss insulation between the inner conductor and the outer conductor, and (2) it maintains the relative position of the inner conductor inside the outer conductor and therefore keeps the capacitance between the two at a constant value. The maximum operating temperature of cables with polyethylene dielectric is 85°C. The maximum operating temperature of cables with teflon dielectric is

200°C. Teflon dielectric coaxial cables can replace polyethylene dielectric cables of the same physical and electrical characteristics.

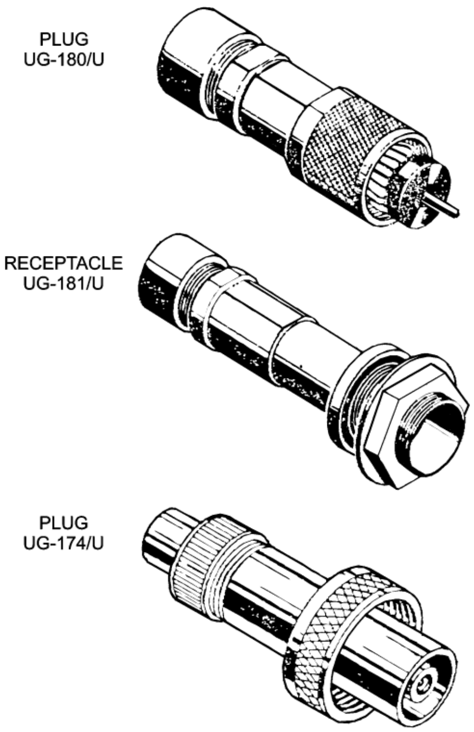


Figure 12–6 Typical Pulse Connectors

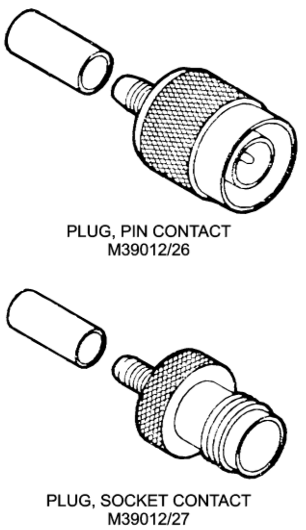


Figure 12–7 Typical TNC Connectors

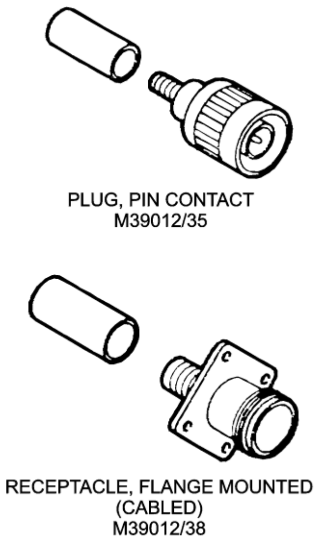


Figure 12–8 Typical SC Connectors

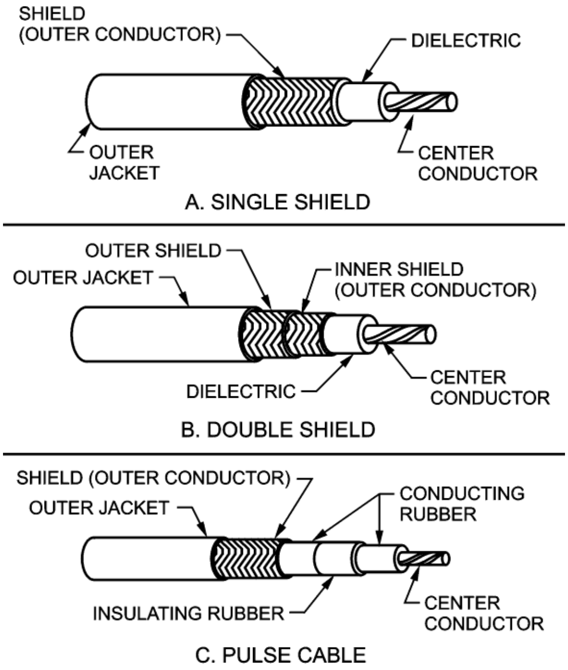


Figure 12–9 Typical Coaxial Cables

GENERAL PRECAUTIONS AND PROCEDURES

General Precautions

7. A good connection depends on holding coaxial cable and connectors to the design dimensions. Any change in these dimensions will cause added losses to the RF power being carried, and may also cause radiation interference. It is important that the assembly directions given for each connection be followed carefully to avoid problems. The following precautions are common to all assemblies of the coaxial cable and RF connectors:

a. When working with coaxial cable, never step on the cable, set anything heavy on it, or bend it sharply. This will flatten the cable and will change its electrical characteristics. Handle coaxial cable carefully at all times. Anything which damages it, or which might lead to its being damaged later, reduces the efficiency of the system.

b. Do not use pliers to assemble or disassemble RF connectors.

c. Pins and sockets for RF connectors are usually packed unassembled. Do not misplace them.

d. Use care in starting the braid clamp nut into a plug or jack body, in order to prevent cross threading.

e. Keep soldering iron clean, smooth, and well tinned at all times. See Section 2, Chapter 7 for care of soldering iron.

f. RF connectors should be physically tight on their coaxial cable. Improperly fitting connectors will allow movement that degrades the electrical connection by bending, nicking, and breaking the braided shield wires. This can cause premature failure or equipment damage if the cable is used in a transmitting system. Degraded signal carrying capability can occur in a receiving or data transfer system. If any rotational movement is found between the RF connector and cable, the connector shall be replaced.

g. In areas where RF connectors are subject to mechanical or physical strain that would tend to break connections or braided shields, strain relieving cable clamps may be installed to prevent damage

WARNING

Failure to ensure that the centre conductor is not shorted may result in equipment damage, personal injury or death.

h. Check assembled coaxial connectors with an ohm-meter to ensure that the centre conductor is not shorted to the shield. This can be accomplished by placing the ohm-meter on its highest scale, ensuring that the other end of the coaxial cable is disconnected from the equipment, then placing the ohm-meter leads on the centre pin and the connector shell. The reading should be infinite ohms. An optional check can be performed using a time domain reflectometer (TDR).

General Procedures

8. During the preparation of coaxial cable assemblies, observe the following general procedures:

a. Cut coaxial cable to length with long handled cable cutters or pruning shears, making sure cut is clean and square.

b. Identify cable by using the methods described in Section 2, Chapter 2.

c. Strip outer jacket from cable by first making a cut carefully around circumference with a sharp knife. Then make a lengthwise slit, and peel off jacket. Take care not to nick, cut, or damage shield.

d. For connectors using braid clamps comb out the braid by using a pointed wooden dowel or a scriber.

CAUTION

Do not damage dielectric or break shield strands.

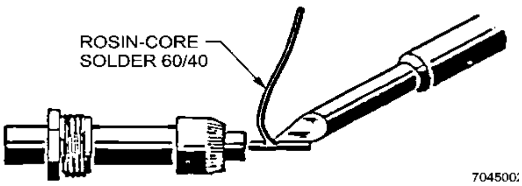


Figure 12–10 Tinning Centre Conductor

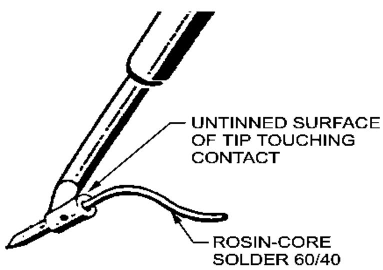


Figure 12–11 Tinning Inside of Contact

e. To remove dielectric, cut with sharp knife around circumference, not quite through to centre conductor, taking care not to nick or cut strands or otherwise damage conductor. Pull off dielectric.

f. For connectors using solder pins or sockets, tin centre conductor with soldering iron as shown in Figure 12–10.

g. Tin inside of solder type pins and sockets with a soldering iron, as shown in Figure 12–11. (Use untinned face of tip to prevent depositing solder on outside of contact.)

h. Solder pins and sockets to centre conductor with clean well tinned soldering iron using solder per standard J-STD-006.

CAUTION

Contact must butt flush against dielectric before and after soldering.

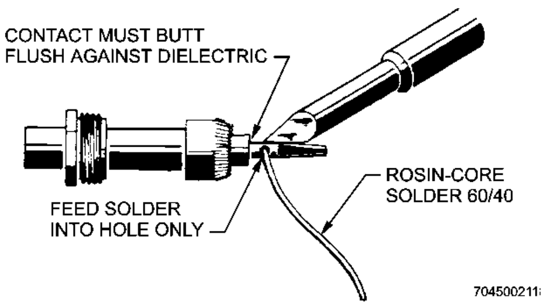


Figure 12–12 Soldering Contact to Coaxial Cable

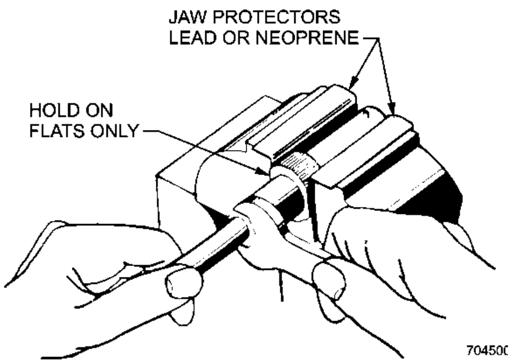


Figure 12–13 Tightening Braid Clamp Nut into Plug or Jack Body

i. When assembling the connector, always start the clamping nut into the body by hand, then hold the body assembly in a vice using lead or neoprene jaw protectors. (See Figure 12–13.) Hold body only on the flats. Do not use excessive pressure, since the body can be easily distorted. Tighten nut with end spanner.

SOLDERING COAXIAL CABLE TO RF CONNECTORS

Preparation of Work

9. The work to be soldered must be clean and free from oxides. Remove grease by cleaning with Stoddard's solvent or other approved cleaner. Oxides, if not too heavy, are removed by the action of the rosin flux during the soldering operation. Heavily oxidised wire cannot be cleaned by the rosin flux and should be discarded.

Selection of Soldering Iron

10. For good soldering, it is important to select a soldering iron of the proper size and heat capacity. For soldering coaxial cable to RF connectors, use an iron with a heating element rated at 65 to 100 watts, and a tip of about 0.25 inch (6.3mm) in diameter. The soldering tip should be shaped as shown in Figure 12–14. Maintain this shape by dressing the tip with a mill smooth file. Make sure the soldering iron is clean, smooth, and well tinned. See Section 2, Chapter 7 for detailed instructions on care and maintenance of the soldering iron.

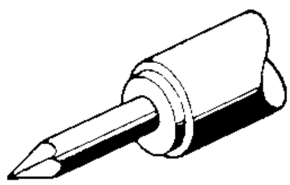


Figure 12–14 Correct Shape for Soldering Iron Tip

NOTE

For soldering coaxial cable to RF connectors, tin only one face of the tip so that areas adjacent to that being soldered will not be coated with solder by accident.

Soldering Procedure

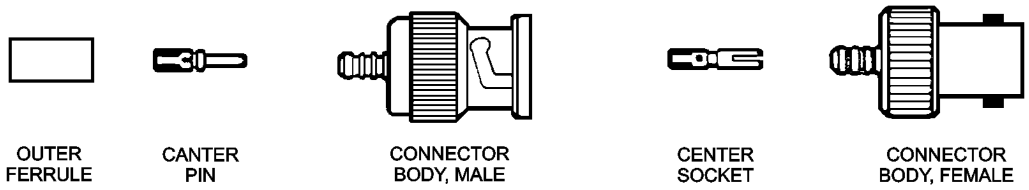
11. See Section 2, Chapter 7 for general soldering procedures and precautions. For soldering cable to RF connectors, use only 60/40 tin-lead solder with a core of rosin flux. Heat the parts to be joined, and apply the solder at the junction of the soldering iron tip and the work as shown in Figure 12–12. Do not apply heat longer than is necessary to melt the solder; excessive heat will swell the dielectric and make it difficult to insert into the body shell. Do not allow solder to flow over the outside of the contact. After the joint has cooled, remove excess flux by wiping with a clean cloth, using denatured alcohol as a solvent if necessary.

BNC AND TNC SERIES CONNECTORS

BNC and TNC Connector Types

12. There are three versions of connectors, differing in the method of attaching coaxial cable to the connector body. (See Figure 12–15.)

- **a.** “Crimp Ferrule, Crimp Centre Pin or Socket” consists of connector body, crimp outer ferrule, and crimp centre pin or socket.
- **b.** “Crimp Ferrule, Solder Centre Pin or Socket” consists of connector body, crimp outer ferrule, and solder centre pin or socket.
- **c.** “Braid Clamp, Solder Centre Pin or Socket” consists of connector body, nut, gasket clamp, bushings, and solder centre pin or socket.



SELECT CORRECT CONNECTOR FOR CABLE. SEE TABLE 11-1.

STRIP CABLE JACKET, BRAID AND DIELECTRIC TO DIMENSIONS SHOWN. ALL CUTS ARE TO BE SHARP AND SQUARE. IMPORTANT: DO NOT NICK BRAID, DIELECTRIC, AND CENTER CONDUCTOR. TINNING OF CENTER CONDUCTOR IS NOT NECESSARY IF CONTACT IS TO BE CRIMPED. FOR SOLDER METHOD, TIN CENTER CONDUCTOR AVOIDING EXCESSIVE HEAT.

SLIDE OUTER FERRULE ONTO CABLE AS SHOWN. FLARE SLIGHTLY END OF CABLE BRAID AS SHOWN TO FACILITATE INSERTION ONTO INNER FERRULE. IMPORTANT: DO NOT COMB OUT BRAID.

PLACE CONTACT ON CABLE CENTER CONDUCTOR SO IT BUTTS AGAINST CABLE DIELECTRIC. CENTER CONDUCTOR SHOULD BE VISIBLE THROUGH INSPECTION HOLE. CRIMP OR SOLDER CENTER PIN OR SOCKET IN PLACE AS FOLLOWS:

CRIMP METHOD: SELECT APPROPRIATE TOOL FROM TABLE 11-1 (SEE FIGURE 11-17). CRIMP CENTER PIN OR SOCKET.

SOLDER METHOD: SOFT SOLDER CONTACT TO CABLE CENTER CONDUCTOR. DO NOT GET ANY SOLDER ON OUTSIDE SURFACE OF CONTACT. AVOID EXCESSIVE HEAT TO PREVENT SWELLING OF DIELECTRIC.

INSTALL CABLE ASSEMBLY INTO BODY ASSEMBLY SO INNER FERRULE PORTION SLIDES UNDER BRAID. PUSH CABLE ASSEMBLY FORWARD UNTIL CONTACT SNAPS INTO PLACE IN INSULATOR.

SLIDE OUTER FERRULE OVER BRAID AND UP AGAINST CONNECTOR BODY. CRIMP OUTER FERRULE USING CAVITY OF DIESET (SEE FIGURE 11-16) SPECIFIED IN TABLE 11-1.

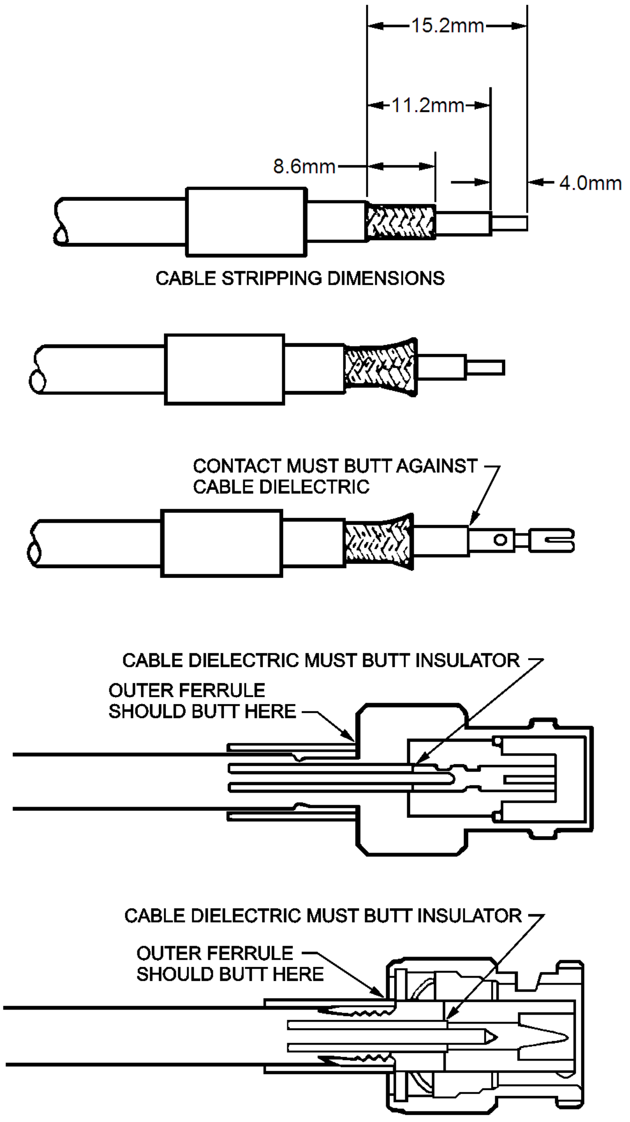
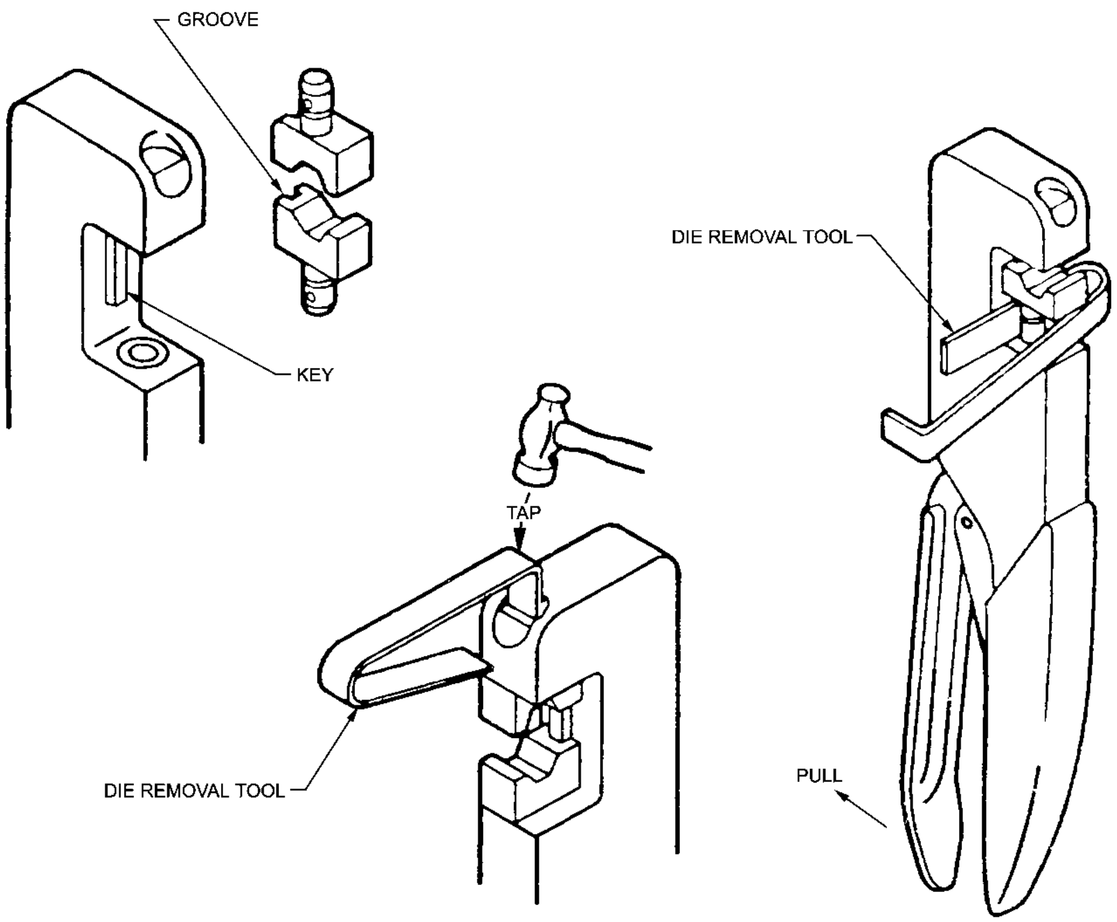


Figure 12–15 Attaching BNC & TNC (M39012) Crimp Connectors to Coaxial Cable



DIE INSTALLATION

ALIGN GROOVE IN DIE WITH KEY IN CRIMPING TOOL AND PUSH SHANK OF DIE INTO THE HOLE. CLOSE HANDLE TO MAKE SURE DIES ARE PROPERLY SEATED AND LOCKED IN PLACE. THE TOOL IS NOW READY FOR USE.

DIE REMOVAL

WITH CRIMPING TOOL HANDLE OPEN, PLACE DIE REMOVAL TOOL AGAINST END OF KNOCK-OUT PAD AND TAP GENTLY. THE DIE WILL BE RELEASED FROM THE LOCK SPRING AND EJECTED APPROXIMATELY 0.063 INCH. IT CAN NOW BE REMOVED BY HAND.

CLOSE THE CRIMPING TOOL HANDLE AND SLIDE THE DIE REMOVAL TOOL BETWEEN THE DIE AND TOOL BODY. PULL HANDLE OPEN WITH A SNAP ACTION. THE DIE WILL BE RELEASED FROM THE LOCK SPRING AND THEN CAN BE REMOVED BY HAND.

CRIMPING

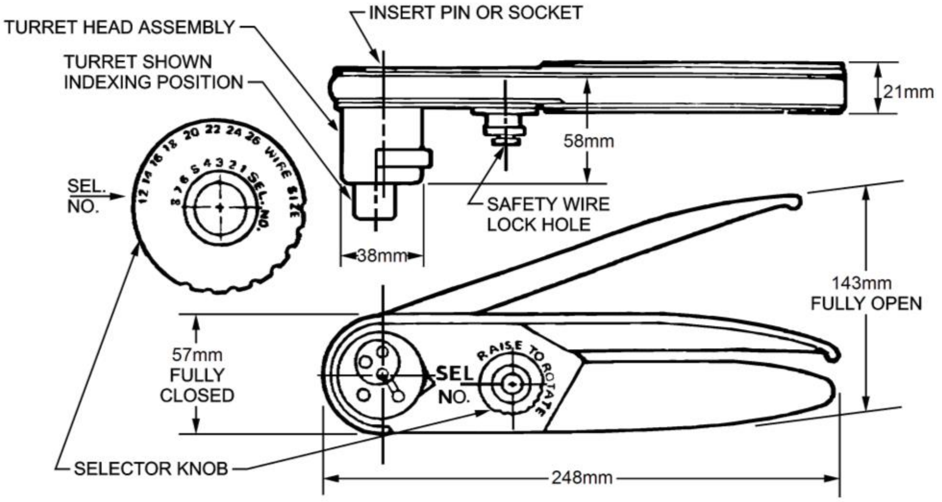
ASSEMBLE CABLE IN CONNECTOR BODY AND SLIDE FERRULE OVER BEAD.

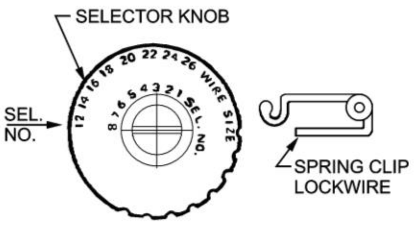
OPEN DIES AND POSITION FERRULE IN PROPER DIE CAVITY.

CLOSE HANDLE OF TOOL UNTIL DIES ARE CLOSED AND RATCHET RELEASES.

M22520/5-01 CRIMPING TOOLS ARE DESIGNED TO CRIMP VARIOUS SIZES AND TYPES OF FERRULES AND COAXIAL CONNECTORS. DIFFERENT DIES FOR CRIMPING THESE ITEMS CAN BE INSTALLED AND LOCKED IN PLACE SO THEY CANNOT FALL OUT UNDER ADVERSE HANDLING - YET CAN EASILY BE REMOVED. THE DIES CAN ALSO BE PERMANENTLY MOUNTED IN THE CRIMPING TOOL.

Figure 12–16 M22520/5-01 Crimping Tool and Hex Dies





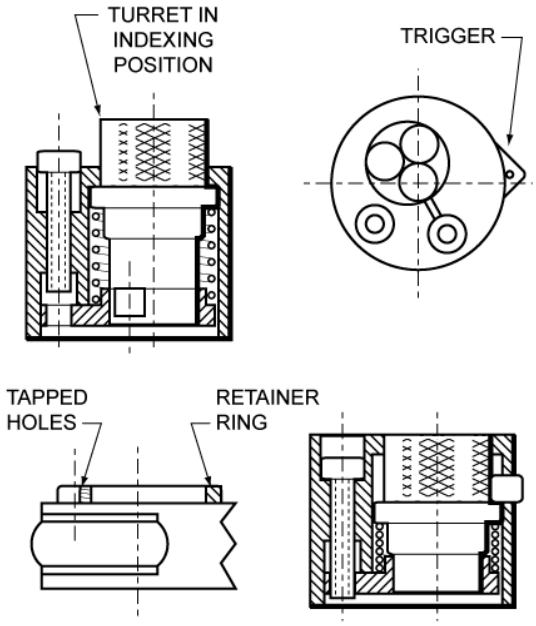
INSTRUCTIONS FOR USING INDENTOR CLOSURE SELECTOR

1. REFER TO DATA PLATE ON TURRET HEAD ASSEMBLY FOR THE CORRECT INDENTOR CLOSURE NUMBER.
2. REMOVE THE SPRING CLIP LOCK FROM SELECTOR KNOB.
3. TOOL MUST BE IN OPEN POSITION WHEN USING SELECTOR.
4. RAISE SELECTOR KNOB AND ROTATE TO DESIRED SELECTOR NUMBER.
5. REPLACE THE SPRING CLIP AND TOOL IS READY FOR USE.
6. REPEAT INSTRUCTION PROCEDURES WHEN CHANGING CONNECTOR PART NUMBER.

DATA PLATE

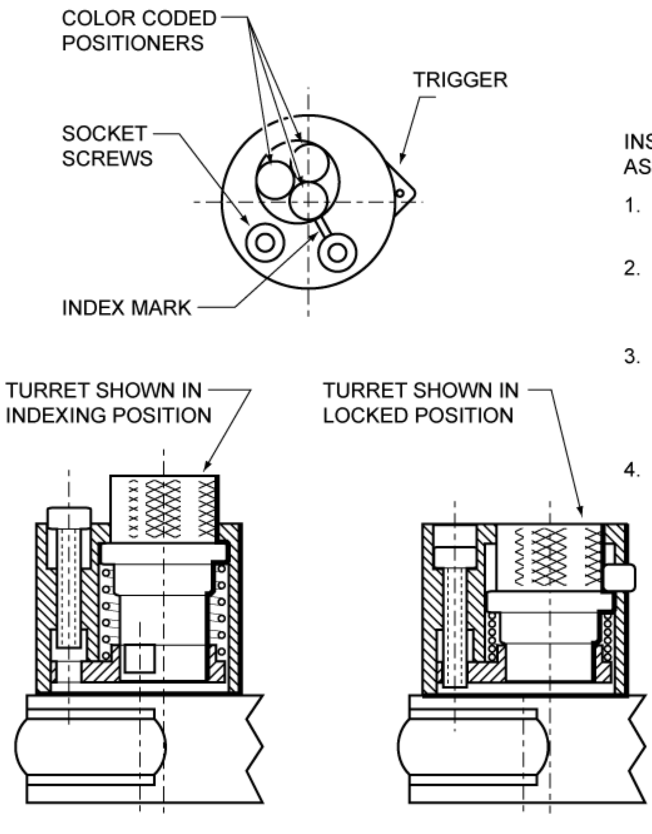
M39012/	POSITIONER COLOR	RG 122/U	RG 142/U	RG 180/U	RG 195/U	RG 400/U	CABLE SIZE
16-0503, 26-0503	BLUE		5			5	SELECTOR SETTING
16-0502, 26-0502				3	3		
16-0501, 26-0501		6					
17-0503, 27-0503			5			5	
17-0502, 27-0502				3	3		
17-0501, 27-0501		6					
18-0503, 29-0503			5			5	
18-0502, 29-0502				3	3		
18-0501, 29-0501		6					
20-0503, 30-0503	GREEN		5			5	
20-0502, 30-0502				3	3		
20-0501, 30-0501		6					
19-0503, 28-0503	RED		5			5	
19-0502, 28-0502				3	3		
19-0501, 28-0501		6					

Figure 12–17 M22520/1-01 Crimping Tool and Turret



INSTRUCTIONS FOR CHANGING TURRET HEAD

1. PRESS TRIGGER WHICH RELEASES TURRET TO INDEXING POSITION.
2. PLACE SELECTED TURRET HEAD ASSEMBLY ONTO RETAINER RING WITH SCREWS LINED UP WITH TAPPED HOLES.
3. AFTER TURRET HEAD ASSEMBLY IS SEATED AGAINST RING, TIGHTEN SOCKET HEAD SCREWS WITH 0.14 INCH ALLEN WRENCH. TURRET SHOULD INDEX EASILY WITHOUT BINDING.
4. TO REMOVE, LOOSEN SOCKET HEAD SCREWS UNTIL THREADS ARE DISENGAGED FROM RETAINER RING AND REMOVE WITH A STRAIGHT LIFTING MOTION.
5. ALL HEADS (SINGLE POSITION, UNIVERSAL AND TURRET) ARE ATTACHED BY MEANS OF TWO SOCKET HEAD SCREWS.



INSTRUCTIONS FOR INDEXING TURRET HEAD ASSEMBLIES

1. PRESS TRIGGER WHICH RELEASES TURRET TO INDEXING POSITION.
2. SELECT POSITIONER DESIRED FROM COLOR CODED DATA PLATE OR SIDE OF TURRET HEAD ASSEMBLY.
3. INDEX TURRET UNTIL COLOR CODED POSITION ER IS LINED UP WITH INDEX MARK ON TOP OF TURRET HEAD ASSEMBLY AT WHICH TIME THE TRIGGER WILL POSITION THE TURRET.
4. PRESS TURRET UNTIL IT SNAPS INTO LOCKED POSITION.

Figure 12–18 M22520/1-01 Crimping Tool Turrets

Table 12–1 BNC & TNC Series M39012 Connectors and Associated Cables (MIL-C-17)

Cable	**Connector**	**Centre or Socket**	**Pin**	**Tool Ferrule**	**Crimp**	**Tool Alternate**	
BNC (Cabled) Plug, Pin, Contact							
RG-58	M39012/16-0504	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-141	M39012/16-0013	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-303	M39012/16-0013	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-223	M39012/16-0014	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-142	M39012/16-0503	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-59	M39012/16-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-62	M39012/16-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-140	M39012/16-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-210	M39012/16-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-122	M39012/16-0501	Positioner M22520/1-12		Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-71	M39012/16-0017	Solder		Cavity M22520/5-63	A	Cavity M22520/5-15	A
RG-302	M39012/16-0020	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-400	M39012/16-0503	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-180	M39012/16-0502	Positioner M22520/1-12		Cavity M22520/5-05	B	Cavity M22520/5-41	B
BNC (Cabled) Plug, Socket, Contact							
RG-58	M39012/17-0504	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-141	M39012/17-0013	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-303	M39012/17-0013	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-223	M39012/17-0014	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-142	M39012/17-0503	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-59	M39012/17-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-62	M39012/17-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-140	M39012/17-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-210	M39012/17-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-122	M39012/17-0501	Positioner M22520/1-12		Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-71	M39012/17-0017	Solder		Cavity M22520/5-63	A	Cavity M22520/5-15	A
RG-302	M39012/17-0020	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A

Table 12–1 BNC & TNC Series M39012 Connectors and Associated Cables (MIL-C-17) (Continued)

Cable	Connector	Centre or Socket	Pin	Tool Ferrule	Crimp	Tool Alternate	
RG-400	M39012/17-0503	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-180	M39012/17-0502	Positioner M22520/1-12		Cavity M22520/5-05	B	Cavity M22520/5-41	B
BNC (Cabled) Receptacle, Socket, Contact, Flange Mounted							
RG-58	M39012/18-0504	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-141	M39012/18-0013	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-303	M39012/18-0013	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-223	M39012/18-0014	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-142	M39012/18-0503	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-59	M39012/18-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-62	M39012/18-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-140	M39012/18-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-210	M39012/18-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-122	M39012/18-0501	Positioner M22520/1-12		Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-71	M39012/18-0017	Solder		Cavity M22520/5-63	A	Cavity M22520/5-15	A
RG-302	M39012/18-0020	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-400	M39012/18-0503	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-180	M39012/18-0502	Positioner M22520/1-12		Cavity M22520/5-05	B	Cavity M22520/5-41	B
BNC (Cabled) Receptacle, Socket, Contact, Jam Nut Mounted							
RG-58	M39012/19-0504	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-141	M39012/19-0013	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-303	M39012/19-0013	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-223	M39012/19-0011	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-142	M39012/19-0503	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-59	M39012/19-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-62	M39012/19-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-140	M39012/19-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-210	M39012/19-0015	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-122	M39012/19-0501	Positioner M22520/1-12		Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-71	M39012/19-0017	Solder		Cavity M22520/5-63	A	Cavity M22520/5-15	A

Table 12–1 BNC & TNC Series M39012 Connectors and Associated Cables (MIL-C-17) (Continued)

Cable	Connector	Centre Pin or Socket	Tool Ferrule	Crimp	Tool Alternate	
RG-302	M39012/19-0020	Solder	Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-400	M39012/19-0503	Positioner M22520/1-12	Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-180	M39012/19-0502	Positioner M22520/1-12	Cavity M22520/5-05	B	Cavity M22520/5-41	B
BNC (Cabled) Plug, Pin, Contact, Right Angle						
RG-58	M39012/20-0504	Positioner M22520/1-12	Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-141	M39012/20-0006	Solder	Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-303	M39012/20-0006	Solder	Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-223	M39012/20-0007	Solder	Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-142	M39012/20-0503	Positioner M22520/1-12	Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-122	M39012/20-0501	Positioner M22520/1-12	Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-302	M39012/20-0010	Solder	Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-400	M39012/20-0503	Positioner M22520/1-12	Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-180	M39012/20-0502	Positioner M22520/1-12	Cavity M22520/5-05	B	Cavity M22520/5-41	B
TNC (Cabled) Plug, Pin, Contact						
RG-58	M39012/26-0504	Positioner M22520/1-12	Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-316	M39012/26-0022	Solder	Cavity M22520/5-05	B	Cavity M22520/5-41	A
RG-303	M39012/26-0010	Solder	Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-223	M39012/26-0011	Solder	Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-142	M39012/26-0503	Positioner M22520/1-12	Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-59	M39012/26-0012	Solder	Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-62	M39012/26-0012	Solder	Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-174	M39012/26-0022	Solder	Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-210	M39012/26-0012	Solder	Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-122	M39012/26-0501	Positioner M22520/1-12	Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-71	M39012/26-0014	Solder	Cavity M22520/5-63	A	Cavity M22520/5-15	A
RG-302	M39012/26-0021	Solder	Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-400	M39012/26-0503	Positioner M22520/1-12	Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-180	M39012/26-0502	Positioner M22520/1-12	Cavity M22520/5-05	B	Cavity M22520/5-41	B

Table 12–1 BNC & TNC Series M39012 Connectors and Associated Cables (MIL-C-17) (Continued)

Cable	Connector	Centre Pin or Socket	Crimp Tool Ferrule		Crimp Tool Alternate	
TNC (Cabled) Plug, Socket, Contact						
RG-58	M39012/27-0504	Positioner M22520/1-12	Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-316	M39012/27-0022	Solder	Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-303	M39012/27-0010	Solder	Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-223	M39012/27-0011	Solder	Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-142	M39012/27-0503	Positioner M22520/1-12	Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-59	M39012/27-0012	Solder	Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-62	M39012/27-0012	Solder	Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-174	M39012/27-0022	Solder	Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-210	M39012/27-0022	Solder	Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-122	M39012/27-0501	Positioner M22520/1-12	Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-71	M39012/27-0014	Solder	Cavity M22520/5-63	A	Cavity M22520/5-15	A
RG-302	M39012/27-0021	Solder	Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-400	M39012/27-0503	Positioner M22520/1-12	Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-180	M39012/27-0502	Positioner M22520/1-12	Cavity M22520/5-05	B	Cavity M22520/5-41	B
TNC (Cabled) Receptacle, Socket, Contact, Jam Nut Mounted						
RG-58	M39012/28-0504	Positioner M22520/1-12	Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-316	M39012/28-0022	Solder	Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-303	M39012/28-0010	Solder	Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-223	M39012/28-0011	Solder	Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-142	M39012/28-0503	Positioner M22520/1-12	Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-59	M39012/28-0012	Solder	Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-62	M39012/28-0012	Solder	Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-174	M39012/28-0022	Solder	Cavity M22520/5-05	A	Cavity M22520/5-41	B
RG-210	M39012/28-0012	Solder	Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-122	M39012/28-0501	Positioner M22520/1-12	Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-71	M39012/28-0014	Solder	Cavity M22520/5-63	A	Cavity M22520/5-15	A
RG-302	M39012/28-0021	Solder	Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-400	M39012/28-0503	Positioner M22520/1-12	Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-180	M39012/28-0502	Positioner M22520/1-12	Cavity M22520/5-05	B	Cavity M22520/5-41	B

Table 12–1 BNC & TNC Series M39012 Connectors and Associated Cables (MIL-C-17) (Continued)

Cable	**Connector**	**Centre or Socket**	**Pin**	**Tool Ferrule**	**Crimp**	**Tool Alternate**	
TNC (Cabled) Receptacle, Socket, Contact, Flange Mounted							
RG-58	M39012/29-0504	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-316	M39012/29-0022	Solder		Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-303	M39012/29-0010	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-223	M39012/29-0011	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-142	M39012/29-0503	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-59	M39012/29-0012	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-62	M39012/29-0012	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-174	M39012/29-0022	Solder		Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-210	M39012/29-0012	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-122	M39012/29-0501	Positioner M22520/1-12		Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-71	M39012/29-0014	Solder		Cavity M22520/5-63	A	Cavity M22520/5-15	A
RG-302	M39012/29-0021	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-400	M39012/29-0503	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-180	M39012/29-0502	Positioner M22520/1-12		Cavity M22520/5-05	B	Cavity M22520/5-41	B
TNC (Cabled) Plug, Pin, Contact, Right Angle							
RG-58	M39012/30-0504	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-316	M39012/30-0022	Solder		Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-303	M39012/30-0010	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-223	M39012/30-0011	Solder		Cavity M22520/5-19	B	Cavity M22520/5-11	A
RG-142	M39012/30-0503	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-59	M39012/30-0012	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-62	M39012/30-0012	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-174	M39012/30-0022	Solder		Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-210	M39012/30-0012	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-122	M39012/30-0501	Positioner M22520/1-12		Cavity M22520/5-05	B	Cavity M22520/5-41	B
RG-71	M39012/30-0014	Solder		Cavity M22520/5-63	A	Cavity M22520/5-15	A
RG-302	M39012/30-0021	Solder		Cavity M22520/5-19	A	Cavity M22520/5-13	A
RG-400	M39012/30-0503	Positioner M22520/1-12		Cavity M22520/5-05	A	Cavity M22520/5-19	B
RG-180	M39012/30-0502	Positioner M22520/1-12		Cavity M22520/5-05	B	Cavity M22520/5-41	B

Attaching Improved BNC Connectors to Coaxial Cable

13. When attaching improved BNC connectors to coaxial cable (see Figure 12–19), use the following procedure:

> NOTE
>
> While attaching connector, observe all general precautions and procedures listed in paragraphs 7 and 8.

> **CAUTION**
>
> Do not nick or damage shield.

- **a.** Remove 7.8mm of outer jacket, exposing shield.
- **b.** Slide nut and gasket (V-groove away from nut), in that order, onto jacket. Slide sleeve clamp over tapered shield until inside shoulder of clamp butts flush against cut end of jacket.
- **c.** Comb out shield. Use care to prevent breaking shield strands.
- **d.** Strip dielectric 4.7mm from edge of jacket to edge of dielectric exposing centre conductor.

> **CAUTION**
>
> Do not nick or damage centre conductor.

- **e.** Comb shield back smoothly over sleeve clamp, and trim to 2.3mm with scissors.
- **f.** Trim dielectric to 3mm from shield, and cut off centre conductor to 3mm from edge of dielectric.
- **g.** Tin centre conductor as shown in Figure 12–10. Tin inside of pin or socket as shown in Figure 12–11.
- **h.** Slip contact over centre conductor so that contact butts flush against dielectric. For RG-62/U and 71/U, add bushing. Solder, using a clean, well tinned, soldering iron. Contact must still be flush against dielectric after solder has cooled; if it is not, remake the joint. (See Figure 12–12.)

> **CAUTION**
>
> Ensure that correct contact is used. a male contact always goes into a plug body, and a female contact always goes into a jack body.

- **i.** Push cable assembly into connector body as far as it will go. Make sure gasket is properly seated, with sharp edge of sleeve clamp entering gasket groove. Slide nut into connector body and fasten in vice. Start nut by hand and tighten with end spanner until enough pressure is applied to make a good seal by splitting the gasket. (See Figure 12–13.)

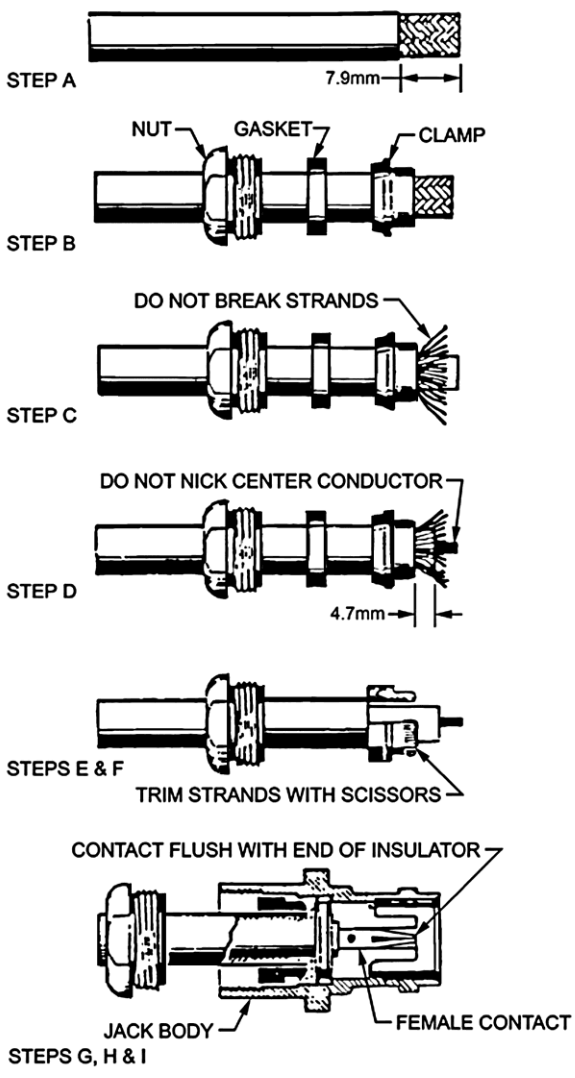


Figure 12–19 Attaching Improved BNC Connectors to Coaxial Cable

Attaching BNC Connectors with Captivated Contacts to Coaxial Cable

14. When attaching BNC connectors with captivated contacts to coaxial cable (see Figure 12–20), follow this procedure:

> NOTE
>
> While attaching connector, observe all general precautions and procedures listed in paragraphs 7 and 8.

a. Remove 9.5mm of outer jacket, exposing shield, for all except plugs 31-301 and 31-304; strip jacket for these plugs 10.7mm. Disassemble nut, grooved gasket, and sleeve clamp from plug or jack body. Slide nut and grooved gasket (V-groove away from nut), in that order, over shield onto jacket.

> **CAUTION**
>
> Do not nick or damage shield.

b. Comb out shield. Use care to prevent breaking shield strands.

c. Cut off cable dielectric to 4.7mm for cables RG-55/U, 58/U, 59/U, 140/U, 141/U, and 142/U. Cut to 0.156 inch (4mm) for cables RG-62/U and RG-71/U.

> **CAUTION**
>
> Do not nick or damage centre conductor.

d. Comb shield back smoothly over sleeve clamp and trim to proper length; form evenly over clamp. Tin centre conductor as shown in Figure 12–10. Slide on contact. These parts must butt as shown. When attaching to cables RG-62/U and RG-7l/U, add insulator bushing.

e. Solder pin or socket to centre conductor (see Figure 12–14). Remove excess flux and solder from outside of contact.

f. Slide front insulator over contact and butt against contact shoulder. Do not reverse direction of insulator.

g. Insert cable assembly into connector body. Make sure that the sharp edge of the clamp seats properly in the gasket. Tighten the nut, holding the body stationary. (See Figure 12–13.)

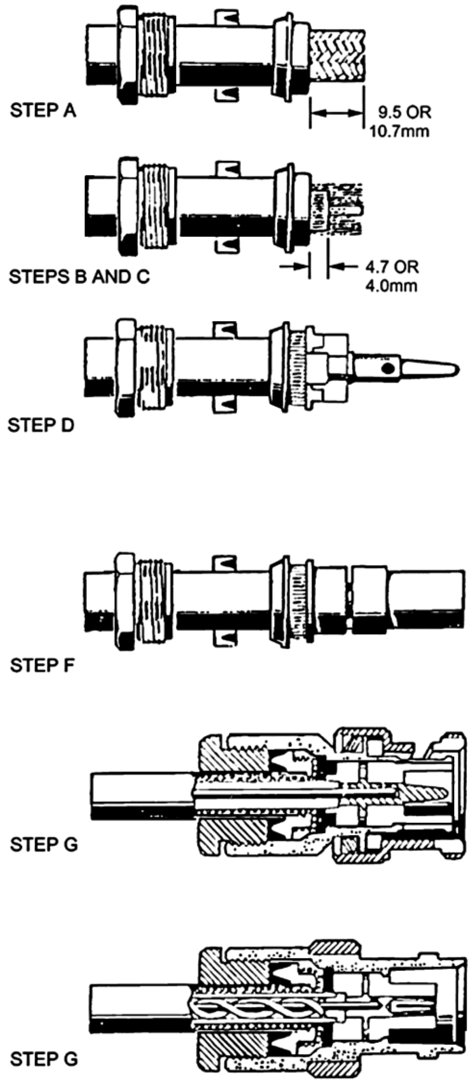


Figure 12–20 Attaching BNC Connectors With Captivated Contacts to Coaxial Cable

C AND SC SERIES CONNECTORS

15. There are three versions of C and SC connectors, differing in the method of attaching coaxial cable to the connector body.

Attaching Series C and SC Crimp Connectors to Coaxial Cable

16. When attaching C and SC connectors to coaxial cable (see Figure 12–21), use the following procedure:

a. Select correct connector for cable. See Table 12–2.

CAUTION

Do not nick or damage braid, dielectric, or centre conductor.

b. Strip cable jacket, braid, and dielectric to dimensions shown ±0.25mm (see Figure 12–22). All cuts are to be sharp and square. Tinning of centre conductor is not necessary if contact is to be crimped. For solder method, tin centre conductor avoiding excessive heat. Slide outer ferrule onto cable as shown.

c. As shown, (see Figure 12–22) flare end of cable braid slightly to facilitate insertion onto inner ferrule. Do not comb out braid.

d. Place contact on cable centre conductor so that it butts against cable dielectric. Centre conductor should be visible through inspection hole. Crimp or solder the pin or socket in place as follows:

e. **Crimp Method.** Select appropriate tool from Table 12–2. Crimp centre pin or socket. (See Figure 12–16.)

f. **Solder Method.** Soft solder contact to cable centre conductor. Do not get any solder on outside surfaces of contact. Avoid excessive heat to prevent swelling of dielectric.

g. Install cable assembly into body assembly so that inner ferrule portion slides under braid. Push cable assembly forward until contact snaps into place in insulator. Slide outer ferrule over braid and up against connector body. Crimp outer ferrule using cavity of die set specified in Table 12–2. (See Figure 12–16.)

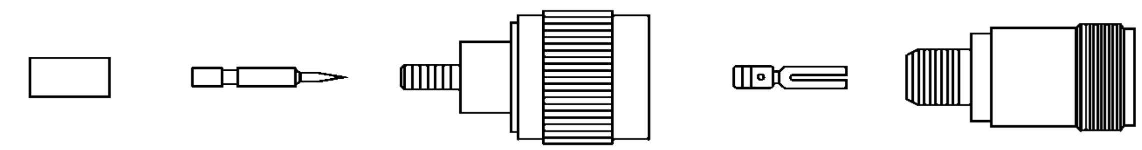


Figure 12–21 Attaching Series C and SC Connectors to Coaxial Cable

Table 12–2 Series C and SC M39012 Connectors and Associated Cables (MIL-C-17)

Cable	Connector	Centre Pin or Socket	Tool Crimp Ferrule		Tool Alternate	
C (Cabled) Plug, Pin, Contact						
RG-212	M39012/06-0027	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-304	M39012/06-0027	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-213	M39012/06-0028	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-214	M39012/06-0029	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-165	M39012/06-0028	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-225	M39012/06-0030	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-11	M39012/06-0031	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A

Table 12–2 Series C and SC M39012 Connectors and Associated Cables (MIL-C-17) (Continued)

Cable	Connector	Centre Pin or Socket	Tool Crimp Ferrule		Tool Alternate	
C (Cabled) Plug, Socket, Contact						
RG-212	M39012/07-0014	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-304	M39012/07-0014	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-213	M39012/07-0011	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-214	M39012/07-0012	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-165	M39012/07-0011	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-225	M39012/07-0013	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-11	M39012/07-0015	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
C (Cabled) Receptacle, Socket, Contact, Flange Mounted						
RG-212	M39012/08-0013	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-304	M39012/08-0013	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-213	M39012/08-0010	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-214	M39012/08-0011	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-165	M39012/08-0010	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-225	M39012/08-0012	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
C (Cabled) Pin, Contact, Right Angle						
RG-213	M39012/10-0006	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-214	M39012/10-0007	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-165	M39012/10-0006	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-225	M39012/10-0008	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
C (Cabled) Socket, Contact, Receptacle, Jam Nut Rear Mounted						
RG-212	M39012/11-0012	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-304	M39012/11-0012	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-213	M39012/11-0013	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-214	M39012/11-0014	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-165	M39012/11-0013	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-225	M39012/11-0015	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-11	M39012/11-0016	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A

Table 12–2 Series C and SC M39012 Connectors and Associated Cables (MIL-C-17) (Continued)

Cable	Connector	Centre Pin or Socket	Tool Crimp Ferrule		Tool Alternate	
SC (Cabled) Plug, Pin, Contact						
RG-212	M39012/35-0010	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-304	M39012/35-0010	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-213	M39012/35-0502	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-214	M39012/35-0501	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-165	M39012/35-0011	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-225	M39012/35-0501	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-11	M39012/35-0013	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-144	M39012/35-0013	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-400	M39012/35-0503	M22520/1-14	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-142	M39012/35-0503	M22520/1-14	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-393	M39012/35-0501	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
SC (Cabled) Plug, Socket, Contact						
RG-212	M39012/36-0009	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-304	M39012/36-0009	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-213	M39012/36-0502	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-214	M39012/36-0501	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-165	M39012/36-0007	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-225	M39012/36-0501	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-11	M39012/36-0010	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-144	M39012/36-0010	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-400	M39012/36-0503	M22520/1-14	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-142	M39012/36-0503	M22520/1-14	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-393	M39012/36-0501	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A

Table 12–2 Series C and SC M39012 Connectors and Associated Cables (MIL-C-17) (Continued)

Cable	Connector	Centre Pin or Socket	Tool Crimp Ferrule		Tool Alternate	
SC (Cabled) Receptacle, Socket, Contact, Flange Mounted Rear						
RG-212	M39012/38-0008	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-304	M39012/38-0008	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-213	M39012/38-0502	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-214	M39012/38-0501	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-165	M39012/38-0006	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-225	M39012/38-0501	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-400	M39012/38-0503	M22520/1-14	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-142	M39012/38-0503	M22520/1-14	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-393	M39012/38-0501	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
SC (Cabled) Plug, Pin, Contact, Right Angle						
RG-213	M39012/39-0502	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-214	M39012/39-0501	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-165	M39012/39-0004	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-225	M39012/39-0501	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-400	M39012/39-0503	M22520/1-13	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-142	M39012/39-0503	M22520/1-13	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-393	M39012/39-0501	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
SC (Cabled) Receptacle, Socket, Contact, Jam Nut Rear Mounted						
RG-212	M39012/40-0014	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-304	M39012/40-0014	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-213	M39012/40-0502	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-214	M39012/40-0501	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-217	M39012/40-0018	Solder	M22520/5-27			
RG-165	M39012/40-0015	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-225	M39012/40-0501	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-11	M39012/40-0021	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-144	M39012/40-0021	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-216	M39012/40-0017	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-400	M39012/40-0503	M22520/1-14	Cavity M22520/5-19	B	Cavity M22520/5-57	A

Table 12–2 Series C and SC M39012 Connectors and Associated Cables (MIL-C-17) (Continued)

Cable	Connector	Centre Pin or Socket	Tool Crimp Ferrule		Tool Alternate	
SC (Cabled) Receptacle, Socket, Contact, Jam Nut Rear Mounted (Continued)						
RG-142	M39012/40-0503	M22520/1-14	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-393	M39012/40-0501	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A

HN SERIES CONNECTORS

HN Connector Types

17. There are two versions of HN connectors with differing methods of attaching coaxial cable to the connector body. See Figure 12–3 for typical examples of HN connectors. Table 12–3 lists the more common connectors in the HN series and shows the coaxial cables associated with each.

> NOTE
>
> The HN series of RF connectors are used for replacement purposes only.

a. **Improved Version.** Consists of a plug or jack body assembled to coaxial cable with nut, gasket, and braid clamp (see Figure 12–23). Plug UC-59E/U and jack UG-60E/U are typical of this version.

b. **Captivated Contact Version** Consists of a plug or jack body assembled to coaxial cable with nut, gland, gasket, clamp, sleeve, and front and rear insulators (see Figure 12–24). Plug UG-l213/U and jack UG-l214/U are typical of this version.

Attaching Improved HN Connectors to Coaxial Cable

18. When attaching improved HN connectors to coaxial cable (see Figure 12–25), use the following procedure:

> NOTE
>
> While attaching connector, observe all general precautions and procedures listed in paragraphs 7 and 8.

a. Disassemble nut, grooved gasket and braid clamp from plug or jack body. (See Figure 12–23.)

b. Remove 17.5mm from outer jacket, exposing shield. Slide nut and gasket, in that order, over shield onto jacket. Make sure that groove in gasket faces away from the nut.

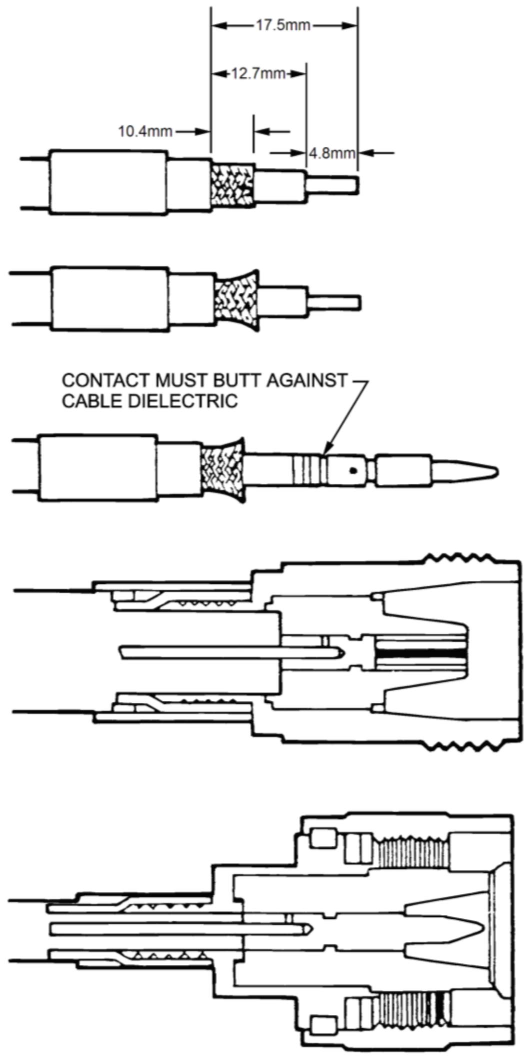


Figure 12–22 Cable Crimping Instructions

> **CAUTION**
>
> Do not nick or damage shield or centre conductor

c. Comb out shield and strip dielectric 6.3mm.

d. Slide clamp over shield until inside shoulder of clamp butts flush against cut end of jacket.

e. Fold shield strands back over clamp without overlaps. Trim strands with scissors, so that all strands end at end of clamp taper.

f. Tin centre conductor as shown in Figure 12–10.

g. Tin inside of contact (male or female) as shown in Figure 12–11.

h. Slip pin or socket over centre conductor so that contact butts flush against dielectric. Solder, using a clean, well tinned, soldering iron. Contact must still be flush against dielectric after solder has cooled; if not, remake the joint. (See Figure 12–12).

CAUTION

Ensure correct pin or socket is used. a male pin always goes into a plug body, and a female socket always goes into a jack body.

i. Push cable assembly into connector body as far as it will go. Slide gasket into connector body; make sure gasket is properly seated with sharp edge of braid clamp entering groove in gasket. Slide nut into connector body and fasten body in vice (see Figure 12–13). Start nut by hand and tighten with spanner until moderately tight.

NOTE

Gasket should be cut in half during tightening.

Attaching HN Connectors with Captivated Contacts to Coaxial Cable

19. When attaching HN connectors with captivated contacts to coaxial cable (see Figure 12–26), use the following procedure:

NOTE

While attaching connector, observe all general precautions and procedures listed in paragraphs 7 and 8.

a. Disassemble nut, gland, gasket, clamp, sleeve, and front and rear insulators front plug or jack body. (See Figure 12–24.)

b. Slide nut and gland onto jacket. Make sure that sharp edge of gland is toward end of cable. Then slide gasket onto jacket, with "V" groove toward gland. Remove 4cm from outer jacket, exposing shield. Slide clamp over the braid until inside shoulder of clamp butts flush against end of jacket.

CAUTION

Take care not to nick or damage shield or centre conductor

c. Comb out shield and cut off dielectric 23mm from end of jacket.

d. Fold shield strands back over clamp without overlaps. Trim strands with scissors so that all strands end at end of clamp taper.

e. Tin centre conductor as shown in Figure 12–10, using minimum amount of heat.

f. Slide sleeve and rear insulator over cable dielectric. Slip contact over centre conductor. Rear insulator must seat against cable dielectric, and contact shoulder must be flush with insulator face. Solder contact to centre conductor. (See Figure 12–12.)

g. For jacks only, install front insulator.

CAUTION

Ensure that correct pin or socket is used. a male pin always goes into a plug body, and a female socket always goes into a jack body.

h. Push cable assembly carefully into connector body as far as it will go. Make sure that sharp edge of gland remains in the gasket groove, Tighten nut with spanner, holding body stationary. (See Figure 12–13.)

NOTE

Gasket should be cut in half during tightening.

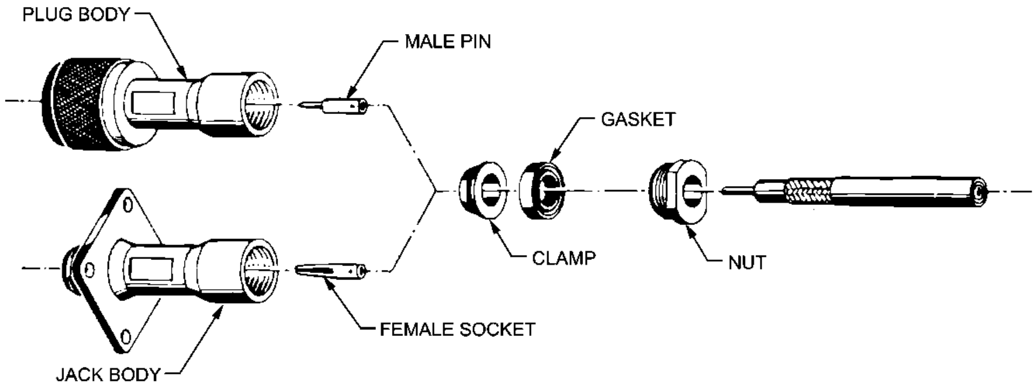


Figure 12–23 Improved HN Connectors - Exploded View

Table 12–3 HN Series Connectors (MIL-C-3643) with Associated Cables

Plug	Jack	Panel Jack	For Use With Cable Types
*UG-59E/U **UG-1213/U	*UG-60E/U **UG-1214/U	*UG-61E/U **UG-1215/U	RG8/U, 9/U, 213/U AND 214/U
*Improved Version	**Captivated Contact Version		

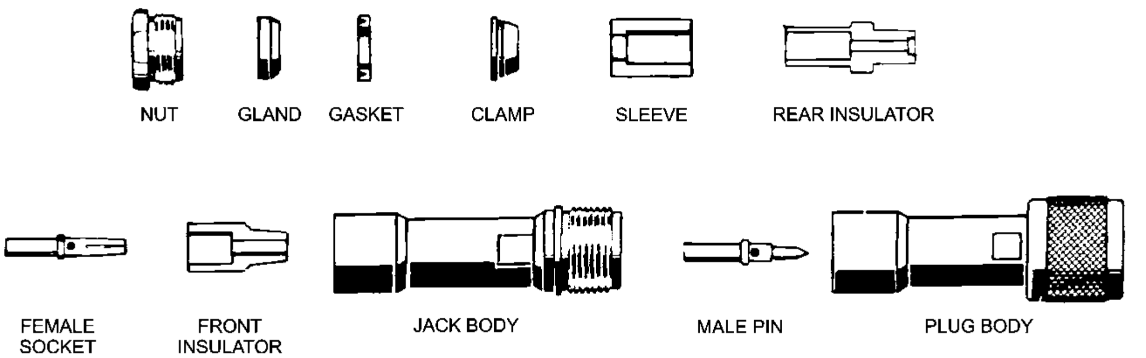


Figure 12–24 HN Connectors with Captivated Contacts - Exploded View

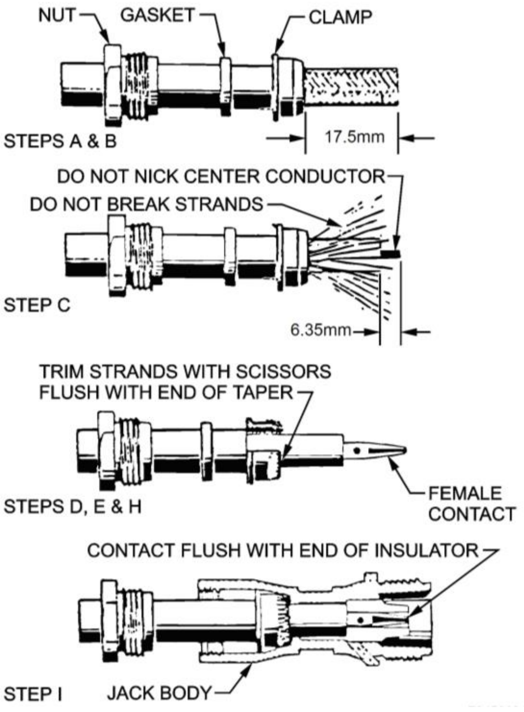


Figure 12–25 Attaching Improved HN Connectors to Coaxial Cable

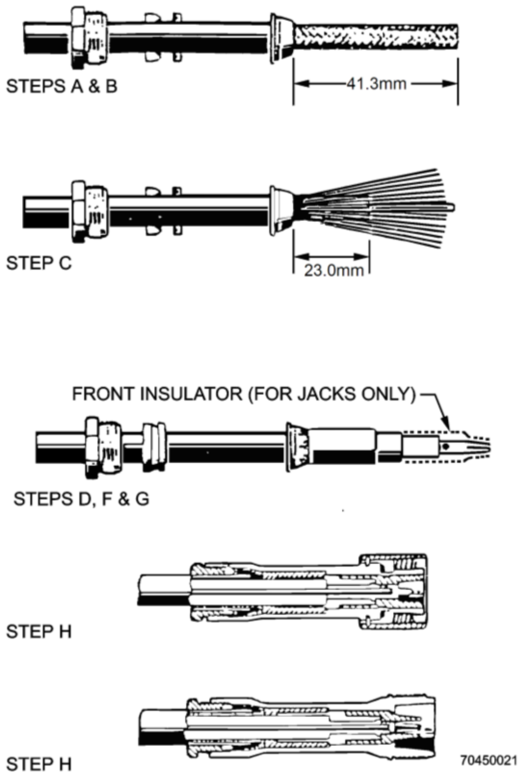


Figure 12–26 Attaching HN Connectors with Captivated Contacts to Coaxial Cable

N SERIES CONNECTORS

N Connector Types

20. There are three versions of N connectors, differing in method of attaching coaxial cable to the connector body. Refer to paragraph 4.

Attaching N Type Crimp Connectors, M39012, to Coaxial Cables

21. N Type Crimp Connectors are attached as follows:

a. Select correct connector for cable Table 12–4.

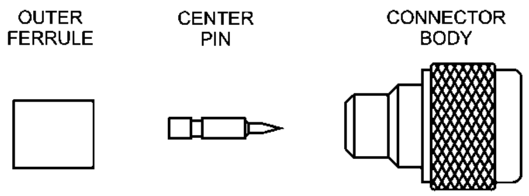


Figure 12–27 N Crimp Connectors

CAUTION

The 50 ohm N type RF connectors are not compatible and should not be mated.

NOTE

Some 70 ohm coaxial cables do not have suitable 70 ohm connectors and therefore equipment manufacturers may have substituted compatible 50 ohm connectors. This practice is accepted, but physical matching of male and female connectors is essential.

b. Strip cable jacket, braid, and dielectric to dimensions shown (see Figure 12–28). All cuts are to be sharp and square. Important: Do not nick braid, dielectric, and centre conductor. Tinning of centre conductor is not necessary if contact is to be crimped. For solder method, tin centre conductor avoiding excessive heat.

c. Slide outer ferrule onto cable as shown. Flare slightly end of cable braid as shown to facilitate insertion onto inner ferrule.

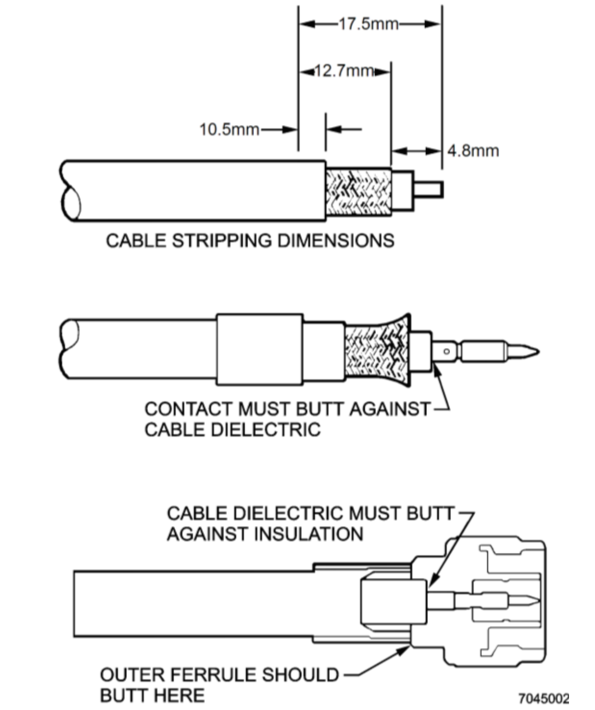


Figure 12–28 Cable Stripping Instructions

NOTE

Do not comb out braid.

d. Place contact on cable centre conductor so it butts against cable dielectric. Centre conductor should be visible through inspection hole in contact. Crimp or solder centre pin or socket in place as follows:

e. **Crimp Method.** Select appropriate tool from Table 12–4. Crimp centre pin or socket (see Figure 12–16).

f. **Solder Method.** Soft solder contact to cable centre conductor. Do not get any solder on outside surface of contact. Avoid excessive heat to prevent swelling of dielectric.

g. Install cable assembly into body assembly so inner ferrule portion slides under braid. Push cable assembly forward until contact snaps into place in insulator.

h. Slide outer ferrule over braid and up against connector body. Crimp outer ferrule using cavity of Die Set specified in Table 12–4. (See Figure 12–16.)

Attaching N Type Connectors with Captivated Contacts to Coaxial Cables

22. When attaching captivated contact N Type connectors to coaxial cable (see Figure 12–29), use the following procedure:

NOTE

While attaching connector, observe all general precautions and procedures listed in paragraphs 7 and 8.

CAUTION

Do not nick shield or centre conductor.

a. Remove 9.1mm of outer jacket, exposing shield.

b. Comb out shield and cut off cable dielectric 3.1mm from end of jacket.

c. Disassemble nut, gasket, clamp, washer, and insulator from plug or jack body.

d. Taper shield toward centre conductor, and wrap with tape. Slide nut and gasket, in that order, over tapered shield onto jacket. Make sure grooved side of gasket faces away from nut. Then slide clamp over tapered shield and push back against cable jacket.

e. Remove tape and fold shield strands back over clamp taper without overlaps. Trim shield with scissors so that strands end at end of clamp taper.

f. Check that exposed dielectric is 1.1mm beyond shield.

g. Tin centre conductor as shown in Figure 12–10, using minimum amount of heat.

h. Slide on washer, rear insulator, and contact, so that the counter-bored end of the rear insulator butts flush against the dielectric, and the pin or socket shoulder butts flush against the rear insulator, Solder the contact to centre conductor. (See Figure 12–12.)

Table 12–4 Series N M39012 Connectors and Associated Cables (MIL-C-17)

Cable	Connector	Centre Pin or Socket	Tool Crimp Ferrule		Tool Alternate	
N (Cabled) Plug, Pin, Contact						
RG-212	M39012/01-0016	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-222	M39012/01-0016	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-213	M39012/01-0502	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-214	M39012/01-0501	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-217	M39012/01-0019	Solder	M22520/5-27			
RG-165	M39012/01-0021	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-225	M39012/01-0501	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-11	M39012/01-0023	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-144	M39012/01-0023	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-216	M39012/01-0024	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-6	M39012/01-0027	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-400	M39012/01-0503	M22520/1-13	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-142	M39012/01-0503	M22520/1-13	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-393	M39012/01-0501	M22520/1-13	Cavity M22520/5-61	B	Cavity M22520/5-25	A
N (Cabled) Plug, Socket, Contact						
RG-212	M39012/02-0019	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-222	M39012/02-0019	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-213	M39012/02-0502	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-214	M39012/02-0501	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-217	M39012/01-0022	Solder	M22520/5-27			
RG-165	M39012/02-0024	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-225	M39012/02-0501	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-11	M39012/02-0026	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-144	M39012/02-0026	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-216	M39012/02-0039	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-6	M39012/02-0040	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-400	M39012/02-0503	M22520/1-13	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-142	M39012/02-0503	M22520/1-13	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-393	M39012/02-0501	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A

Table 12–4 Series N M39012 Connectors and Associated Cables (MIL-C-17) (Continued)

Cable	Connector	Centre Pin or Socket	Tool Crimp Ferrule		Tool Alternate	
N (Cabled) Receptacle, Socket, Contact, Flange Mounted						
RG-212	M39012/02-0027	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-222	M39012/02-0027	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-213	M39012/02-0512	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-214	M39012/02-0511	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-165	M39012/02-0041	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-225	M39012/02-0511	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-11	M39012/02-0042	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-144	M39012/02-0042	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-216	M39012/02-0030	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-6	M39012/02-0043	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-400	M39012/02-0513	M22520/1-13	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-142	M39012/02-0513	M22520/1-13	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-393	M39012/02-0511	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
N (Cabled) Receptacle, Socket, Contact Jam Nut, Mounted						
RG-212	M39012/03-0013	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-222	M39012/03-0013	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-213	M39012/03-0502	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-214	M39012/03-0501	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-217	M39012/03-0016	Solder	M22520/5-27			
RG-165	M39012/03-0018	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-225	M39012/03-0501	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-11	M39012/03-0020	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-144	M39012/03-0020	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-216	M39012/03-0021	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-6	M39012/03-0023	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-400	M39012/03-0503	M22520/1-14	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-142	M39012/03-0503	M22520/1-14	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-393	M39012/03-0501	M22520/1-14	Cavity M22520/5-61	A	Cavity M22520/5-25	A

Table 12–4 Series N M39012 Connectors and Associated Cables (MIL-C-17) (Continued)

Cable	Connector	Centre Pin or Socket	Tool Crimp Ferrule		Tool Alternate	
N (Cabled) Plug, Right Angle						
RG-212	M39012/05-0016	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-222	M39012/05-0016	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-213	M39012/05-0502	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-214	M39012/05-0501	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-165	M39012/05-0015	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-225	M39012/05-0501	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-11	M39012/05-0014	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-144	M39012/05-0014	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-216	M39012/05-0017	Solder	Cavity M22520/5-61	A	Cavity M22520/5-25	A
RG-6	M39012/05-0013	Solder	Cavity M22520/5-35	A	Cavity M22520/5-29	A
RG-400	M39012/05-0503	M22520/1-13	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-142	M39012/05-0503	M22520/1-13	Cavity M22520/5-19	B	Cavity M22520/5-57	A
RG-393	M39012/05-0501	M22520/1-13	Cavity M22520/5-61	A	Cavity M22520/5-25	A

CAUTION

Ensure that the correct pin or socket is used. a pin always goes into a plug body, and a socket always goes into a jack body.

i. Slide front insulator over pin or socket; make sure the counter-bored end of the insulator is toward the mating end of the contact.

j. Push the cable assembly into the connector body. Make sure that the sharp edge of the clamp seats properly in the gasket. Tighten the nut, holding the body stationary. (See Figure 12–13.)

WARNING

Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft.

WARNING

Use of nitrogen with hot air gun in an enclosed area can be hazardous. Ensure area is well ventilated.

k. Cut two lengths of heat shrink, one 7cm and one 8cm. Slide the 7cm piece of heat shrink over the connector covering only the back 15.8mm of it. Heat the heat shrink until it is secure on the cable and connector. Repeat the same procedure with the 8cm piece of heat shrink.

PULSE SERIES CONNECTORS

Pulse Connector Types

23. There are two versions of pulse connectors. These versions differ in the material of the inserts, and in the method of attaching the coaxial cable to the connector body. See Figure 12–6 for typical examples of pulse connectors. Table 12–5 lists the more common connectors in the pulse series and shows the coaxial cables associated with each.

a. **Ceramic Insert Version.** Consists of a plug or jack body assembled to coaxial cable with nut, cable clamp, washer, and corona shield. (See Figure 12–30). Plug UG-174/U is typical of this version.

Rubber Insert Version consists of a plug or jack body assembled to coaxial cable with clamp, washer, gasket, sleeve, and ferrule. (See Figure 12–31). Plug UG-l80A/U and jack UG-182A/U are typical of this version.

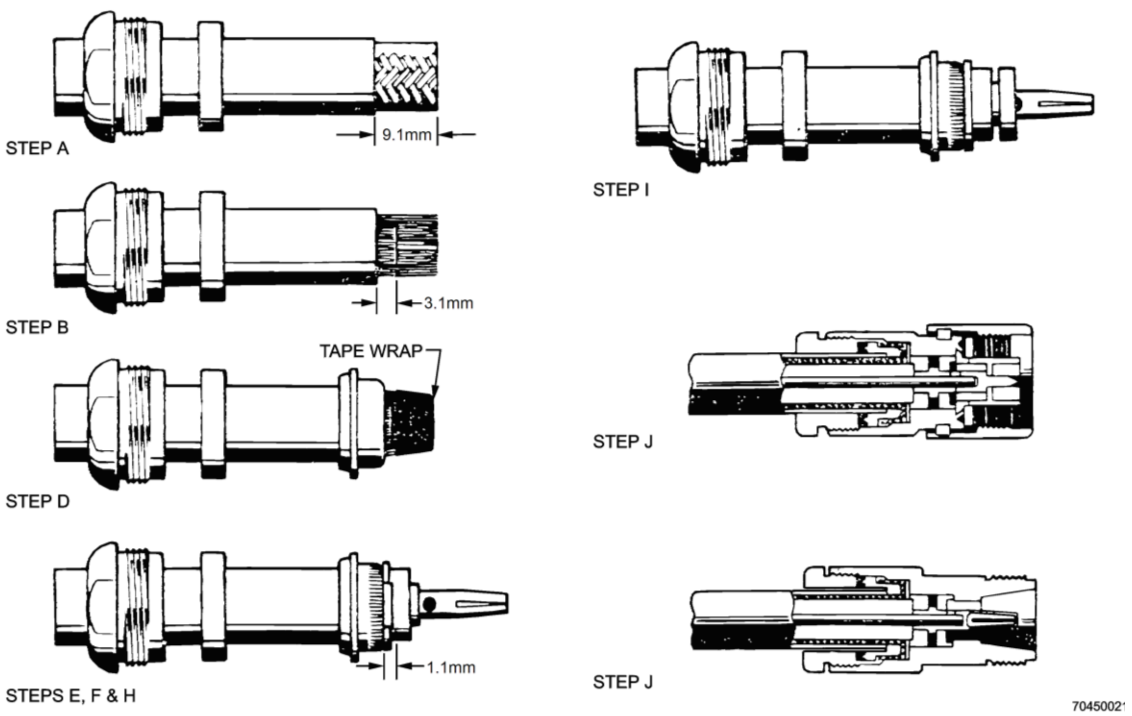


Figure 12–29 Attaching N Connectors with Captivated Contacts to Coaxial cable

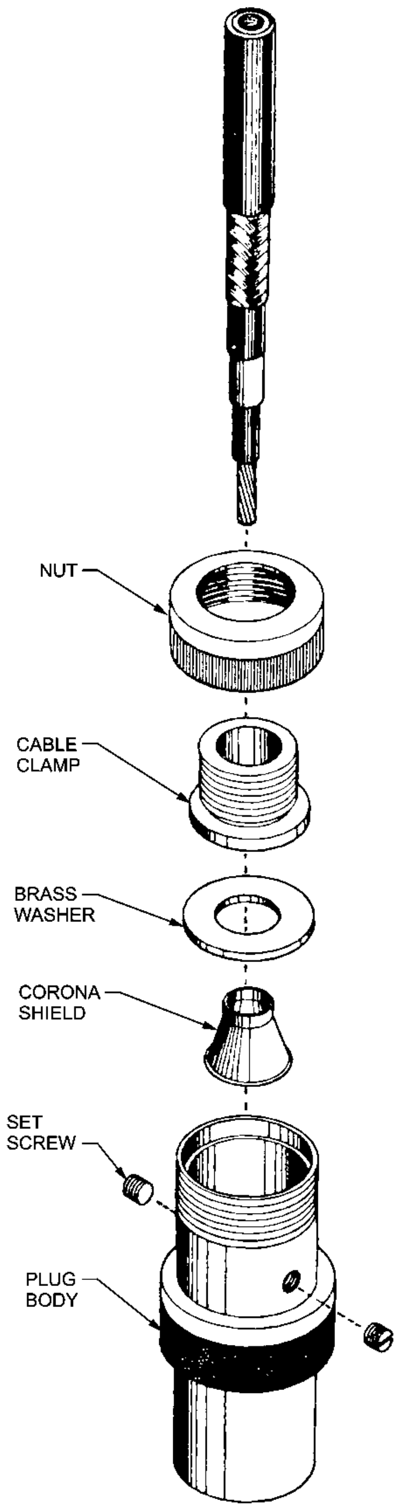


Figure 12–30 Pulse Connector - Ceramic Insert

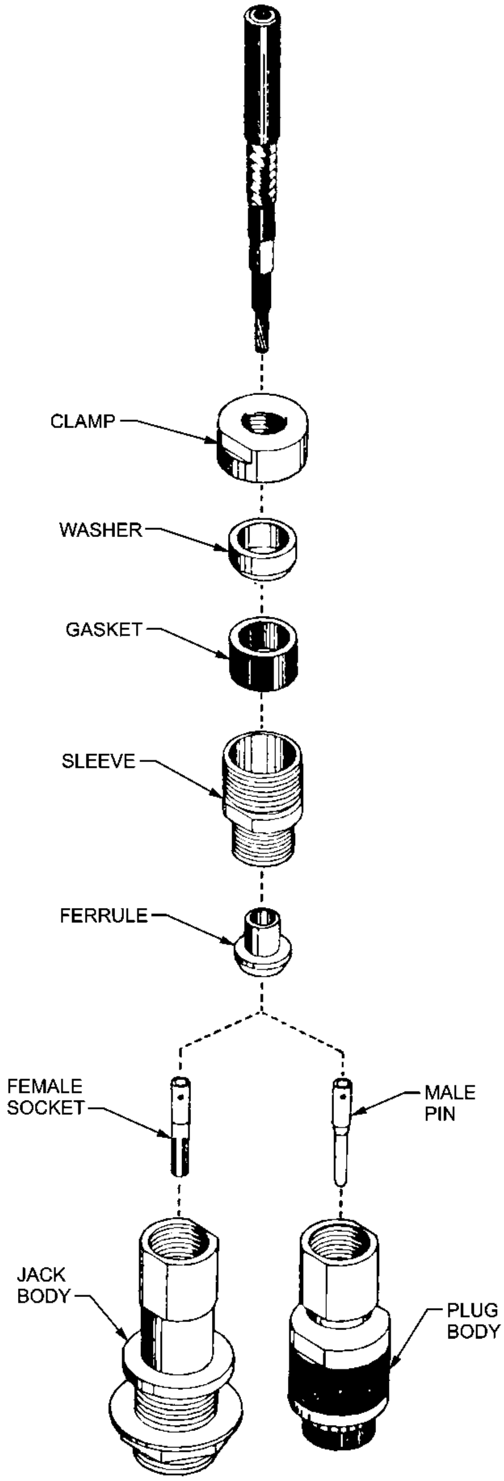


Figure 12–31 Pulse Connector - Rubber Insert

Table 12–5 Pulse Series Connectors (MIL-C-3643) with Associated Cables

Plug	Jack	Panel Jack	For Use With Cable Types
Ceramic Insert:			
UG-34/U UG-174/U			RG-25/U RG-28/U
Rubber Insert:			
UG-180A/U	UG-182A/U UG-1086/U	UG-181A/U	RG-25/U, 64/U, 77/U, 78/U & 88/U

Attaching Ceramic Insert Pulse Connectors to Coaxial Cable

NOTE

The following procedure is for assembling UG-l74/U plug to RG-28/U cable, and UG-34/U plug to RG-25/U cable. Both assemblies differ in dimensions. Both cables have a double shield.

24. When attaching ceramic insert pulse connectors to coaxial cable (see Figure 12–32), use the following procedure:

NOTE

Observe all general precautions and procedures listed in paragraphs 7 and 8.

a. Disassemble nut, cable clamp, washer, and corona shield from plug or jack body. (See Figure 12–30.)

b. Slide nut and cable clamp, in that order, onto cable jacket. Remove 9.2cm of outer jacket of RG-28/U cable and 7cm of RG-2S/U cable, exposing first shield.

CAUTION

Do not nick shield.

c. Remove first shield to 0.76mm from cut edge of outer jacket exposing insulating tape.

d. Comb out shield and bend at right angles, as shown. Remove insulating tape even with cut edge of outer jacket, exposing second shield. Slide cable clamp forward against fanned-out first shield. Trim shield strands 1.5mm below diameter of cable clamp flange.

e. Slide brass washer carefully over second shield against fanned-out shield. Remove second shield to 4.7mm from brass washer for RG-281U cable, and 31mm for RG-25/U cable, exposing conducting rubber.

f. Remove layer of conducting rubber to 9.5mm from face of brass washer for RG-28/U cable and 4.7mm for RG-25/U cable by making small slit at end of cable core and removing conducting rubber with dull knife. Scrape insulating rubber underneath to remove any traces of conducting rubber.

CAUTION

Do not damage insulating rubber.

g. Slide corona shield over conducting rubber and under second shield until straight part of corona shield enters hole in brass washer approximately 1.5mm.

h. Solder second shield to brass washer and to corona shield. Remove excess flux. Remove insulating rubber and conducting rubber underneath it to 6.7cm from face of brass washer for RG-28/U cable and 27mm for RG-25/U cable, exposing centre conductor. Taper rubber down to conductor 9.5mm for RG-28/U or 6.3mm for RG-25/U. Tin centre conductor. Remove excess flux.

i. Scrape nickel plating from recess of plug into which brass washer fits. Remove set screws.

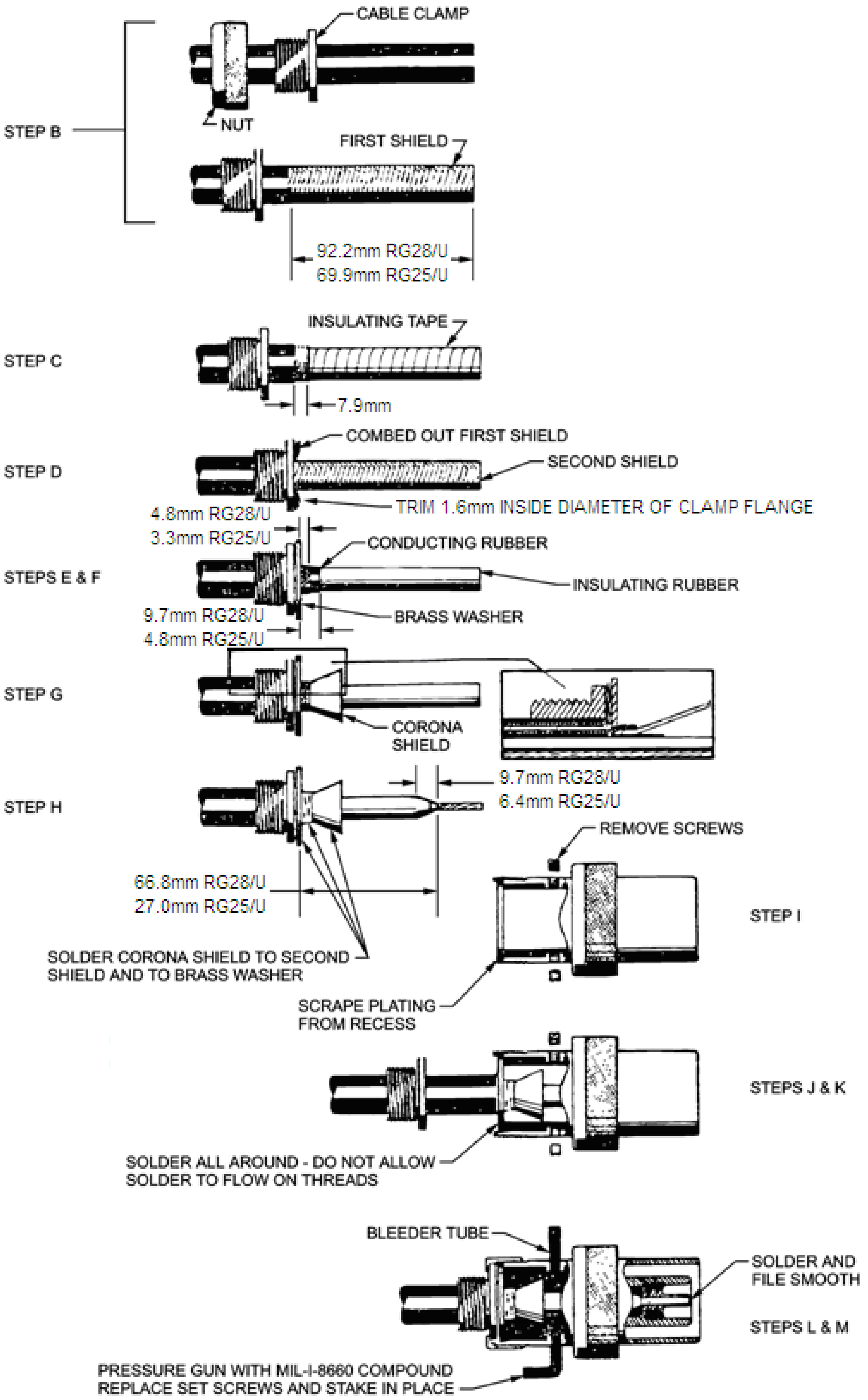


Figure 12–32 Assembly of Ceramic Insert Pulse Connector

j. Slide cable assembly into plug body, allowing cable clamp to slide back on cable. Solder brass washer to recess in plug by flowing solder into space between washer and groove. Remove excess flux.

k. Slide cable clamp against washer, and nut onto plug body. Start nut by hand and tighten with spanner. Hold plug with strap wrench to prevent it from turning.

l. Cut off excess conductor protruding beyond contact pin. Solder conductor to contact by flowing solder down into hole. Leave a drop of solder on end of contact and file smooth. Remove excess flux.

m. Insert bleeder tube in top hole so it is vertical. Insert pressure gun in lower hole and fill plug cavity with SAE AS 8660 compound until material oozes from bleeder tube. Replace set screws and stake with prick punch.

Attaching Rubber Insert Pulse Connectors to Coaxial Cable

25. When attaching rubber insert pulse connectors to coaxial cable (see Figure 12–33), use the following procedure:

> NOTE
>
> While attaching connector, observe all general precautions and procedures listed in paragraphs 7 and 8.

a. Disassemble nut, washer, gasket, sleeve, and ferrule from plug or jack body. (See Figure 12–31.)

> **CAUTION**
>
> Do not nick shield or cut cable core.

b. Slide nut, washer, gasket, and sleeve, in that order onto cable jacket. Remove 6.7cm of outer jacket exposing shield.

c. Cut shield to 9.5mm from cut edge of outer jacket, exposing cable core.

d. Push ferrule over cable core and under shield.

e. Solder shield carefully to ferrule all around its circumference. Ensure solder flows through to all shields. If it is necessary to solder shields separately, fold back outer shield. Solder inner shield, then bring forward outer shield and solder separately on top of inner shield. After solder has cooled, grasp cable in left hand, ferrule in right hand, and give several quick pulls to remove' any slack in shield. Remove excess flux. Remove cable core with sharp square cut leaving 28.5mm from ferrule for connection to UG-180A/U and 25mm from ferrule for connection to UG-181A or 182A/U. Trim centre conductor to 4.7mm and tin.

> NOTE
>
> Cable RG-25A/U, 64A/U, 78/U, and 88A/U have a thin layer of red insulating rubber over the cable core. Do not remove this layer. Cables RG-25/U and RG-64/U have a thin layer of black conducting rubber over the cable core. Remove this layer to 1.5mm from ferrule very carefully with a sharp knife.

f. Tin inside of pin or socket as shown in Figure 12–11. Slip contact over centre conductor so that contact butts flush against cable cow. Solder, using a clean well tinned soldering iron. Pin or socket must still be flush against cable core after solder has cooled; if it is not, remake this joint. (See Figure 12–12.) Remove excess flux.

> **CAUTION**
>
> Ensure correct pin or socket is used. a pin always goes into a plug body, and a socket always goes into a jack body.

g. Push cable core into plug or jack body as far as it will go. Insert sleeve and tighten as far as it will go against ferrule, holding body with spanner so it will not turn. (See Figure 12–13.)

h. Insert gasket, then washer into sleeve. Install nut on sleeve and tighten until gasket deforms around cable to hold it securely.

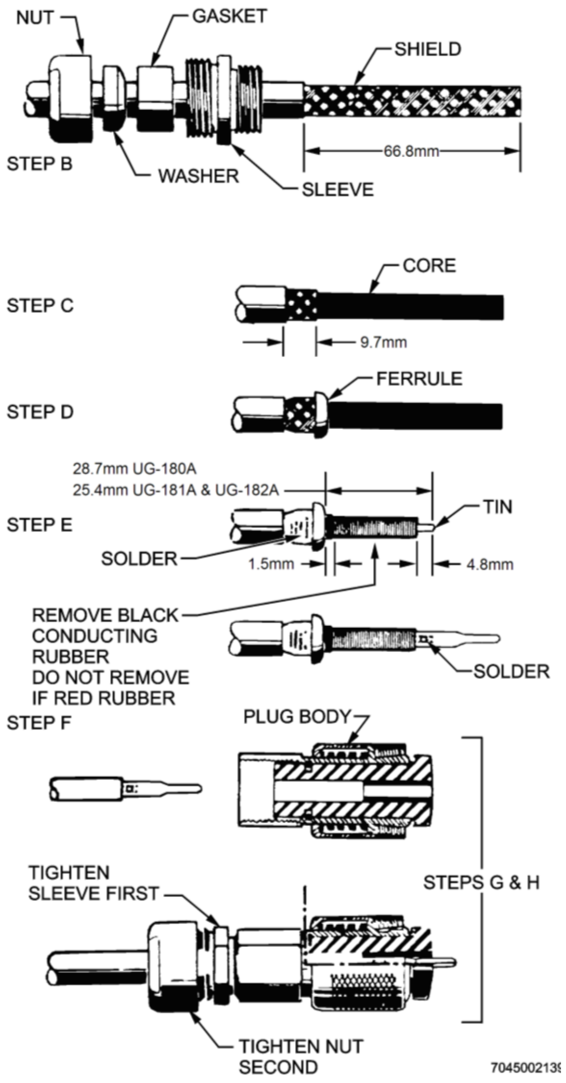


Figure 12–33 Assembly of Rubber Insert Pulse Connector

MINIATURE RF CONNECTORS

MB Miniature Connector Series

26. These are small, lightweight, bayonet type, quick connect/disconnect connectors, used with small RF cables where peak voltage is not more than 500 volts. These connectors do not carry a military number. No soldering is required in the assembly of plugs to solid centre conductors, such as RG58/U, 59/U, 62/U, 71/U, and 141/U. All jacks require soldering. Table 12–6 lists the more common connectors in the MB series and shows the coaxial cables associated with each. These connectors consist of a plug or jack body assembled to coaxial cable with clamp nut, braid clamp, and insulator bushing. (See Figure 12–34.)

Attaching MB Connectors to Coaxial Cable

27. The assembly procedure differs according to the cable used. For assembly to cables RG-58/U and RG-141/U, the procedure is as follows (see Figure 12–35):

a. Remove cable jacket to A dimension given in Table 12–7. Insert clamp nut over cable jacket and braid clamp over braid wire.

b. Comb out braid wire, fold back over braid clamp, and trim to length. Cut off cable dielectric to dimension C in Table 12–7, and tin exposed conductor. If solderless contact is used, omit tinning.

c. Insert contact over conductor. The end of the solderless contact with the shortest slot is inserted over the conductor. If a solder contact is used, solder it to the conductor, and remove excess solder from the outside of the contact.

d. Insert assembly minus clamp nut into body and rotate slightly to make sure braid clamp is seated. When assembling straight plugs, insert insulator over contact before assembly into body. Thread clamp nut into body and tighten nut, holding body stationary.

28. For assembly into cables RG-59/U and 62/U, the procedure is as follows:

a. Remove cable jacket to dimension A in Table 12–7. Insert clamp nut over cable so that internal shoulder seats against end of cable jacket. Insert braid clamp over wire.

b. Comb out braid wires, fold back over braid clamp, and trim to length. Cut off cable dielectric to dimension C in Table 12–7, and tin exposed conductor. If solderless contact is used, omit tinning.

c. Insert contact over conductor. The end of the solderless contact with the shortest slot is inserted over the conductor. Insert insulator bushing over contact if cable RG-62/U is being used. If solder contact is used, solder it to the conductor, and remove excess solder from the outside of the contact.

d. Insert insulator over contact. Insert assembly minus clamp nut into body and rotate slightly to make sure braid clamp is seated. Thread clamp nut into body and tighten nut, holding body stationary.

e. Right angle jacks or plugs: Strip cable jacket and dielectric, install parts, and form braid as instructed in steps a and b above.

f. Tin conductor, and insert assembly into body.

g. With cap removed, solder the conductor in slot of angle plug contact.

h. Insert cap, and spot solder or spot stake.

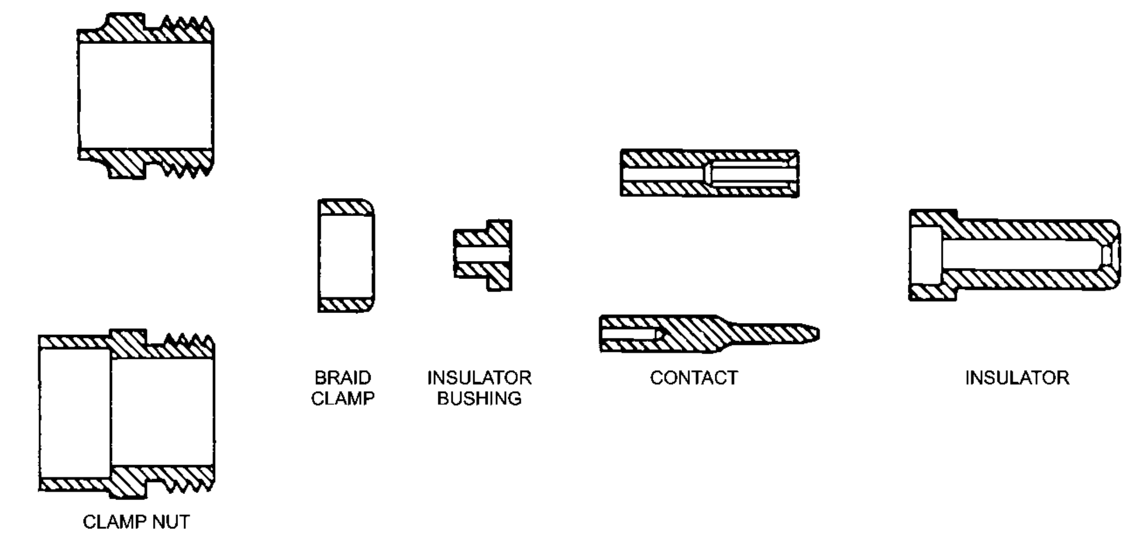


Figure 12–34 MB Connectors - Exploded View

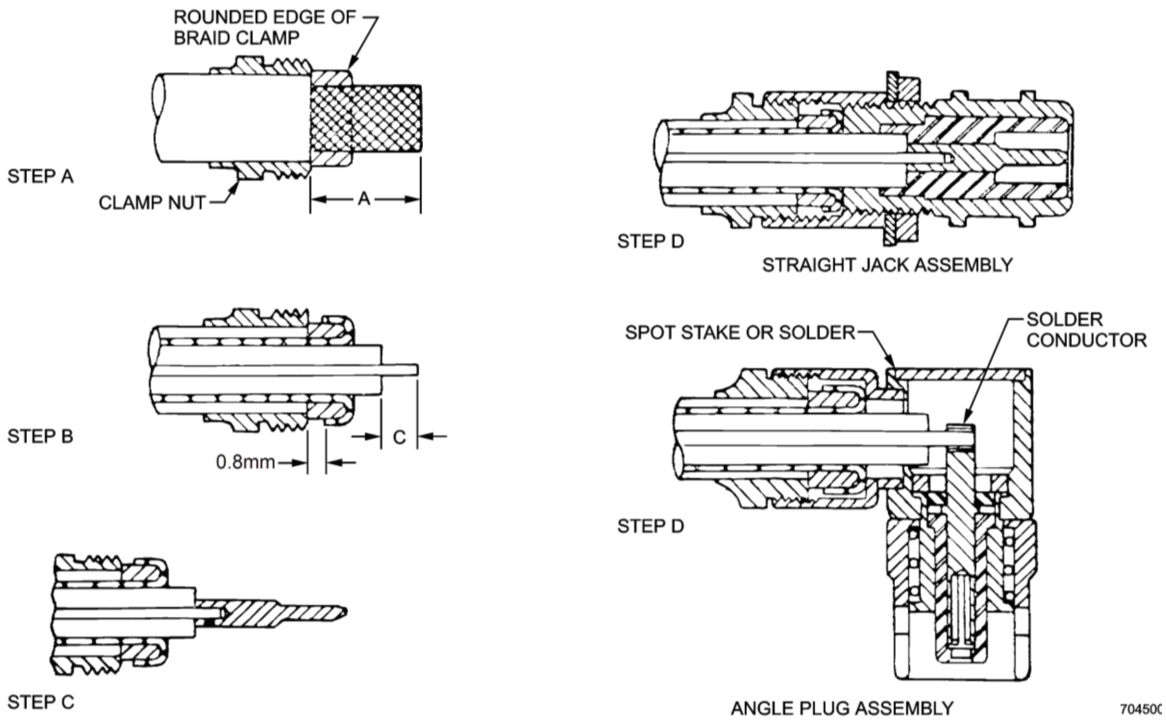


Figure 12–35 Attaching MB Connectors to Coaxial Cable

Table 12–6 MB Series Connectors with Associated Cables

Plug		Jack		Panel Jack		
IPC	King	IPC	King	IPC	King	Cable RG-
79875 79525	KA51-03 KA51-02	79600 79500	KA31-02 KA31-03	79425 79925	KA11-04 KA11-03	55/U, 58/U 59/U

Table 12–7 Stripping Dimensions for Coaxial Cable Assembled to MB Connectors

	Connector Part (IPC)	RG- /U Cable	Stripping Dimensions	
			A (mm)	C (mm)
Plugs	45000 45025 45050 45550	58, 141 59, 62 58, 141 59, 62	161.1 282.0 161.1 282.0	51.0 51.0 51.0 51.0
Jacks	46300 46325 46700 46775	58, 141 59, 62 58, 141 59, 62	161.1 322.6 161.1 322.6	61.0 61.0 61.0 61.0
Angle Plugs	53000 53500	58, 141 59, 62	241.3 241.3	71.0 71.0

SUBMINIATURE RF CONNECTORS

Subminiature RF Connectors (Amphenol #27 Series)

29. These connectors are very small, lightweight connectors designed for use with RG-l74/U miniaturized coaxial cable, where peak voltage does not exceed 500 volts. Coupling is either of the screw thread type or the push-on type. The connectors consist of a plug or jack body assembled to coaxial cable with a sleeve and an insulator. (See Figure 12–36.) The assembly is crimped into the body, and a vinyl boot shrunk on for cable strain relief. Table 12–8 lists types of Amphenol #27 series connectors commonly used in aircraft.

Attaching Subminiature RF Connectors to Coaxial Cable

30. When attaching subminiature RF connectors to coaxial cable, follow this procedure (see Figure 12–37):

a. Dilate the boot and slip it over the cable. The boot will remain dilated for approximately five minutes.

CAUTION

Do not nick braid.

b. Trim jacket to dimension A in Table 12–8.

c. Slip sleeve over braid against cable jacket. Fold braid back over the sleeve and comb out so it lays even without overlapping.

CAUTION

Avoid overheating during soldering, excessive heat may deform dielectric.

d. Trim dielectric to dimension B in Table 12–8. Tin exposed centre conductor, and clean off excess solder.

e. **Straight plugs and jacks.** Slip contact over centre conductor so that it butts flush against cut end of dielectric. Solder contact to conductor, and remove excess solder from outside of contact.

f. Slip cable assembly into body and trim off excess braid protruding beyond body end. Crimp the assembly securely (see paragraph 31 for detailed crimping instructions), and pull boot over body as shown.

g. **Angle plugs.** Unscrew front part of body. Follow procedure of steps a through d above. Then thread cable through back part of body as shown and crimp. Thread female insulator over conductor and insert into body. Holding the female insulator in place in the body, pull the cable as far forward as possible to remove all slack. Trim conductor to 2.1mm minimum.

h. Slip contact over conductor and butt contact flush against the female insulator. Solder contact to conductor, and remove excess solder.

i. Place male insulator over the contact, and screw the front body part into back body arid tighten with end spanner.

Crimping Procedure for Subminiature Connectors

31. Crimp subminiature connector bodies as follows:

a. Open jaws of tool 227-900 by loosening nut and pulling down lock screws (see Figure 12–38). Place the connector assembly in jaws, and set optimum distance between jaws for each assembly by means of the travel limit screw. Refer to connector placement Figure 12–38, A, B and C for straight plugs and jacks, and Figure 12–38, D for angle plugs.

b. Lock jaws by pulling lock screws up, and tighten nut.

c. Squeeze handles to crimp.

d. Release handles to open jaws, and remove crimped assembly. Trim off any excess braid protruding beyond end of body.

e. Slip boot over body end.

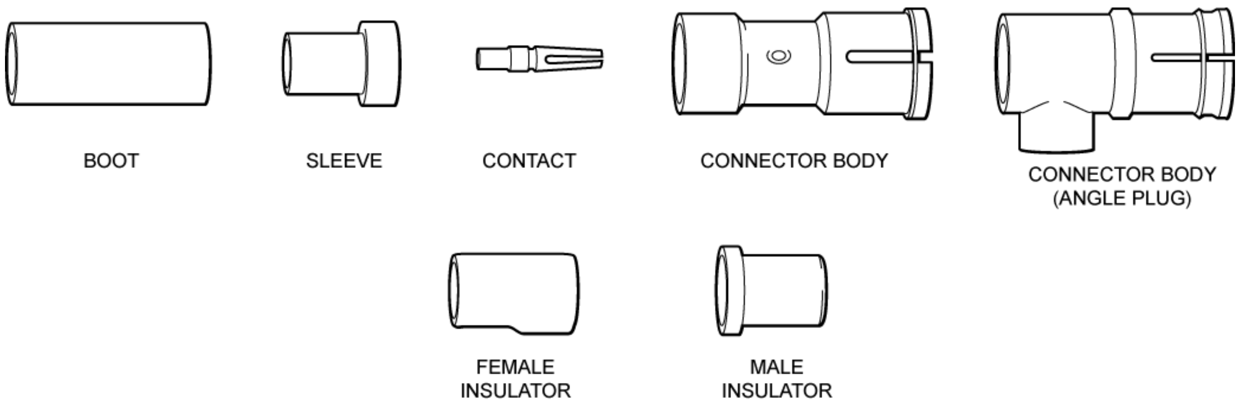


Figure 12–36 Subminiature RF Connector - Exploded View

Table 12–8 Stripping Dimensions and Crimping Tool Positions for Subminiature RF Connectors

Body Type	A (mm +0 –0.4)	B (mm Max)	Position in Tool 27-900 Figure No.
Straight Plug	231.1	40.6	11-38 A
Jack, Push-on	241.3	40.6	11-38 B
Jack, Screw-on	241.3	53.3	11-38 C
Bulkhead Jack	241.3	53.3	11-38 C
Angle Plug	503.0	53.3	11-38 D

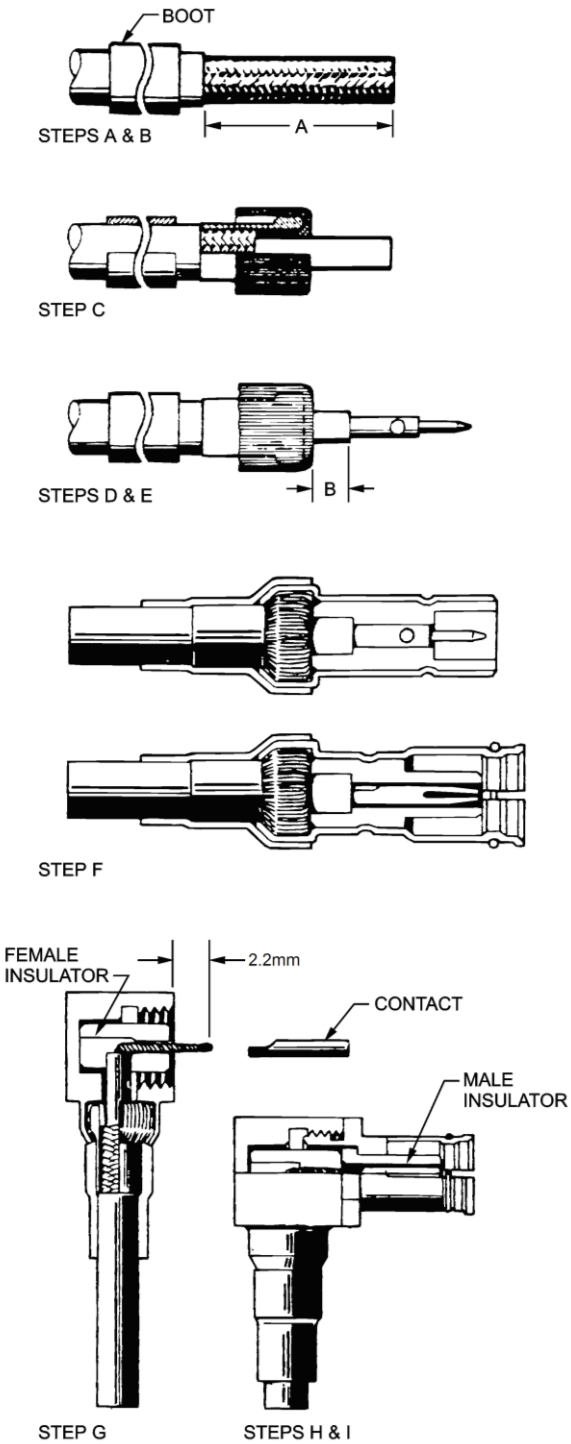


Figure 12–37 Attaching Subminiature RF Connectors to Coaxial Cable

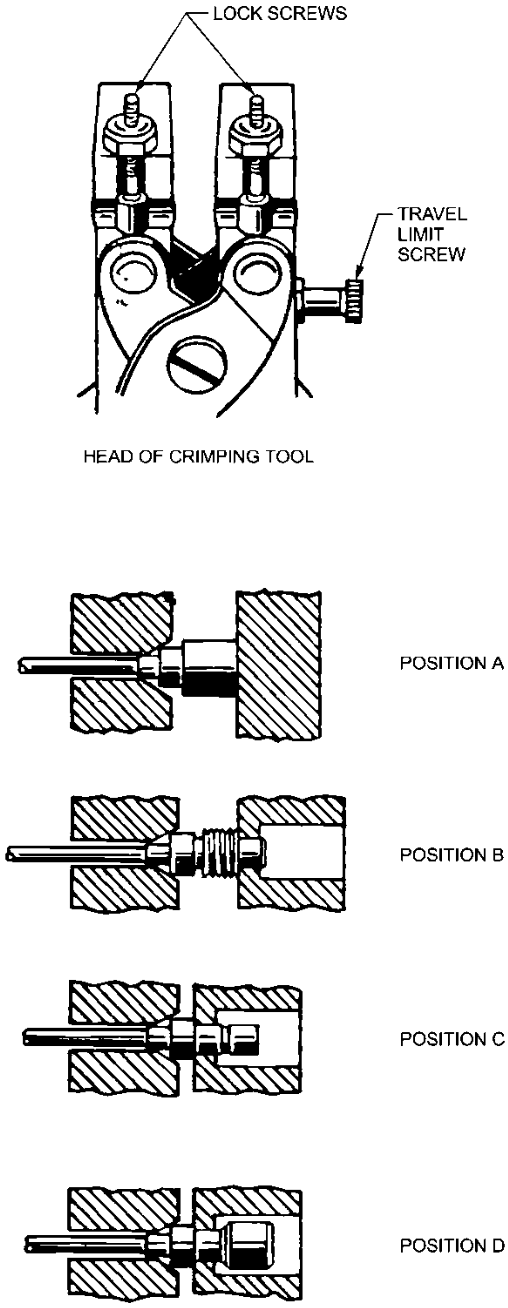


Figure 12–38 Crimping Subminiature RF Connectors

RF CONNECTORS USED IN FUEL-QUANTITY INDICATING SYSTEMS

32. Because of their transmission line efficiency, RF connectors are often used in aircraft fuel-quantity-indicating systems. The connectors most commonly used for this purpose are of two types. One is similar to the standard BNC connector; typical of this type are the 163 series made by Avien, and the Liquidometer 9100 series. The second type is the miniature RF connector; the Nu-Line 1200 series (MIL-DTL-25516) and Liquidometer S62 and S63 are typical. These connectors are designed to be used with coaxial cable, but they are also frequently used with standard shielded or unshielded wire. They do not carry a military number.

Assembling BNC Type Fuel-Quantity-Indicating Connectors

33. For assembly of Avien 163-088 and 163-089 connectors to RG-58A/U coaxial cables, (see Figure 12–39), use the following procedures:

- **a.** Slide nut, washer, and gasket onto cable. Strip outer jacket 11mm, taking care not to nick the braid. Slide the clamp over the braid so it rests flush against the cut end of the jacket.
- **b.** Comb out braid and fold it back over the clamp, and trim the braid even with edge of clamp.
- **c.** Strip dielectric 2.4mm from edge of clamp.
- **d.** Cut exposed conductor to 2.8mm.
- **e.** Slide contact onto conductor, and check that there is no exposed conductor between the insulation and the contact solder hole. Check that the distance from the braid to the end of the contact is 12.7mm, as shown in Figure 12–39.
- **f.** Tin conductor and solder hole, and solder contact to conductor. Remove any excess solder.
- **g.** Push assembly into connector body, screw nut into body, and tighten.

34. For assembly of Avien 163-07 and 163-027 connectors to AN No. 20 unshielded wire, (see Figure 12–40), use the following procedure:

- **a.** Strip wire to expose 6.3mm of conductor, and tin the stripped wire. Tin inside of contact.
- **b.** Slide nut, washer, and gasket over the wire. Install TFE clamp over the wire so that the inside shoulder of the clamp butts against the cut insulation.

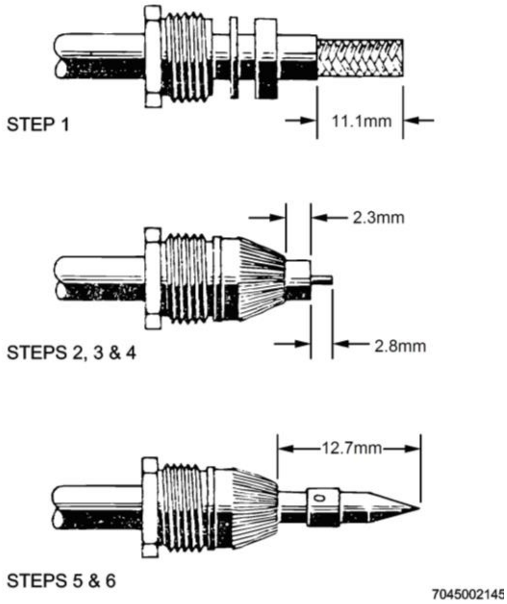


Figure 12–39 Attaching Avien 163-088 and 163-089 Connectors to Coaxial Cable

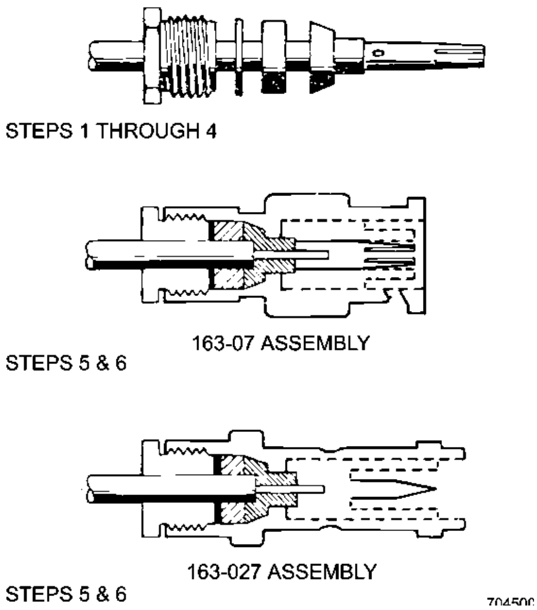


Figure 12–40 Attaching Avien 163-088 and 163-089 Connectors to Unshielded Wire

c. Slide contact over the wire so that it butts against end of the clamp. While doing this, hold the insulation firmly in place against the clamp shoulder.

d. Solder the contact to the conductor, and remove any excess solder.

e. Insert the assembly into the connector body. The contact end should be flush with the end of the TFE clamp, but a recess of 0.8mm maximum is acceptable.

f. Tighten nut while holding the body stationary.

35. For assembly of Liquidometer 9100 series connectors to RG-58/U coaxial cable, (see Figure 12–41), use the following procedure:

a. Slide nut, washer, and gasket over the cable; strip outer jacket 9.5mm, taking care not to nick the braid. Slide the large eyelet over the braid so that it butts against the cut end of the jacket.

b. Comb out the braid up to the large eyelet, and slide the smaller eyelet over the dielectric.

c. Clamp the braid between the two eyelets with special slotted pliers, as shown in Figure 12–43. Trim off excess braid.

d. Cut dielectric 3.0mm from the small eyelet, and cut off the exposed conductor to 3.0mm.

e. Tin the exposed conductor and the inside hole of the contact.

f. Slide the contact onto the conductor and solder. Remove any excess solder.

g. Seat contact and eyelets into connector body and install the gasket firmly against the eyelets. Insert washer firmly against the gasket.

h. Screw nut into connector body and tighten, holding connector body stationary. Tighten to 40 – 47 Newton metres (Nm) torque.

Assembling Miniature RF Fuel-Quantity-Indicating Connectors

36. For assembly of Nu-Line 1200 Series coaxial connectors to coaxial cable, (see Figure 12–42), use the following procedure:

a. Remove 12.7mm of outer jacket, exposing shield.

b. Slide nut, washer, and gasket, in that order, onto outer jacket.

c. Screw threaded braid clamp over jacket as shown.

d. Comb out braid, and fold braid back over braid clamp, without overlap.

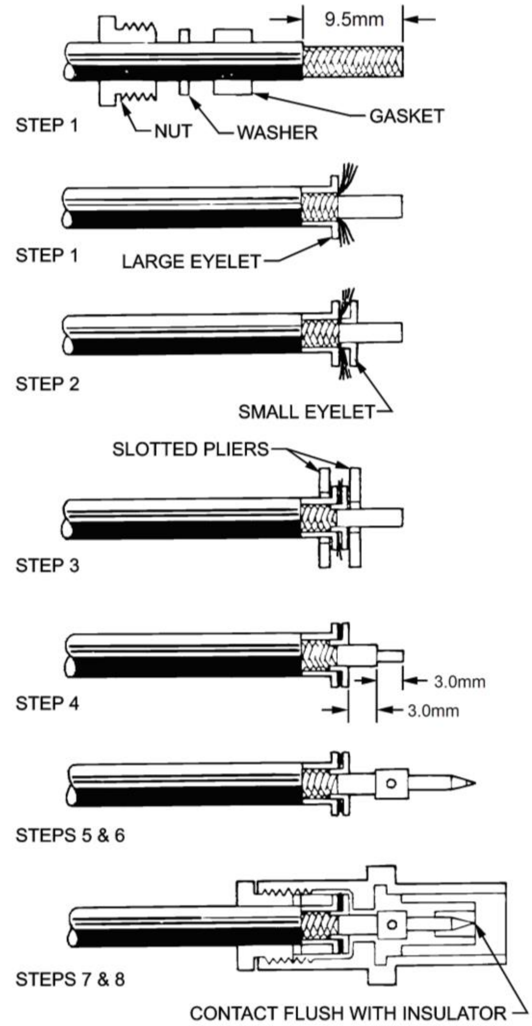


Figure 12–41 Attaching Liquidometer 9100 Series Connectors to Coaxial Cable

e. Slide braid clamp sleeve (large ID toward gasket) over braid, and trim off excess braid with scissors. Install O-ring as shown.

f. Place contact retainer firmly over dielectric, and strip off dielectric flush with contact retainer, exposing centre conductor.

g. Cut off centre conductor 2.0mm from cut end of dielectric.

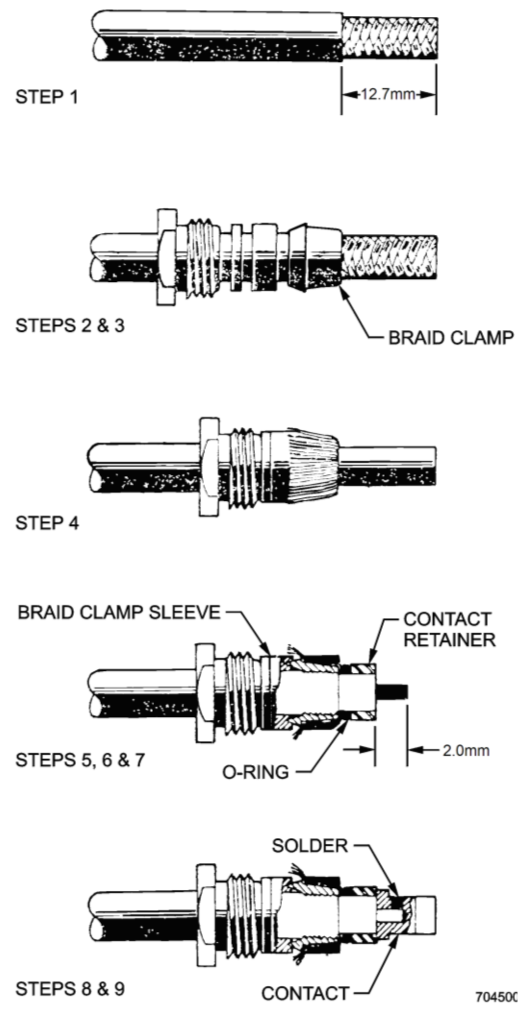


Figure 12–42 Attaching Nu-Line 1200 Series Connectors to Coaxial Cable

h. Slide contact, male or female, over centre conductor so that contact butts flush against dielectric.

i. Solder contact to centre conductor; contact must still be flush against dielectric after soldering.

j. Slide cable assembly into connector body as far as it will go. Apply (MIL-S-22473, Grade C, sealing compound completely around the hex nut threads. Torque nut to approximately ten inch pounds.

NOTE

When connector is properly torqued, the gap between nut and body assembly should not exceed 1.0mm.

37. For assembly of Liquidometer S62 and S63 series connectors to RG-58/U coaxial cable (see Figure 12–43), use the following procedure:

a. Slide nut and bushing back over cable. Cut outer jacket to dimension A in Table 12–9, being careful not to nick braid.

b. Place the two halves of the cable clamp over the cable, lining up front (large) end of clamp with cut end of outer jacket. Slide bushing over tapered end of clamp. Compress bushing over cable clamp with special pliers as far as it will go.

NOTE

Special pliers No. TJF-107 are available from connector manufacturers.

c. Comb braid back over clamp and trim braid around edge of clamp.

NOTE

Omit step (d) when using connectors S624 and S634.

d. Slide washer, gasket, and second washer over dielectric and push up to cable clamp. Cut off dielectric to expose 2.4mm of conductor, and tin conductor.

e. Slide contact over conductor and solder. Remove any excess solder.

f. Slide assembly into plug or jack body until contact shoulder seats on insulator. Screw clamp nut into body, using a torque of 20Nm.

Table 12–9 Stripping Dimensions for Coaxial Cable Assembled to Liquidometer S62 and S63 Series Connectors

Connector (Liquidometer Number)	Stripping Dimension A
S62-1 and -4	8.7mm
S62-2 and -3	7.9mm
S63-1 and -4	7.9mm
S63-2 and -3	3.9mm

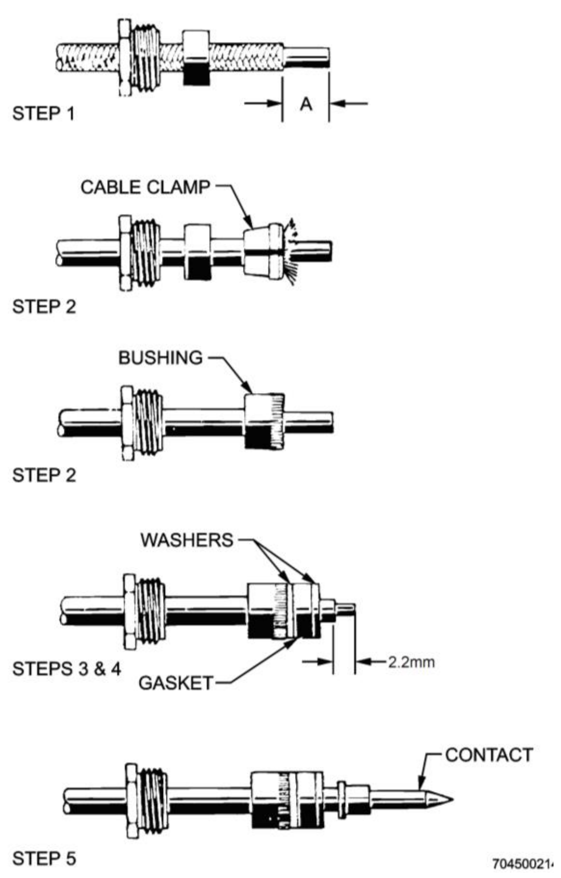


Figure 12–43 Attaching Liquidometer S62 and S63 Series Connectors to Coaxial Cable

ASSEMBLY PROCEDURE FOR SUB-MINIATURE CONNECTOR, ONO89558

38. For assembly of connector to RG-l95/U coaxial cable, use the following procedure:

- **a.** Install the sealing boot and slide the outer ferrule onto cable prior to stripping the cable. (See Figure 12–44.)
- **b.** Strip cable jacket, braid, and dielectric to dimensions indicated. (See Figure 12–44.) All cuts are to be square and sharp. Do not nick braid, dielectric or centre conductor when cutting. If the wire ends of the centre conductor are frayed, twist them to normal lay.
- **c.** Flair the ends of the wire braid to facilitate insertion of inner ferrule of body assembly. (See Figure 12–44.) Do not comb out the braid.
- **d.** Place the stripped centre conductor into the contact until the cable dielectric butts against it. End of the wire must show through the inspection hole. (See Figure 12–44.)
- **e.** Insert the contact into the crimping tool until it is fully seated in the contact locator. Crimp with one full stroke. (See Table 12–10 for crimping tool information.)

Table 12–10 Crimping Tool Details

Crimp on Centre Contact		
Basic Tool	**Basic Tool Setting**	**Contact Locator**
M22520/2-01	No. 5	M22520/2-24

- **f.** Install the centre contact in the body assembly while sliding the inner ferrule underneath the wire braid. (See Figure 12–45.) The centre contact shall be inserted until it is locked into place in the body assembly. A 1.5 kilogram min to 2.3 kilogram max pull shall be exerted on the cable to assure that the contact is securely locked in place.
- **g.** Slide the outer ferrule over the wire braid and up against the body assembly. No slack shall exist in the wire braid.
- **h.** Crimp the outer ferrule with M22520/5-01 tool and M22520/5-10 die. See Figure 12–46.
- **i.** The shielded contact now assembled shall be inserted into the connector assembly with insertion tool ONO89564.
- **j.** Push the sealing boot forward into the grommet of the connector until the O-ring riser of the boot has effected its snap-in seal. (See Figure 12–47). The installation of the shielded contact is complete.

39. For assembly of connector to twisted pair of 26 or 24 A.W.G. wires, use the following procedure:

- **a.** Install the sealing boot onto the untwisted wire prior to stripping the wires. (See Figure 12–48.)
- **b.** Strip the wires to the dimensions indicated. (See Figure 12–48.) All cuts are to be square and sharp. Do not nick the conductors when stripping the insulation.

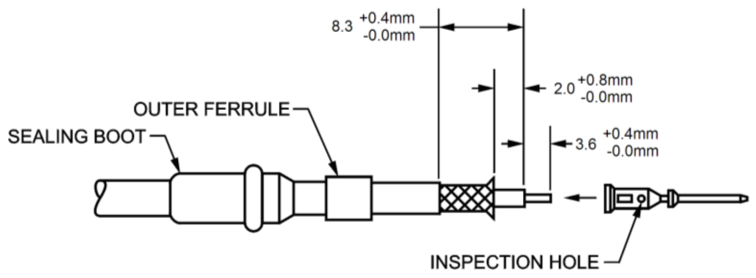


Figure 12–44 Stripping Dimensions, Scaling Boot, Ferrule and Contact Before Crimping the Contact

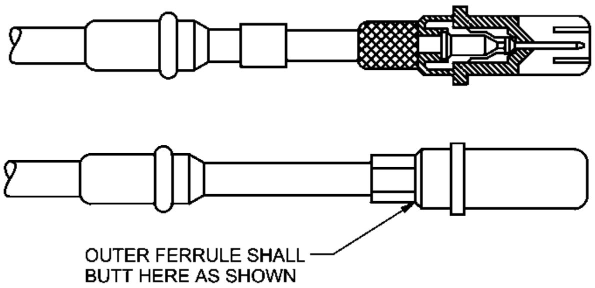


Figure 12–45 Final Assembly and Outer Ferrule Crimping

c. Fold the longer stripped wire to a 5.5mm dimension. (See Figure 12–48.)

d. Place the insulator and the contact onto the shorter stripped wire. The wire which is now the centre conductor must be visible through the contact inspection hole (See Figure 12–49.)

e. Insert the contact into the crimping tool until it is fully seated in the contact locator. Crimp with one full stroke. (See Table 12–11 for crimping tool information.)

Table 12–11 Crimping Tool Details

Crimp on Centre Contact			
	Basic Tool Setting		
Basic Tool	26 A.W.G.	24 A.W.G.	Contact Locator
M22520/2-01	No. 6	No. 7	M22520/2-24

f. Slide the outer ferrule onto the cable prior to installing the centre contact in the body assembly. (See Figure 12–50.)

g. Position the folded wire on top of the inner ferrule. (See Figure 12–50.) The centre contact shall be inserted until it is locked in place in the body assembly. A 1.5kg min to 2.3kg maximum pull shall be exerted on the cable to assure that the contact is securely locked in place.

h. Slide the outer ferrule over the folded wire and against the body assembly. Crimp the outer ferrule with crimp tool ONO89140.

i. The shielded contact now assembled shall be inserted into the connector assembly with insertion tool ONO89564.

j. Push the sealing boot forward into the grommet of the connector until the O-ring riser of the boot has effected its snap-in seal. (See Figure 12–49). The installation of the shielded contact is complete.

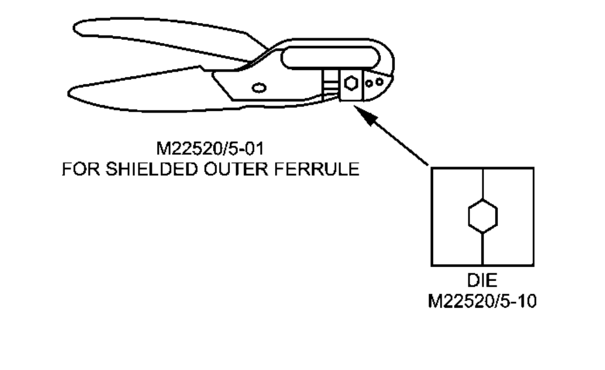


Figure 12–46 Crimping Tool for Shielded Outer Ferrule

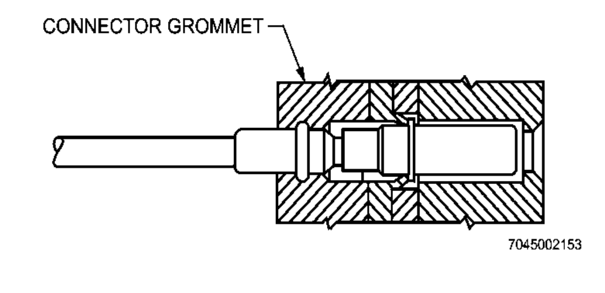


Figure 12–47 Final Connection Assembly

40. For assembly of Dage Type Connectors, use the following procedure:

a. Cut off end of cable even and square.

b. Slide cable nut and bushing over cable. Do not nick, braided shield or conductor.

c. With a knife cut through and remove 9.5mm of outer jacket.

d. Comb out braid and cut inner dielectric 2.5mm from end of cable.

e. Place cable clamp in place making sure end of clamp is flush with end of outer jacket. (See Figure 12–51.)

f. Slide nut into place to hold cable clamp in position.

g. Carefully fold back braid over cable clamp, position first washer and gasket in place and trim excess braid flush with washer.

h. Place second washer in place, tin centre conductor and contact hole.

i. Solder contact on centre conductor flush with inner dielectric. Place insulator in place.

> **CAUTION**
>
> Turn nut only. Do not rotate body of cable.

j. Insert cable assembly into connector, push firmly in place and tighten nut until flush with body of connector.

k. Place front gasket in place.

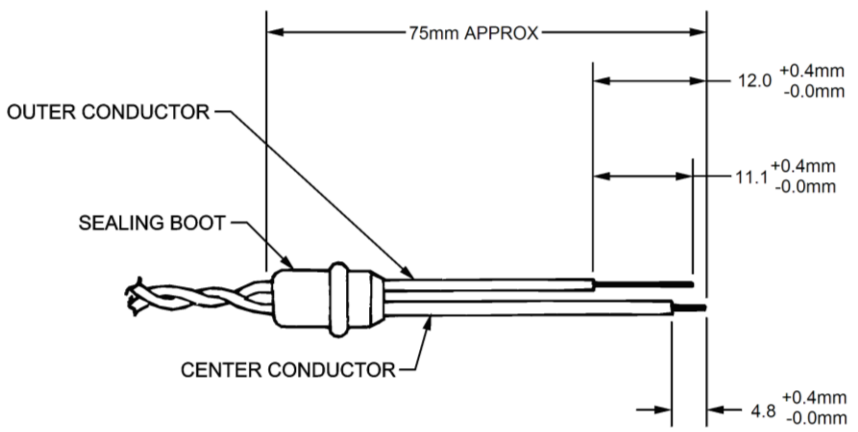


Figure 12–48 Stripping Dimensions and Sealing Boot Before Crimping the Contact

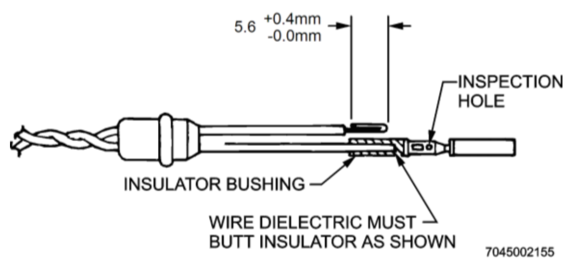


Figure 12–49 Assembly Before Crimping

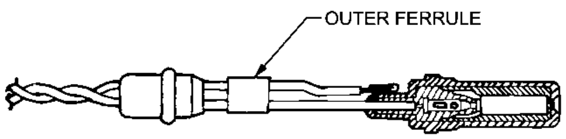


Figure 12–50 Final Assembly and Outer Ferrule Before Crimping the Outer Ferrule

ASSEMBLY PROCEDURE FOR SMA TERMINATION OF SEMI-RIGID CABLE USING HAND TOOL M22520/36

41. SMA connectors, Category F, designed for use with RG-402/U (3.6mm OD) and RG405/U (2.2mm OD) semi-rigid cable, consist of a plug (with or without a centre contact) or jack body. The plug (or jack) is assembled and terminated to the semi-rigid cable by means of an integrated grip sleeve. See Figure 12–52. A plug couples to a jack by means of screw threading.

Tooling for Preparing Semi-Rigid Cable

42. Before terminating the SMA connectors to the semi-rigid cable, the cable must be prepared using the components of the preparation tooling listed in Figure 12–53.

Preparing the Semi-Rigid Cable

43. Prepare both cable ends as follows:

a. Place cable dressing fixture in vice.

b. Insert end of cable into cable size-designated hole (see Figure 12–53).

c. Position 2.8mm to 3.3mm thick jeweller's saw in slot of fixture, and carefully cut through cable shield while rotating cable and maintaining pressure against fixture.

d. Remove cable from fixture.

> **CAUTION**
>
> Do NOT nick or score centre conductor with blade.

e. Using a razor blade, cut and remove dielectric to expose centre conductor.

f. Using the trimmer tool, smooth copper shield and dielectric (Figure 12–53). This is accomplished as follows:

(1) Slip correct end of tool over exposed end of cable.

(2) Push lightly against cable while slowly revolving tool clockwise two or three times.

(3) Remove tool and clean any chips from end of cable.

g. Re-insert cable into cable dressing fixture for pointing. Keep pressure against fixture and rotate cable slowly while filing on 45° surface (Figure 12–54) with a small pillar file or mill file. Continue filing until conductor offers no resistance to the file.

h. Remove cable and brush off any chips.

Selection of Cable, Connector, and Tool Components

44. Refer to Figure 12–55, and select the correct combination of cable, connector, hand tool locator, and die set from Table 12–12.

Tool Setup Procedure

45. Before the connector can be terminated to the prepared cable the hand tool must be set up with an appropriate locator and dies as follows:

a. Having selected the proper locator die set for the selection chart (see Table 12–12), loosen locator locking screw on tool (see Figure 12–56).

b. Insert locator into cavity of ram, making sure locator bottoms on top surface of ram.

c. Re-tighten locking screw.

d. Position each die of the die set on its respective tool jaw, orienting chamfer on die as shown in Figure 12–57. Die chamfers positioned improperly will result in an unacceptable termination.

e. Secure, without tightening, the dies to jaws with the die-holding screws.

f. Align dies by placing cable inside locator and squeezing the handles to dose tool. After ensuring that the dies are aligned with each other, tighten the die-holding screws (see Figure 12–58).

Cable Termination

46. Refer to Figure 12–59 (plug termination) or Figure 12–60 (jack termination), then proceed as follows:

a. Slide connector over cable, flange end first.

b. Place connector and cable inside locator of tool.

c. Ensure that centre conductor or centre contact enters hole in locator if applicable.

d. Ensure that connector is seated squarely on locator.

e. When terminating PANEL JACK to cable, align sides of panel jack with tool jaws as shown in Figure 12–60.

f. Support cable connector assembly and close tool handles until ratchet releases to complete termination.

Cable Bending Procedures

47. The 90° bending fixture assembly makes precise right-angle bends on the cable adjacent to the flange end of the plug. Refer to Figure 12–61 for tangent-of-radius to end-of-connector dimensions. Bends can have a radius of either 3.1mm on RG-402/U or RG-405/U cable, or 6.3mm on RG-402/U cable only. The spacer shown in Figure 12–62 must be positioned behind the dummy jack when bending the following: RC-402/U cable to either radius when cable is terminated with either plug M39012/79-3308 or plug M39012/79-3208; RG-405/U cable to 3.2mm radius when cable is terminated with plug M39012/79-3307 or plug M39012/79-3207. Simply loosen dummy jack to insert spacer, and retighten jack before proceeding.

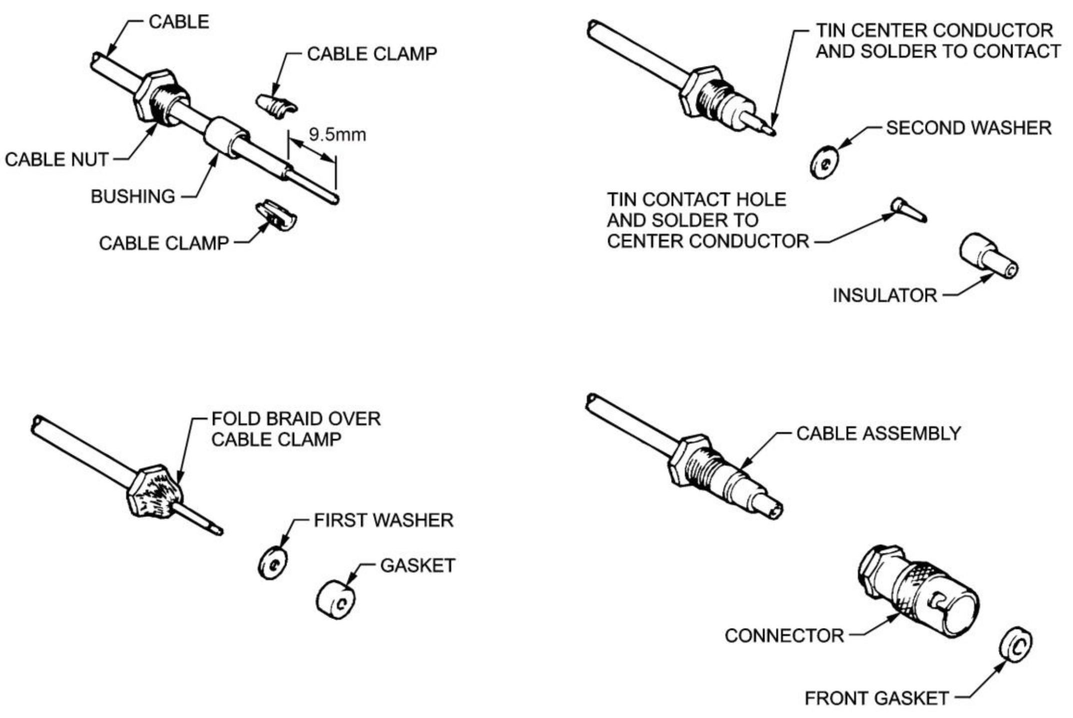


Figure 12–51 Assembly of Dage Type Connectors

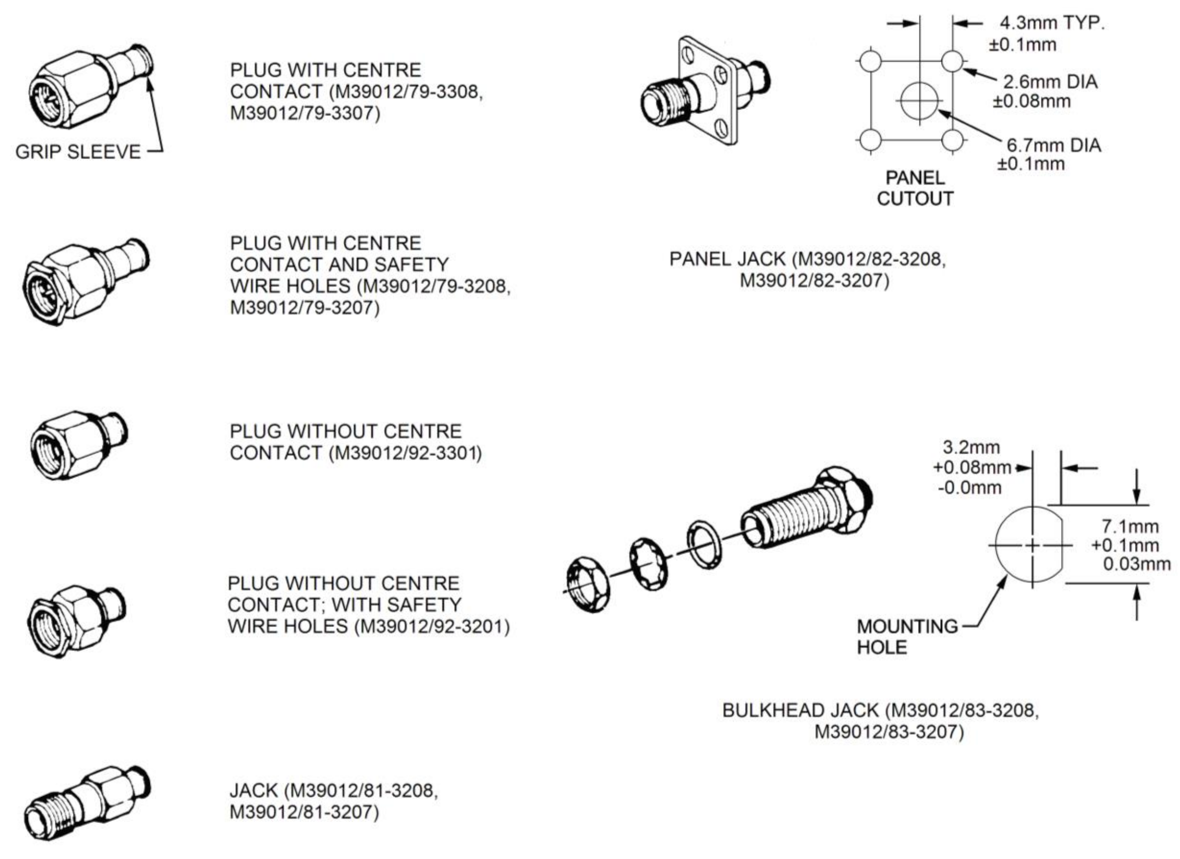


Figure 12–52 SMA Connectors M39012, Category F

Table 12–12 Cable, Connector and Tool Component Selection

Connector Part Number		Connector Description	Locator Part Number
For RG-402/U (3.6mm OD.) Cable Using Dies M22520/36-02	**For RG-405/U (2.2mm OD.) Cable Using Dies M22520/36-03**		
M39012/79-3308	M39012/79-3307	Plug with centre contact	M22520/36-04
M39012/79-3208	M39012/79-3207	Plug with centre contact, with safety wire holes	M22520/36-04
M39012/92-3301		Plug without centre contact	M22520/36-06
M39012/92-3201		Plug without centre contact, with safety wire holes	M22520/36-06
M39012/81-3208	M39012/81-3207	Jack	M22520/36-05
M39012/82-3208	M39012/82-3207	Panel Jack	M22520/36-05
M39012/83-3208	M39012/83-3207	Bulkhead Jack	M22520/36-05

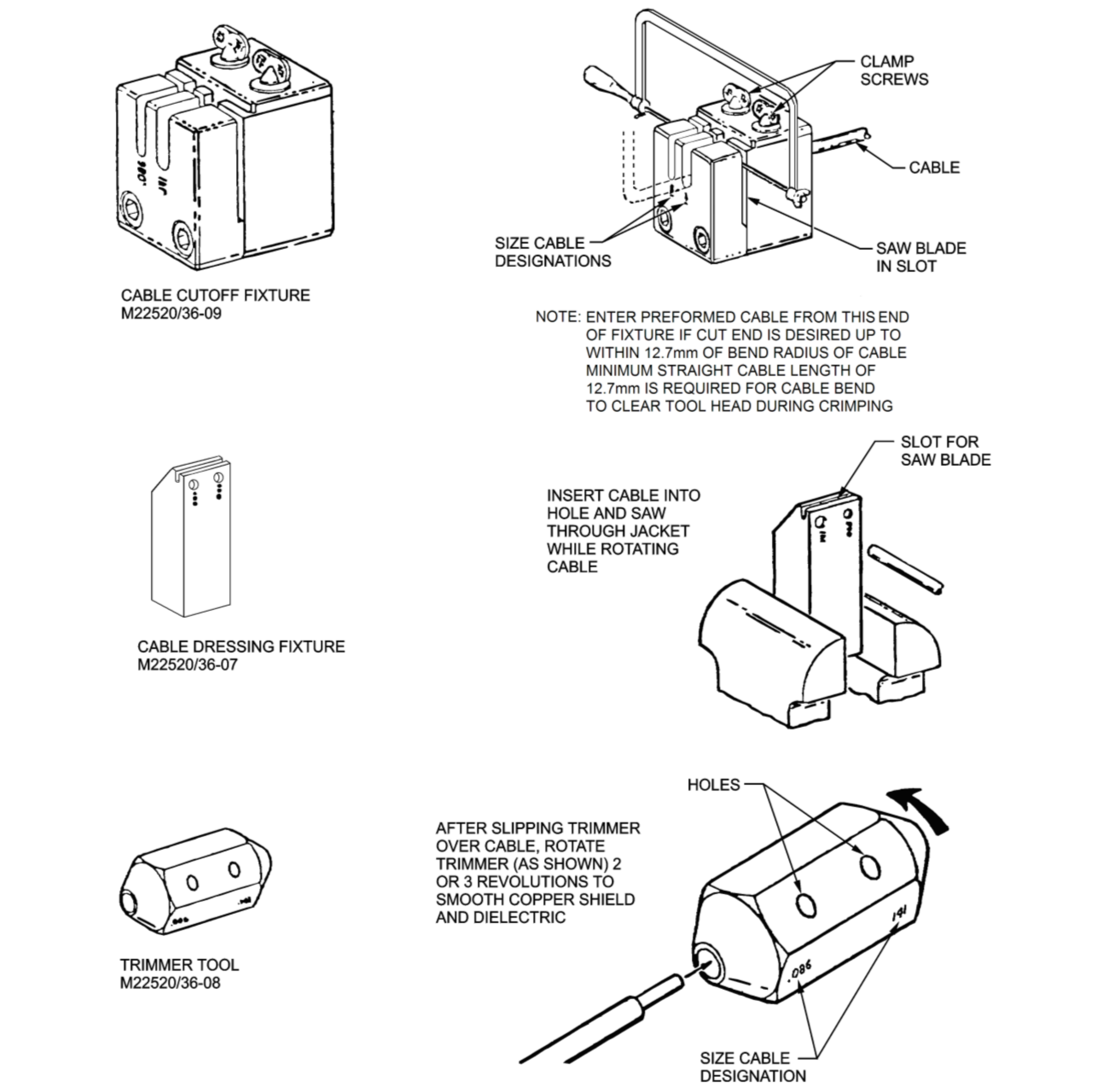


Figure 12–53 Tooling to Prepare Semi-rigid Cable

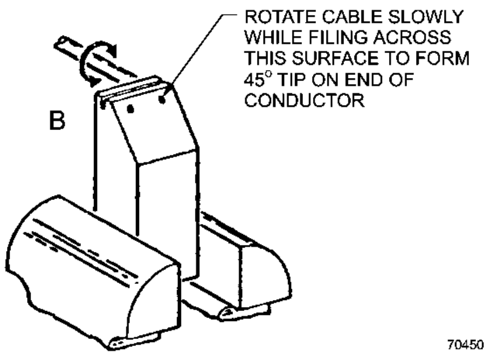


Figure 12–54 Pointing the Cable End

6.3mm Bends on RG-402/U Cable or 3.2mm Bends on RG-405/U Cable

48. Refer to Figure 12–63, and proceed as follows:

a. Screw terminated plug onto dummy jack of holder.

b. Refer to Table 12–13, and slip appropriate bend segment under cable.

NOTE
TOP marking is not designated on bend segment M22520/36-12.

c. Using finger pressure, bend cable around segment to desired angle, 90° maximum.

d. Unscrew plug from dummy jack on holder.

0.125-Inch Radius Bends on RG-402/U Cable

49. Refer to Figure 12–64, and proceed as follows:

a. Form a 6.3mm radius bend as described in paragraph 48.

b. Remove plug from dummy jack on holder.

c. Replace 6.3mm bend segment with the 3.2mm segment for RG402/U cable.

d. Re-attach plug to dummy jack of holder.

e. Place conforming block over cable with tongue of block in slot of holder (see Figure 12–64).

f. Insert limiting pin through hole in conforming block, and slide block against holder.

g. Place assembly in a vice with a 7cm opening and tighten vice to force conforming block into holder slot. Continue to tighten vice until legs of holder prevent further movement of vice jaws.

h. Remove assembly from vice, and unscrew plug from dummy jack on holder.

i. Remove conforming block and bend segment from holder.

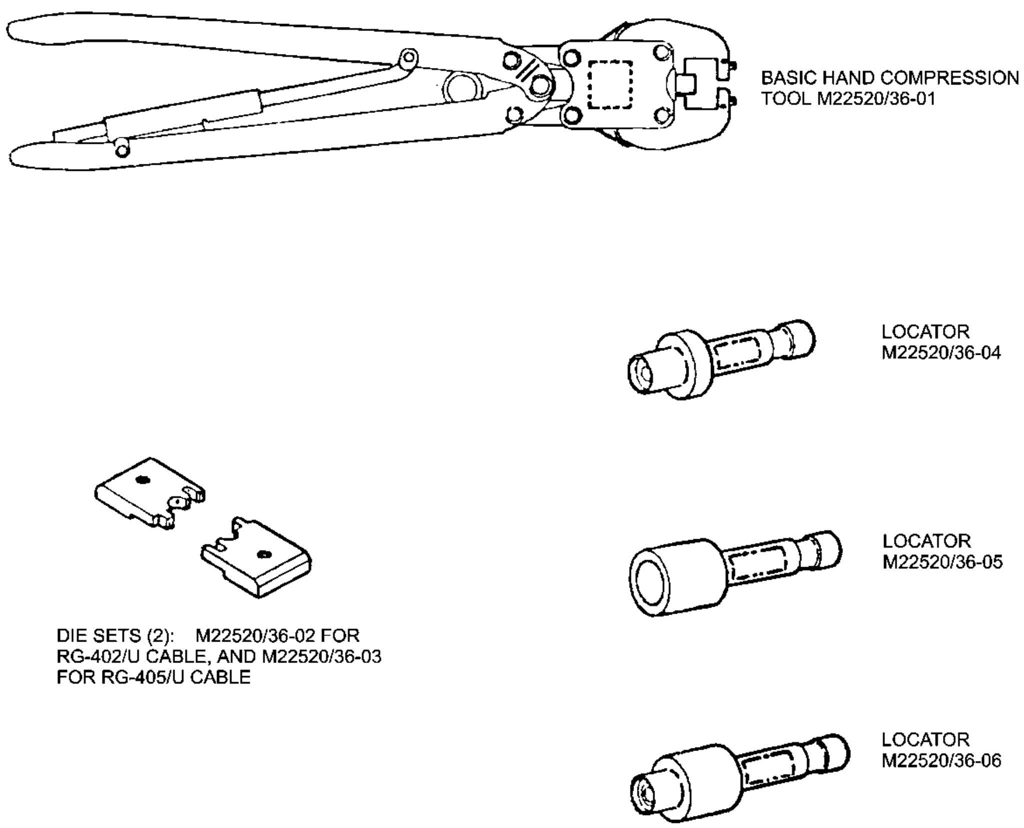


Figure 12–55 Termination Tooling

Table 12–13 Bend Segment Selection

Cable	Bend Segment Number	Radii Dimension	Plug Number
RG-402/U	M22520/36-12	6.3mm	M39012/79-3308
	M22520/36-11	3.2mm	M39012/79-3208 M39012/92-3301 M39012/92-3201
RG-405/U	M22520/36-13	3.2mm	M39012/79-3307 M39012/79-3207

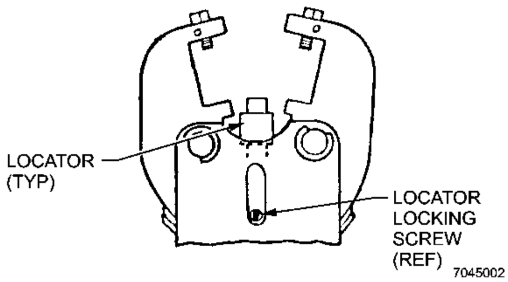


Figure 12–56 Locator and Locking Screw

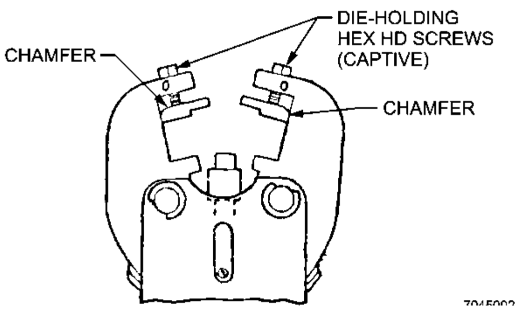


Figure 12–57 Orientation of Die Chambers

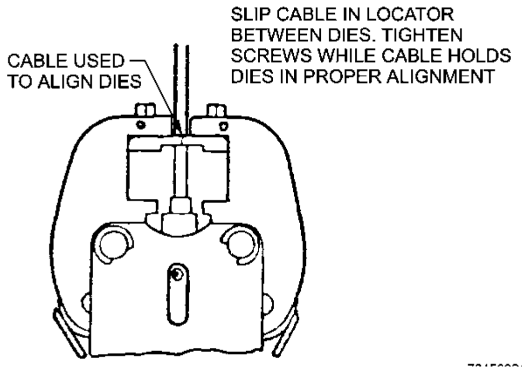


Figure 12–58 Die Alignment

Daily Maintenance

50. Each operator of the hand tool shall be made aware of, and responsible for, the following four steps of daily maintenance.

- **a.** Remove dust, moisture, and other contaminants with a clean brush, or a soft, lint-free cloth. Do NOT use objects that could damage the tool.
- **b.** Make sure proper retaining pins are in place and secured with proper retaining rings.
- **c.** Make certain all pins, pivot points and bearing surfaces are protected with a THIN coat of any good SAE No. 20 motor oil. Do NOT oil excessively.
- **d.** When tool is not in use, keep handles closed to prevent objects from becoming lodged in the dies; store tool in a clean, dry area.

Periodic Inspection

51. Regular periodic inspection and testing of hand crimping tools shall be performed in accordance with the requirements of Section 2 Chapter 6.

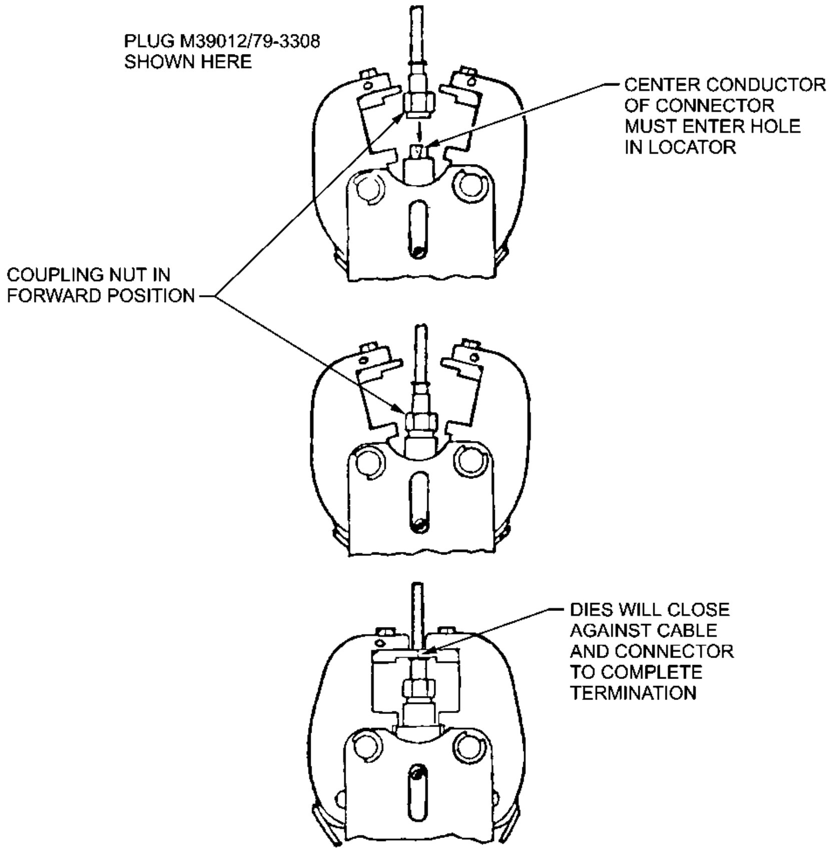


Figure 12–59 Plug Termination

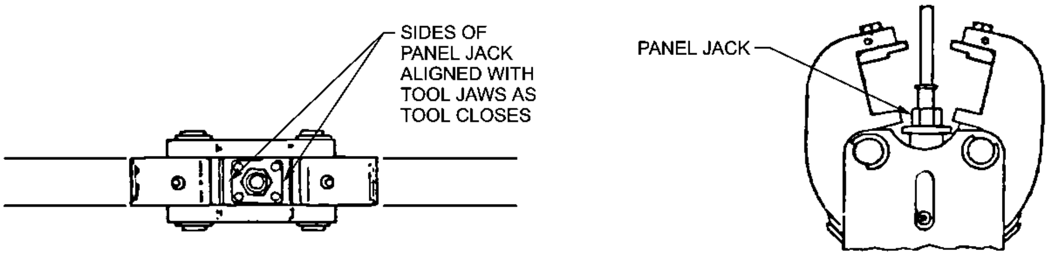
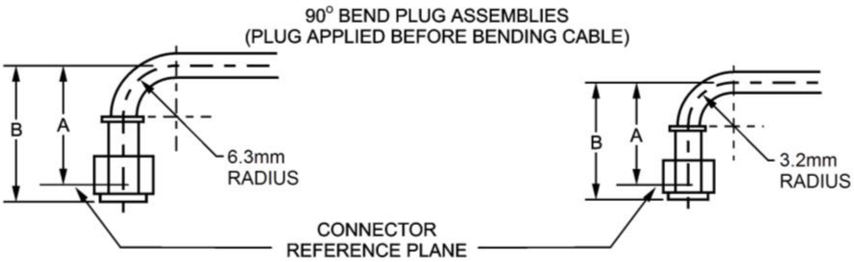


Figure 12–60 Jack Termination



PLUG PART NO. M39012/ -	6.3mm RADIUS DIM.		0.125 RADIUS DIM.	
	A	B	A	B
92-3301, 92-3201	14.7mm	18.1mm	11.5mm	14.9mm
79-3308, 79-3208	19.0mm	22.6mm	16.0mm	19.4mm
79-3307, 79-3207	—	—	15.3mm	18.7mm

Figure 12–61 Radii Dimensions for Semi-Rigid Cable Bending

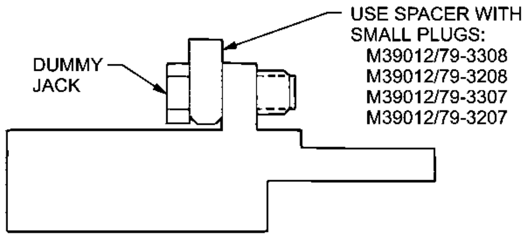


Figure 12–62 Spacer on Dummy Jack

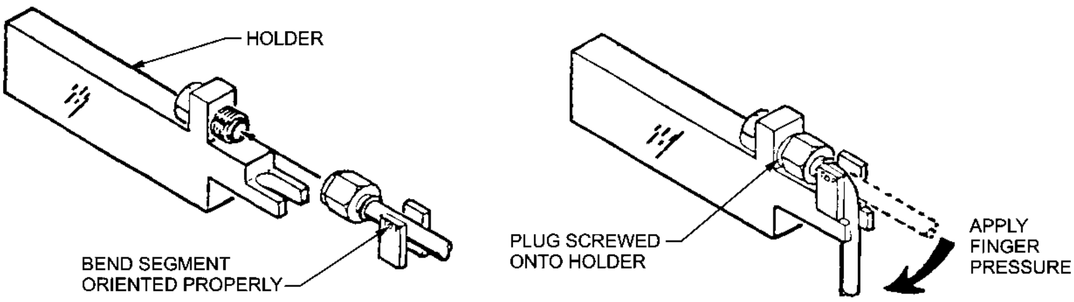


Figure 12–63 0.025 Inch Radius Bends on RG-402/U Cable and 0.125 Inch Radius Bends on RG-405/U Cable

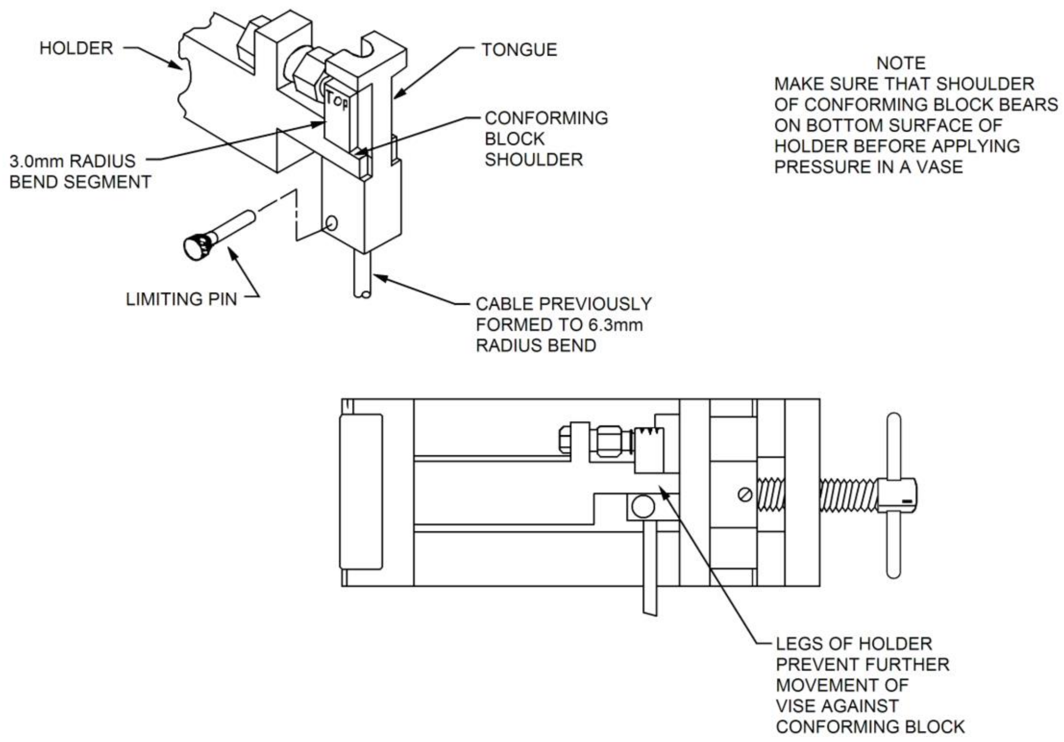


Figure 12–64 3.2mm Radius Bends on RG-402/U Cable

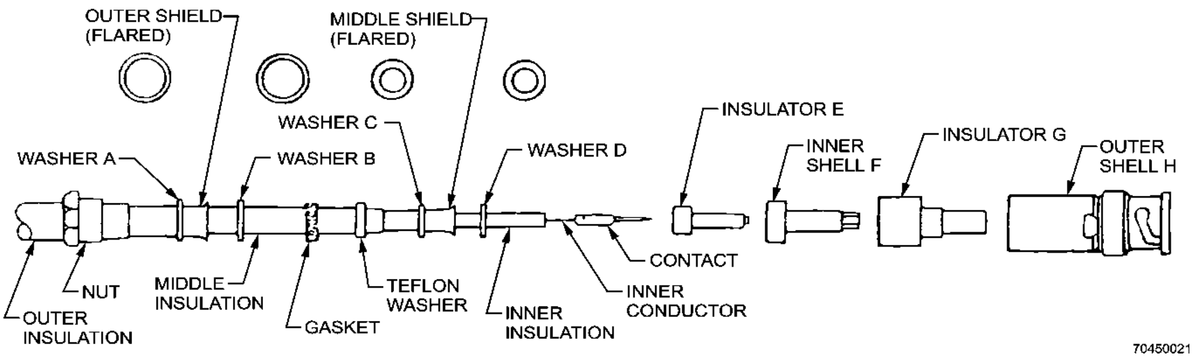


Figure 12–65 Triaxial Connector Assembly - Exploded View

TRIAXIAL CONNECTORS

52. MIL-PRF-49142 triaxial connectors and other such related connectors and fittings are intended for use with triaxial cable and can be used for radio frequency application when more shielding is required. It can be used in video circuits and for serial digital transfer.

Assembling Triaxial Cable Connectors

53. When assembling triaxial cable connectors to wire or cable, refer to Figure 12–65 through to Figure 12–68.

a. Remove 12.7mm of outer insulation.

b. Comb outer shield. Taper the shield over end middle insulation.

c. Slide nut over outer insulation.

d. Slide washer 'A' over tapered shield. Press the washer firmly against outer insulation.

e. Cut outer shield to dimension shown in Figure 12–66.

f. Flare outer shield. Install washer B firmly against shield. If necessary, trim shield flush with circumference of washers 'A' and 'B'.

g. Install gasket firmly against washer 'B'.

h. Cut middle insulation to dimension shown in Figure 12–67.

i. Install teflon washer firmly against gasket.

j. Install washer C firmly against teflon washer.

k. Cut middle shield to dimension shown in Figure 12–67.

l. Flare middle shield. Install washer firmly against shield. If necessary, trim shield flush with circumference of washers 'C' and 'D'.

m. Cut inner insulation and inner conductor to dimensions shown in Figure 12–68.

n. Tin inner conductor. Solder contact to inner conductor (do not over heat). Remove excess solder.

o. Install items 'E', 'F', 'G' and 'H'. Tighten nut to 14±1 inch-pounds while holding outer shell and outer insulation fixed.

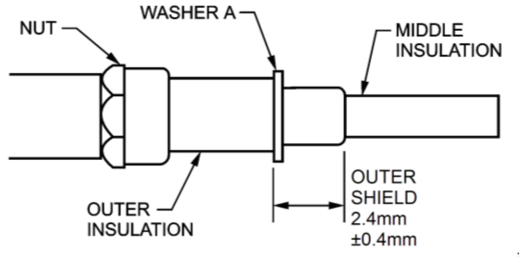


Figure 12–66 Attaching Triaxial Connector to Cable

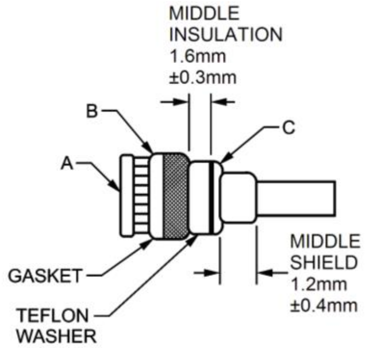


Figure 12–67 Attaching Gasket to Middle Insulation

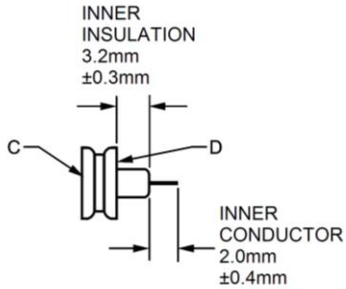


Figure 12–68 Attaching Outer Shell to Gasket

SECTION 2

CHAPTER 13

BONDING AND GROUNDING

INTRODUCTION

1. Bonding and grounding connections are made for the following purposes:

- **a.** To protect aircraft and personnel against hazards from lightning discharge.
- **b.** To provide current return paths.
- **c.** To prevent development of RF potentials.
- **d.** To protect personnel from shock hazard.
- **e.** To provide stability and homogeneity of radio transmission and reception.
- **f.** To prevent accumulation of static charge.
- **g.** To provide fault current return paths.

2. This chapter describes and illustrates the recommended procedures to be followed in the preparation and installation of bonding and grounding connections.

REFERENCE SPECIFICATIONS

3. The following specifications are applicable to bonding and grounding connections:

A-A-857	Thinner, Dope, & Lacquer (Cellulose-nitrate)
MIL-C-83413/8	Connectors and Assemblies, Electrical, Aircraft Grounding: Type IV Jumper Cable Assembly, Lead Electrical
MIL-DTL-22520	Crimping Tools, Wire Termination, General Specification For
MIL-PRF-23377	Primer Coatings, Epoxy, High Solids
MIL-PRF-85582	Primer Coatings, Epoxy, Waterborne
MIL-STD-464	Electromagnetic Environmental Effects Requirements for Systems
MIL-T-81714	Terminal Junction System, Environment Resistant, General Specification For
MS27429	Splice, Conductor, Disconnect, Crimp Style, Copper, Insulated Barrel, Type II, Class 1
SAE AMS-M-3171	Magnesium Alloy; Processes for Pre-treatment and Prevention of Corrosion
SAE AS 50881	Wiring, Aerospace Vehicle
SAE AS 7928	Terminals, Lug and Splices, Conductor Crimp Style, Copper, General Specification

DEFINITIONS

Bonding

4. The electrical connecting of two or more conducting objects not otherwise adequately connected.

Grounding

5. The electrical connecting of conducting object to primary structure or earth electrode, for return of current.

Primary Structure

6. The main frame, fuselage, and wing structure of the aircraft (commonly referred to as ground).

GENERAL PRECAUTIONS AND PROCEDURES

7. When making bonding or grounding connections in aircraft, observe the following general precautions and procedures:

- **a.** Bond or ground parts to the primary aircraft structure where practicable.
- **b.** Make bonding or grounding connections in such a way as not to weaken any part of the aircraft structure.
- **c.** Bond parts individually wherever possible.
- **d.** Make bonding or grounding connections against smooth, clean surfaces.

e. Install bonding or grounding connections so that vibration, expansion or contraction, or relative movement incident to normal service use will not break or loosen the connection.

f. Locate bonding and grounding connections in protected areas whenever possible. Locate connections, whenever possible, near hand holes, inspection doors, or other accessible areas to permit easy inspection and replacement.

g. Do not compression-fasten bonding or grounding connections through any non-metallic material.

h. Inspect the grounding and bonding straps to ensure that they are free of corrosion which will adversely affect performance, and are not frayed or cut more than 25% of the original strap.

i. No more than four ground wires should be connected to a common ground stud. Ground modules in accordance with MIL-T-81714 may be used for multiple grounds. No more than 16 ground wires should be connected in a ground module. Each ground for electric power sources (primary, secondary, emergency) should be connected to separate ground points. Grounds for utilisation equipment may be connected to a common ground point only when supplied from the same power source, provided this equipment does not perform duplicate or overlapping functions.

SELECTION OF HARDWARE

8. Hardware used to make bonding or grounding connections is selected on the basis of mechanical strength, current to be carried, and ease of installation. Where connection is made by aluminium or copper jumpers to structure of dissimilar material, a washer of suitable material should be installed between the dissimilar materials so that any corrosion which may occur will occur in the washer, which is expendable, rather than in the structure.

> NOTE
>
> When repairing or replacing existing bonding or grounding connections, use the same type of hardware as used in the original connection.

Hardware Material and Finish

9. Select hardware material and finish from Table 13–1, Table 13–2 or Table 13–3, depending on material of structure to which attachment is made, and material of jumper and terminal specified for the bonding or grounding connection.

Selection of Stud

10. Use either an AN screw or bolt of the proper size for the specified jumper terminal. Length of screw or bolt should be such that when bonding or grounding connection is fully tightened, approximately 3.7mm of screw protrudes beyond top of nut.

Selection of Nuts

11. Use AN nuts, either plain or self-locking, where indicated in Figure 13–1 and Figure 13–3. Use an all-metal, self-locking nut if practicable. Always use an all-metal, self-locking nut where current will be present. Where installation conditions require, use an AN nut-plate, riveted to structure.

Selection of Washers

12. Use AN plain washers and split lock washers as indicated in Figure 13–1, Figure 13–2 and Figure 13–3. Unless otherwise directed by applicable equipment technical order, use split lock washers with nuts, either plain or self-locking. With aluminium terminals, use a plain washer of at least the diameter of the terminal tongue, next to the aluminium terminal. If an AN washer does not meet this requirement, use a washer of the SAE heavy series, or a special washer made for this application.

Selection of Cable Clamp

13. For bonding or grounding to cylindrical surfaces, use an AN735 clamp. Where an AN735 clamp is not available, or where installation conditions do not allow its use, a non-cushioned AN742 clamp may be substituted.

> **CAUTION**
>
> Do not use cushioned clamps in any bonding or grounding connection.

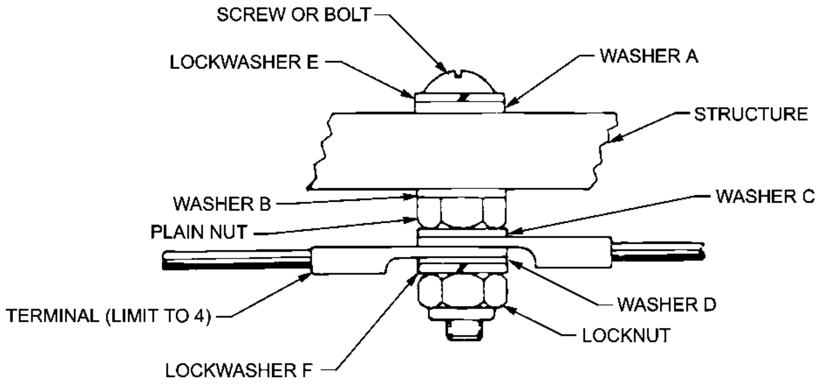


Figure 13–1 Stud Bonding or Grounding to Flat Surface

Table 13–1 Hardware for Stud Bonding or Grounding to Flat Surface (Refer to Figure 13–1)

Aluminium Terminal and Jumper							
Structure	**Screw or Bolt; Locknut**	**Plain Nut**	**Washer A**	**Washer B**	**Washer C & D**	**Lockwasher E**	**Lockwasher F**
Aluminium Alloys	Cadmium Plated Steel	Tin Plated Brass	Aluminium Alloy	Aluminium Alloy	Cadmium Plated Steel or Aluminium	Cadmium Plated Steel	Cadmium Plated Steel
Magnesium Alloys	Cadmium Plated Steel	Cadmium Plated Steel	Magnesium Alloy	Magnesium Alloy	Cadmium Plated Steel or Aluminium	Cadmium Plated Steel	Cadmium Plated Steel
Steel, Cadmium Plated	Cadmium Plated Steel	Cadmium Plated Steel	None	None	Cadmium Plated Steel or Aluminium	Cadmium Plated Steel	Cadmium Plated Steel
Steel, Corrosion Resisting	Corrosion Resisting Steel	Cadmium Plated Steel	None	None	Cadmium Plated Steel or Aluminium	Corrosion Resisting Steel	Cadmium Plated Steel
Tinned Copper Terminal and Jumper							
Structure	**Screw or Bolt; Locknut**	**Plain Nut**	**Washer A**	**Washer B**	**Washer C & D**	**Lockwasher E**	**Lockwasher F**
Aluminium Alloys	Cadmium Plated Steel	Cadmium Plated Steel	Aluminium Alloy	Aluminium Alloy	Cadmium Plated Steel	Cadmium Plated Steel	Cadmium Plated Steel or Aluminium
Magnesium Alloys	AVOID CONNECTING COPPER TO MAGNESIUM						
Steel, Cadmium Plated	Cadmium Plated Steel	Cadmium Plated Steel	None	None	Cadmium Plated Steel	Cadmium Plated Steel	Cadmium Plated Steel
Steel, Corrosion Resisting	Corrosion Resisting Steel	Corrosion Resisting Steel	None	None	Cadmium Plated Steel	Corrosion Resisting Steel	Corrosion Resisting Steel

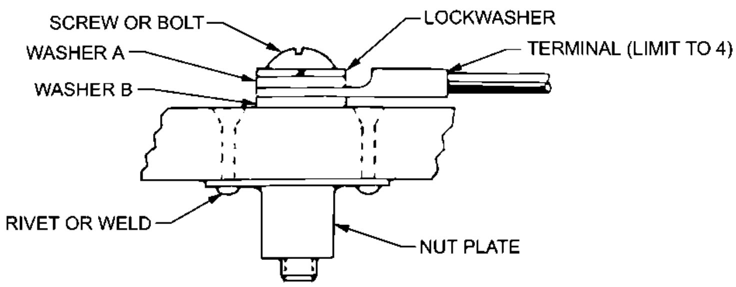


Figure 13–2 Plate Nut Bonding or Grounding to Flat Surface

Table 13–2 Hardware for Plate Nut Bonding or Grounding to Flat Surface (Refer to Figure 13–2)

Aluminium Terminal and Jumper					
Structure	**Screw or Bolt; Nut Plate**	**Rivet**	**Lockwasher**	**Washer A**	**Washer B**
Aluminium Alloys	Cadmium Plated Steel	Aluminium Alloy	Cadmium Plated Steel	Cadmium Plated Steel or Aluminium	None
Magnesium Alloys	Cadmium Plated Steel	Aluminium Alloy	Cadmium Plated Steel	Cadmium Plated Steel or Aluminium	None or Magnesium Alloy
Steel, Cadmium Plated	Cadmium Plated Steel	Corrosion Resisting Steel	Cadmium Plated Steel	Cadmium Plated Steel or Aluminium	None
Steel, Corrosion Resisting	Corrosion Resisting Steel or Cadmium Plated Steel	Corrosion Resisting Steel	Cadmium Plated Steel	Cadmium Plated Steel or Aluminium	Cadmium Plated Steel
Tinned Copper Terminal and Jumper					
Structure	**Screw or Bolt; Nut Plate**	**Rivet**	**Lockwasher**	**Washer A**	**Washer B**
Aluminium Alloys	Cadmium Plated Steel	Aluminium Alloy	Cadmium Plated Steel	Cadmium Plated Steel	Aluminium Alloy
Magnesium Alloys	AVOID CONNECTING COPPER TO MAGNESIUM				
Steel, Cadmium Plated	Cadmium Plated Steel	Corrosion Resisting Steel	Cadmium Plated Steel	Cadmium Plated Steel	None
Steel, Corrosion Resisting	Corrosion Resisting Steel	Corrosion Resisting Steel	Cadmium Plated Steel	Cadmium Plated Steel	None

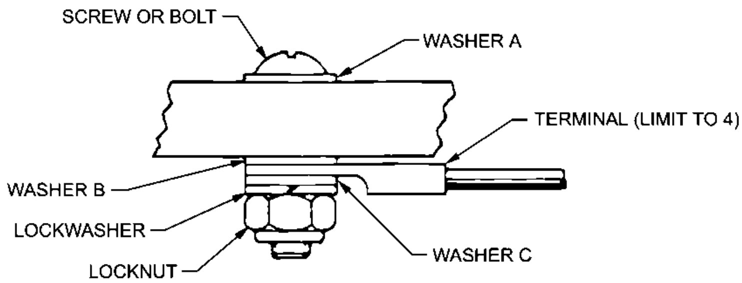


Figure 13–3 Bolt and Nut Bonding or Grounding to Flat Surface

Table 13–3 Hardware for Bolt and Nut Bonding or Grounding to Flat Surface (Refer to Figure 13–3)

Aluminium Terminal and Jumper					
Structure	**Screw or Bolt; Locknut**	**Lockwasher**	**Washer A**	**Washer B**	**Washer C**
Aluminium Alloys	Cadmium Plated Steel	Cadmium Plated Steel	Cadmium Plated Steel or Aluminium	None	Cadmium Plated Steel or Aluminium
Magnesium Alloys	Cadmium Plated Steel	Cadmium Plated Steel	Magnesium Alloy	None or Magnesium Alloy	Cadmium Plated Steel or Aluminium
Steel, Cadmium Plated	Cadmium Plated Steel	Cadmium Plated Steel	Cadmium Plated Steel	Cadmium Plated Steel	Cadmium Plated Steel or Aluminium
Steel, Corrosion Resisting	Corrosion Resisting Steel or Cadmium Plated Steel	Cadmium Plated Steel	Corrosion Resisting Steel	Cadmium Plated Steel	Cadmium Plated Steel or Aluminium
Tinned Copper Terminal and Jumper					
Structure	**Screw or Bolt; Locknut**	**Lockwasher**	**Washer A**	**Washer B**	**Washer C**
Aluminium Alloys	Cadmium Plated Steel	Cadmium Plated Steel	Cadmium Plated Steel	Aluminium Alloy	Cadmium Plated Steel
Magnesium Alloys	AVOID CONNECTING COPPER TO MAGNESIUM				
Steel, Cadmium Plated	Cadmium Plated Steel	Cadmium Plated Steel	Cadmium Plated Steel	None	Cadmium Plated Steel
Steel, Corrosion Resisting	Corrosion Resisting Steel or Cadmium Plated Steel	Cadmium Plated Steel	Corrosion Resisting Steel	None	Cadmium Plated Steel

PREPARATION OF BONDING OR GROUNDING SURFACES

14. Clean bonding and grounding surfaces thoroughly before making the connection. Remove paint, anodic or conversion coating film and surface corrosion from planned attachment area with abrasive mat, A-A-58054.

> **CAUTION**
>
> Do not use abrasives such as emery cloth, crocus cloth, steel wool, etc. These may leave particles imbedded in the surface or scattered in the area which may cause corrosive action.

Cleaning Procedure for Aluminium Surfaces

15. Apply a coating of petrolatum compound to bonding or grounding surface of aluminium structure and clean surface thoroughly, using stainless steel wire brush with pilot as shown in Figure 13–4. Wipe off the petrolatum compound with a clean dry cloth.

Cleaning Procedure for Magnesium Alloy Surfaces

16. Prepare magnesium alloy surfaces for bonding or grounding as follows:

> **WARNING**
>
> Cleaning solvents are toxic to skin, eyes and respiratory tract. Skin and eye protection is required. Avoid repeated or prolonged contact. ensure adequate general ventilation and avoid breathing fumes generated by solvents.

a. Remove grease and oil from surface with P-D-680, Type III.

> **WARNING**
>
> A-A-857 is flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection is required. Avoid prolonged contact. Use only with adequate ventilation.

b. If present, remove paint or lacquer from surface with lacquer thinner, A-A-857.

c. Brush area liberally with chrome pickle solution, SAE AMS-M-3171, Type I for one minute, then rinse within five seconds by brushing with clean water.

d. Dry thoroughly.

Cleaning Procedure for Steel Surfaces

17. When the surface is corrosion resisting or plated steel, clean bonding or grounding surface as described in paragraph 16, steps a and b.

> **CAUTION**
>
> Do not remove zinc or cadmium plate from steel surfaces.

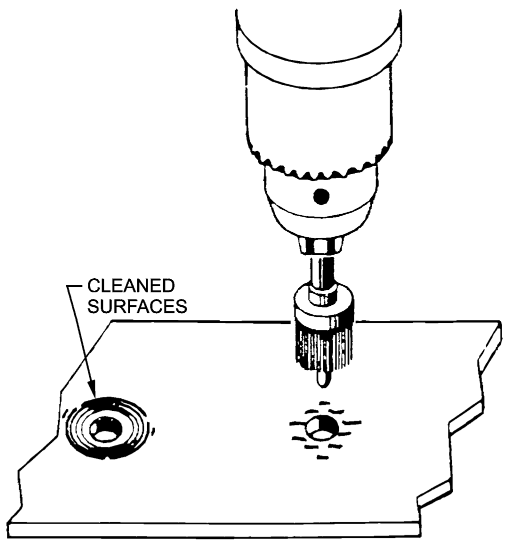


Figure 13–4 Stainless Steel Wire Brush With Pilot for Cleaning Aluminium Surfaces

METHODS OF BONDING OR GROUNDING

18. Bonding or grounding connections are made directly to a flat surface of basic structure, or to a cylindrical surface of basic structure.

Connection to Flat Surfaces

19. Bonding and grounding of through bolts or screws, where installation has easy access. There are three types of bolted connection, as follows:

a. **Stud Connection.** In this type of connection, a bolt or screw is locked securely to structure, thus becoming, in effect, a stud. (See Figure 13–1 and Table 13–1.) Grounding or bonding jumpers can be removed or added to the shank of stud without removing stud from structure. Not more than four lugs should be connected to any one stud.

b. Nut Plate and Bolt Connection. Nut plates are used where access to the nut for repairs may be difficult. Nut plates are riveted or welded to a clean area of the structure. (See Figure 13–2 and Table 13–2.) Cleaning of structure is done in accordance with paragraphs 15 through 17 as applicable.

c. Nut and Bolt Connection. In this connection the bolt or screw is not attached permanently to structure. (See Figure 13–3 and Table 13–3.) When jumpers are to be added or removed, the entire connection is remade. The table lists materials and platings that are compatible with the structure to which they are mounted. These materials are selected so that corrosion, if it occurs, will occur in the washers, which are expendable, rather than in the structure.

Connection to Tab Riveted to Structure

20. For bonding leads carrying high current, (size AWG 4 or larger), do not make the connection directly to the structure, but to a tab of suitable size adequately bonded to the aircraft structure. (See Figure 13–5.) When a bonding or grounding connection is made to a tab riveted to the structure rather than directly to the structure, clean the bonding or grounding surface and make the connection exactly as though the connection were being made to structure. If it is necessary to remove the tab for any reason, replace rivets with one size larger. Make sure mating surfaces of structure and tab are clean and free of anodic film.

Connection to Cylindrical Surfaces

21. Make bonding or grounding connections to aluminium alloy, magnesium alloy, or corrosion resisting steel tubular structure as shown in Figure 13–6 and Figure 13–7. Figure 13–6 shows the arrangement of hardware for bonding with an aluminium jumper. Because of the ease with which aluminium is deformed, it is necessary to distribute screw and nut pressure by means of plain washers as shown. Figure 13–7 shows the arrangement of hardware for bonding with a copper jumper. No extra washers are used. If installation conditions require, use an AN742 clamp (non-cushioned) instead of an AN735 clamp. Do not change any other hardware if this substitution is made.

Bonding Conduit to Structure

22. Bond aluminium alloy or corrosion-resisting steel conduit to structure as shown in Figure 13–8. If installation conditions require, an AN742 clamp may be used instead of an AN735 clamp, using same hardware.

Tightness of Connections

23. Make sure that all connections are tight, as evidenced by the split lockwashers being completely compressed.

> **CAUTION**
>
> When terminal is under head of screw or bolt (as shown in Figure 13–2), it is preferable not to install more than one terminal. Otherwise, the screw may loosen and cause improper operation of equipment.

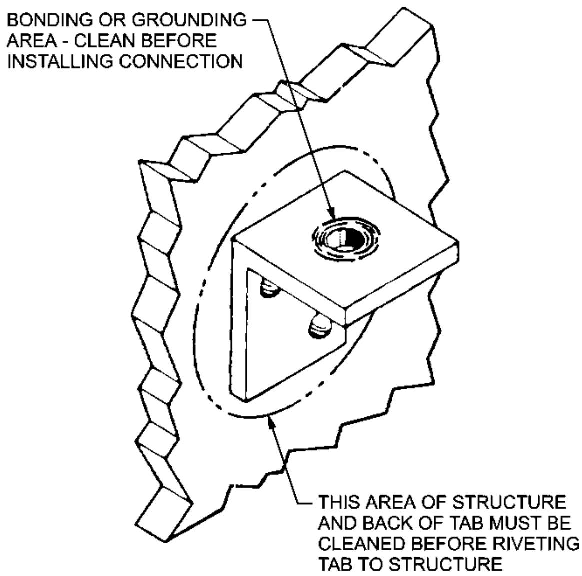


Figure 13–5 Bonding Tab Riveted to Structure

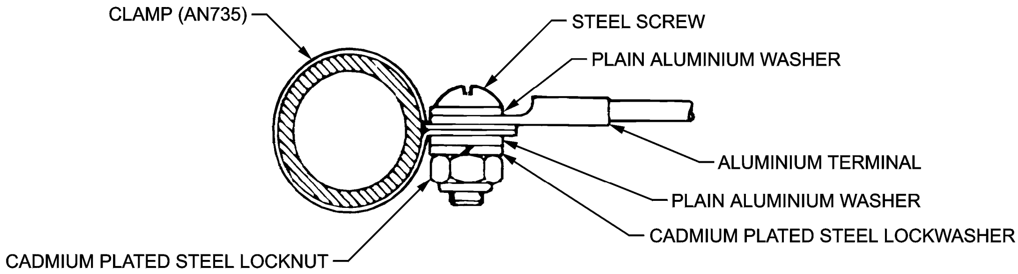


Figure 13–6 Aluminium Jumper Connection to Tubular Structure

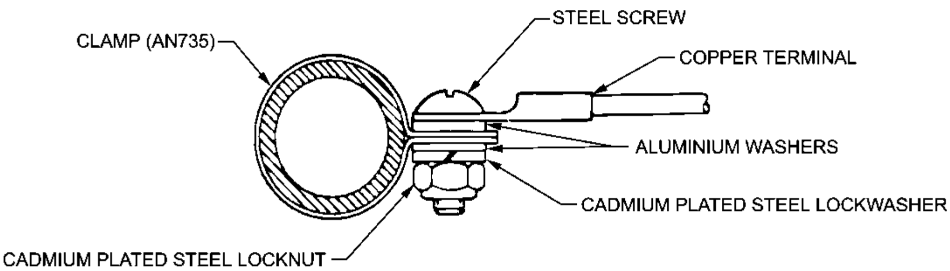


Figure 13–7 Copper Jumper Connection to Tubular Structure

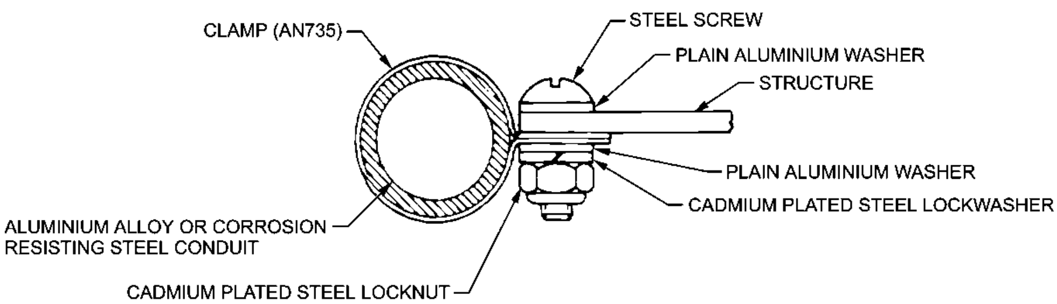


Figure 13–8 Bonding Conduit to Structure

BONDING AND GROUNDING JUMPERS

24. To accomplish the purpose of bonding or grounding, it is necessary to provide a conductive path where direct electrical contact does not exist. Jumpers are used for this purpose in such applications as between moving parts, between shock-mounted equipment and structure, and between electrically conducting objects and structure. Keep jumpers as short as possible; if practical, under 76mm. Do not use two or more jumpers in series.

Fabricating Bonding and Grounding Jumpers

25. Jumpers of tinned copper wire are fabricated in accordance with MIL-C-83413/8. For smaller size wire, terminate with MS25036 insulated copper terminal lugs of appropriate size. Use M22520/5-01 tool with M22520/5-100 for crimping terminals to wire. For larger wire size, terminate with MS20659 uninsulated copper terminal lugs, crimped to the wire with M22520/24-10 or MS25441 tool. The appropriate size copper wire braid should be selected from Table 13–4.

Table 13–4 Tinned Copper Woven Braid for Fabrication of Electrical Grounding and Bonding Leads

	Construction								
			Strand Diameter		Width				
Part Number	Lays	Strands	Mil	SWG	mm	Ins	Area Cir Mils	Current Rating	Terminal Lug Size
G154-8-3-.122	8	3	0.122	40	1.19	.047	380	4	26-24
G154-16-3-.122	16	3	0.122	40	1.58	.063	1000	7	22-18
G154-24-3-.1226	24	3	0.122	40	2.78	.110	1900	10	22-18
G154-24-4-.122	24	4	0.122	40	3.18	.125	2550	13	16-14
G154-24-6-.1228	24	6	0.122	40	4.76	.187	3800	15	16-14
G154-24-8-.122	24	8	0.122	40	6.35	.250	5100	20	16-14
G154-24-14-.122	24	14	0.122	40	9.52	.375	7650	30	12-10
G154-32-16-.122	32	16	0.122	40	12.70	.50	10200	40	12-10
G154-32-20-.122	32	20	0.122	40	15.88	.625	12700	50	12-10
G154-48-16-.122	48	16	0.122	40	19.05	.75	14300	60	8
G154-48-32-.122	48	32	0.122	40	25.40	1.0	21700	80	8

> Note
>
> For RF bonding, a rule of thumb for achieving minimum bond strap inductance is that the length-to-width ratio of the strap should be 5:1 or less.

Quick-Disconnect Jumpers

26. Where a quick disconnect jumper is required, crimp an MS27429 electrical disconnect splice into a copper wire jumper, fabricated as described in paragraph 25, using M22520/5-01 tool with M22520/5-100 die. Note that the disconnect splice is not centred in the jumper, but is installed so that the coupler remains on the short end when the jumper is disconnected.

TESTING BONDS AND GROUNDS

Resistance Tests After Connection

> NOTE
>
> The resistance figures provided below are for general electrical and RF bonding. Specific requirements detailed in aircraft or component publications should take precedence.

27. The resistance across a bonding or grounding jumper is required to be 0.1 ohms or less for general electrical bonding whether using bonding jumpers or where metallic components are directly attached. Where bonding of RF components is required, the resistance should be a maximum 0.0025 ohms (2.5 milliohms) (Reference – MIL-STD-464). Test is made after the mechanical connection is completed, and consists of a milli-ohmmeter reading of the overall resistance between the cleaned areas of the object and the structure.

Resistance Test Procedure

28. Measurements of the specified resistance value are made with special calibrated low-range ohmmeters. The Avtron T477W or functional equivalent meeting UL-913 explosion-proof test criteria should be used in enclosed areas where hazards exist, such as explosive vapours from fuel systems. The AN/USM-21A can be used in non-hazardous areas. Proceed as follows, observing the precautions emphasised in the meter instruction manual.

a. With the Function Control OFF, set the Range Control to the 0.1 ohm position.

b. Attach the instrument test clips for good electrical contact with the cleaned areas immediately adjacent to the jumper terminal lugs of object and structure.

c. Set the Function Control to CALIBRATE, then use the Calibration Adjustment Control to obtain a 0.1 ohm full scale deflection.

d. Set the Function Control to OHMS position, and note the bond (only) reading. It should be less than 0.1 ohm.

REFINISHING

Refinishing Metal Surfaces

WARNING

Appropriate personal protective equipment should be worn when handling and using cleaning and corrosion control solutions.

29. Following the connection and successful testing of bonding or grounding leads, the bare metal surface must be protected from corrosion.

SECTION 2

CHAPTER 14

EARTHING AND BONDING OF AIRCRAFT AND GROUND SUPPORT EQUIPMENT

INTRODUCTION

1. Electrical bonding of aircraft to earth has generally been aimed at protecting aircraft and personnel from the hazards associated with static electrical discharge. However, with utilisation of external power sources, electrical bonding to earth must also protect aircraft and personnel from the potential hazards associated with the electrical ground power supplies.

2. The latter concern has led to an extensive examination of the hazards and electrical bonding procedures, and this has resulted in a different approach to electrical bonding requirements. This approach emphasises the need to counteract the potential hazards associated with electrical ground power supplies. If protection against these is adequate then protection against the hazards associated with static electrical build-up and discharge is also adequate.

3. Increasing utilisation of electrically operated GSE, primarily mains powered equipment (240V, 50Hz), has highlighted the need to protect personnel against the potential hazards associated with this type of equipment.

4. The purpose of this chapter is to clearly present the approach that should be adopted in relation to electrical protection, bonding and earthing and to define the procedures to be employed. In particular the aims are:

- **a.** To describe the nature of the hazards associated with static electricity, ground power supplies and mains operated GSE.
- **b.** To specify the procedures to be used for electrical protection of personnel, and electrical bonding and earthing of aircraft and ground support equipment.

ELECTRICAL GROUNDING FOR AIRCRAFT SAFETY

Introduction

5. The following paragraphs provide maintenance personnel with the rationale behind the requirements for, and the detailed information required to carry out electrical safety grounding of aircraft. This includes grounding for both static electricity and the potential hazards associated with ground power supplies. The grounding methods presented make a clear distinction between static grounding and power grounding. The following definitions apply:

- **a. Static Ground.** An approved ground point with an impedance of less than 10,000 ohms referenced to earth.
- **b. Power Ground.** An approved ground point with an impedance of less than 10 ohms to the power system neutral.

6. Static grounding of aircraft is required whenever the aircraft is parked; including during refuelling, de-fuelling, hot refuelling, stores loading and whenever external power is connected.

7. All aircraft require externally generated electrical power supplies to facilitate servicing and maintenance. For safe use of these power supplies the aircraft must be correctly grounded. This grounding is to provide protection against the potential hazards of these external power supplies and is in addition to aircraft static grounding or earthing procedures.

8. There are two basic types of power supply available for supplying electrical power for aircraft servicing. They are:

- **a. Reticulated Power Supplies.** These are usually supplies peculiar to the aircraft or equipment, reticulated from another source and terminated in the hangar. From these, the power is fed to the aircraft. Typical supply values are 115/208V 400Hz AC and 28VDC.
- **b.** Mobile Generating Sets. These may be:
  - **(1)** engine driven generating sets;
  - **(2)** static rectifiers; and
  - **(3)** frequency changers.

External Power Supply System Characteristics

9. The use of external power supplies always involves two basic electrical characteristics:

- **a.** a voltage (potential) above earth mass potential to create the electrical pressure necessary to cause a current flow; and

b. a return path, normally at earth mass potential, to complete the electrical circuit.

10. The electrical cable used in sub para 9a. is termed the active or positive lead, and in sub para 9b. the neutral or negative lead.

11. External power supplies, both mobile and reticulated, are designed so that the return path from the aircraft load to the power source is always via the negative or neutral lead. However, parallel return paths can be established and it is these that provide the hazards associated with external power supplies.

12. The current flow in a return path will depend on the total resistance of the circuit and be in proportion to the resistance (and therefore currents) of other parallel paths. Not only may equipment operation be unbalanced by multiple return paths, but more importantly, personnel may sustain serious injury by becoming part of a return path.

13. All efforts are aimed at ensuring that, generally, only one return path is possible and that adequate safety measures are taken so that personnel are afforded the best possible protection from the potential hazards associated with external electrical power supplies.

Mobile External Power Supplies

14. Mobile aircraft external power supplies are to have the output AC neutral lead and/or the DC negative lead connected to the chassis. A return path may be established if the chassis is bonded to the earth mass, consequently a general policy should require that the power source chassis is NOT bonded to the earth mass. This is illustrated in Figure 14–1.

15. GSE and safety interconnection leads are not designed to withstand a high value of continuous current flowing in the components that could form part of a parallel return path. In addition, the electrical instability engendered by multiple return paths, if these are established, is generally undesirable.

Reticulated Aircraft External Power Supplies

16. Reticulated aircraft external power supplies have certain characteristics which set them apart from mobile power supplies, ie:

a. very effective earthing of the source of the power at the mains or sub-mains earth/neutral link; and

b. an extensive reticulation system is required to provide electrical power to the aircraft.

17. The above characteristics allow for supplementary return paths, ie earth loops to be established in parallel with the neutral or negative lead. Current flow will be proportional to the resistance of the return circuit. Under normal conditions the current flow is of an acceptably low value in the earth loops. This is due to the relatively high resistance between hangar floor earths and the earth/neutral link at the sub-mains.

18. The most acute hazard associated with reticulated power supplies serving hangar facilities is the possibility of the aircraft frame being connected to the hanger structure. In this situation, the earth loop will carry a greater proportion of the return current. This current flow will be greater still if the resistance of the power supply neutral or negative is high or the main return path is disconnected.

19. If earth loop currents are high, due to either incorrect earthing or faulty neutral/negative return leads, the following hazardous situations will exist when power is applied to the aircraft:

a. arcing will occur when the safety interconnection lead is connected or disconnected; and

b. personnel becoming part of this circuit will suffer electric shock.

20. For the above reasons it is imperative that all personnel ensure that correct earthing techniques are always employed.

WARNING

Connection/disconnection of safety interconnection leads should not be made whilst reticulated external electrical power is applied to the aircraft.

21. Illustrated in Figure 14–2 and Figure 14–3 are the two static aircraft external power supply situations, and the correct connections to ensure equipment and personnel safety.

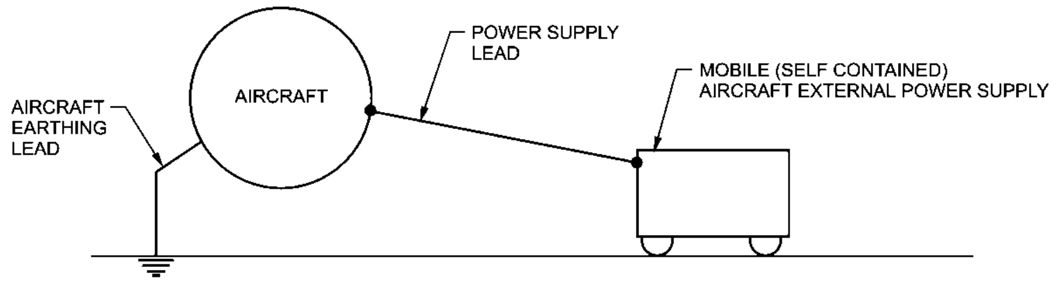


Figure 14–1 Mobile (Self Contained) Aircraft External Power Supply

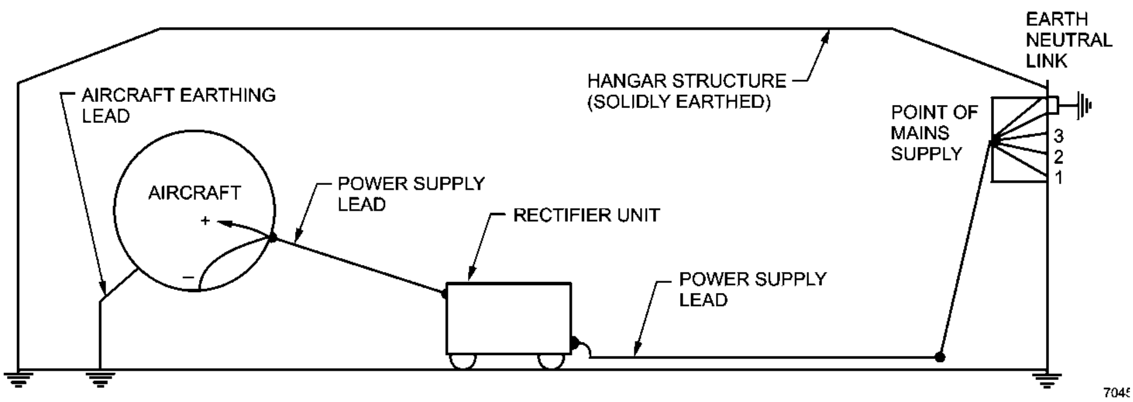


Figure 14–2 Mobile Rectifier/Frequency Converter Aircraft External Power Supply

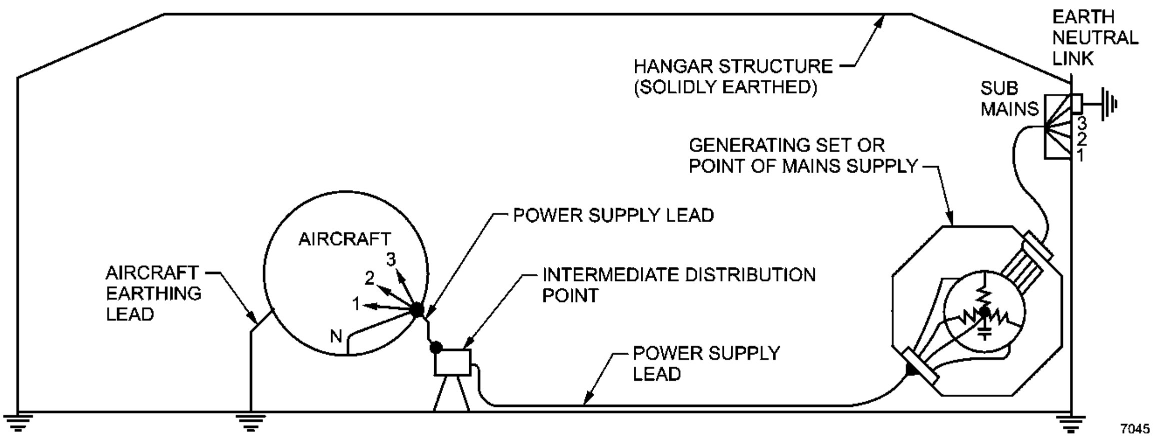


Figure 14–3 Reticulated Aircraft External Power

ELECTRICAL EARTHING AND BONDING PROCEDURES FOR AIRCRAFT AND GSE

Introduction

22. The following paragraphs contain the procedures and sequences to be used for electrical earthing and bonding of aircraft and ground support equipment. The observance of these procedures is recommended for personnel involved in aircraft ground handling and maintenance.

23. Correct electrical earthing and bonding procedures are essential to minimise the hazards associated with static electricity. Safety interconnection leads, which have been designed to provide this earthing and bonding for aircraft and equipment, must be connected correctly and in the proper sequence.

Aircraft Earthing Procedure

24. Unless otherwise directed by the specific aircraft documentation, a safety interconnection lead manufactured to the requirements detailed in this chapter is to be connected/disconnected using the following sequence:

- **a.** The safety interconnection lead clamp is connected to a known serviceable earth reference point followed by the connector pin or clamp being attached to an appropriate location on the aircraft. The interconnection should exist at all times whilst the aircraft is parked.
- **b.** Disconnection procedure is the reverse of the connection sequence ie. the connector pin or clamp is removed from the aircraft followed by the lead clamp removal from the earth reference point.

25. Any one of the configurations detailed in Figure 14–4, Figure 14–5, Figure 14–6 or Figure 14–7 may be used to earth the aircraft.

Bonding GSE to Aircraft

CAUTION

External electrical power supply units are <u>NOT</u> to be connected to an earth reference point, or interconnected to aircraft earth receptacles.

26. Personnel operating GSE in conjunction with aircraft are responsible for ensuring the proper sequence of earthing and bonding is observed and that the connections are correctly made.

Replenishing or Removing Flammable Fluids

NOTE

Whilst oxygen is classified as non-flammable, the dangers involved during aircraft oxygen replenishment dictate that oxygen should be treated as a flammable fluid. However, when replenishing airborne oxygen systems, bonding of the filling connector to the aircraft is not required.

27. Before replenishing an aircraft with flammable fluid or removing flammable fluid from an aircraft, the following bonding procedures and sequences are to be observed (Refer to the note following Paragraph 23 regarding operating from civilian airports):

- **a.** Check that a safety interconnection lead is connected between a serviceable earth reference point and the aircraft.
- **b.** Connect a safety interconnection lead from the GSE to the same earth reference point to which the aircraft is earthed.
- **c.** Connect a safety interconnection lead from the GSE to an earth point on the aircraft.
- **d.** Personnel involved in the operation are to touch an earthed conductor to themselves and their clothing to discharge any static electricity that they may have generated.
- **e.** Before opening the inlet of the replenishment point, connect the replenishment hose bonding connector plug or clamp to an earth point adjacent to the fluid inlet.

28. After the replenishment connections have been removed at the completion of the operation, disconnect the bonding leads in the reverse sequence.

Replenishing or Removing Non-Flammable Fluids

29. The sequence for electrical bonding of GSE used for replenishing or removing non-flammable fluids from an aircraft is as follows:

- **a.** Check that a safety interconnection lead is connected between a serviceable earth reference point and the aircraft, and;
- **b.** Connect a safety interconnection lead from the GSE to the same earth reference point to which the aircraft is bonded.

NOTE

When operating at airports where earth points are unavailable, a bonding lead should be connected from the GSE to the aircraft. The GSE can then be connected and operated.

Servicing Aircraft with Flammable Fluids from Drums or Containers

30. Before replenishing an aircraft with flammable fluid from a drum or other container, or removing flammable fluids from an aircraft into a drum or other container, the following earthing and bonding procedures and sequences should be observed.

- **a.** Check that a safety interconnection lead is connected between a serviceable earth reference point and the aircraft.
- **b.** The drums or containers are to be bonded to each other with safety interconnection leads, (Leads as detailed in Figure 14–7 should be used).
- **c.** Connect a safety interconnection lead between the bonded drums or containers and the same earth reference point to which the aircraft is earthed.
- **d.** Connect a safety interconnection lead between the pumping unit (can be a tanker, fuel servicing unit or wheel or sled mounted centrifugal pumping unit) and the same earth reference point to which the aircraft and containers are connected.
- **e.** Connect a safety interconnection lead between the bonded drums or containers and the pumping unit.
- **f.** Connect a safety interconnection lead between the pumping unit and the aircraft.
- **g.** Personnel involved in the fuelling operation are to touch an earthed connector to themselves and their clothing to discharge any static electricity that they may have generated.
- **h.** Prior to opening the inlet of the aircraft replenishing point, connect the hose connector plug or clamp to an earth point adjacent to the fluid inlet.

31. After the fuelling connections have been removed at the completion of the replenishment operation, disconnect the bonding leads in the reverse sequence.

Refuelling Aircraft from Hydrant Systems

32. Before refuelling an aircraft from a hydrant system, the following bonding procedures and sequence should be observed:

- **a.** Check that a safety interconnection lead is connected between a serviceable earth reference point and the aircraft.
- **b.** Connect a safety interconnection lead from the fuel servicing unit (FSU) to the same earth reference point to which the aircraft is earthed.
- **c.** Before connecting the FSU supply hose to the hydrant supply point, connect the FSU supply hose bonding connector or clamp to an earth point adjacent to the hydrant supply point.
- **d.** Connect a safety interconnection lead from the FSU to the aircraft.
- **e.** Personnel involved in the fuelling operation are to touch an earthed conductor to themselves and their clothing to discharge any static electricity that they may have generated.
- **f.** Before opening the inlet of the aircraft replenishment point, connect the FSU replenishment hose bonding connector plug or clamp to an earth point adjacent to the fuel inlet.
- **g.** After the fuelling connections have been removed at the completion of the replenishment operation, disconnect the bonding leads in the reverse sequence.

Bonding Procedures to be Observed when Refuelling GSE

33. The following bonding procedures should be used when refuelling GSE on aircraft tarmac areas:

- **a.** Ensure that GSE is inoperative and disconnected from the aircraft.
- **b.** Connect a safety interconnection lead from the refuelling vehicle to the GSE.
- **c.** Personnel are to touch an earthed conductor to themselves and their clothing to discharge any static electricity they may have generated.
- **d.** Prior to opening the inlet of the GSE replenishing point connect the replenishing hose bonding connector plug or clamp to an earth point adjacent to the refuelling inlet.
- **e.** After the fuelling connections have been removed at the completion of the replenishment operation, disconnect the bonding leads in the reverse sequence.

Aircraft Other Than Australian Aircraft

34. Aircraft of any nation that are to be serviced or replenished should to be treated in accordance with the procedures detailed in this chapter.

AIRCRAFT AND GSE INTERCONNECTION HARDWARE

Introduction

35. The following paragraphs describe the interconnection hardware required to earth aircraft and GSE used to service aircraft.

Hardware to be Fitted to Aircraft

36. The requirement for aircraft earthing receptacles is based on the US Military Specification MIL-C-83413 and receptacle location as indicated at Paragraph 39.

37. The recommended earthing receptacle locations on aircraft are as follows:

- **a.** one receptacle at each inlet for aircraft fuel;
- **b.** one receptacle at each pylon hard-point or other attachment point for armament equipment; and
- **c.** one or more receptacles at points convenient for an interconnection lead between aircraft and earth mass.

Fluid Dispensing GSE

38. GSE used for dispensing fluids, (gases and liquids) except engine and hydraulic oil replenishing dollies, is to be fitted with interconnection hardware as detailed in Figure 14–4, Figure 14–5, Figure 14–6 or Figure 14–7. Specific interconnection hardware requirements for GSE dispensing flammable and non-flammable fluids are as follows:

- **a. GSE Dispensing Flammable Fluids.** GSE such as AVGAS and AVTUR tankers and underground fuel supply hydrant carts which dispense flammable fluids should be provided with two or more safety interconnection leads. Additionally, a safety interconnection lead should be provided at the delivery end of the fuel dispensing hoses, for connection to the aircraft. This lead should be a minimum of 122cm in length to allow connection to earth points that may be located a maximum of 104cm from the refuelling point.
- **b. GSE Dispensing Gaseous Oxygen.** Gaseous oxygen carts should be provided with two or more safety interconnection leads. Whilst gaseous oxygen is classified as non-flammable, the dangers involved during aircraft oxygen replenishment dictate that oxygen should be treated as a flammable fluid. However, when replenishing airborne oxygen systems, earthing of the filling connector to the aircraft is not necessary.
- **c. GSE Dispensing Non-Flammable Fluids.** GSE dispensing non-flammable fluids such as hydraulic rigs, air-conditioning carts, air supply carts and nitrogen gas replenishment trolleys, should be fitted with one safety interconnection lead.

GSE Supplying Electrical Power

39. GSE capable of supplying only electrical power to an aircraft is **NOT** to be fitted with safety interconnection leads. At no time is an item of GSE supplying external electrical power to an aircraft to be bonded to the earth mass.

CAUTION

The safety interconnection lead on multi-purpose GSE is to be used when the GSE is supplying replenishing fluid only. The lead is not to be connected when the GSE is supplying electrical power only, or when simultaneously supplying electrical power and replenishing fluid.

Multi-purpose GSE

40. When an item of GSE is capable of supplying both non-flammable fluids and electrical power to an aircraft, it should be fitted with one safety interconnection lead for bonding to an earth reference point. The GSE safety interconnection lead is connected to the earth reference point before dispensing hoses are coupled to the aircraft. (See caution above).

General Purpose GSE

> **CAUTION**
>
> Work stands used in conjunction with fuel tank maintenance should comply with the requirements of paragraph 41.

41. Work stands used in conjunction with fuel tank maintenance should be fitted with bonding leads to enable the stand to be connected to an earth point and bonded to the aircraft. The stand should also be fitted with a static discharge plate made of copper, zinc or zinc coated material. The plate should be welded to the handrail at the entrance to the stand and should be marked “Personnel Static Discharge Plate”.

42. Generally, stands, jacks, electronic test equipment, vacuum cleaners etc, whether mains power operated or not, need not be fitted with safety interconnection leads.

Safety Interconnection Leads

43. Safety interconnection leads used on aircraft and GSE should to conform to one of the configurations detailed in Figure 14–4, Figure 14–5, Figure 14–6 and Figure 14–7. Four configurations are provided to enable companies to utilise the type most appropriate for local requirements. In some cases fitment of streamers to fuel tanker interconnection leads may not be appropriate. Accordingly, the fitment of streamers to fuel tanker safety interconnection leads is left to the discretion of individual companies.

TESTING INTERCONNECTION LEADS

Introduction

44. The following paragraphs detail the test and inspection procedures that should be followed when servicing safety interconnection leads used to provide electrical bonding between GSE, aircraft and earth reference points.

Responsibilities and Periodicity

45. The testing of safety interconnection leads should be carried out by electrical tradesmen at six monthly intervals.

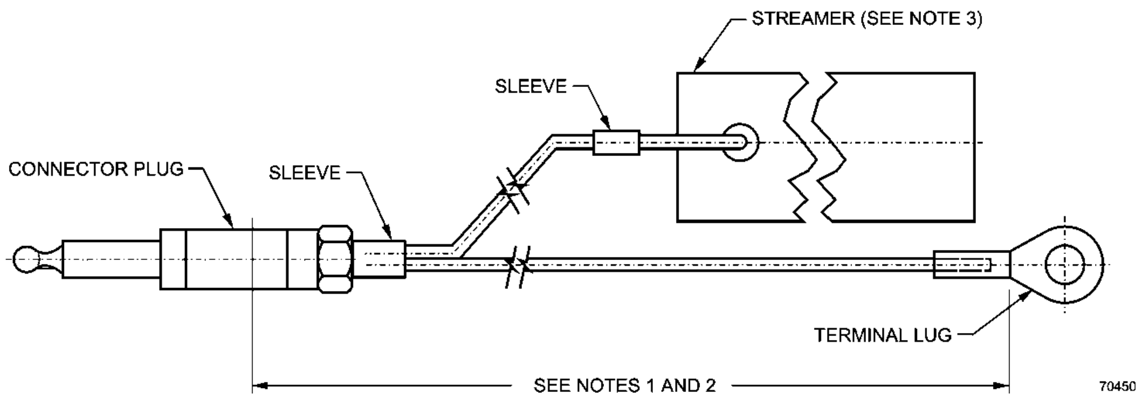


Figure 14–4 Safety Interconnection Lead (Configuration 1)

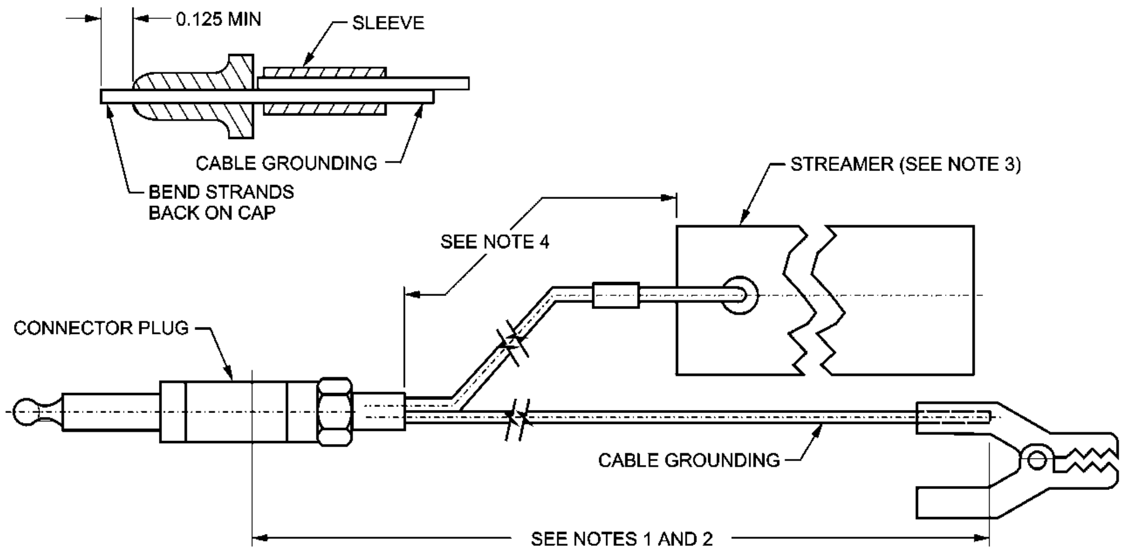


Figure 14–5 Safety Interconnection Lead (Configuration 2)

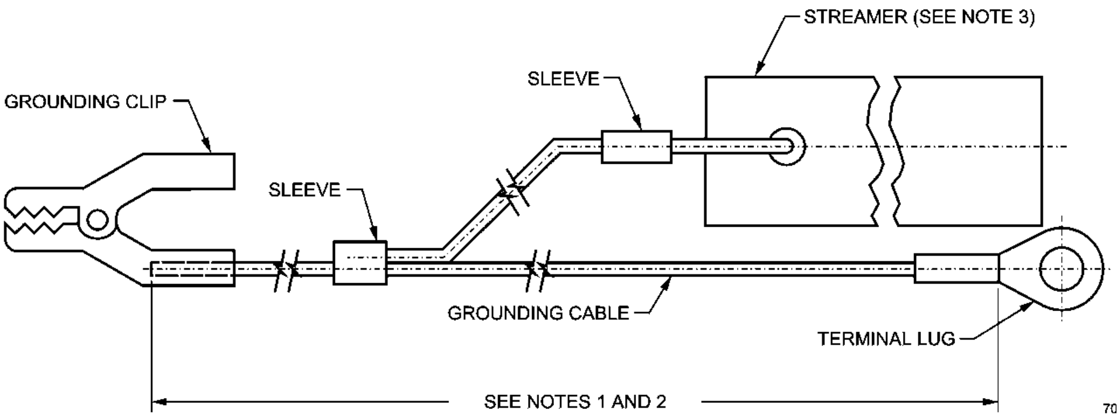


Figure 14–6 Safety Interconnection Lead (Configuration 3)

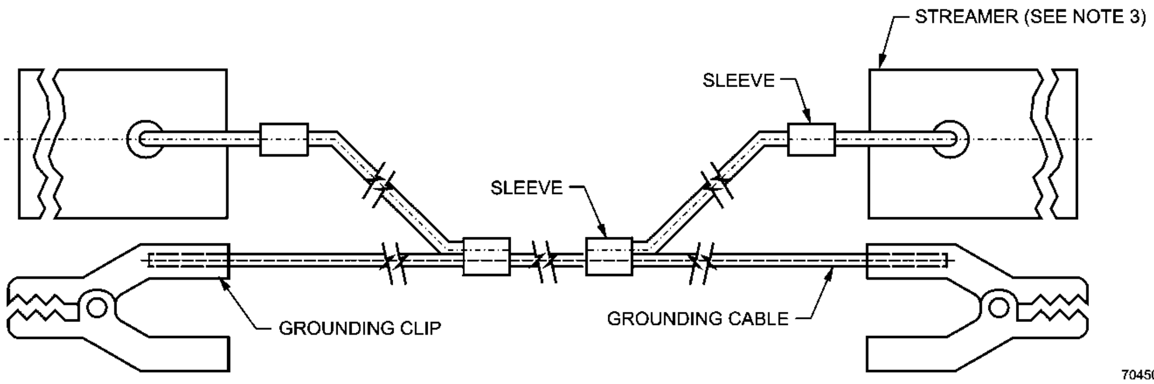


Figure 14–7 Safety Interconnection Lead (Configuration 4)

NOTES

(Refer to Figures 9–4 to 9–7)

1. Safety interconnection lead length should be determined by user requirements. (Maximum length 30 meters). Lengths are to be continuous. Splices are prohibited.
2. The maximum total resistance of the assembled lead should be:
   a. For leads less than 15 meters in length - 5 ohms.
   b. For safety interconnection leads, as fitted to fuel tankers, 15 to 30 meters - 10 ohms.
3. The streamer should be red, 50 ± 10 cm long, 8 ± 3 cm wide and have stencilled in white on both sides 'REMOVE BEFORE FLIGHT'.
4. The streamer should be no more than 40 cm from the connector plug or grounding clip.
5. A reel may be used to facilitate storage of the interconnection lead.
6. Refer to Table 14–1 for component identification.

Table 14–1 Parts List For Interconnection Leads

Item No	Description	Part Number
1	Connector, Plug	M83413/4-1
2	Clip, Grounding, Electrical	M83413/7-1
3	Cable, Grounding, Insulated	B1054-300
4	Terminal Lug, Crimp Style, Insulated	MS25036-XXX (Dash number as appropriate)
5	Streamer, Rayon or Cotton	Local Manufacture
6	Sleeve (cut crimp end from terminal lug)	MS25036-XXX (Dash number as appropriate)

Test Equipment

46. The test equipment to be used is either:

a. Resistance - Capacitance - Inductance Bridge, PN 250DA,

b. Gossen Earth Tester, PN GEOHM2, 66; or

c. a low voltage ohmmeter.

Procedure

47. Visually examine leads for deterioration of components.

NOTE

The cable, when new, has bright orange PVC insulation which fades in sunlight. Fading of this insulation in itself is not cause for replacement.

48. Measure the resistance between the safety interconnection lead extremities with any of the items detailed in Paragraph 46. The maximum permissible resistance end-to-end is:

a. For leads less than l5m in length, 5 ohms; or

b. For safety interconnection leads, as fitted to fuel tankers, with lead lengths 15 to 30m 10 ohms.

49. Leads passing this test may be released for further use.

50. Unserviceable leads fitted with Clip Grounding, PN M83413/7-1, should be removed from service and repaired as follows:

a. Withdraw roll pins and remove the steel jaw.

b. Clean the mating surfaces of the steel jaws and aluminium handles with a wire brush.

c. Smear mating surfaces with deoxidising product PN 50-851, and assemble clips using roll pin PN MS9048-007.

d. Check serviceability of cable and integrity of all electrical connections. Replace or repair as necessary.

e. Retest the safety interconnection leads in accordance with Paragraph 51.

51. Unserviceable leads not fitted with grounding clips are to be tested in accordance with Paragraph 53, steps d and e.

Recording Action

52. Safety interconnection leads should be marked with a serial number and tests are to be appropriately recorded. A suggested format for a log sheet is shown at Figure 14–8.

AIRCRAFT EARTHING RECEPTACLE INSPECTION PROCEDURE

Introduction

53. The following paragraphs detail the testing procedures for earthing receptacles fitted to aircraft. Where the contents of this chapter are at variance with an aircraft maintenance manual and the maintenance manual specifies a maximum resistance of less than 0.l ohm between the earthing receptacles and the aircraft skin, the maintenance manual should take precedence.

Responsibilities and Periodicities

54. The testing of earthing receptacles should be carried out by suitable qualified tradesmen. A test requirement should be incorporated in the aircraft schedule service.

> **WARNING**
>
> When testing bonding connections in enclosed areas where explosive vapours may be present, use ohmmeter PN T477W.

Test Equipment

55. The equipment to be used for this test is either:

a. Ohmmeter PN T477W, or equivalent for areas where explosive vapours may be present,

b. Milliohmmeter PN BT51, or equivalent for other areas.

YEAR:

Lead No	Location	Inspection Date	 Date	Resistance Readings	Rectification and Remarks

Figure 14–8 Suggested Format for Test and Inspection Log

Procedures

56. Visual Inspection. Inspect for loosely mounted receptacles and evidence of corrosion on washers, lugs, nuts and the aircraft skin.

57. Mechanical. Tests are performed using stainless steel plug PN M83413/4-1,. The plug is inserted in the receptacles being tested to ensure that the contact (spring) is seated in the plug detent.

58. Withdrawal Force. The longitudinal force required to remove the plug from the receptacle is 2.72 to 4.54kg. Less than 2.72kg indicates a weak or damaged receptacle contact (spring). (Ref. MIL-C-83413)

59. Engagement. There should be no free axial movement of the contact tip in the plug detent due to clearance between the contact (spring) tip and plug detent. Free axial movement indicates the contact is not maintaining connection with the plug.

60. Electrical Resistance Tests. Electrical resistance measurements to aircraft skin should be at a point where the aircraft skin is clean and unpainted. The DC resistance of cables, or test leads, including the plug used for making a specific resistance test, should be measured and subtracted from the reading for that specific test.

61. The DC resistance between earthing receptacles and the aircraft skin should be less than 0.l ohm. Greater resistance indicates a defective receptacle contact (spring), loose receptacle mounting or defective bonding strap, if used.

62. The DC resistance between earthing receptacles (electrical interconnection through aircraft frame or skin) should be less than l ohm. Greater resistance indicates defective or insufficient bonding.

TESTING GSE CONNECTION POINTS

Introduction

63. The following paragraphs detail the testing procedures for terminal connection points of safety interconnection leads that are fitted to GSE and refuelling equipment. Testing of safety interconnection leads is detailed in Paragraph 46.

Responsibilities and Periodicity

64. The testing of safety interconnection lead terminal connection points should be carried out by suitably qualified tradesmen.

Test Equipment

65. The test equipment to be used is either:

- **a.** Ohmmeter, PN T477W, or equivalent for areas where explosive vapours may be present; or
- **b.** Milliohmmeter, PN BT51, or equivalent for other areas..

Procedure

66. Test and inspection procedures for bonding connections are contained in Section 2, Chapter 13. The maximum permissible bonding resistance is 0.1 ohms.

GROUND EARTHING POINTS

Introduction

67. Ground earthing points are the connection points between aircraft or GSE and the earth mass. The point is constructed from a galvanised mild steel stake with a cast bronze head brazed to it. The assembly is driven into the ground, and, if the electrical resistance of the assembly to earth is within limits, it may be used to electrically bond aircraft and ground support equipment to earth mass.

68. Ground earthing points may be of two configurations, namely:

- **a.** standard ground earthing points, which are permanent installations; and
- **b.** temporary ground earthing points, which are for use when standard points are not available.

CAUTION

Ground earthing points other than those described below should not to be used for earthing aircraft.

Standard Ground Earthing Points

69. Standard ground earthing points, similar to the detailed drawing at Figure 14–9, should be located adjacent to aircraft parking positions. Ideally, sufficient points are to be available so that no more than one aircraft is connected to any one point; however, this requirement is not mandatory.

70. The installation of standard ground earthing points should be coordinated through aerodrome managers. Appropriate contractors should be made responsible for the installation and repair requirements. Testing of installed points should be conducted in accordance with Paragraph 81.

71. The rod and cap should be assembled by welding (brazing) with the rod projecting 25mm above the cap. When the rod has been driven into the earth mass so that the base of the cap is at the level of the hard-stand, the rod should then be cut off flush with the top of the cap.

72. The ground earthing point should be installed in such a manner that when the base of the cap has been driven to the level of the hard-stand there should be no lateral or vertical movement of the ground earthing point cap.

Construction

73. A sample ground earthing point specifications are detailed in Figure 14–9 and Figure 14–10.

Temporary Ground Earthing Points

74. Temporary ground earthing points should be manufactured using one of the following methods:

- **a. Preferred Method.** Made in the same form as a standard ground earthing point, (see Figure 14–9), except the minimum length is 50 cm.
- **b. Alternate Method.** When the standard earth point shown in Figure 14–9 is not available, temporary earth points may be manufactured using a galvanised mild steel rod with a brass top plate as shown in Figure 14–10.

> **CAUTION**
>
> In all cases where temporary points are to be installed, the local authority controlling the airfield is to be contacted to ensure that underground services will not be interfered with.

75. Temporary earth points should be used when operating from remote airfields where suitable standard ground earthing points are not available.

76. Temporary earth points need not be used for in-transit stops at civil or remote airfields where standard ground earthing points are unavailable; however aircraft and refuelling vehicles (or containers) must still be appropriately bonded. (Refer Paragraph 22).

77. Installation, maintenance and testing of temporary ground earthing points should be conducted by appropriately trained personnel.

TESTING GROUND EARTHING POINTS

Introduction

78. Manual of Standards Part 139 – Aerodromes section 11.1.16 Ground Earth Points details the requirements for installation and testing of earthing points. All standard ground earthing points used for the earthing of aircraft and GSE are to be regularly, tested and inspected. The following paragraphs describe the procedures that are to be used for testing, marking and recording of test results.

Maintenance of Standard Ground Earthing Points

79. Maintenance Periodicities. The following periodicities should apply to the maintenance of newly installed and existing standard ground earthing points:

- **a.** Newly Installed Ground Earthing Points - Resistance Measurement:
  - **(1)** Immediately after installation. (or any replacement)
  - **(2)** Six month after installation, or replacement.
  - **(3)** Thereafter as part of Aerodrome Technical Inspection
- **b.** Physical Inspection - Ground earthing points are to be physically inspected as part of the quarterly technical inspection to ensure that:
  - **(1)** The ground earthing point is firmly connected to the earthing rod and seated on the pavement.
  - **(2)** The earthing rod is firmly embedded in the ground.
  - **(3)** The fins used for making the electrical connections are free from dirt, grease, paint or any other substances.
  - **(4)** No ground earthing points have been buried or removed.

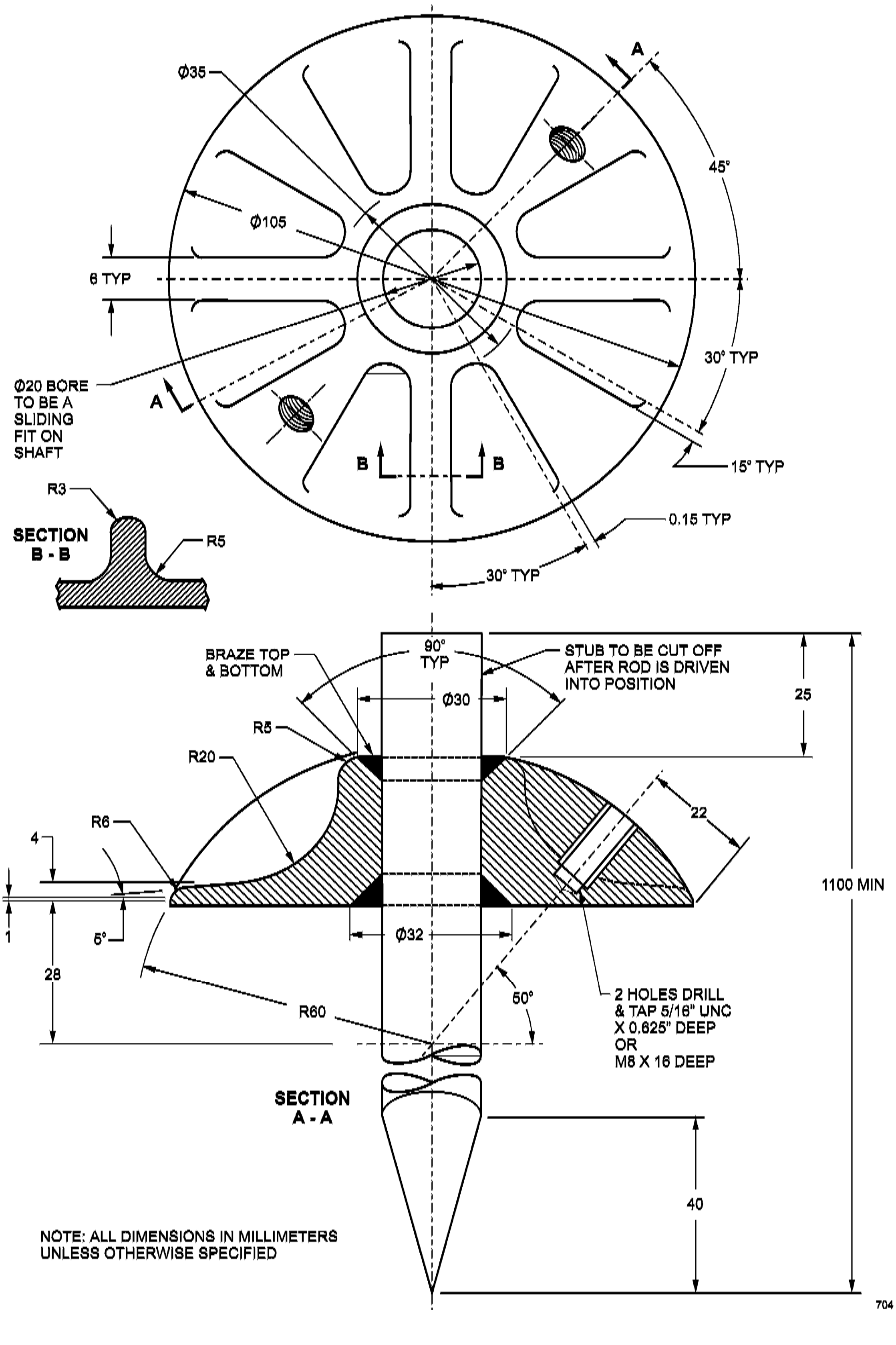


Figure 14–9 Standard Ground earthing Point

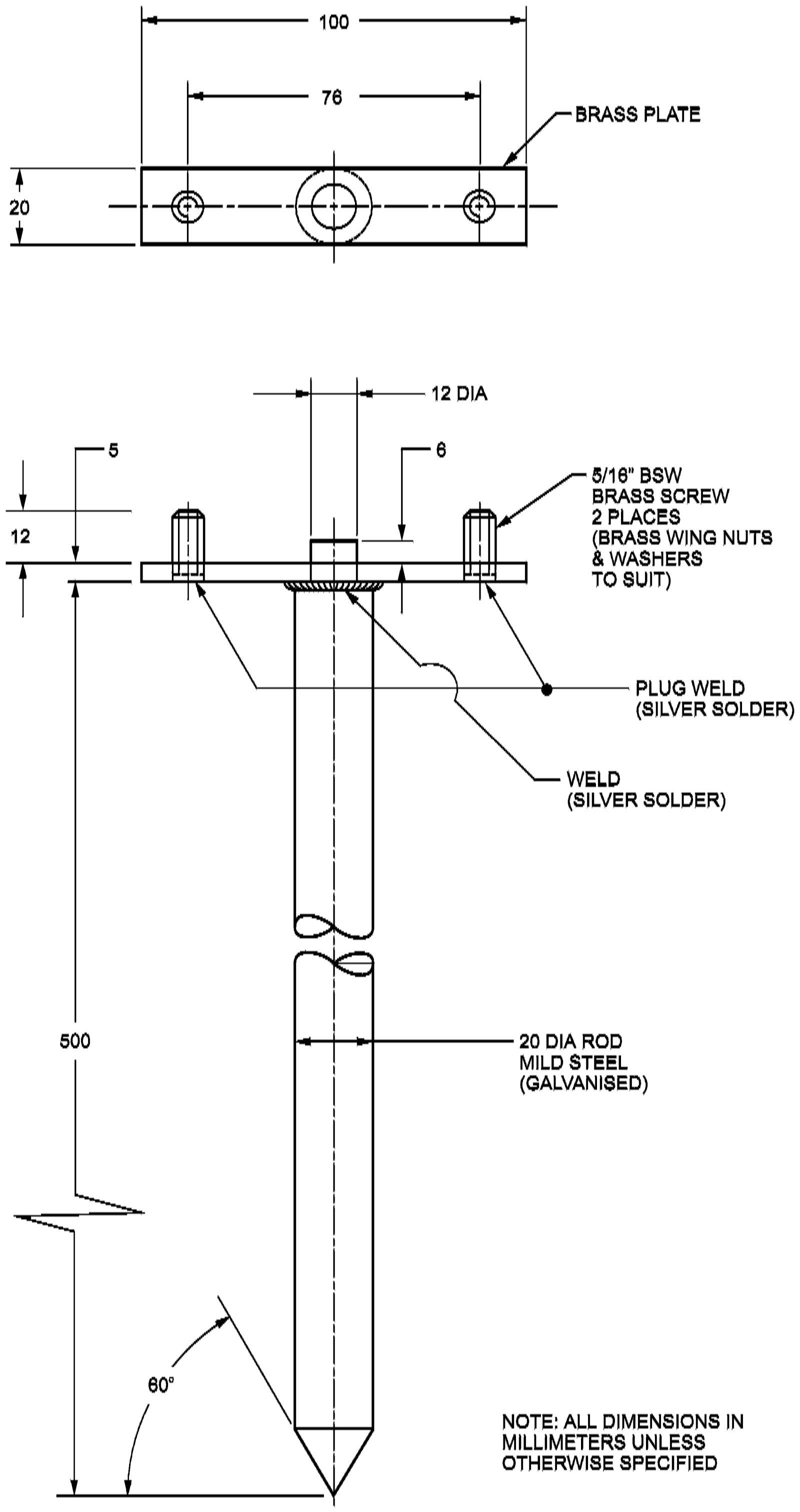


Figure 14–10 Temporary Ground earthing Point

Ground Earthing Check

80. Several methods may be used to measure the resistance of ground earthing points depending on the equipment used. The following method is recommended when using either a 'Gossen Earth Tester' Part No GEOHM or Part No GEOHM2:

a. Three Electrode Method. This is the preferred method of measuring the earth resistance of an ground earthing point. Using three collinear electrodes, (ie three ground earthing points A, B and C as shown in Figure 14–11), measure the resistance between each in turn. The resistance of earth point A is calculated from:

$$RA = \frac{RAB + RAC - RBC}{2}$$

Where:

RA is the resistance of reference point A

RAB is the resistance between points A and B

RAC is the resistance between points A and C

RBC is the resistance between points B and C

Serviceability of Ground Earthing Points

81. A serviceable ground earthing point is one having a resistance to earth mass of l0,000 ohms or less. Any point which has a resistance greater than 10,000 ohms is unserviceable and is to be serviced by authorised personnel.

Marking of Ground earthing Points

82. Serviceable ground earthing points should have a 15cm diameter circular white disc painted around the head.

83. Unserviceable ground earthing points that cannot immediately be repaired or replaced, the head of the ground earthing point must be either removed or marked with a 15cm diameter circle, painted red, to show it cannot be used.

Testing Temporary Ground earthing Points

84. Testing and recording requirements for temporary ground earthing points are as follows:

a. testing procedures are the same as those outlined in paragraph 80 for standard ground earthing points, except that either temporary or standard points may be used in the three electrode method;

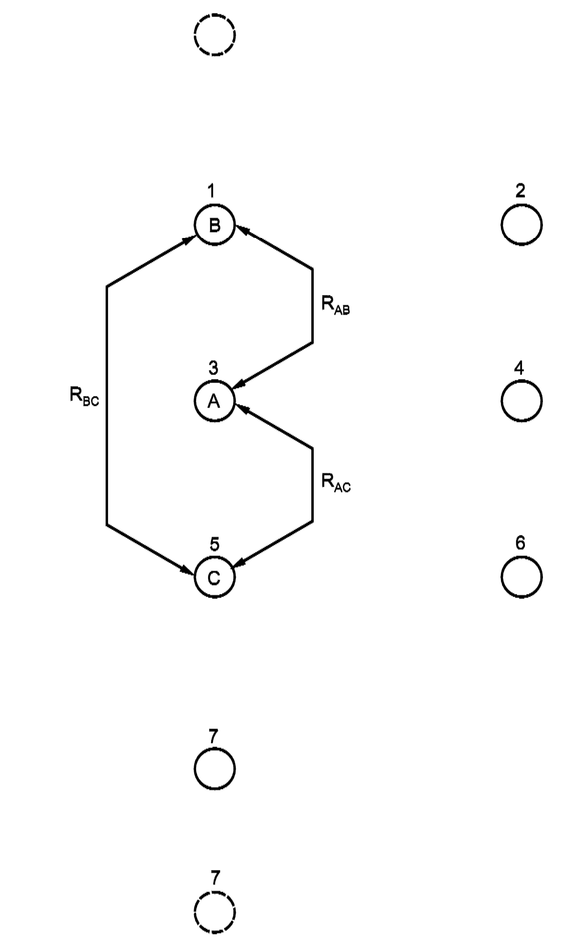


Figure 14–11 Ground earthing Point Test Setup for GEOHM Type Testers

Earth Point Number	Location	Six Monthly Inspection (Include Date)			Biennial Resistance Reading (Include Date)	Rectification Details or Remarks

Figure 14–12 Suggested Format for Test and Inspection Log

b. a point is to be classified serviceable if the resistance to earth is less than 10,000 ohms; and

c. points having a resistance in excess of 10,000 ohms are to be relocated and re-tested.

NOTE
Unserviceable temporary ground earthing points should not to be left embedded in the ground under any circumstances.

Log Books

85. A log book should be maintained in which details of earthing point locations, identification numbers, periodical test figures, rectifications and re-tests are recorded. Inclusion of a plan of ground earthing point location should also be provided. Log books should be capable of retaining information for at least six (6) consecutive years. Figure 14–12 is a suggested layout for a log book.

Helicopter Earthing Poles

86. Helicopter earthing poles are used to earth helicopters while in the hover, prior to personnel contacting the aircraft during cargo hookup etc. Details of a helicopter earthing pole are shown Figure 14–13. Each earthing pole should be inspected for general cleanliness, corrosion and fraying or damage to leads. Carry out a continuity test between the pole tip and the earthing clip or spike to ensure that the resistance is no greater than 2 ohms. This inspection and test should be carried out monthly and recorded in a log.

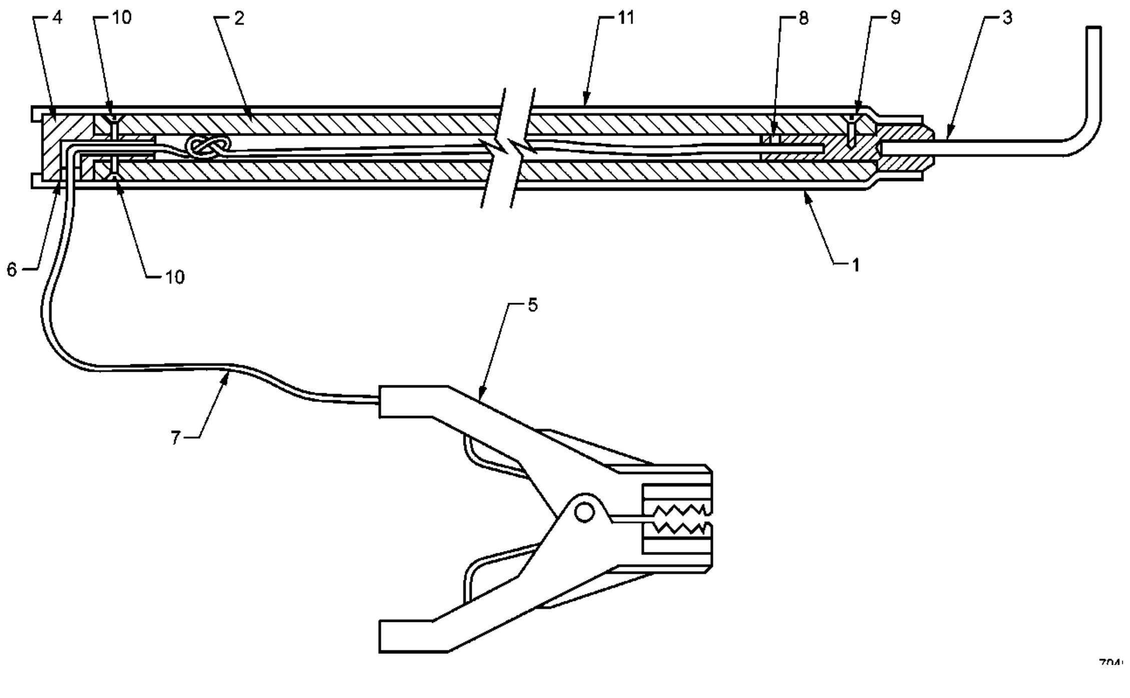


Figure 14–13 Helicopter Earthing Pole

MAINS OPERATED GSE

Introduction

87. Protection of personnel against electrical hazards associated with the use of mains powered GSE, ie soldering irons, drills, vacuum cleaners etc, is a significant aspect of aircraft earthing considerations. The mains earthing system will provide protection against hazards developing from internal faults in the equipment. However, when mains powered GSE is used inside aircraft there is a possibility of the aircraft structure becoming electrically live should the power lead become partially severed, or by other mischance the active conductor contacts the aircraft. In this event there is no guarantee that the protective circuit breaker/fuse would operate to disconnect the fault, owing to the possible high resistance to earth mass of the aircraft earth reference point.

Residual Current Devices, 250V, 50Hz

88. To provide protection for personnel in the event of a 250V, 50Hz, mains powered GSE equipment power lead shorting to an aircraft frame, core balanced residual current devices (RCD) are to be used wherever the type of GSE listed in paragraph 102, is operated in or near aircraft. The RCD's are available in either a 10 amp or 15 amp current rating.

Use of Residual Current Devices

89. RCD's are to be connected as close as possible, and directly to 240V 50Hz reticulated mains power outlets. This provides maximum protection of personnel in the event of damage to long trailing or extension leads.

Operation of 415V, 50Hz, Three Phase Mains Powered GSE

90. Protection of personnel using 415V, 50Hz, three phase mains powered GSE on aircraft would involve the installation of permanent three phase RCD's on maintenance facility power distribution boards. On consideration of the size and types of GSE requiring 415V, three phase power, eg. hydraulic test rigs, large vacuum cleaners etc, operation of these items physically in or on an aircraft is extremely unlikely. Therefore there should be no need to introduce 415V, three phase RCD's to existing installations unless warranted by specific circumstances in a particular area to ensure safety of personnel either using 415V, three phase equipment, or working in the immediate area.

91. Operation of 415V, three phase GSE, physically in or on an aircraft should be avoided. Also trailing leads supplying three phase power are not to be routed across aircraft, servicing stands or other GSE.

SECTION 2

CHAPTER 15

INSTALLATION OF BUSBARS, JUNCTION BOXES, PROTECTIVE DEVICES, AND TERMINAL BOARDS

INTRODUCTION

1. Procedures for installing equipment in aircraft are recommended in order to make installation easier, to standardize the methods used, and to provide the best possible protection for personnel and equipment.

2. This chapter describes procedures for installing busbars (including preparation), junction boxes, protective devices, and terminal boards in aircraft. It also describes methods of identification and protection and the correct use of hardware.

REFERENCE SPECIFICATIONS

3. The following specifications are applicable to busbars, conduit, junction boxes, protective devices, and terminal boards:

AN3064	Box Connector, Electrical
AN960	Washer, Flat
MIL-C-85049	Connector Accessories, Electrical
MS18029	Cover Assembly, Electrical, for MS27212 Terminal Board Assembly
MS21919	Clamp, Loop-Type, Cushioned Support
MS25082	Nut, Plain, Hexagon, Electrical-Thin
MS3373	Strip, Mounting, Nut Insulating, for MS27212 Terminal Board
MS35335	Washer, Lock, Flat - External Tooth
MS51957	Screw, Machine Pan Head, Cross-recessed, Corrosion Resistant Steel, UNC-2A
NASM21042	Nut, Self-Locking, 450°F, Reduced Hexagon, Reduced Height, Ring Base, Non-Corrosion Resistant Steel
NASM21044	Nut, Self-Locking, Hexagon-Regular Height, 250°F, 125 KSI FTU and 60 KSI FTU
NASM21047	Nut, Self-Locking Plate, Two Lug, Low Height, Steel, 125 KSI FTU, 450°F
NASM35338	Washer, Lock-Spring, Helical, Regular (medium) Series
NASM35649	Nut, Plain Hexagon, Machine Screw, UNC-2B
NASM35650	Nut, Plain-Hexagon , Machine Screw, UNF-2B
SAE AS 27212	Terminal Board Assembly, Molded-In Stud, Electric
SAE AS 7351	Clamp, Loop Type Bonding

PREPARATION AND INSTALLATION OF BUSBARS

General

4. Busbars are used in aircraft for power distribution. The most commonly used materials for busbars are bare aluminium, plated aluminium, or plated copper. Aluminium used for busbars is EC (electrical) grade.

Preparation of Busbars

5. Busbars for an aircraft electrical system must be clean and free from grease, dirt, and oxide. Any of these at the electrical junction will cause the connection to heat up and fail. Busbars are cleaned prior to installation in the aircraft and are also treated to prevent or minimize oxidation after installation.

> **WARNING**
>
> Use only approved cleaning compounds and approved procedures to clean aircraft electric components. The use of inappropriate cleaning compounds or failure to follow proper procedures may cause fires or explosions.

WARNING

Appropriate personal protective equipment should be worn when handling and using cleaning solutions.

Preparation of Unplated Aluminium Alloy Busbars

6. Clean unplated aluminium busbars by immersing in MIL-PRF-680 (Stoddard's solvent) or by wiping with a clean, soft cloth saturated with the solvent. Wipe dry with a clean, soft cloth.

7. After cleaning, treat all electrical contact surfaces as follows:

a. Cover contact surfaces completely with an even coating of petrolatum-zinc dust compound (50% petrolatum, 50% fine zinc dust, by weight).

a. Scratch brush the coated areas, using a rotary steel wire brush with a pilot as shown in Figure 15–1. Brush through the compound.

b. Remove most of the compound from busbar by wiping lightly with a clean, soft cloth.

c. Examine busbar to make sure that there are no steel brush bristles lodged in the aluminium.

d. Apply a thin coating of clean petrolatum-zinc compound to contact surfaces. This compound is the same as that supplied in MS aluminium terminal lugs.

NOTE

Allow final coat of compound to remain on busbar when installed. Excess will be squeezed out of connections and removed later.

WARNING

Use only approved cleaning compounds and approved procedures to clean aircraft electric components. The use of inappropriate cleaning compounds or failure to follow proper procedures may cause fires or explosions.

WARNING

Appropriate personal protective equipment should be worn when handling and using cleaning solutions.

Preparation of Plated Aluminium and Copper Busbars

8. Clean plated aluminium and copper busbars thoroughly by immersing in MIL-PRF-680 (Stoddard’s solvent) or by wiping with a clean, soft cloth saturated with the solvent. Wipe dry with a clean, soft cloth.

Repairing Damaged Plating

9. Examine contact surfaces of plated aluminium or copper busbars for damage to plating. Reject damaged aluminium busbars and return for rework. Repair slight damage to plated copper busbars by tinning with a soldering iron. Thoroughly wash and dry repaired areas. Do not attempt to repair plating on aluminium.

Mounting Hardware

10. When installing a copper busbar, always place cadmium plated steel plain washer between the busbar and the lockwasher or self-locking nut. (See Figure 15–2.) When installing an aluminium alloy busbar, place an aluminium alloy plain washer between the busbar and the lockwasher or self-locking nut.

Insulation

11. Insulate the busbar from structure, junction box, or support with a fibreglass, phenolic, or other rigid insulating stand-off as shown in Figure 15–2. Do not use any moisture-absorbing material.

Protection

12. Install busbars inside panels, junction boxes, or in protected areas when possible. If this cannot be done, protect the busbar with insulating tubing or other means of insulation. See Section 2, Chapter 4 for details.

INSTALLATION OF JUNCTION BOXES

General

13. Junction boxes are containers with hinged or removable covers used in aircraft to provide a protected area for electrical power distribution equipment such as busbars and terminal boards. The material of junction boxes is either metal or hard fibreglass.

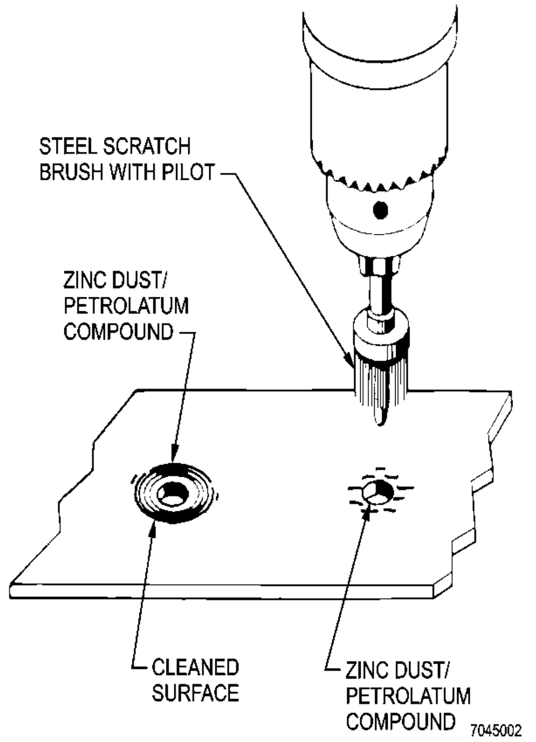


Figure 15–1 Scratch Brushing Unplated Aluminium Alloy Busbars

Mounting Hardware

14. Use standard AN bolts or screws of the appropriate size to attach junction boxes to aircraft structure. (See Figure 15–3.) Insert screws or bolts so that the head of the screw or bolt is inside the junction box. Do not install attaching hardware so that threaded part of the screw or bolt protrudes inside the junction box, as the sharp thread edges will damage wire insulation.

Insulation

15. The inside of metallic junction boxes is coated with white glyptal or similar material to insulate wiring from the metal, to improve visibility and to make inspection easier. Non-metallic junction boxes need not be so insulated. If this coating is damaged during the installation procedure, repair the damaged parts with, the same material as used in the original installation. When a new metallic box is installed, make sure the insulating coating is present and undamaged.

Junction Box Covers

16. Junction box covers may be hinged or attached by means of screws. Screw threads must not extend into the box in the vicinity of wiring. The sharp threads may cut wire insulation. If covers are not hinged, secure the cover to the box with an insulated bead chain, or No. 14 wire, as shown in Figure 15–4. Make this attachment outside the box so that when the box is closed the chain or wire will not interfere with the wiring.

NOTE

If covers are bent during installation or repair, straighten them before final attachment.

Preparation of Wire Entry Holes

17. Determine the outside diameter of the wire, or wire bundle, and make sure that the opening is at least 3mm larger in diameter to allow for later enlargement of the bundle. Use a box connector and cable clamp to protect wiring if this is indicated on the engineering drawing.

CAUTION

Deburr the inner surface of box connectors.

NOTE

When a box connector is not used, protect the edges of the entry hole with plastic or fibre grommets. (See Figure 15–5.)

Drainage of Junction Boxes

18. Provide one or more drainage holes (4.7mm diameter minimum) at the lowest point of the junction box when the aircraft is on the ground. After drilling drainage holes in metal junction boxes, deburr the edges of the hole with a deburring tool or a file.

CAUTION

Do not drill holes in vapour-tight junction boxes.

Vapour Tight Boxes

19. Vapour-tight junction boxes in aircraft are identified as such on the covers. When doing work of any kind on vapour-tight boxes, carefully follow the instructions given in the aircraft manufacturer's handbook of maintenance instructions for the specific aircraft model.

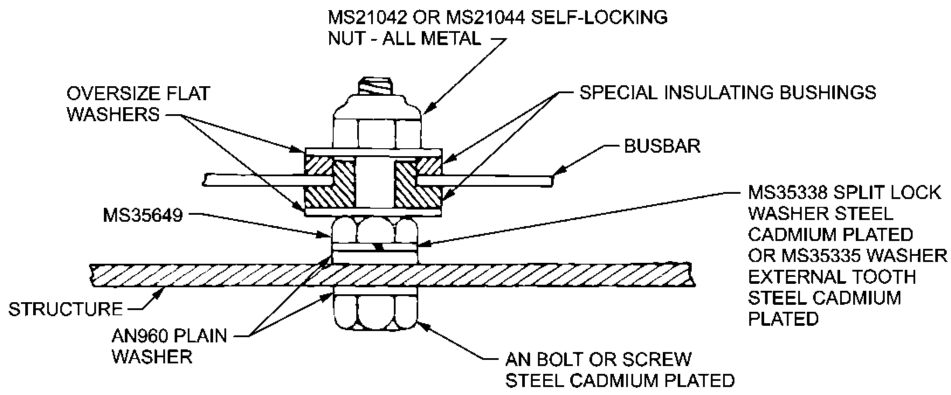


Figure 15–2 Mounting Busbars to Structure

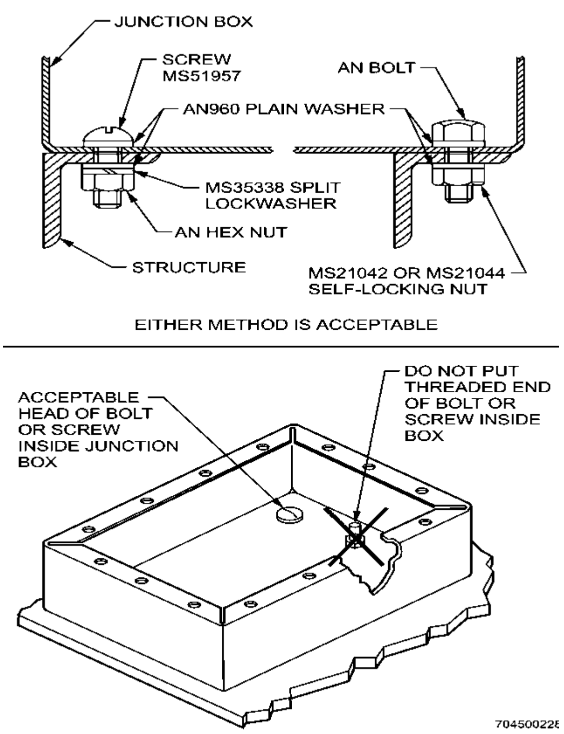


Figure 15–3 Attaching Junction Box to Structure

Identification

20. If junction boxes, as originally installed, are not identified, it is not necessary to do so. If the junction box does have identification marking, make sure marking is replaced as in original.

Bonding or Grounding Junction Boxes

21. Bond or ground junction boxes to structure by direct metal-to-metal contact or by means of a bonding jumper. Test bond or ground as described in Section 2, Chapter 13. Grounding of equipment in non-metallic boxes shall be on an individual basis, not in series.

INSTALLATION OF PROTECTIVE DEVICES

General

22. Protective devices are items of electrical equipment such as circuit breakers, fuses, etc., installed in aircraft to protect the electrical system against overloads caused by short circuits or other faults.

Circuit Breakers

23. A circuit breaker is a device designed to open and close an electric circuit and to open the circuit automatically at a predetermined overload current, without damage to itself. The primary purpose of circuit breakers in aircraft is to provide overcurrent protection for wire and cable and to minimise the danger of smoke and fire.

24. Correct circuit breaker selection should result in a protective device with the lowest standard rating that will not trip inadvertently. It must interrupt the fault or overload current by disconnecting the faulted line from the power distribution point before any wire or insulation damage occurs.

25. The nameplate current rating of circuit breakers is a nominal rating for identification and the actual useable rating for a particular application may be considerably different. Most circuit breakers must carry approximately 115% of their rated current indefinitely. This excess is to provide a tolerance for the effects of wear, vibration etc. The instantaneous trip current is usually in the order of ten times the current rating of the circuit breaker. The applicable Military Standard (MS) should be reviewed when determining the actual trip current for a circuit breaker.

26. When selecting a circuit breaker for a particular application all the variables should be considered. These variables include time-current characteristics of the circuit breaker, start-up surges of equipment, wire type, size and location (ambient temperature) and the maximum altitude at which the equipment is likely to operate. The current carrying capacity of a wire varies considerably depending on the application and should be determined using the graphs contained in SAE AS50881.

27. Both magnetic and thermal type circuit breakers are available however circuit protection in aircraft is primarily provided by thermal circuit breakers which are dependent on temperature rise in the sensing element for actuation. Operation is achieved by deflection of a bi-metal strip that will open the circuit at a pre-determined temperature. Temperature rise in the sensing element is caused principally by the load current however this is affected by ambient temperature which can raise or lower the actual current at which the circuit breaker will trip.

28. Trip-free circuit breakers are normally used for all aircraft applications. Manual resetting of this type of circuit breaker cannot be effected while an over current circuit fault remains. Non trip-free circuit breakers are used when the application requires over-riding of the tripping mechanism, in an emergency, when the fault still exists. Both types of circuit breaker can be manually operated to both ON and OFF positions with power applied, without damage to the electrical contacts however circuit breakers should not be used as switches unless specifically designed for this purpose.

29. The trip characteristics of a circuit breaker can change when the trip mechanism has been dormant for long periods. This phenomenon is due to the high internal spring forces which are inherent in most circuit breakers and which can cause a static type of wear to the trip mechanism when in the closed position. Test data suggest that this condition can be prevented by periodically operating the circuit breaker manually with no electrical load, however manual operation should be limited to two or three times a year to avoid excessive dynamic wear of the tripping mechanism.

30. Where practicable, ‘power in’ and ‘power out’ wires should be physically separated to avoid the possibility of a short circuit negating the effect of the circuit breaker.

Mounting Hardware

31. If attaching hardware is furnished with the protective device, use it. If no attaching hardware is furnished, mount the protective device with standard AN cadmium plated steel screws or bolts of the appropriate size. When replacing a protective device, use hardware exactly the same as in the original installation except that a longer screw may be used if necessary.

Mounting with Through Bolts or Screws

32. When possible, attach protective devices to aircraft structure or other support with through bolts or screws. Install a plain washer under the head of the bolt or screw, and a plain washer and a split lockwasher under the nut. (See Figure 15–6.)

Mounting Into Tapped Hole or Nut Plate

33. When it is necessary to install a protective device with a screw into a tapped hole or a nut plate, install a plain washer and a split lockwasher under the screw or bolt head. (See Figure 15–7.)

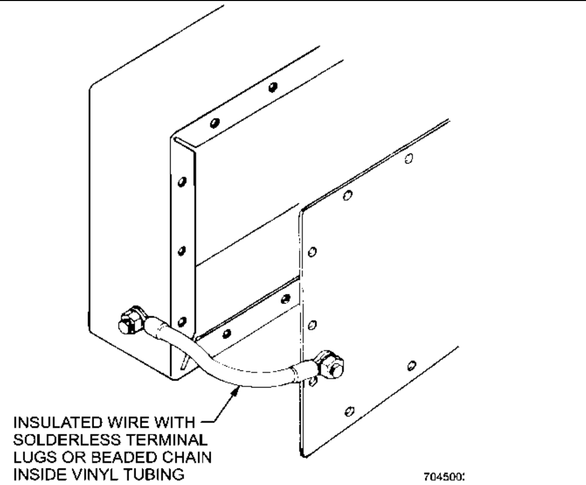


Figure 15–4 Attaching Cover to Junction Box

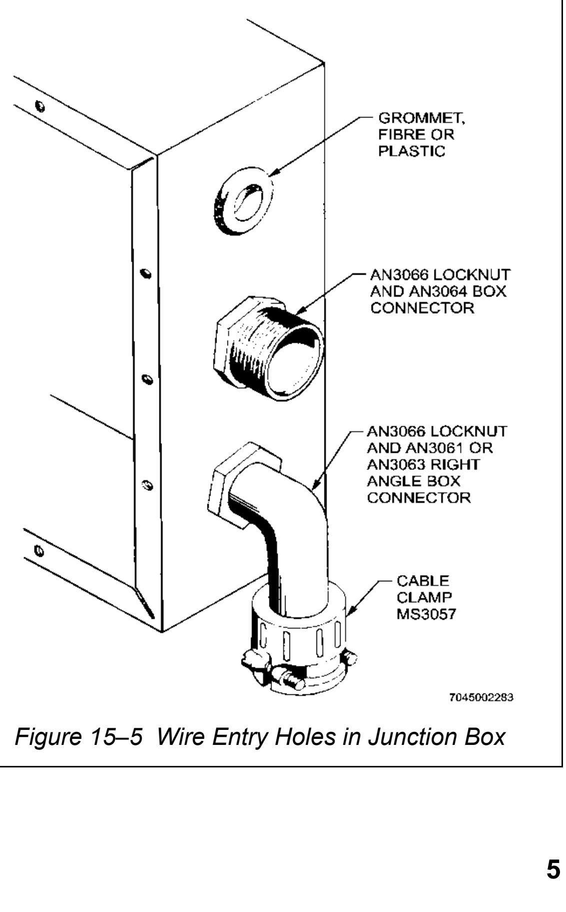


Figure 15–5 Wire Entry Holes in Junction Box

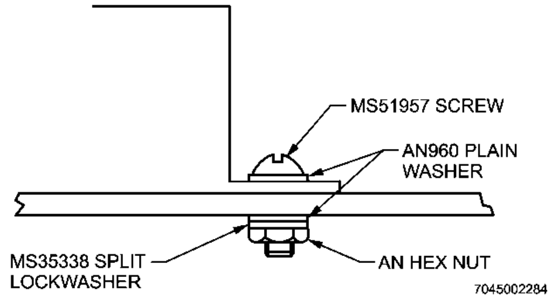


Figure 15–6 Mounting Protective Devices

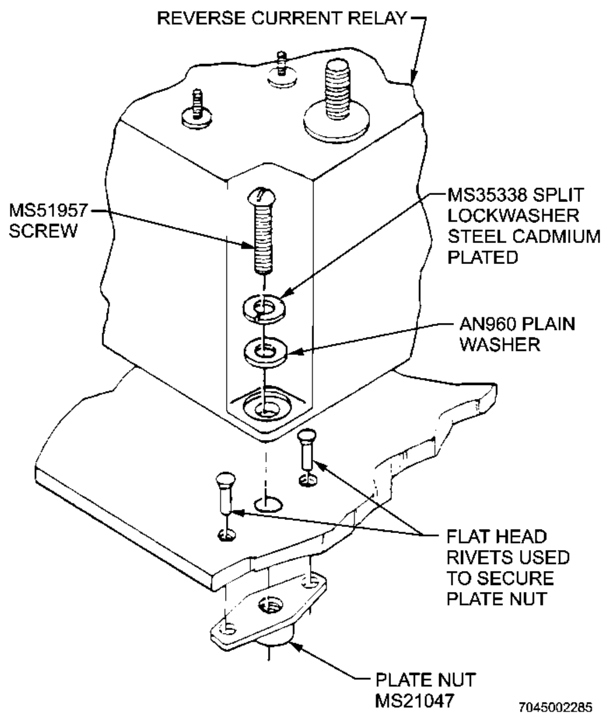


Figure 15–7 Typical Mounting Hardware for Protective Devices

Mounting Into Blind Hole

34. When a protective device must be attached with a screw into a blind tapped hole, make sure that the screw will give maximum thread engagement without bottoming in the hole. The length is determined as follows (see Figure 15–8):

a. Select a screw of approximately the correct length and install a plain washer and lockwasher on it.

NOTE
Do not mount the protective device when determining screw length.

b. Insert the screw into the blind tapped hole and thread it in until it bottoms in the hole. Plain and lock washers should remain free.

c. Back out the screw two turns and measure the length of screw between the under surface of the head and the top washer.

d. Measure the thickness of the mounting part of the protective device and subtract it from the measurement obtained in step c. If the device to be mounted is thicker than the dimension obtained in step c, repeat steps a, b, and c, using a longer screw.

e. Subtract dimension obtained in step d from the overall length of the screw; this will give the maximum length that can be used without bottoming in the tapped hole. If the final length is not a standard length, use the next shorter standard screw.

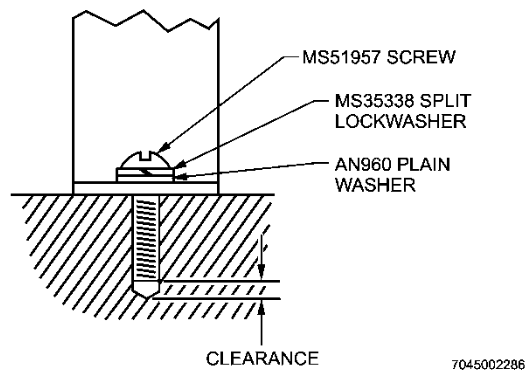


Figure 15–8 Determining Screw Length for Mounting into Blind Holes

Mounting Circuit Breakers

35. Mount switch circuit breakers so that when the switch breaker is in the off or open position, the handle will be down or to the rear.

Mounting Toggle Switches and Switch Guards

36. Mount switches and switch guards as follows:

a. Insert toggle switch through the mounting surface.

b. Adjust lower jam nut to obtain approximately 5 threads above the mounting surface.

c. Place switch guard over the switch and install upper jam nut.

d. Adjust the switch up or down as required with upper and lower jam nuts to obtain proper height of the switch lever.

e. When switch is adjusted to the proper height, it can be closed with switch guard and the guard will not interfere with switch operation (see Section 2, Chapter 9, Figure 9–10).

Mounting Relays

37. Mount relays so that foreign particles cannot fall between the terminals and so that liquid cannot accumulate inside the cover.

Special Precautions for Bonding or Grounding Connections

38. When a bond or ground connection is made through the mating surfaces of structure and mounting pad, prepare the contacting surfaces as described in Section 2, Chapter 13, before attaching the device to structure.

Protection

39. If possible, mount protective devices in junction boxes or protected areas. If this is not possible, and the devices are to be installed in locations where they may be subject to damage or where the terminals may be dangerous to personnel, provide a cover to go over the protective device.

Circuit Breaker Lockout/Deactivation

CAUTION

Use only red or white TEFLON devices for deactivating circuit breakers. Do not use black for this purpose.

40. When positive lockout/deactivation of an electrical circuit breaker is required, install circuit breaker collar PN 12E2081-9. and secure with a self-clinching cable tie-wrap.

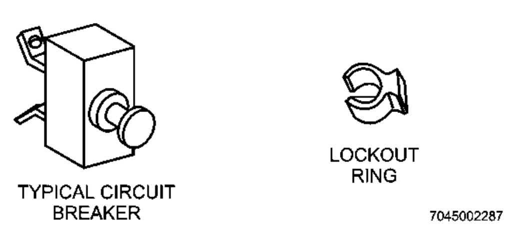


Figure 15–9 Circuit Breaker Lockout Ring

Circuit Breaker Blanking Plugs

41. When a circuit breaker is removed a blanking plug should be installed in the mounting hole. The following blanking plugs are suitable for this purpose: Metal Plug, PN NAS451-43 or Rubber Plug, PN G34.

Identification

42. Make sure that each protective device is identified by a plate or decal, permanently attached to adjacent aircraft structure. If the location of a protective device is changed, make sure that the identification marking is also relocated and completely visible. Make sure the new identification marking is exactly the same as the original.

INSTALLATION OF TERMINAL BOARDS

General

43. Terminal boards are used in aircraft to provide junction points of good electrical conductivity for circuits that are not frequently disconnected.

Mounting Hardware

44. Use standard AN cadmium plated steel hardware of the appropriate size.

Method of Attachment

45. Install mounting screws so that the screw protrudes through the bottom of the terminal board, as shown in Figure 15–10. The length of the screw should allow for some protrusion beyond the nut. Pass a steel scale or other flat piece of metal over the top of the nut. If it passes over freely, the screw is too short and is to be replaced with the next longer length. Protrusion of screw should not exceed two threads.

Alternative Method of Attachment

46. If it is not possible to install the mounting screw from the top of the terminal board, install it from the back, as shown in Figure 15–11. In this case, the end of the screw should project just beyond the top of the nut, but do not use a screw that will extend beyond the level of the terminal board mounting surface.

Insulation

47. Place an insulating strip over each mounting screw, long enough so it will go over the two adjacent terminal studs. If there is no terminal mounted to the stud the insulating strip should be secured to the board under a nut and washers as shown in Figure 15–12. The MS14151 washer is not required if a busbar is installed on the terminal stud.

Attaching Busbar to Terminal Board

48. When a MS25226 busbar is to be attached to a MS25123 terminal board, mount the busbar directly on top of the nut that holds the terminal stud in place. When MS25226 busbar is to be attached to a MS27212 terminal board, mount the busbar directly on the base of the moulded-in stud, and above the insulating strip (MS3373) if used. (See Figure 15–12 and Section 2, Chapter 4, Figure 4–18).

> NOTE
>
> If aluminium busbars are removed and are to be reinstalled, examine the busbar for deformation before reinstalling it. If there is any deformation, discard it and install a new busbar.

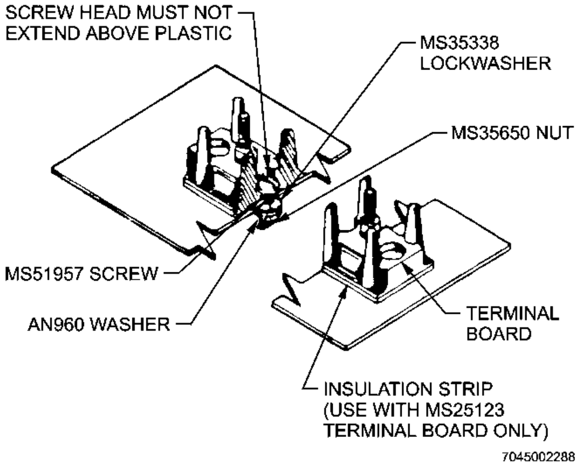


Figure 15–10 Mounting of Terminal Board

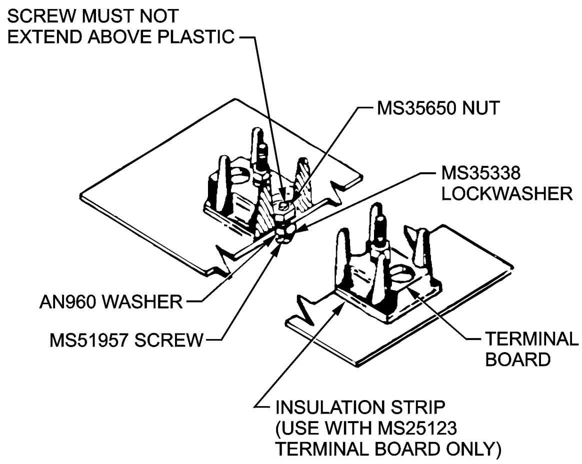


Figure 15–11 Alternative Mounting of Terminal Board

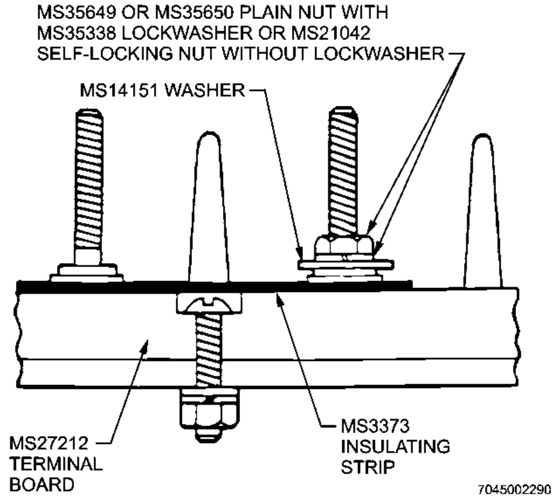


Figure 15–12 Insulation of Terminal Board

Protection of Terminal Boards

49. Where possible, mount terminal boards inside junction boxes or other enclosures. If this is not possible, and the terminal board is located where it may be damaged, or may be dangerous to personnel, provide a cover. Use terminal board cover MS18029 on the MS27212 terminal board. Attach no more than two terminal lugs on the stud that is to be used for mounting the cover to the terminal board. If no cover is available the terminal board may be protected by a wrapping of insulating sheeting. Use a piece of insulating sheet large enough to make a generous lap over the studs. Punch holes in the insulating sheet, install it over the grounded studs, and fasten with nuts and washers.

Identification

50. Each terminal board in the aircraft electrical system is identified by the letters TB, followed by a number which is the number of the individual board. Each stud on the terminal board is identified by a number located adjacent to it, with the lowest number in the series at the end nearest the terminal board identification number. (See Figure 15–13.) The identification may be marked on the aircraft structure to which the terminal board is attached or may be on an identification strip cemented to the structure under the terminal board. When a terminal board is replaced, do not remove the identification marking unless it has been damaged. In that case replace the identification marking exactly as in the original, in accordance with the applicable wiring diagram.

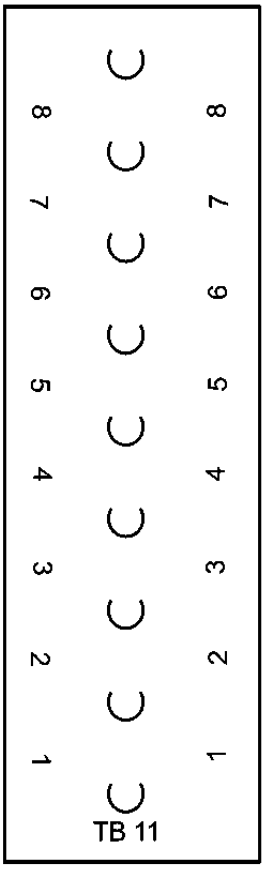


Figure 15–13 Identification of Terminal Board

SECTION 2

CHAPTER 16

THERMOCOUPLE WIRE SOLDERING AND INSTALLATION

INTRODUCTION

1. Thermocouples are used in aircraft to detect and measure temperature changes. They consist of a pair of dissimilar metallic conductors that detect changes in temperature and are used to measure that change. Thermocouples are supplied with short leads that end in terminals such as AN5548 or AN5539. At installation, the technician fabricates extension leads to carry the voltages generated by the thermocouple to the indicating instruments. The components of a thermocouple system are designed to have a high degree of accuracy; correct installation is required to maintain this accuracy.

2. This chapter describes and illustrates recommended procedures for fabrication and installation of thermocouple extension leads.

3. The importance of good workmanship in the fabrication and installation of thermocouple wires cannot be over-emphasised.

REFERENCE SPECIFICATIONS

4. The following specifications are applicable to thermocouple wire soldering and installation:

A-A-54192	Rosins: Gum, Wood, and Tall Oil
AN5537	Connector Assembly – Thermocouple Lead
AN5538	Terminal – Thermocouple Lead Soldering
AN5539	Terminal – Thermocouple, Brass
AN5548	Terminal – Lug, Thermocouple, Chrome1 and Alumel
MIL-PRF-680	Degreasing Solvent (Stoddard's Solvent)
MS25036	Terminal, Lug, Crimp Style, Copper, Insulated, Ring-Tongue, Bell-Mouthed, Type II, Class 1
O-F-499	Flux, Brazing, Silver Alloy, Low Melting Point
QQ-B-654	Brazing Alloy, Silver
SAE AS 7928	Terminal, Lug and Splice, Crimp Style, Copper
TT-I-735	Isopropyl Alcohol

DESCRIPTION

Thermocouple Wire Leads

5. Thermocouple extension wires (see Figure 16–1) are paired in a braided jacket and colour-coded as detailed in Table 16–1. The material for extension leads is the same as the thermocouple material. Iron-constantan extensions are used for iron-constantan thermocouples, chromel-alumel extensions for chromel-alumel thermocouples, and copper-constantan extensions for copper-constantan thermocouples.

Thermocouple Terminals and Connectors

6. Selection of terminals for thermocouple wiring is based on location within the airframe, and on temperature conditions. Hot areas are those subject to high temperature, such as engine compartment, exhaust areas, etc. Cool areas are those on the side of the firewall away from the engine or other heat sources. Where the temperature does not exceed 120°C, use terminals listed in Table 16–2. Dash letters after basic numbers indicate whether terminal is plain or lock type, except for AN5538, where dash number indicates change in size only.

> NOTE
>
> Solderless terminals and splices may be used on thermocouple wires in cool areas.

7. Thermocouple connector AN5537 (shown in Figure 16–3) is used to carry thermocouple connections through firewalls. This is a plug and jack connection, supplied with an insulating plate for attachment to the firewall. Plugs and jacks are supplied in chromel-alumel or iron-constantan combinations. The jack part of the connector is installed on the cool side of the firewall. The pin plug part of the connector is installed on the hot side of the firewall.

Table 16–1 Thermocouple System

IRON CONSTANTAN SYSTEMS

	Conductor	Insulation Colour	Polarity	
	Iron Constantan	Black Yellow	Positive (+) Negative (–)	
	Type II – 8 ohms per 30.5 m.		**Type III – 8 ohms per 61.0m.**	
	Class A	Class B	Class A	Class B
Outer Jacket Base Colour	Light Blue	Light Blue	Light Blue	Light Blue
Tracer Colour	None	One Red	Two Black	Two Red
Temperature Limit of Insulation	120°C	230°C	120°C	230°C

CHROMEL-ALUMEL SYSTEM

	Conductor	Insulation Colour	Polarity
	Chromel Alumel	White Green	Positive (+) Negative (–)
	Type II – 7 ohms per 7.6m.	**Type III – 7 ohms per 15.2m**	**Type IV – 7 ohms per 30.5m**
	Class A	Class A	Class A
Outer Jacket Base Colour	White	White	White
Tracer Colour	One Green	Two Green	Three Green
Temperature Limit of Insulation	315°C	315°C	315°C

COPPER-CONSTANTAN SYSTEM

<table>
<tr><td></td><td>Conductor</td><td colspan="2">Insulation Colour</td><td>Polarity</td></tr>
<tr><td></td><td>Copper
Constantan</td><td colspan="2">Red
Yellow</td><td>Positive (+)
Negative (–)</td></tr>
<tr><td></td><td colspan="4">Type II – 7 ohms per 61.0m.</td></tr>
<tr><td></td><td colspan="2">Class A</td><td colspan="2">Class A</td></tr>
<tr><td>Outer Jacket Base Colour</td><td colspan="2">Black</td><td colspan="2">Black</td></tr>
<tr><td>Tracer Colour</td><td colspan="2">One White</td><td colspan="2">Two White</td></tr>
<tr><td>Temperature Limit of Insulation</td><td colspan="2">120°C</td><td colspan="2">230°C</td></tr>
</table>

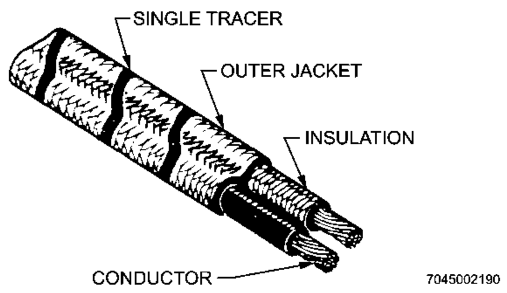


Figure 16–1 Thermocouple Wire

Table 16–2 Thermocouple Terminals

	Hot Areas (Silver Soldered)	Cool Areas (Tin-Lead Soldered)
Iron-Constantan	AN5539	AN5538
Chromel-Alumel	AN5548	AN5538

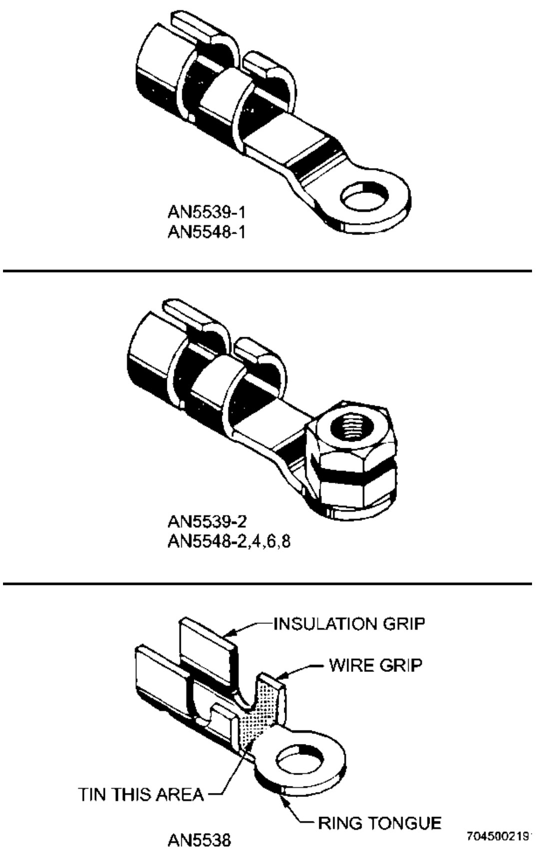


Figure 16–2 Thermocouple Terminals

Thermocouple Contacts in MS Connectors

8. MS type connectors may be supplied with iron-constantan or chromel-alumel contacts in sizes 12, 16, or 20 in insert arrangements for thermocouple connections. These contacts are coded to identify the material. (See Table 16–3.)

DEFINITIONS

9. Definitions are as follows:

a. Soft Solder. A mixture of 60% tin and 40% lead, as specified in J-STD-006. It may be in bar form to be melted for tinning, or in the form of rosin core solder wire for use with soldering iron.

b. Hard Solder. Silver alloy with flow point at approximately 635°C, as specified in QQ-B-654.

c. Soft Solder Flux. Fluxes shall conform to the requirements of J-STD-004.

d. Hard Solder Flux. For hard solder, use flux qualified to Federal Specification O-F-499, mixed to a paste-like consistency with water.

e. Soldering and Brazing. For purposes of this chapter, the term “soldering” includes soft soldering, silver (hard) soldering, and brazing.

THERMOCOUPLE WIRE PREPARATION

Cutting and Identifying Thermocouple Wire

10. Cut thermocouple wire with diagonal pliers to length specified in drawing. Cut so that end is clean and square. Identify wire with sleeves as described in Section 2, Chapter 2. If outer covering is removed more than 76mm from termination, install sleeve just back of serving at branching point (refer to Paragraph 21).

Stripping Thermocouple Wire

11. Remove outer covering, of thermocouple wire with a knife by slitting between parallel conductors and trimming the fabric braid with scissors or diagonal pliers. The stripping dimensions for each use are shown in Figure 16–4, Figure 16–5 and Figure 16–6. Note that longer stripped lengths are required if the wires are to be resistance tinned. Use a hand stripper, as illustrated in Section 2, Figure 3–3, for removing the primary insulation from each conductor.

Cleaning Wire Prior To Soldering

12. If necessary, clean stripped conductor as follows:

> **WARNING**
>
> Appropriate personal protective equipment should be worn when handling and using cleaning solutions.

a. Remove grease and dirt by brushing or wiping with MIL-PRF-680 (Stoddard’s Solvent).

b. Dry with clean lint free cloth.

> **CAUTION**
>
> Do not use extra heat and special fluxes as a substitute for clean soldering surfaces.

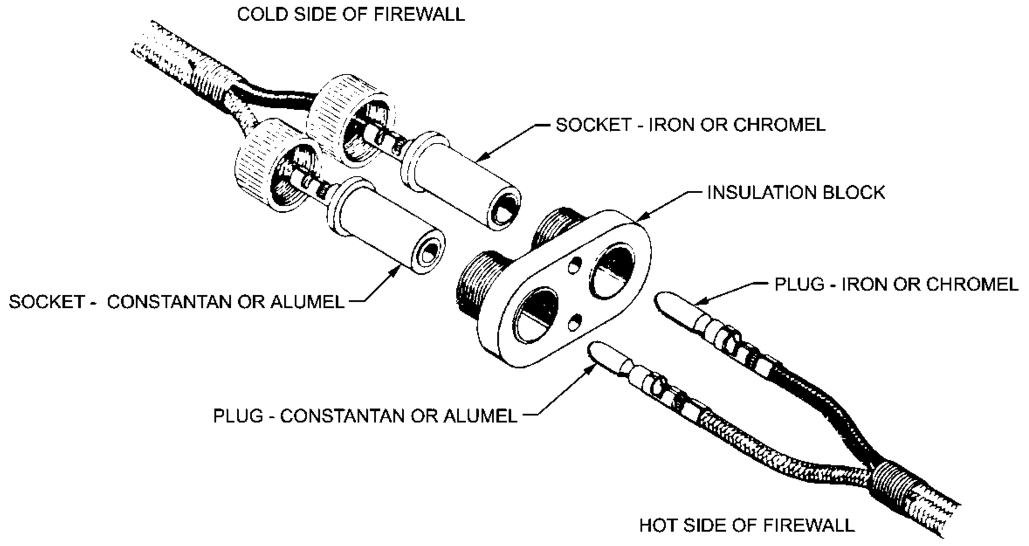


Figure 16–3 Thermocouple Connector Assembly (AN5537)

Table 16–3 Coding for Thermocouple Contacts in MS Connectors

Manufacturer	Method of Coding	Code			
		Iron	**Constantan**	**Chromel**	**Alumel**
Amphenol	Colour	White	Red	Green	Orange
Bendix	Letters	Ir.	Con.	Ch.	Al.
Cannon	Letters	IR	CO	CH	AL

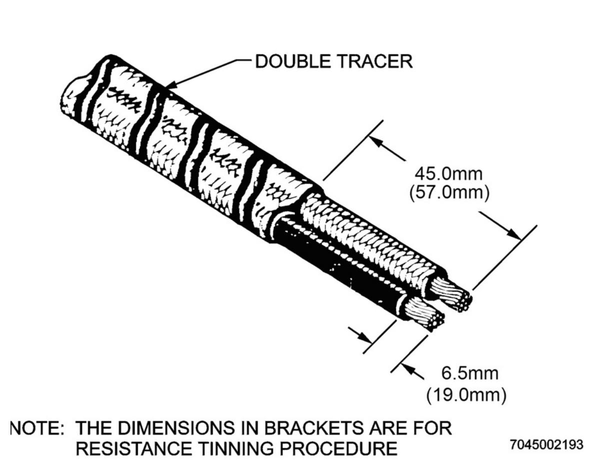


Figure 16–4 Stripping Thermocouple Wire for Terminal and for AN5537 Connector Installation

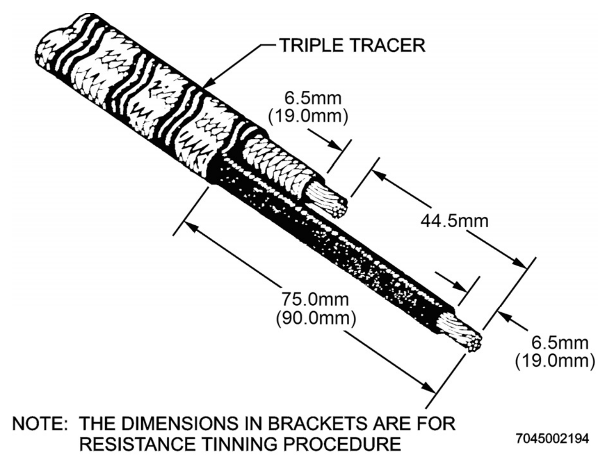


Figure 16–5 Stripping Thermocouple Wire for Splice Installation

HARD SOLDERING THERMOCOUPLE WIRE

Torch Tinning with Silver Solder

13. Before wires are soldered to terminals or other connections, they are tinned. The-inability to obtain a good tinned surface indicates that the wire was not clean. The procedure for torch tinning is as follows (see Figure 16–7):

WARNING

Open flames shall not be used on or near fuelled aircraft or in other hazardous locations.

a. Dip half of exposed, clean conductor into hard solder flux.

b. Protect wire insulation with notched copper sheet shield, to prevent scorching.

c. Apply flame to wire until flux bubbles. Then feed a small amount of silver solder, in wire form, to fluxed area while flame is kept there. After the silver solder has flowed, remove the flame and allow the wire to cool in the air.

CAUTION

Silver solder will flow and adhere to conductor at approximately 635°C. Avoid greater heat than necessary. Excess heat will decompose flux and prevent alloying of silver solder to the wire.

Dip Tinning Wire with Silver Solder

14. Thermocouple wires can be dip-tinned in molten silver solder if a solder pot capable of maintaining the required 635°C heat is available. The process is similar to that used in a dip tinning copper wire in soft solder as described in Section 2, Chapter 7. The procedure for dip tinning with silver solder is as follows (see Figure 16–8):

a. Dip half of exposed, clean conductor into hard solder flux.

b. Dip fluxed conductor into solder pot. Do not dip conductor deeper than one-half of exposed area.

NOTE

Powdered borax sprinkled over top of molten solder will retard oxidation of solder and aid alloying of silver solder to the wire.

c. After solder has flowed between strands, remove the wire and allow it to cool in air.

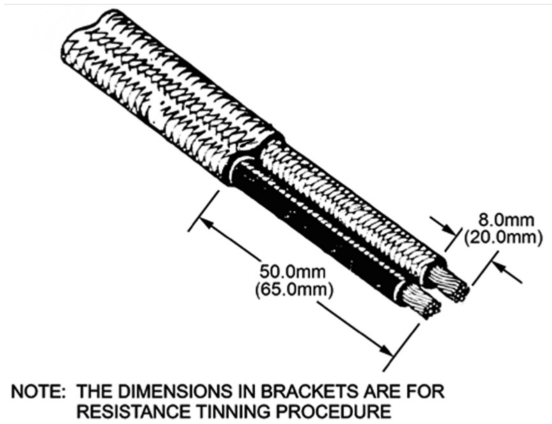


Figure 16–6 Stripping Thermocouple Wire for MS Connector Installation

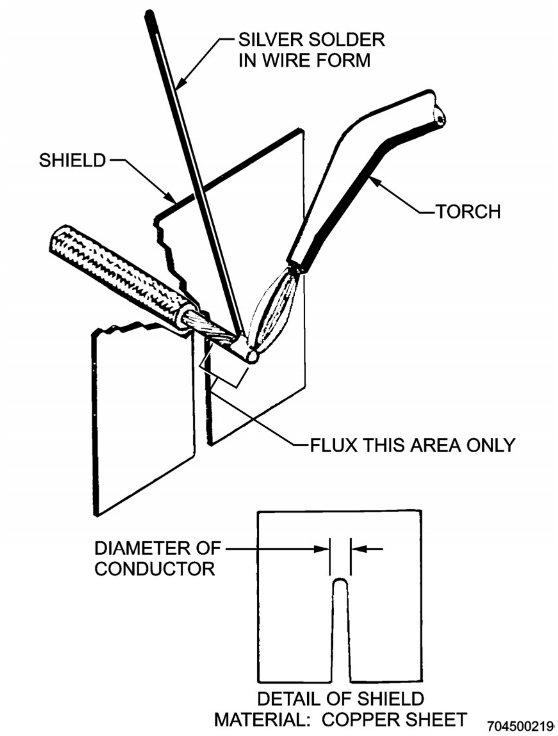


Figure 16–7 Torch Tinning Thermocouple Wire

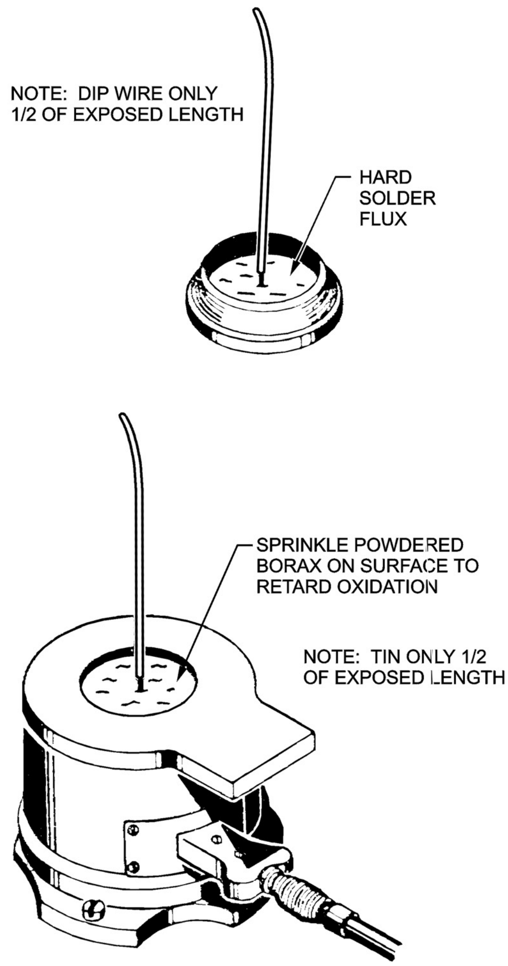


Figure 16–8 Dip Tinning Thermocouple Wire in Silver Solder

WARNING

Resistance soldering shall not be used on or near fuelled aircraft or in other hazardous locations.

Resistance Tinning Wire with Silver Solder

15. Electrical resistance heat is a good method for silver soldering thermocouple wires. Use a unit that has a capacity of 1000 watts (Figure 16–9). Wire that is to be tinned by means of electrical resistance should be stripped 12.7mm longer than wire which is to be dip-tinned or torch-tinned. The extra 12.7mm provides a holding area which is removed after tinning is complete. See Figure 16–4, Figure 16–5 and Figure 16–6 for stripping dimensions. The procedure for resistance tinning is as follows:

- **a.** Apply hard solder flux to area to be tinned. This is an area about 3mm long, as shown in Figure 16–9.
- **b.** Grasp end of wire in resistance heating pliers. Grasp wire only as shown.
- **c.** Apply current for approximately five seconds and then touch silver solder wire to area previously fluxed.
- **d.** After solder has flowed between strands, shut off the current and allow the wire to cool in air.

CAUTION

Do not overheat the wire by allowing the current to remain on longer than necessary to flow the silver solder.

- **e.** Trim off the holding area of the exposed conductor. The conductor should be trimmed with diagonal pliers to the point of tinning.

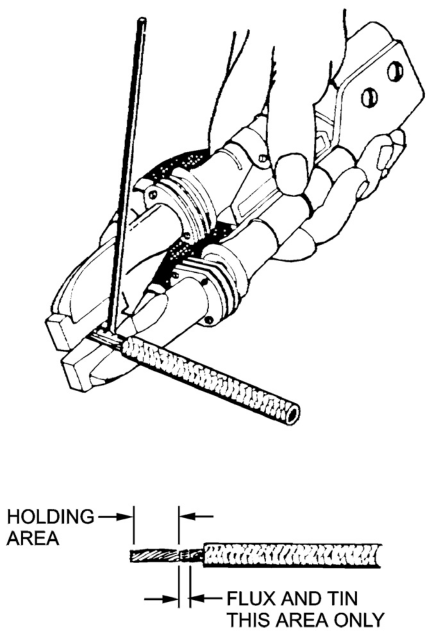


Figure 16–9 Resistance Heating to Tin Wire

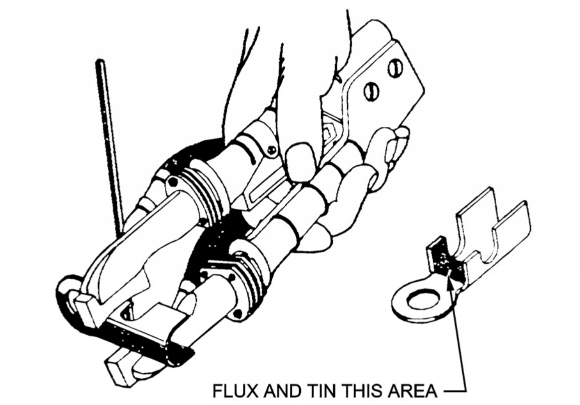


Figure 16–10 Resistance Tinning of Terminal

WARNING

Soldering may result in the emission of hazardous metallic fumes and vapours from fluxes used. Workers should position themselves so as not to directly inhale the fumes/vapours.

Tinning Terminals with Silver Solder

16. Tin only section of thermocouple terminals inside wire grip as shown in Figure 16–10. Terminals for silver soldering should not be plated.

CAUTION

Do not allow any flux or solder to get on the insulation grip or on the ring tongue.

a. With a brush, apply a small amount of hard solder flux to the area to be tinned.

b. Using a torch or the resistance heating pliers, melt a thin coat of silver solder onto inside of wire grip. See Figure 16–10 for use of resistance heating pliers in this operation.

c. Allow terminal to cool in air.

Procedure for Attaching Terminals to Thermocouple Wire

17. Secure terminal to thermocouple wire as follows:

a. Flux previously tinned areas of terminal and wire.

b. Install terminal on wire so that insulation is flush with or protrudes slightly beyond insulation grip. The tinned portion of the conductor should then be inside the wire grip. (See Figure 16–11.)

CAUTION

Do not crimp insulation grip until after soldering operation. The heat of soldering may damage insulation if insulation grip is tight during soldering.

c. Crimp wire grip over conductor using modified crimping tool illustrated in Figure 16–12.

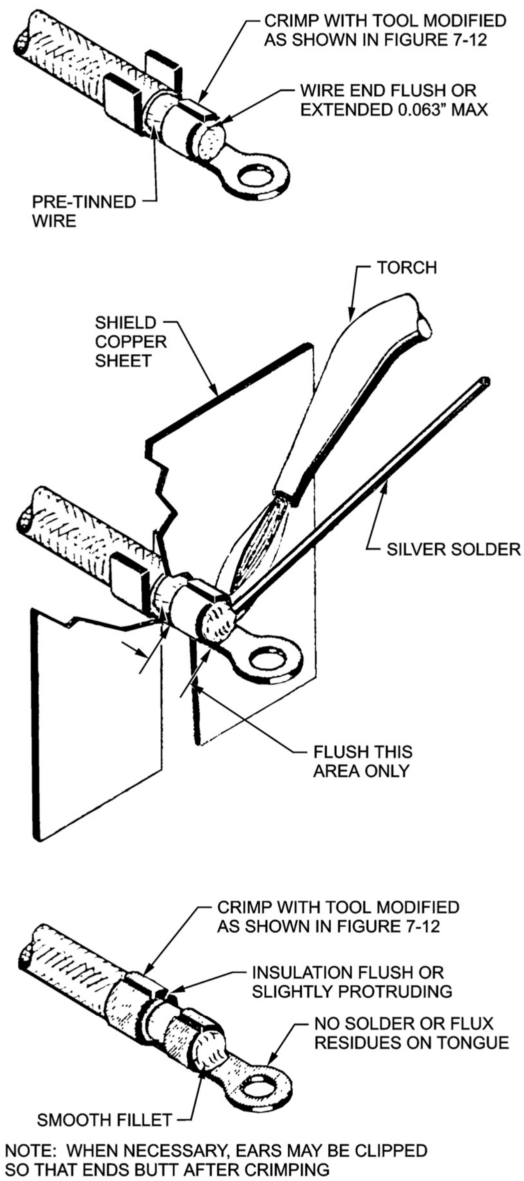


Figure 16–11 Silver Soldering Thermocouple Wire to Terminal

Torch Soldering Terminals to Thermocouple Wire

18. Secure terminal to thermocouple wire as follows: (See Figure 16–11.)

a. Use copper shield to protect insulation.

b. Heat joint until flux bubbles and then apply silver solder wire to joint as shown. Keep flame in motion to assure uniform heating.

c. When solder has flowed down into wire grip, remove flame and allow joint to cool without disturbing it.

NOTE

AN 5539 terminals require reinforcement with silver solder at indicated areas. (See Figure 16–13).

CAUTION

Do not allow solder to flow onto ring tongue as this will prevent proper assembly into system.

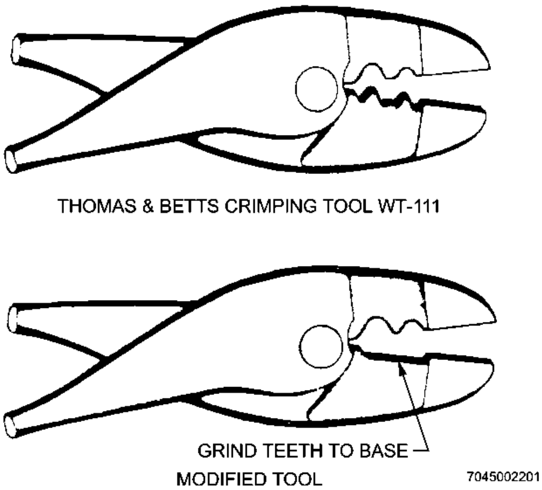


Figure 16–12 Modified Crimping Tool for Thermocouple Terminals

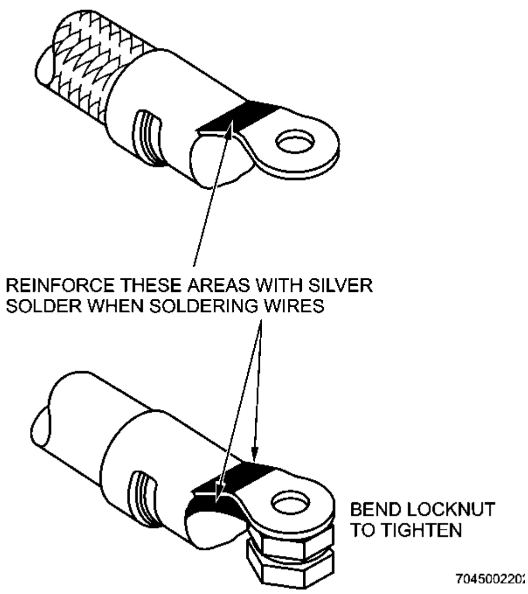


Figure 16–13 Reinforcing Solder on AN5539 Terminals

Resistance Soldering Terminals to Thermocouple Wire

19. Secure terminal to thermocouple wire as follows:

a. Grasp terminal and wire assembly, prepared in accordance with Paragraph 17, at wire grip area. The resistance heating pliers are to be in the position shown in Figure 16–10.

b. Apply current until flux bubbles; then apply silver solder wire to connection from conductor end of assembly.

c. Continue to apply heat and watch for flow of solder inside wire grip. When solder is visible at opposite end of wire grip from where it was applied, turn off current.

d. Allow assembly to solidify before removing from pliers.

Cleaning and Completing Silver Soldered Terminal Connections

20. After the silver solder has solidified and cooled, the junction must be completed as follows:

a. Remove flux residues with warm water and a bristle brush, then dry thoroughly.

b. Secure insulation grip on insulation using modified crimping tool shown in Figure 16–12. The final result is shown in Figure 16–11.

NOTE

Insulation grip tabs may be trimmed so they butt.

c. Examine junction to be sure that silver solder has alloyed to wire and terminal. Examine also to be sure that insulation has not been scorched. Rework any connection that is defective.

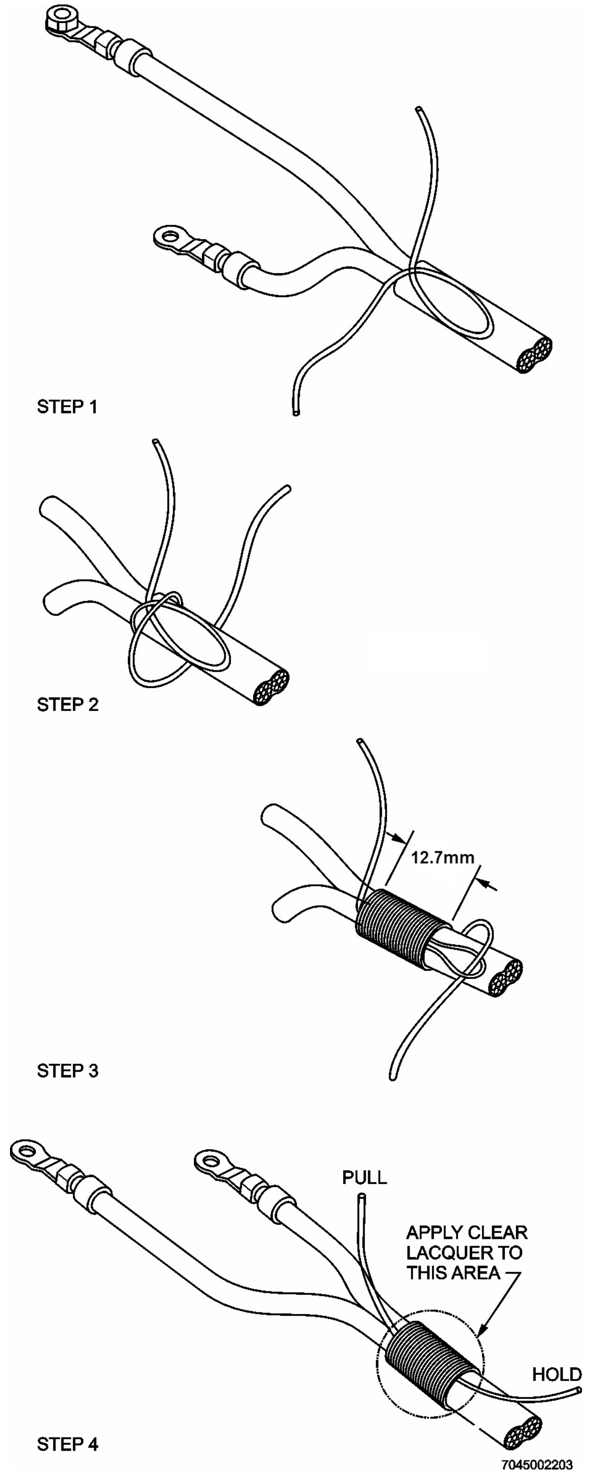


Figure 16–14 Serving Thermocouple Wire

Serving Thermocouple Wire

21. After soldering operation has been completed, and solder has cooled, serve thermocouples at the branching point as shown in Figure 16–14. Use nylon or waxed cotton cord in cool areas, and fibreglass cord in hot areas. Coat the serving with clear lacquer. The serving will prevent unravelling of the outer jacket.

SOFT SOLDERING THERMOCOUPLE WIRE

Soft Soldering Thermocouple Wire

22. Tin thermocouple wire for soft soldering in the same manner as copper wire as described in Section 2, Chapter 7. Either dip tinning or soldering iron tinning is satisfactory. Occasionally, if wires are oxidised, rosin-alcohol flux may not do a satisfactory job of tinning. If this happens, use flux A-A-59142 or equivalent. After tinning, remove flux and flux residue on the tinned surface by using a cleaning solution of 50 percent water and 50 percent isopropyl alcohol, grade A, technical (TT-I-735). Dry thoroughly.

Tinning Terminals for Soft Soldering

23. Tin terminal section inside wire grip, using a 200 to 250 watt soldering iron and rosin core solder. Do not allow flux or solder to get on the insulation grip or on the ring part of the tongue.

Soft-Soldering Wire to Terminals

24. The procedure for soft-soldering thermocouple wires to terminals is as follows:

a. Install terminals on thermocouple wires as described in Para 17, and illustrated in Figure 16–11.

b. Soft solder, using 200 to 250 watt iron and rosin core solder. Make sure that solder flows inside wire grip and forms a smooth fillet.

CAUTION

For soft-soldering, do not use any flux other than rosin-alcohol, regardless of flux used for tinning.

c. Remove excess flux by brushing with denatured alcohol (A-A-51693).

d. Bend insulation grip ears around insulation using modified crimping tool shown in Figure 16–12. Trim ears so they butt flush around small wires. (See Figure 16–11.)

Soldering Wire to MS Connectors

25. Thermocouple contacts in MS series connectors are not tinned by the manufacturer. Therefore, it is necessary to properly tin these contacts with soft solder before thermocouple wire is soft soldered into place. MS connector contacts must be removed from inserts for soldering because of the extra heat required to raise thermocouple wire to solder temperature. Best results are obtained when electrical resistance heating pliers are used to tin the contact and also for soldering wire into contact. The procedure for tinning and soldering is as follows:

a. Tin contact by use of resistance heating pliers or torch. Use rosin-alcohol flux and 60/40 tin-lead solder or, if necessary, use flux described in paragraph 22 with the same 60/40 tin-lead solder.

> **WARNING**
>
> Appropriate personal protective equipment should be worn when handling and using cleaning solutions.

b. Remove flux residues by brushing vigorously with Stoddard's solvent (MIL-PRF-680) or with denatured alcohol (A-A-51693). Lactic acid flux is removed by brushing in warm water. Dry each tinned contact thoroughly before proceeding with next step.

c. Check contact coding and wire coding carefully to avoid mismatch of materials. (See Table 16–1 and Table 16–3.)

> **CAUTION**
>
> It is important that thermocouple materials match. Ensure that the thermocouple wire is soldered to a contact of the same material.

d. Insert properly pre-tinned wire into contact and solder using resistance pliers or torch. Use only rosin core solder for this operation. (See Figure 16–15.)

e. After solder has flowed and alloyed, allow connection to cool without motion. Then remove flux residues with Stoddard's solvent (MIL-PRF-680) or with denatured alcohol (A-A-51693).

f. Examine joint to be sure solder has flowed to form a smooth fillet, and that no solder is left on outside of solder cup.

g. Reassemble contacts into MS connector as described in Section 2, Chapter 10. Be careful to reassemble each contact into the hole from which it was removed.

> NOTE
>
> For chromel and alumel contacts, material verification can be made with the aid of a magnet, since a magnet will attract the alumel contact but not the chromel contact.

Soft Soldering With Silver Solder Bonding Paste

26. In areas where temperatures do not exceed 120°C and a high tensile strength or high electrical conductivity is required, silver solder bonding paste may be used as an alternative to the procedures described in paragraphs 22 to 25, as follows:

a. For attaching terminals, clean terminals and wire with isopropyl alcohol. Next, install terminal, apply bonding paste to wire, and heat with a 140 watt soldering iron. Wipe clean with isopropyl alcohol.

b. For soldering MS and AN connectors, clean wire and socket contacts of connector with isopropyl alcohol. Apply bonding paste to wire and insert into socket. Heat with a 140 watt soldering iron, then clean with isopropyl alcohol. Inspect joint to ensure smooth fillet and that no excess solder is outside of solder cup or socket. Assemble the connector.

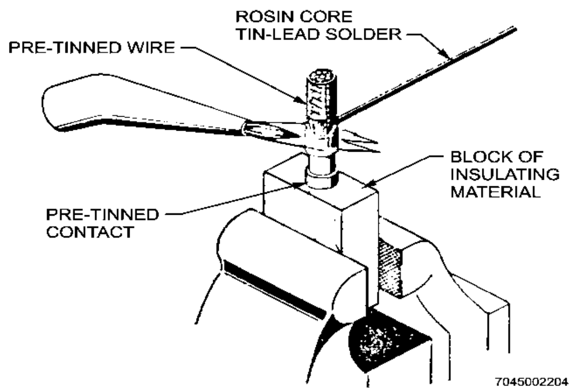


Figure 16–15 Torch Soldering Thermocouple Wire to MS Connector Contact

Soldering Wire to AN5537 Firewall Connector

27. Thermocouple wires are brought through firewalls by means of AN5537 firewall connectors. To preserve the integrity of the system, it is necessary to hard solder wires to the connector on the hot side of the firewall. The cool side of the firewall may be either hard or soft soldered. The procedure for attaching wires is as follows (refer to Figure 16–3):

CAUTION

Ensure wire leads are connected to mating materials of connector. Connector plugs and sockets are coded with letters to indicate materials. Sizes are also different to aid in quick identification. (SEE Table 16–4 for code.)

a. Disassemble connector as shown. Slide nuts over the pre-tinned leads that will be installed on the hot side of the firewall.

b. Tin the wire grips of the socket assemblies using hard solder as described in Paragraph 16.

c. Assemble and hard-solder wires to socket assemblies as described in Paragraphs 17 through 19.

d. Complete assembly of hot side wires by cleaning and crimping insulation grips.

e. Attach plugs to wires on cold side of firewall by using hard or soft solder, as required on applicable drawing for the specific installation. The method of attachment, soldering, cleaning, etc, is the same as that previously described.

Table 16–4 Code for Markings on AN5537

Material	Code	Size
Iron	FE	Large
Constantan	CON	Small
Chromel	CR	Large
Alumel	AL	Small

THERMOCOUPLE WIRE SPLICING

Installing Thermocouple Wire Splices on MIL-W-5846, Type I, Stranded Conductor, AWG 20 Alumel-Chromel Thermocouple Cable

28. Similar metal terminations are required to make connections from the thermocouple probe to the circuitry cable at any point where temperature changes may be expected. Termination of thermocouple cables in areas where all components would be at the same temperature normally would not require similar metal terminations. Splicing and connections of Alumel-Chromel thermocouple cables in engine nacelles, individual cable runs and wire bundles will be made using Alumel-Chromel Butt Splice with Insulation Support. These splices are uninsulated and separate insulation must be installed over the splice at the time of installation. An additional outer jacket must also be installed for cable protection and mechanical support.

29. Install thermocouple splices as detailed in Figure 16–16.

WARNING

Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft.

WARNING

Use of nitrogen with hot air gun M83521/5-01 in an enclosed area can be hazardous. Ensure area is well ventilated.

30. Tools and Equipment:

a. Heat Gun: Raychem Part Nos. AA-400, CV5700 or M83521/5-01 Heat Gun Kit.

b. Crimp Tool: Amp Part No. 46673.

31. Materials:

a. Materials Installation Kit: Raychem Part No. D-436-0133.

b. MIL-W-5846 (M5846/1E2/20-(AC)) Alumel Chromel Thermocouple Cable (as required).

c. 12.7mm wide fibreglass tape with thermosetting adhesive (optional).

NOTE

The following materials are contained in the Raychem Part No. D-436-0133 Materials Installation Kit:

- Qty 1 D-436-133-01 Chromel Splice, Colour Coded Gray.
- Qty 1 D-436-133-02 Alumel Splice, Colour Coded Green.
- Qty 2 D-436-133-03 Splice Sealing Sleeves.
- Qty 1 D-436-133-04 Overall Insulation Sleeve.

32. Butt Splicing Procedure. Procedures for butt splicing are shown in Figure 16–16.

33. Quality Assurance Summary:

a. Ensure butt splices have been properly selected to match colour code of conductors:

(1) ALUMEL (AL) Green

(2) CHROMEL (CH) Gray

b. Ensure butt splices are completely insulated by D436-133-03 sealing sleeves.

c. Ensure splices have been staggered. See Figure 16–16, step 6.

Stub Splicing in Stub Splice Areas

34. In stub splice areas, all components can be expected to be at the same temperature. Similar metal connections and terminations are not required.

WARNING

Use only hot air gun M83521/5-01 or equivalent on fuelled aircraft.

WARNING

Use of nitrogen with hot air gun M83521/5-01 in an enclosed area can be hazardous. Ensure area is well ventilated.

35. Tools and Equipment:

a. Heat Gun: Raychem Part Nos. AA-400, CV-5700, M83521/5-01 Heat Gun Kit.

b. Crimp Tool: Amp Part No. 49935 or Raychem Part No. AD1377.

36. Materials:

a. Parallel Connector, 34130 or D-609-04.

b. Raychem D-300-08 End Cap, Shrinkable, Self sealing.

c. 12.7mm Fibreglass Tape, with thermo-setting adhesive.

37. Stub Splicing Procedure. Procedures for stub splicing are shown in Figure 16–17.

38. Quality Assurance Summary:

a. Ensure like colour-coded wires have been spliced together.

b. Ensure individual stub splices have been completely insulated.

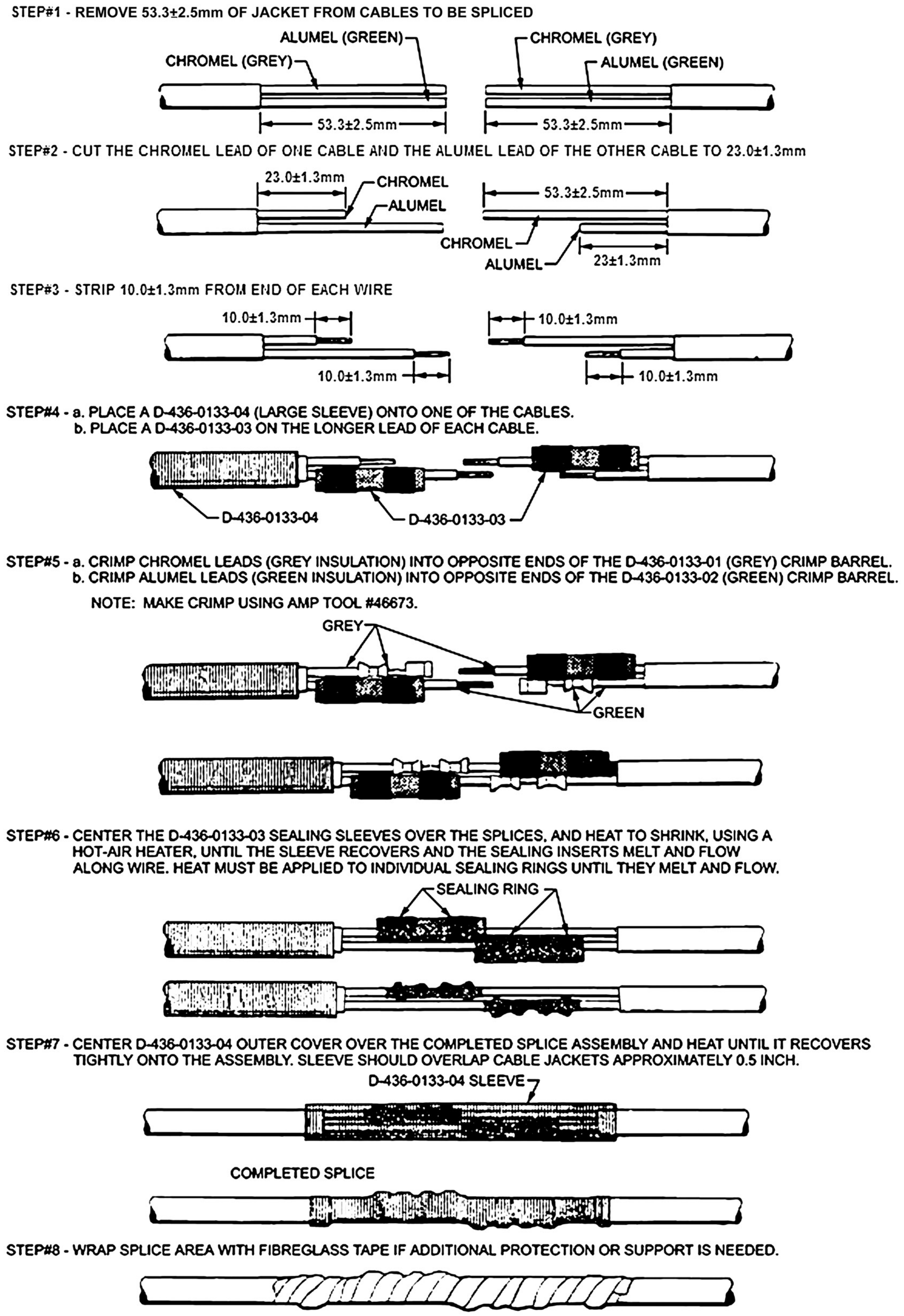
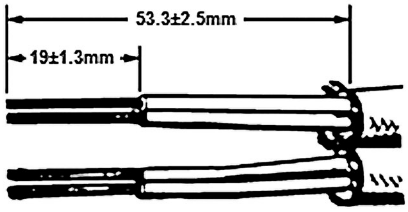
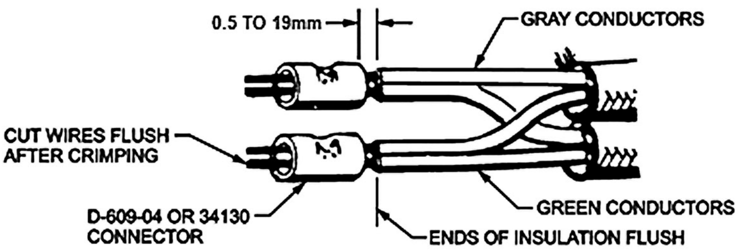


Figure 16–16 Butt Splicing Procedure

STEP#1 - END STRIP OUTER JACKET OFF ALUMEL_CHROMEL THERMOCOUPLE WIRE 53.3±2.5mm.



STEP#2 - END STRIP BOTH CONDUCTORS 19±1.3mm.



STEP#3 - KEEPING THE ENDS OF INSULATION FLUSH, TWIST STRIPPED WIRE ENDS AS NECESSARY TO PERMIT THEIR INSERTION INTO CONNECTOR.

NOTE

TWIST ENDS OF SAME COLOUR CODED WIRES TOGETHER

ALUMEL-GREEN
CHROMEL-GRAY

STEP#4 - POSITION WIRES IN PARALLEL CONNECTORS SO THAT AFTER CRIMPING WITH CRIMP TOOL 49935 AND CONNECTOR 34130 OR CRIMP TOOL AD1377 AND D-609-04 CONNECTOR THERE WILL BE A MAXIMUM OF 0.8 TO 2.3 mm BETWEEN CONNECTION AND WIRE INSULATION.

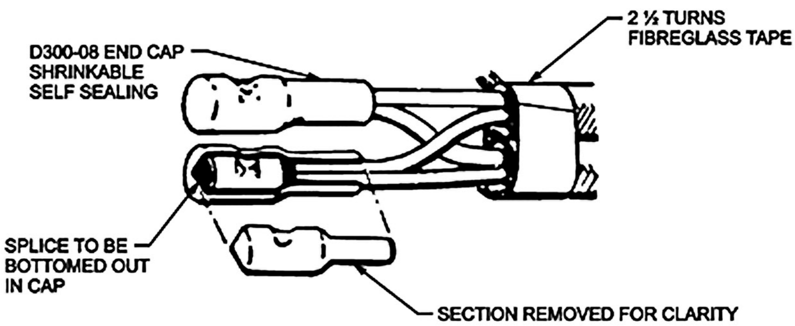
NOTE

USE CRIMP TOOL AD1377 WITH D-609-04 CONNECTOR, USE CRIMP TOOL 49935 WITH 34130 CONNECTOR.

IF CONNECTOR HAS A WELDED SEAM, THE SEAM MUST BE IN THE NEST SECTION OF CRIMPING TOOL.

STEP#5 - CRIMP CONNECTOR

STEP#6 - CUT PROTUDING WIRE FLUSH WITH END OF CONNECTOR. ,



STEP#7 - POSITION D-300-08 SELF-SEALING, SHRINKABLE END CAP OVER CONNECTOR SUCH THAT CONNECTOR IS BOTTOMED OUT IN CAP.

STEP#8 - SHRINK END CAP USING HEAT GUN.

STEP#9 - WRAP 2 ½ TURNS OF 0.5 INCH FIBREGLASS TAPE AROUND BOTH CABLE JACKETS FOR MECHANICAL SUPPORT.

Figure 16–17 Stub Splicing Procedure

MOUNTING AN5537 CONNECTOR ASSEMBLY

39. AN5537 firewall connector assemblies are mounted as follows (refer to Figure 16–3):

- **a.** Attach insulating block to firewall on hot side. Bosses on block should fit into holes in firewall so that block face is flush against wall.
- **b.** Push socket assemblies through holes and lock into place with coupling nuts.
- **c.** Push plugs into socket assemblies from cold side of firewall.

ROUTING THERMOCOUPLE WIRING

40. Route thermocouple wiring as described in Section 2, Chapter 4. In addition, observe the following special precautions:

- **a.** Support thermocouple wiring so it will not come into contact with heat producing surfaces, such as exhaust pipe or combustion chamber, at any point.
- **b.** Do not bend thermocouple leads sharply.
- **c.** Do not splice thermocouple leads except where specifically indicated, and then only with approved splices such as shown in Figure 16–16.
- **d.** Protect adjacent wiring against abrasion from thermocouple splices as described in Paragraph 41.
- **e.** Route thermocouple wiring away from hot spots.

Protection

41. Insulate thermocouple spliced terminal connections with sleeves to protect the insulation of adjacent wires from abrasion. Use plastic sleeving in cool areas and silicon impregnated rubber or glass sleeving in hot areas. Tie sleeving securely at both ends.

CAUTION

Do not use sleeving as a substitute for safe routing.

Slack in Thermocouple Wiring

42. Thermocouple wire installations require the use of fixed wire lengths to maintain a specified resistance (See Figure 16–18). The slack that results should be distributed by one of the following methods:

- **a.** Distribute excess slack evenly between wire supports, as shown in Figure 16–18.
- **b.** If sufficient slack is available, take it up at a support, in the form of a loop of which the diameter is at least 20 times the thickness of the thermocouple wire, as shown in Figure 16–18.

CAUTION

Do not bend thermocouple leads to less than a 50mm radius. When calibration resistors are used in the circuit to adjust for short lengths, do not allow any excess slack, except for approximately 76mm at each end for maintenance.

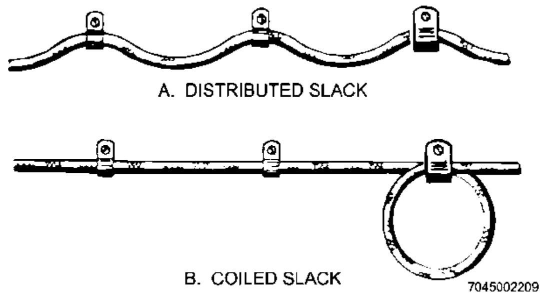


Figure 16–18 Distributing Slack in Thermocouple Wire

SECTION 2

CHAPTER 17

AGED AIRCRAFT WIRING

INTRODUCTION

1. A generally accepted belief in the aviation industry, reinforced by several studies, is that poor maintenance practices are a significant contributor to wiring degradation problems.

2. Wire degradation has been found to be principally caused by installation, environmental, and maintenance factors including: drill shavings and other metal debris in bundles (with cut insulation); lint accumulations; chemicals of various types on wiring (corrosion inhibitor, paint, hydraulic fluid, oil, grease, soft drinks, coffee, lavatory fluid, etc.); aging and deterioration of materials (cracks in wire insulation, clamp cushions crumbling, crumbled potting in pump connectors, cracked o-rings, etc.); extensive nicks, cuts, and chafes; workmanship issues; and compromised wiring segregation.

3. The damage caused to wiring looms and harnesses is not always immediately evident and may be initiated through incorrect installations; however, incorrect handling rapidly accelerates any dormant problems.

4. If maintenance personnel are cognisant of the causes of wiring degradation and adopts a policy of improved wiring husbandry, inspection processes and correct installation practices the possibility of wiring defects causing significant problem will be reduced.

5. This chapter provides information and instructions on the inspection, care and maintenance of aged aircraft wiring installations that have degraded and become more prone to damage during maintenance activities.

DEFINITIONS

6. The following definitions have been used in communicating about the subject of aged aircraft wiring:

a. Aged Wiring. Wiring which has degraded by a noticeable amount from its new condition, through time and/or environmental conditions.

b. Arc Tracking (wet). Wet arc tracking occurs when contaminating moisture or aircraft fluids create a short circuit between an exposed conductor and the aircraft structure or an adjacent exposed conductor at a different potential. In wires using aromatic polyimide insulating material this can lead to carbon arc tracking.

c. Arc Tracking (dry). Dry arc tracking occurs in dry conditions when one or more conductors are shorted as a result of abrasion from the aircraft structure, wire to wire abrasion, installation error or battle damage. In wires using aromatic polyimide insulating material this can lead to carbon arc tracking.

d. Carbon Arc Tracking. This failure mode occurs in wires using aromatic polyimide insulating material (Kapton), where the insulation is converted into a conductor. Micro arcs of only a few milli-amps of leakage current, occurring due to a breakdown in the insulation, convert the insulation into micro-spots of conducting carbon. Eventually these micro-spots of conducting carbon join up to complete an electrical path that results in a power arc with further carbonising occurring. At this stage there is a thermal and electrical avalanche which can lead to catastrophic failure of entire wire looms and in some cases aircraft structure. Although the avalanche current is limited by the power source, wiring and the circuit breakers, the duration of the flashover may not be sufficient to trigger the circuit breaker before serious damage has occurred.

e. Combustible. The ability of any solid, liquid or gaseous material to cause a fire to be sustained after removal of the ignition source.

f. Contamination. With regard to wiring contamination refers to the presence of a foreign material that is likely to cause degradation of wiring or the presence of a foreign material that is capable of sustaining combustion after removal of ignition source.

g. Detailed Visual Inspection. An intensive examination of a specific item, installation or assembly to detect damage, failure or irregularity. Available lighting is normally supplemented with a direct source of good lighting at an intensity deemed appropriate. Inspection aids such as mirrors, magnifying lenses or other means may be necessary. Surface cleaning and elaborate access procedures may be required.

h. General Visual Inspection. A visual examination of an interior or exterior area, installation or assembly to detect obvious damage, failure or irregularity. This level of inspection is made from within touching distance unless otherwise specified. A mirror may be necessary to enhance visual access to all exposed surfaces in the inspection area. This level of inspection is made under normally available lighting conditions such as daylight, hangar lighting, flashlight or droplight and may require removal or opening of access panels or doors. Stands, ladders or platforms may be required to gain proximity to the area being checked.

- **i.** **Maintenance.** For the purpose of this chapter, maintenance means inspection, overhaul, repair, preservation, and the replacement of parts. It also includes preventive maintenance.
- **j.** **Needling.** The puncturing of a wire's insulation to make contact with the conductor to test for continuity or the presence of voltage.
- **k.** **Swarf.** A term used to describe the metal particles, generated from drilling and machining operations.
- **l.** **Wiring Installation.** An electrical connection between two or more points including the associated termination devices such as connectors, terminal blocks, splices, switches, relays etc, and the necessary means for its installation and identification.

GENERAL

7. Many aircraft have been in service for around thirty years and the wiring installations have generally performed very well, with only one aircraft accident currently attributable to wiring failure. However numerous aircraft accidents investigated by international agencies implicate deteriorated wiring as a major contributing factor. While varying amounts of wiring have been replaced in aircraft, all airframes contain a substantial amount of original wire that has obviously deteriorated to some degree since its installation.

8. Wire insulation deteriorates through factors such as chronological ageing and temperature cycling over which we have no control, however we do have control over other factors such as incorrect or inappropriate maintenance procedures. Wire may appear to be robust and strong, however minor abuse or apparently insignificant damage will exacerbate deterioration of the insulation with time.

9. Maintenance activity can vary greatly from aircraft to aircraft. The disruptive effects of maintenance activity can be more random than the environmental factors that can lead to accelerated wire degradation. Maintenance practices should focus on maintaining the integrity of the wiring system.

SERVICE DIFFICULTY REPORTING

10. This information is general guidance. Any inspections should be conducted as deemed appropriate by each Certificate of Registration (CoR) holder, based on aircraft maintenance experience. Discrepancies found should be repaired per the aircraft maintenance manuals and reported to CASA as part of the Service Difficulty Report (SDR) process. CoR holders are encouraged to review and incorporate the following guidelines as a part of their current aircraft maintenance program and wiring practices.

11. CoR holders/operators have a responsibility to provide Service Difficulty Reports (SDRs) to the TC holder, the equipment manufacturer or the STC/Subpart 21.M holder and a copy to CASA. This enables appropriate investigations and components/ systems to be modified to improve reliability.

CAUSES OF WIRING DEGRADATION

12. The following items are considered principal causes of wiring degradation and should be used to help focus on the problem areas and generate appropriate maintenance programs:

- **a.** **Vibration** - High vibration areas tend to accelerate degradation over time, resulting in "chattering" contacts and intermittent symptoms. High vibration can also cause tie-wraps, or stringties to damage insulation. In addition, high vibration will exacerbate any existing problem with wire insulation cracking and wiring installed with inadequate support (loose clamps & tie-wraps) and clearances.
- **b.** **Moisture -** High moisture areas generally accelerate corrosion of terminals, pins, sockets, and conductors. It should be noted that wiring installed in clean, dry areas with moderate temperatures appears to hold up well.
- **c.** **Maintenance -** Maintenance activities, if done carelessly and improperly, can contribute to long term problems and wiring degradation. Repairs made to minimum airworthiness standards may have limited durability and should be evaluated to ascertain if rework may be necessary. Repairs that conform to manufacturers recommended maintenance practices are generally considered permanent and should not require rework. e.g. Metal shavings and debris have been discovered on wire bundles after maintenance or repairs have been conducted. As a general rule, wiring that is undisturbed will have less degradation than wiring that is reworked. As wiring and components become more brittle with age, this effect becomes more pronounced.
- **d.** **Indirect Damage -** Events such as pneumatic duct ruptures can cause damage that, while not initially evident, can later cause wiring problems. When such an event has occurred, surrounding wire should be carefully inspected to ensure no damage is evident.
- **e.** **Chemical Contamination -** Chemicals such as hydraulic fluid, battery electrolytes, fuel, corrosion inhibiting compounds, waste system chemicals, cleaning agents, deicing fluids, paint, and soft drinks can contribute to degradation of wiring. Insignificant things like spills of medication left in a wiring loom can contribute to wiring damage. Wiring in the vicinity of these chemicals should be inspected for damage or degradation. Recommended original equipment manufacturer cleaning instructions should be followed. Hydraulic fluids, for example, require special consideration. Hydraulic fluid is very damaging to connector grommet and wire bundle

clamps, leading to indirect damage, such as arcing and chafing. Wiring that may have been exposed to hydraulic fluid should be given special attention during wiring inspections.

f. **Heat** - Wiring exposed to high heat can accelerate degradation, insulation dryness, and cracking. Direct contact with a high heat source can quickly damage insulation. Even low levels of heat can degrade wiring over long periods of time. This type of degradation is sometimes seen on engines, in galleys, and behind lights.

g. **Cleaning** - Overzealous cleaning and use of inappropriate solvents can cause rapid wiring degradation.

HANDLING AGED WIRING

13. To minimise degradation, wiring should be handled in accordance with the following instructions:

a. **Inspection**. General visual inspection is currently considered the most appropriate method of assessing the condition of aircraft wiring. While visual inspection has inherent limitations, the various technologies to detect wire degradation currently under development cannot provide a reliable wire analysis for other than hard faults.

b. Visual inspection is the preferred method for detecting wire degradation however the requirement to inspect aged wiring must be critically assessed against the potential damage that may be caused by the manipulation of wiring looms.

c. The following wire system degradation items are typical of what should be detectable and subsequently addressed as a result of a visual inspection:

(1) Wire/Wire Harnesses

a) Wire bundle chafing.
b) Wire bundle sagging or improperly secured.
c) Wires damaged (large scale damage due to mechanical impact, overheat, localised chafing, etc).
d) Lacing tape and/or ties missing/incorrectly installed.
e) Wiring protection sheath/conduit deformity or incorrectly installed.
f) Grommet missing or damaged.
g) Dust and lint accumulation.
h) Surface contamination by metal shavings/swarf.
i) Contamination by liquids.
j) Deterioration of previous repairs.
k) Inappropriate repairs.
l) Inappropriate attachments to or separation from fluid lines.

(2) Connectors

a) External corrosion.
b) Backshell/tail broken.
c) Rubber pad or packing on backshell missing.
d) No backshell clamp.
e) Missing or broken safety wire.
f) Discolouration/evidence of overheat on terminal lugs/blocks.
g) Torque stripe misalignment.

(3) Ground points

a) Corroded.

(4) Bonding braid/bonding jumper

a) Braid broken or disconnected.
b) Multiple strands broken.

(5) Wiring clamps or brackets

a) Cushion damaged or missing.
b) Corroded.
c) Broken/missing.
d) Bent or twisted.

(6) Circuit breakers, contactors or relays

a) Signs of overheating.

b) Signs of arcing.

d. The following installations and areas should always be adequately addressed in maintenance requirements:

(1) **Clamping points** – Wire chafing is aggravated by damaged clamps, clamp cushion migration, or improper clamp installations. When replacing clamps use those specified by the aircraft manufacturer. Adding new wire to existing wire bundles may overload the clamps causing wire bundle to sag and wires to chafe.

(2) **Connectors** – Worn environmental seals, loose connectors, missing seal plugs, missing unused contacts, or lack of strain relief on connector grommets can compromise connector integrity and allow contamination to enter the connector, leading to corrosion or grommet degradation. Connector pin corrosion can cause overheating, arcing and pin-to-pin shorting. Drip loops should be maintained when connectors are below the level of the harness and tight bends at connectors should be avoided or corrected.

(3) **Terminations** – Terminations, such as terminal lugs and terminal blocks, are susceptible to mechanical damage, corrosion, heat damage and contamination from chemicals, dust and dirt. High current-carrying feeder cable terminal lugs can over time lose their original torque value due to vibration. One sign of this is heat discolouration at the terminal end. Proper terminal build-up hardware and nut torque is especially critical on high current carrying feeder cable lugs. Corrosion on terminal lugs and terminal blocks can cause high resistance and overheating. Dust, dirt and other debris are combustible and therefore could initiate a fire if ignited from an overheated or arcing terminal lug. Terminal blocks and terminal strips located in equipment power centres, avionics compartments and throughout the aircraft need to be kept clean and free of any combustibles.

(4) **Back-shells** – Wires may break at back-shells, due to excessive flexing, lack of strain relief, or improper build-up.

(5) **Sleeving and Conduits** – Damage to sleeving and conduits, if not corrected, will often lead to wire damage.

(6) **Grounding Points** – Grounding points should be checked for security, condition of the termination, cleanliness, and corrosion. Any grounding points that are corroded or have lost their protective coating should be repaired.

(7) **Splices** – Both sealed and non-sealed splices are susceptible to vibration, mechanical damage, corrosion, heat damage, chemical contamination, and environmental deterioration. Power feeder cables normally carry high current levels and are very susceptible to installation error and splice degradation. Splice replacement shall be with environmental splices.

(8) **Wire Raceways and Bundles** – Adding wires to existing wire raceways may cause undue wear and chafing of the wire installation and inability to maintain the wire in the raceway. Adding wire to existing bundles may cause wire to sag against the structure, which can cause chafing.

(9) **Wings** – The wing leading and trailing edges are areas that experience difficult environments for wiring installations. The wing leading and trailing edge wiring is exposed on some aircraft models whenever the flaps or slats are extended. Other potential damage sources include slat torque shafts and bleed air ducts.

(10) **Engine, Pylon, and Nacelle Area** – These areas experience high vibration, heat, frequent maintenance, and are susceptible to chemical contamination.

(11) **Auxiliary Power Unit (APU)** – Like the engine/nacelle area, the APU is susceptible to high vibration, heat, frequent maintenance, and chemical contamination.

(12) **Landing Gear and Wheel Wells** – This area is exposed to severe external environmental conditions in addition to vibration and chemical contamination.

(13) **Electrical Panels and Line Replaceable Units (LRUs) –** Due to limited space, panel wiring is particularly prone to broken wires and damaged insulation when these high density areas are disturbed during maintenance and modifications.

(14) **Batteries** – Wires in the vicinity of aircraft batteries are susceptible to corrosion, discolouration and damage from abrasion and excessive bending. Discoloured wires should be inspected for serviceability.

(15) **Power Feeders** – High current wiring and associated connections have the potential to generate intense heat and should be checked for signs of overheating and security. If any signs of overheating are seen, the splice or termination should be replaced.

(16) **Under Galleys and Lavatories** – Areas under the galleys, lavatories and other liquid containers are particularly susceptible to contamination from coffee, food, water, soft drinks, lavatory fluids, etc. Fluid drain provisions should be periodically inspected and repaired as necessary.

(17) **Cargo Bay/Underfloor** – Damage to wiring in the cargo bay and underfloor area can occur due to cargo handling and maintenance activities in the area.

(18) **Surfaces, Controls, and Doors** – Wiring that is subject to movement or bending during normal operation or maintenance access should be inspected regularly.

(19) **Access Panels** – Wiring near access panels may receive accidental damage as a result of repetitive maintenance access.

(20) **Under Cockpit Sliding Windows** – Areas under cockpit sliding windows are susceptible to water ingress from rain and snow. Fluid drain provisions should be periodically inspected and repaired.

(21) **Areas Difficult to Access** – Areas where wiring is difficult to access may accumulate excessive dust and other contaminants as a result of infrequent cleaning. In these areas it may be necessary to remove components and disassemble other systems to facilitate access to the area.

e. **Care.** Wiring located below or adjacent to maintenance activity, including painting, should be appropriately covered to protect it from damage or contamination.

f. Individual wires and looms should be handled and moved the minimum amount necessary during maintenance activity. Ensure minimum bend radii of looms and individual wires and cables are never exceeded. This is particularly relevant when wiring is moved for access.

g. Wires and wiring components should be kept clean using appropriate cleaning materials. While all wiring insulations used in aircraft are resistant to fuels and lubricants, continuous contact with these chemicals will cause deterioration over time. Additionally, fluids can migrate along looms to connectors and other wiring components that can suffer degradation.

h. Any accumulations of combustible materials such as lint, fluff and dust should be removed using appropriate cleaning methods. These materials can be readily ignited from an electrical arc and then, in turn, ignite less flammable materials.

i. Ensure swarf from structural repairs is completely removed and does not become trapped in wiring looms. Metal shavings left in looms can eventually cut through insulation and cause short circuits.

j. **Maintenance.** Non-environmental splices that exhibit signs of discolouration or other degradation should be replaced with environmentally sealed splices qualified to SAE AS81824.

k. Wires and looms resting against the aircraft structure should be adequately restrained to achieve appropriate clearance. Where this is impractical, looms should be wrapped with abrasion resistant material such as teflon sheet to provide additional protection.

l. Abrasion of wire insulation can also occur because of differences in ‘hardness’ between adjacent wires. Therefore, new wires, added during modification, which have significantly different insulation ‘hardness’ or abrasion characteristics to current aircraft wiring, should be routed in separate bundles. This is particularly important in areas of high vibration.

m. Abrasion of either the insulation or the insulation-facing material of clamps, conduits, or other devices used to secure or support wires or bundles can also be hazardous. Therefore, during maintenance activity, any rework or replacement of wires or looms should ensure that the original integrity of the design is maintained. The insulation-facing material should have ‘hardness’ compatible with that of the insulation.

n. Wiring looms should be appropriately clamped to avoid relative movement that can cause fatigue and chafing.

o. When repairing wire, use serviceable tooling and methods that are appropriate for the wire type being repaired.

p. The practice of ‘pulling through’ wires during replacement or modification should be avoided wherever possible. If cables are ‘laid in’ then damage to insulation surface by snagging or abrasion will be avoided. Additionally, the strain placed on the wire being ‘pulled’ can cause damage to the insulation or conductor.

q. Piercing of wiring insulation for test purposes is not an acceptable practice.

r. Ensure there is adequate strain relief for looms particularly where they are located across hinged, movable panels etc.

14. Wiring should be replaced under the following circumstances:

a. Wiring that has been subjected to chafing or fraying, that has been damaged, or where the primary insulation is suspected of being penetrated.

b. Wiring on which the outer insulation is brittle when slight flexing causes it to crack.

c. Wiring that has weather-cracked outer insulation. NOTE: some wire insulation types appear to be wrinkled when the wire is bent and may not be damaged.

d. Wiring that is known to have been exposed to electrolyte or on which the insulation appears to be, or is suspected of being, in an initial stage of deterioration due to the effects of electrolyte.

e. Wiring where there is visible evidence of insulation damage due to overheating.

f. Wiring that bears evidence of having been crushed or severely kinked.

g. Shielded wiring on which the metallic shield is frayed and/or corroded.

h. Wiring showing evidence of breaks, cracks, dirt, or moisture in the plastic sleeves placed over wire splices or terminal lugs.

15. Replacement wires should have the same physical, electrical and shielding characteristics as the original wires.

16. Studies have indicated that through life handling of aircraft wiring has a greater effect on deterioration than age alone, so the prime requirement when handling aircraft wiring installations is to treat them with the care and attention appropriate for a vital aircraft system.

RECOGNITION OF DAMAGED/DETERIORATED WIRE AND WIRE SYSTEM COMPONENTS

17. Common Faults. Listed below are some of the more common faults that may encounter in electrical looms, cables and connectors:

- Broken Conductors,
- Overheated Conductors and Insulation,
- Chafed Insulation,
- Contamination,
- Cracking, Hardening and Contaminated Insulation, and
- Connector Damage.

18. Broken Conductors Broken conductors are probably the most common fault. Causes for broken conductors are many, ranging from overstressing the cable to damage caused by other maintenance being carried out on the aircraft (eg. drilling).

19. In its most severe case, a broken conductor can be detected visually. A cable may have suffered a clean cut through both the insulation and conductor breaking the circuit path as illustrated in Figure 17-1.

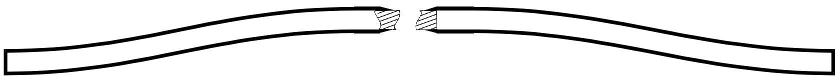


Figure 17-1 Visible Broken Conductors

20. Alternatively, the damage may not be visible. The conductor could be broken while the insulation remains intact. This may occur where the bend radius of the cable has been exceeded as shown in Figure 17-2.

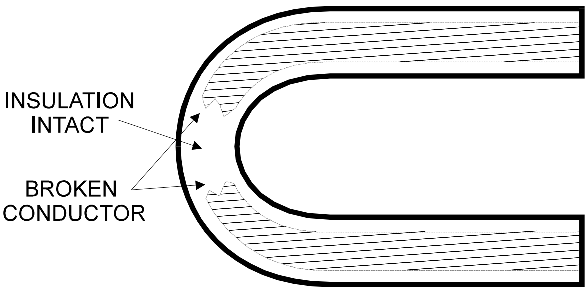


Figure 17-2 Hidden Broken Conductors

21. In both cases, the most reliable method of confirming a broken conductor is to carry out a continuity check. If the check indicates an open circuit, then repair action will be necessary. In both of these examples, the broken conductors can be repaired by using an ‘in line’ splice.

22. Overheated Conductors. Overheating of the conductor can be caused by many factors. The most serious is where the system suffers a short circuit and the circuit breaker fails to operate in time or not at all. This results in the excessive current flow heating the conductor. As the temperature of the conductor increases, the insulation of the wire melts and eventually the conductor also melts.

23. Even if the conductor is not destroyed completely after being subjected to excessive heat for extended periods of time the insulation may become discoloured indicating heat damage. If this damage is not found this could lead to the insulation and or conductor becoming hard and brittle and eventually cracking and breaking. The resistance of the wire will increase possibly affecting the system it connects.

24. Once again, carrying out a continuity check is the best method of detecting where conductor breakdown has occurred. An open circuit indication will not always be the case. An overheated circuit may still indicate as closed but will have a higher circuit resistance.

25. When repairing overheated conductors, it is very hard to isolate the damaged portion of the cable. The best option for repair is to replace the entire cable.

26. Chafed Conductors. Chafing is the result of a cable or harness continually rubbing against another part of the aircraft. It is usually caused by the incorrect routing of the cable or harness, or insufficient support along its entire length.

27. Chafing causes the insulation of the cable to be worn away and if not detected early, could lead to eventual breaking and shorting/arcing of the conductor as shown in Figure 17-3.

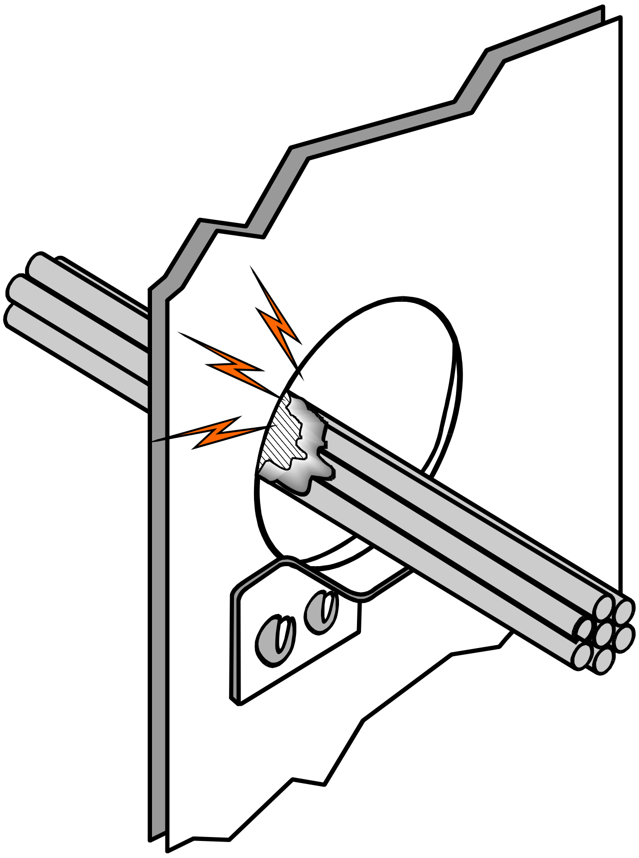


Figure 17-3 Chafed Conductors

28. Chafing can be repaired by using an in line splice, however, if the damage is along the entire length of the wire a jumper lead will be required to bridge the gap. Ensure the loom has sufficient clearance from the cause of the chaffing. If it is not possible to gain the clearance required then the loom should be wrapped with abrasion resistant material such as Teflon sheet to provide additional protection.

29. Chafing can also occur due to differences in hardness of insulation material between adjacent wires. Therefore if a new wire is added to an existing loom it should have the same abrasion characteristics as the existing wires. If a wire of different abrasion characteristic has to be used then it should be routed in separate bundles.

30. Contamination. Whilst all wiring insulations used in aircraft are resistant to fuels and lubricants, continuous exposure with these chemicals will cause deterioration over time. Also if the chemicals are not kept off the looms, the chemicals can migrate to connectors and other wiring components. If contamination occurs, the looms should be cleaned with appropriate cleaning materials.

31. Ideally looms should be protected from damage/contamination during maintenance being carried out in the immediate vicinity. If metal shavings are found they should be removed from looms, as the shavings could become trapped in the looms and cut through the insulation and cause a short-circuit.

32. Connector Damage. Electrical connectors form the link between the component and aircraft system. Whenever an aircraft component is removed or installed the electrical connector should be inspected. This inspection allows for the early detection of deteriorating components or even the cause of system failure. Examples of various electrical connectors are shown in Figure 17-4

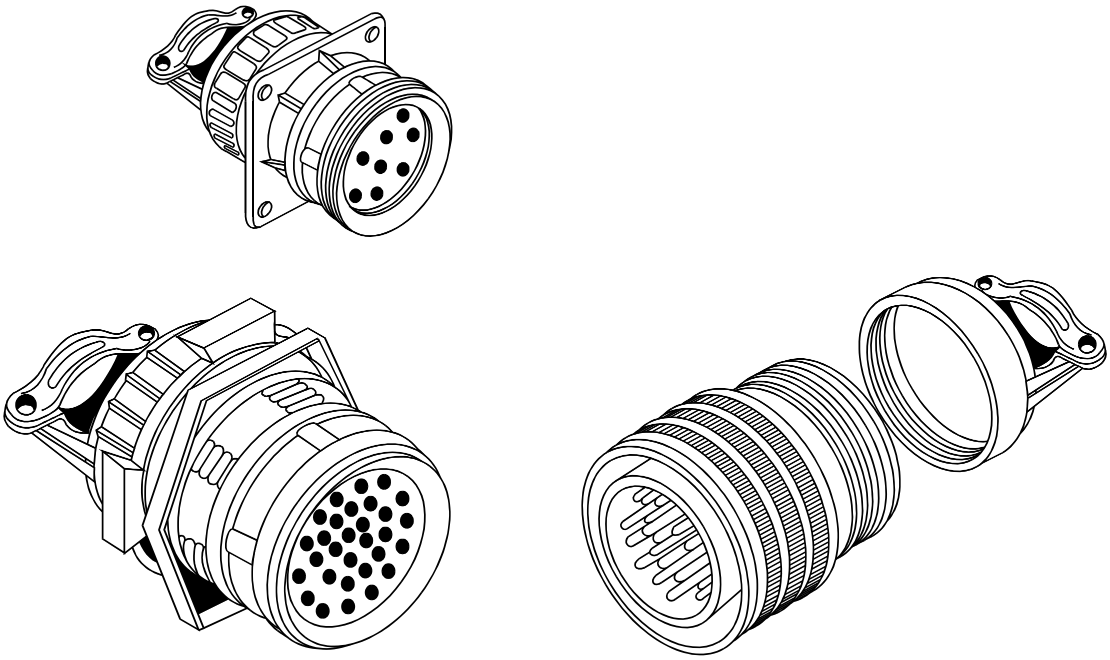


Figure 17-4 Various Connectors

33. Whenever disconnecting or reconnecting an electrical connector it must be examined for the following possible damage:

- Pins or sockets pushed back into the insulator;
- Pins bent over or shorting other pins;
- Moisture, corrosion or contamination (this can cause shorts when power is applied);
- The insulator has no cracks or tears and is not perished;
- Wire/s loose in the back of the plug (possible causes are: contact not seated; or wire no longer connected to contact);
- Overall physical condition of the connector; and
- Burn marks caused by poor connections or shorting.

PRECAUTIONS SHOULD BE OBSERVED WHEN HANDLING ELECTRICAL CONNECTORS:

34. Disconnecting electrical connectors. Prior to disconnecting any electrical connector the following precautions are to be observed:

- Ensure system power has been removed (turned off) before disconnecting any of the systems electrical connectors;
- Always use the correct tool to disconnect an electrical connection (soft jawed multigrips called plug pliers);
- Never use the loom to pull a connector from its receptacle;
- When disconnecting a component with multiple plugs, ensure that they are clearly identified to ensure their correct reconnection; and
- Annotate disconnection of electrical connector in appropriate aircraft documentation.

35. Connecting electrical connectors. Prior to connecting any electrical connector, the following precautions are to be observed:

- Ensure system power has been removed (turned off) before connecting any of the system’s electrical connectors;
- Never force a connector together; always ensure keyways align before attempting connection;
- After connection, ensure that the connector is securely mated (locked in the indent); and
- Ensure that if the connection was previously lock wired the lock wiring is replaced.

SECTION 2

CHAPTER 18

AIRCRAFT ELECTRICAL SYSTEM - INSPECTION

INTRODUCTION

1. The purpose of this chapter is to provide instructions for inspecting aircraft electrical system wiring and interconnecting components and to detail requirements to be met. Compliance with these instructions will be effective in minimising electrical system malfunctions. These instructions should be complied with, except where any procedure conflicts with the aircraft maintenance manual, in which case the aircraft manual shall take precedence.

> **WARNING**
>
> To avoid the possibility of personal injury or equipment damage, it is mandatory that all electrical power be removed from the aircraft prior to commencing an inspection or maintenance.

INSPECTION

Wiring Installation

2. Wires and cables should be inspected for adequacy of support, protection and general condition throughout. The desirable and undesirable features in aircraft wiring are outlined below and indicated as conditions that should or should not exist. Accordingly, aircraft wiring should be inspected to ascertain that:

a. Wiring installation conforms to the following precedence:

(1) Safety of flight.

(2) Ease of maintenance, removal and replacement of the wiring.

(3) Cost effective aircraft production or modification.

b. Wiring has been fabricated and installed so as to achieve the following:

(1) Maximum reliability.

(2) Minimum interference and coupling between systems.

(3) Accessibility for inspection and maintenance.

(4) Prevention of damage.

c. Wiring has been routed to ensure reliability and to offer protection from the following hazards:

(1) Chafing.

(2) Use as handholds, or as support for personal equipment.

(3) Damage by personnel moving within the vehicle.

(4) Damage by stowage or shifting of cargo.

(5) Damage by battery or acid fumes and fluids.

(6) Damage in wheel wells exposed to rocks, ice, mud, etc.

(7) Damage by moving parts.

(8) Harsh environments such as SWAMP areas, high temperatures, or areas susceptible to significant fluid or fume concentration.

d. Wires and cables are provided with enough slack to meet the following requirements:

(1) Permit ease of maintenance.

(2) Prevent mechanical strain on the wires, cables, junctions and supports.

(3) Permit free movement of shock and vibration mounted equipment.

(4) Permit removal and installation of equipment for maintenance or repair.

(5) When wiring is terminated at a connector (excluding RF connectors) a minimum of 25mm of slack has been provided to facilitate complete connector replacement.

(6) At each end of a wire terminated by a lug, a minimum length of slack equal to twice the barrel length of the lug has been provided. For copper wire AWG 2 and larger, and aluminum wire, AWG 4 and larger, the minimum length of slack shall be equal to one barrel length of the lug.

e. Wiring is adequately separated from high temperature equipment such as resistors, exhaust stacks, heating ducts and deicers to prevent insulation damage or deterioration.

f. Conduit, flexible tubing or braided outer jackets, properly supported, covers all wiring in wheel wells. When tubing is used, drainage holes shall be provided at all trap points and at the lowest points between each set of support clamps.

g. Wiring has been supported to meet the following requirements:

(1) Prevent chafing.

(2) Secure wiring where routed through bulkheads and structural members.

(3) Properly support and route wiring in junction boxes, panels and bundles.

(4) Prevent mechanical strain or workhardening that would tend to break the conductors and connections.

(5) Prevent arcing or overheated wiring from causing damage to mechanical control cables and associated moving equipment.

(6) Facilitate reassembly to equipment terminal boards.

(7) Prevent interference between wiring and other equipment.

(8) Prevent excessive movement in areas of high vibration.

(9) Provide rigid support to wiring routed within 15cm of any flammable liquid, fuel or oxygen lines.

h. Primary support of wiring has been provided by cushion clamps at intervals of not more than 60cm, except when contained in troughs, ducts or conduits. The clamps must be of a suitable size and type to retain the wiring in place securely and without damage to the insulation. Clamps must be compatible with their installation environment. Cushion compounds are formulated to meet specific requirements and are not suitable for all applications.

i. Secondary support of wiring (support between primary supports) has been provided by the following devices, as detailed in Chapter 8:

(1) Tying and lacing string.

(2) Plastic cable straps.

(3) Insulation tape.

j. Limitations on support:

(1) Continuous lacing has not been used except in panels and junction boxes where this practice is optional.

(2) The use of insulation tape and sleeving for the protection of wiring has been kept to a minimum. Sleeving is preferred when such protection is necessary.

(3) Wires have not been tied or fastened together in conduit, covered raceways, or insulation sleeving. This will facilitate ease of replacement.

(4) Support does not restrict the wiring in such a manner as to interfere with the movement of shock mounted equipment.

(5) Tape or tying and lacing string has not been used as primary support.

(6) Plastic cable straps have not been used in the following areas:

a) Where the total temperature (ambient plus rise) exceeds 85°C (185°F).

b) Where failure of the strap would permit movement of the wiring against parts which could damage the insulation or allow wiring to foul mechanical linkages.

c) Where failure would permit the strap to fall into moving parts.

d) In high vibration areas.

e) In SWAMP areas such as wheel wells, near wing flaps, or wing folds.

f) Where exposed to ultra-violet light (sunlight) unless the straps are resistant to such exposure.

g) To tie wires into groups within a bundle.

(7) Moisture-absorbent type material is not used as "fill" for clamps or adapters.

k. Radius of bend.

(1) For single wires individually routed and supported, the minimum bend radius is ten times the outside diameter of the wire. At the point where an individual wire breaks out from a group, harness or bundle, the minimum bend radius of the wire is ten times the outside diameter of the wire, provided the wire is suitably supported at the breakout point. If wires used as shield terminators or jumpers are required to reverse direction in a harness, the minimum bend radius of the wire is three times the diameter at the point of reversal providing the wire is adequately supported.

(2) The minimum bend radius of a group, bundle, or harness is six times the diameter of the group, bundle, or harness. In no case shall the bend radius of the group, bundle or harness be less than ten times the diameter of the largest included single wire.

(3) The minimum bend radius of a coaxial cable will not adversely affect the characteristics of the cable. For flexible type coaxial cables, the radius of bend shall not be less than six times the outside diameter. For semi-rigid types, the radius shall not be less than ten times the outside diameter.

l. Wires and cables routed within 15cm of any flammable liquid or fuel line are closely and rigidly supported.

m. A trap or drip loop is provided to prevent fluids or condensed moisture from running into wires and cables dressed downward to a connector, terminal block, panel, or junction box.

n. Drain holes are present in drip loops or lowest portion of tubing placed over wiring.

o. Wires and cables, installed in bilges and other locations where fluids may be trapped are routed as far removed from the lowest point as possible or protected with vinyl tubing when this is not possible.

p. Wires and cables attached to assemblies where relative movement occurs (such as at hinges and rotating pieces; particularly control sticks, control wheels, columns and flight control surfaces) are installed or protected in such manner as to prevent deterioration of the wires and cables caused by the relative movement of the assembly parts.

q. Unused wires are individually dead ended, tied into a bundle, and secured to a permanent structure. Each wire is to have strands cut even with insulation and a pre-insulated end cap, or a 25mm piece of insulating tubing placed over wire with its end folded back and tied.

Wiring Replacement

3. Wiring should be replaced when found to have any of the following defects:

a. Wiring that has been damaged to the extent that the primary insulation has been breached.

b. Wiring that is known to have been exposed to battery acid or on which the insulation appears to be, or is suspected of being, in an initial stage of deterioration, due to the effects of battery acid.

c. Wiring that shows evidence of overheating.

d. Wiring on which the insulation has become saturated with engine oil, landing gear lubricant, hydraulic fluid, etc. Saturated wire will be determined by a visual inspection taking into consideration wire and circuit intent. If the wire is saturated, the wire should be replaced. If spillage has occurred, but the wire does not appear to be saturated, clean with solvent that will not deteriorate the insulation.

e. Wiring that bears evidence of having been crushed or kinked.

f. Shielded wiring on which the metallic shield is frayed and/or corroded. Cleaning agents or preservatives shall not be used to minimize the effects of corrosion or deterioration of wire shields.

g. Wiring that bears evidence of breaks, cracks, dirt, or moisture in the plastic sleeves placed over wire splices or terminal lugs.

h. Sections of wire on which in-line splices do not comply with Chapter 6, Paragraph 27, should be replaced.

Terminals and Terminal Blocks

4. Inspect to ensure compliance with the following installation requirements:

a. Terminal blocks are securely mounted.

b. Terminal connections are securely attached to terminal block studs.

c. Insulating tubing is placed over terminals (except pre-insulated types) to provide electrical protection and mechanical support; and is secured to prevent slippage of the tubing from the terminal.

d. Evidence of overheating and corrosion is not present on connections to terminal block studs.

e. A maximum of four terminal lugs or three terminal lugs and a bus bar have been connected to any one stud.

f. Physical damage to studs, stud threads, and terminal blocks is not evident. Replace cracked terminal strips and those studs with stripped threads.

g. When the terminal lugs attached to a stud vary in diameter, ensure the largest diameter lug is placed on the bottom and the smallest diameter on top.

h. Terminal lugs have been selected with a stud hole diameter which matches the diameter of the stud.

i. Terminal lugs have been positioned so that bending of the terminal lug is not required to remove the fastening screw or nut, and movement of the terminal lugs will tend to tighten the connection.

j. The following discrepancies are cause for replacement of terminal boards:

(1) Crack(s) extending from a terminal to any threaded insert.

(2) Crack(s) extending from a terminal to any other terminal.

(3) Crack(s) extending over 6.35mm in length from any terminal in any direction.

Fuses and Fuse Holders

5. Inspect as follows:

a. For security of mounting of fuse holder.

b. For security of connections to fuse holders.

c. For the presence of corrosion and evidence of overheating on fuses and fuse holders. Replace corroded fuses and clean fuse holders. If evidence of overheating is found, check for correct rating of fuse.

d. For replenishment of spare fuses used in flight, ensure fuses possess the same electrical features including blowtime, current and voltage rating.

e. Inspect fuse holder cap to ensure the rubber grommet is properly installed.

f. Ensure the fuse holder cap retains the fuse when either inserting or removing a fuse. Fuseholder caps which do not securely retain fuses must be replaced.

MS Connectors.

6. Ensure the following criteria for connectors are met or that repairs are effected as required:

a. Inspect connectors for security, evidence of overheating and for corrosion or cracks. Replace where necessary.

b. Ensure installation of cable clamp adapters on all MS connectors except those that are moisture proof, on which they are optional.

c. Ensure that approved tape is wrapped around wires in cable clamp adapters so that tightening of the cable clamp provides sufficient grip on the wires to keep tension from being applied to the connector pins.

d. Ensure that unused plugs and receptacles are appropriately sealed to avoid contamination. The connectors should then be secured to the aircraft structure or to other wiring that is properly anchored.

e. Ensure that the coupling nut of MS connectors is secured, by lock wire or other mechanical locking means, as required by the applicable aircraft maintenance manual.

f. Ensure that moisture-absorbent type material is not used as ‘fill’ under clamps or adapters.

g. Ensure that there is no evidence of deterioration of potting compound in potted connectors.

h. When crimp contact connectors are used, the unused contacts shall be installed. Sealing plugs should be inserted in unused grommet holes of environment resistant connectors.

i. Spare contacts in potted connectors shall have a pigtail attached, consisting of a wire of the largest size that can be accommodated by the contact and which extends 12.7 to 17.8cm beyond the potting material. The pigtails shall be identified and dead ended.

NOTE

A bayonet coupled electrical connector is correctly fastened if all three bayonet pins on the receptacle are located in the holes on the plug coupling ring. A click will be heard when the pins locate into the receptacle ring holes. A threaded coupled electrical connector is correctly fastened if the plug is fully seated in the receptacle and cannot be moved in or out of the receptacle. A slight lateral movement is permissible due to the difference in size between the locating keys and keyways.

Splices

7. Crimp type splices shall comply with the following:

a. Only environmentally sealed splices should be used aircraft wiring for new and replacement applications. Where non-environmental splices are currently fitted, replacement with environmental splices is only required when original splices display signs of degradation.

b. The spacing of splices at staggered intervals to prevent excessive enlargement of the bundle. Groups of non-staggered splices need not be replaced, however it may be necessary to use extra clamps to support the added localized weight.

c. Quick disconnect splices, designed for disconnection without the use of tools, should not be used.

d. There should not be more than one splice in any wire segment between any two connectors or other terminating points.

e. Splices should not be used to salvage scrap lengths of wire.

f. Splices should not be used within 30cm of a connector or other terminating point.

g. Splices should not be used on firing or control circuits associated with ordinance or explosive systems.

Junction Boxes, Panels, Shields and Micro-Switch Housings.

8. These housing assemblies should be examined to ascertain the following:

a. Suitable hole(s) smaller than 9.5mm diameter, but not less than 3.1mm diameter, is (are) provided at the lowest point(s) of the box(es), except vapour-tight boxes, to allow for drainage with the airplane on the ground and in level flight.

b. Vapour-tight or explosion proof boxes are externally labelled "vapour-tight" or "explosion proof."

c. Boxes are securely mounted.

d. Boxes are clean internally and free of foreign objects.

e. Safety wiring is installed on all lid fasteners on J-boxes, panels, shields, or micro-switch housings which are installed in areas not accessible for inspection in flight, unless the fasteners incorporate self-locking devices.

f. There are no unplugged unused holes (except drainage holes) in boxes.

Conduit - Rigid Metallic, Flexible Metallic and Rigid Non-Metallic.

9. Inspect conduit assemblies to ensure that:

a. Conduit is installed so that strain and flexing of ferrules is relieved.

b. Conduit is not collapsed or flattened from excessive bending.

c. Conduits are installed so that fluids or condensed moisture will not be trapped. Suitable drain holes shall be provided at the low points, except for metallic flexible conduit.

d. Bonding clamps are installed in a manner that damage to the conduit cannot result.

e. The diameter of wiring bundles installed in conduits shall not exceed 80% of the conduits inner diameter.

Electrical Bonds

10. An electrical bond is defined as any fixed union existing between two metallic objects that results in electrical conductivity between them. Such union results from either physical contact between conductive surfaces of the objects or from the addition of an electrical connection between them. Other desirable features which must be present in order for a good bond to exist are as follows:

a. Metallic conduit bonded to the aircraft structure at each terminating and break point. The bonding path may be through the equipment at which the conduit terminates.

b. Bond connections are secure and free from corrosion.

c. Bonding jumpers do not interfere in any way with the operation of movable components of the aircraft.

d. Self-tapping screws have not been used for bonding purposes. Only standard threaded screws or bolts of appropriate size should be used.

e. Exposed conducting frames or parts of electrical or electronic equipment have a low resistance bond of less than 0.1 ohm to structure.

f. Bonding jumpers have been kept as short, straight and direct as possible.

g. Bonds have been attached directly to the basic aircraft structure rather than through other bonded parts as far as practical.

h. Bonds have been installed to ensure that the structures of aircraft are electrically stable and free from the hazards of lightning, static discharge, electrical shock, etc., and to provide for the suppression of radio interference resulting from these hazards.

Wire and Cable Junctions

11. Ensure that only approved devices, such as solderless type terminals, terminal blocks, connectors, disconnect splices and permanent splices are used for wire and cable junctions. Inspect for compliance with the provisions listed below:

a. Electrical junctions are protected from short circuits resulting from movement of personnel, cargo, shell cases, clips, and other loose or stored materials. Protection shall be provided by covering the junctions, installing them in junction boxes, or by locating them in such a manner that additional protection is not required.

b. Exposed junctions and busses shall be protected with insulating materials. Junctions and busses located within enclosed areas containing only electrical and electronic equipment are not considered to be exposed.

c. Electrical junctions shall be mechanically and electrically secure. They shall not be subject to mechanical strain or used as a support for insulating materials, except for insulation on terminals.

Switches, Toggle

12. In the event the following inspections reveal that the switches are unserviceable, replace defective switches with switches of the same type and current rating. Inspect as follows:

a. Conduct visual examination for physical damage and that switches are securely attached to the mounting panel.

b. Check for loose or deformed electrical connections or evidence of corrosion of the terminals, terminal lugs or screws.

c. Check for manual operation by actuating toggle lever several times. This also serves to remove any superficial contamination or foreign deposits on the internal electrical contacts

d. Test for electrical continuity as measured across the external terminals by means of an ohmmeter. Electrical resistance across any set of closed contacts should not exceed one (1) ohm. Intermittent or excessive resistance normally indicates that the internal contacts are corroded. In the event a few additional actuations of the switch do not clear up this condition, replace the switch with like item. Continuity tests of installed switches require that the switch be electrically isolated from other circuitry to preclude measurement of low resistance parallel systems. This can usually be accomplished by opening the circuit breaker or fuse on the line side of the switches.

e. Switches that are exposed to direct water spray, rain or heavy dust concentrations require more frequent checks for manual operation, corrosion and continuity.

Circuit Breakers

WARNING

Installed circuit breakers should be selected off and all electrical power including batteries should be disconnected prior to proceeding with inspection or maintenance.

WARNING

Replacement circuit breakers must have equivalent electrical characteristics

13. When replacement is necessary use circuit breakers of the same type and current rating. Inspect as follows:

a. Ensure that the circuit breaker is firmly secured to the mounting panel and there is no evidence of physical damage.

b. Inspect for loose electrical terminations or evidence of corrosion of the terminals, terminal lugs and screws.

c. Ensure positive manual operation by actuating the push-pull button or toggle several times. This operation also serves to remove any superficial contaminates or foreign deposits present on the surface of the internal electrical contacts.

d. Check for evidence of circuit breaker overheating.

e. Test for electrical continuity, as measured across the external breaker terminals. Use an appropriate ohmmeter to determine that the maximum electrical resistance does not exceed one tenth (0.1) of an ohm. Intermittent or excessive resistance readings normally indicate that the internal breaker contacts are corroded. In the event a few additional actuations of the breaker do not correct this condition, the breaker should be replaced. Continuity tests of installed breakers require that the breaker be electrically isolated from other circuitry to preclude measurement of low resistance parallel systems. This can usually be accomplished by opening the switch or switches on the load side of the breaker.

f. Circuit breakers that are exposed to direct water spray, rain, snow or heavy dust concentrations require more frequent checks for manual operation, corrosion, continuity, evidence of burning or electrical arcing.

Grounding/Bonding Receptacles

14. Inspect grounding/bonding receptacles for serviceability in accordance with Section 2, Chapter 14, Para 56. Replace defective items as required.

SECTION 2

CHAPTER 19

FIBRE OPTICS

INTRODUCTION

1. This chapter provides general information on the use, handling, termination and repair of fibre optic cables.

INFORMATION

2. General. Fibre optics is a term describing a lightwave or optical communication system used to transfer information. In this type of system electrical energy is converted to light, transmitted to another location, and converted back to electrical information. It consists of the following:

a. Information Source. The information source provides an electrical signal for transmission.

b. Transmitter. The transmitter or optical source converts the electrical signal into an optical light waveform suitable for transmission. A light emitting diode (LED) is most commonly used as the light source due to its low drive voltage, small size, excellent brightness and fast response time. Lasers are also used as a light source and appropriate safety precautions should be observed.

c. Fibre Optic Cable. The fibre optic cable (Figure 19-1) provides a suitable medium for transfer of the lightwave. It consists of an optical fibre, which is a cylinder or core of transparent dielectric, usually plastic or glass, with a high refractive index, surrounded by a second dielectric with a lower refractive index, called the cladding. Due to the fragile nature of these fibres, they are covered with a protective cover or buffer and a plastic jacket. A further strength member of Kevlar or fibreglass and an outer jacket are often added. The cable must be interconnected with the least possible loss to signal transmission. This loss can be caused by End Separation (Figure 19-2), Lateral Displacement (Figure 19-3) or Angular Displacement (Figure 19-4).

d. Receiver. The optical receiver normally consists of a photo detector, amplifier, filter and demodulating electronics that are used to convert the lightwave signal to an electrical signal.

e. Destination. The destination equipment utilises the electrical signal.

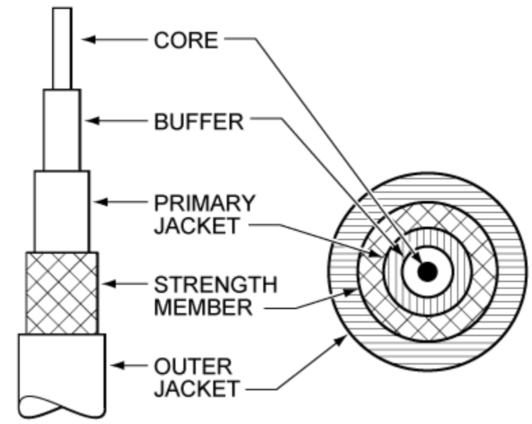


Figure 19–1 Typical Fibre Optic Cable Construction

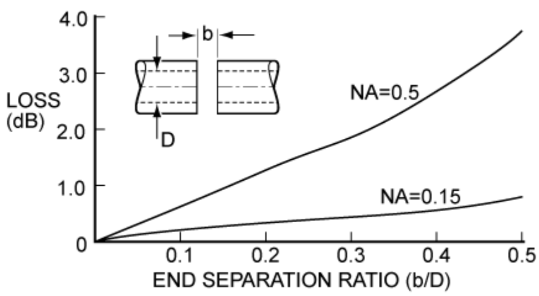


Figure 19–2 Loss Due To End Separation

NOTE

Numerical Aperture (NA) of an optical fibre is a measure of the maximum angle at which light, entering the fibre, will propagate in the core of the fibre.

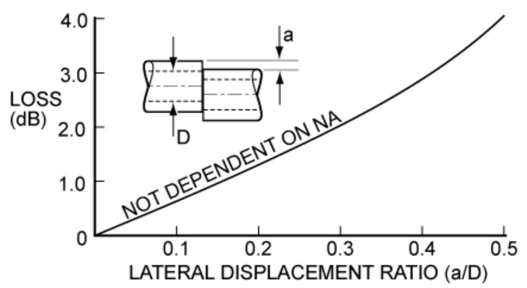


Figure 19–3 Loss Due To Lateral Displacement

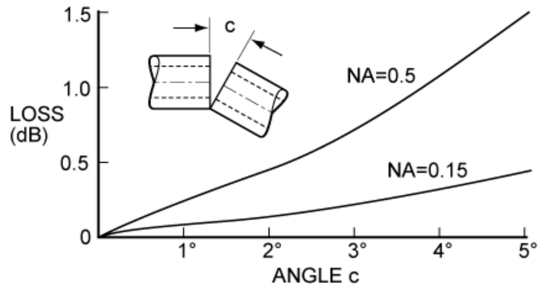


Figure 19–4 Loss Due To Angular Displacement

3. Advantages. The use of fibre optics overcomes many problems associated with conventional electrical wiring such as short circuits, spark and fire hazard, intermittent problems caused by dirty contacts, and electromagnetic environmental effects (E^3). By using multiple fibres bundled together, the information carrying capability is increased with a significant weight reduction. Security is also improved as it is much more difficult to tap into a fibre optic cable and impossible to use an electromagnetic pickup.

4. Disadvantages. Fibre optic cable is not as flexible or robust as copper wire and requires extra support and protection. Minium bend radius is critical to avoid fracturing the optic fibre. Coupling and alignment of fibres is time consuming and critical as loss factors increase considerably if these procedures are not carried out correctly.

Safety

5. Following are the minium safety procedures to be observed when working with fibre optics:

- **a. Hazards to Sight.** Radiation emitted from optical fibre transmission or test equipment is in the near infra-red (IR) region of the spectrum and is invisible to the human eye. Staff working with such equipment should be aware of the hazards of exposure to radiation that can result in serious and permanent impairment of vision.
- **b. Safety glasses.** Safety glasses should be worn at all times when the bare fibre is being worked as fibre fragments are small and extremely sharp and, if mishandled, can lodge in an eye.
- **c. Fibre Off-Cuts.** Glass fibre off-cuts or fragments can be extremely sharp and are difficult to locate using the unaided eye. Immediately after cleaving, fibre off-cuts or fragments should be placed in a specially marked resealable plastic or glass container.
- **d. Cleaning Solvents.** Cleaning solvents used with optical fibres are volatile and highly flammable. Use only in well ventilated areas away from heat sources, flames and sparks. Avoid contact with skin.
- **e. General.** Only the correct tools and equipment should be used when working with optical fibres or cable. All tools should be kept clean and in good working order. Care should be exercised when using cable cutters, cable sheath strippers and other tools with cutting blades.

Installation Considerations

6. Fibre optic cables are reasonably rugged and, when handled by competent tradesmen, pose no special problems.

7. The installation should be planned to ensure that the manufacturer’s recommended maximum tensile and crushing forces are not exceeded.

8. Minium bend radii must be observed at all times. The tendency to ‘keep it neat’ by exceeding the minimum bend radius of the fibre optic cable, to match installed looms, is to be avoided.

9. As with copper wires, allowance in the length of optic cable should be made to facilitate post installation re-termination of connectors.

10. When using cable clamps the following precautions should be observed:

- **a.** support clamps should be used as often as practicable,
- **b.** clamping force should be the minium required to prevent slippage, and
- **c.** a small amount of cable slack should be incorporated between clamps to allow for temperature variations and vibration.

Connectors

11. The purpose of connectors in a fibre optic system is to join fibre ends for efficient signal transfer. Connectors are designed to be used in applications where there is a requirement for the fibre optic cable to be disconnected and reconnected during system repair, maintenance etc. Several types of fibre optic connectors are currently available and fitting is to be carried out in accordance with manufacturers' instructions.

Fibre Optic Repairs

12. When damaged or broken, fibre optic cables should be replaced from one permanent termination to the next. Where this is impractical, repairs must be accomplished so as to provide minium signal loss.

13. **Splicing.** Splicing is an acceptable method of repairing fibre optic cables. Splices must provide precise alignment of the fibre ends when completed. Several splicing methods are currently available with the two most common methods being epoxy and fusion splicing. Epoxy splicing is achieved by aligning the prepared ends of the fibre with an alignment tool and joining the fibre ends with epoxy. Index matching fluid is sometimes used to minimise losses. An alternate fibre joining method is to use fusion splicing. With this method, the fibre ends are aligned by manipulation under a microscope or by monitoring optical throughputs, and the ends then fused by electric arc. Splicing is to be carried out in accordance with manufacturers instructions.