Fundamentals
M7
MAINTENANCE PRACTICES

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M7.7
Electrical Wiring Interconnection System (EWIS)

EASA Part-66
CAT B1

Training Manual

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Lufthansa Technical Training

Dept HAM US
Lufthansa Base Hamburg
Weg beim Jäger 193
22335 Hamburg
Germany

Tel: +49 (0)40 5070 2520
Fax: +49 (0)40 5070 4746
E-Mail: Customer-Service@LTT.DLH.DE

www.Lufthansa-Technical-Training.com

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M7 MAINTENANCE PRACTICES

M7.7 ELECTRICAL WIRING INTERCONNECTION SYSTEM (EWIS)

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IDENT. INSP. AND DAM.TOLERANCES OF WIRES

General

The installation of on-board electrical systems in an aircraft differs considerably from the conventional electric installations used in industry and household. These on-bord electrical systems are comparable with those of automobiles.

Like in automobiles, for weight reasons the metal structure of the cell is used as a return line which means that most circuits are single core.

In aircraft with wood– or plastic construction, two–core circuits are necessary due to the lack of conductivity.

The ever increasing use of electric and electronic systems in state–of–the–art aircraft types also requires an improved knowledge and understanding of the processing methods and installation techniques.

Thus, the purpose of this book is to provide essential information in the field of electric installations in aircrafts, which, in combination with the corresponding documentation and the regulations of the manufacturer, shall enable the reader to perform professional installations, modifications or repair work.

Generally, electric installations in aircrafts have to be done according to the manufacturer's instructions, for example:

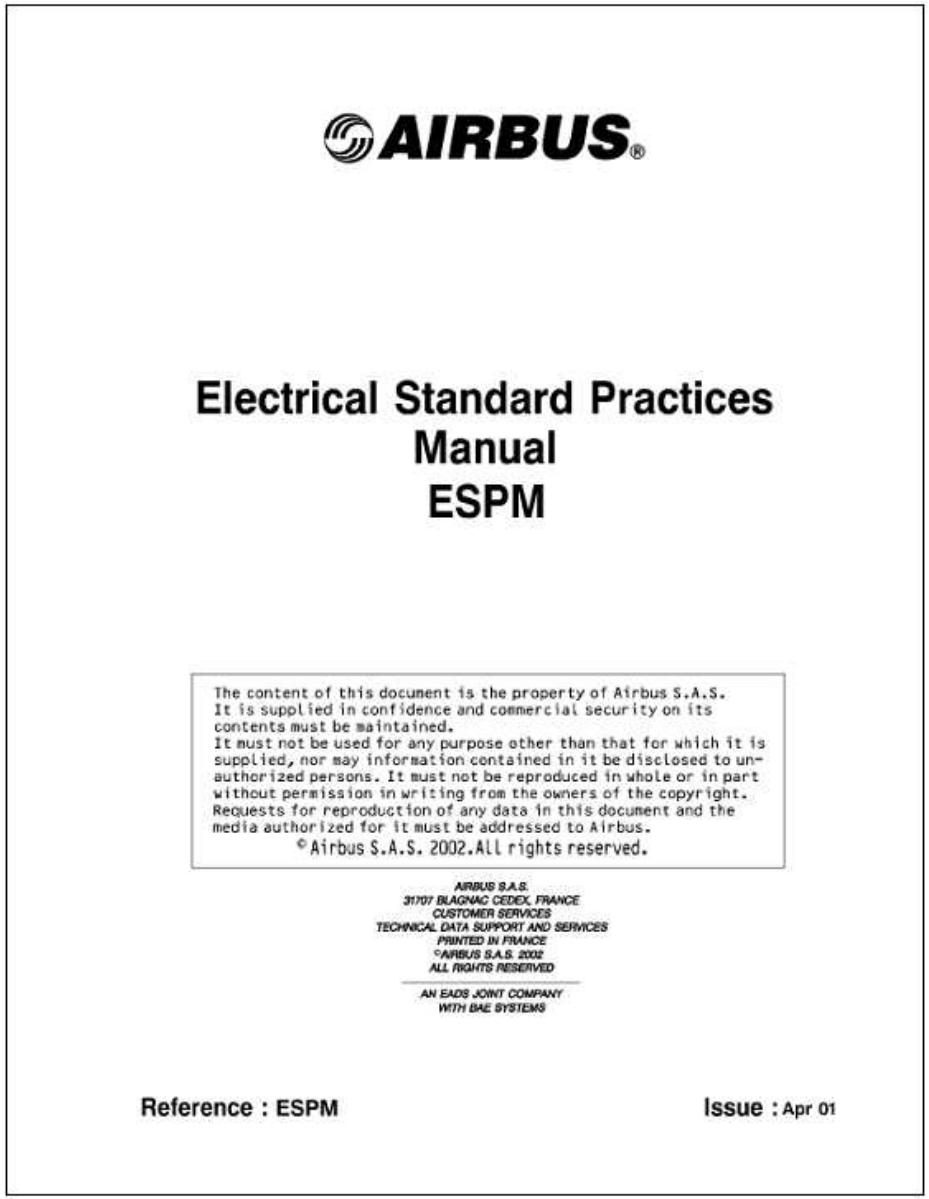
Boeing: SWPM (**S**tandard **W**iring **P**ractices **M**anual)

Airbus: ESPM (**E**lectrical **S**tandard **P**ractices **M**anual)

The corresponding subchapters of this book give reference to respective chapters of regulations.

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AIRBUS

Electrical Standard Practices Manual
ESPM

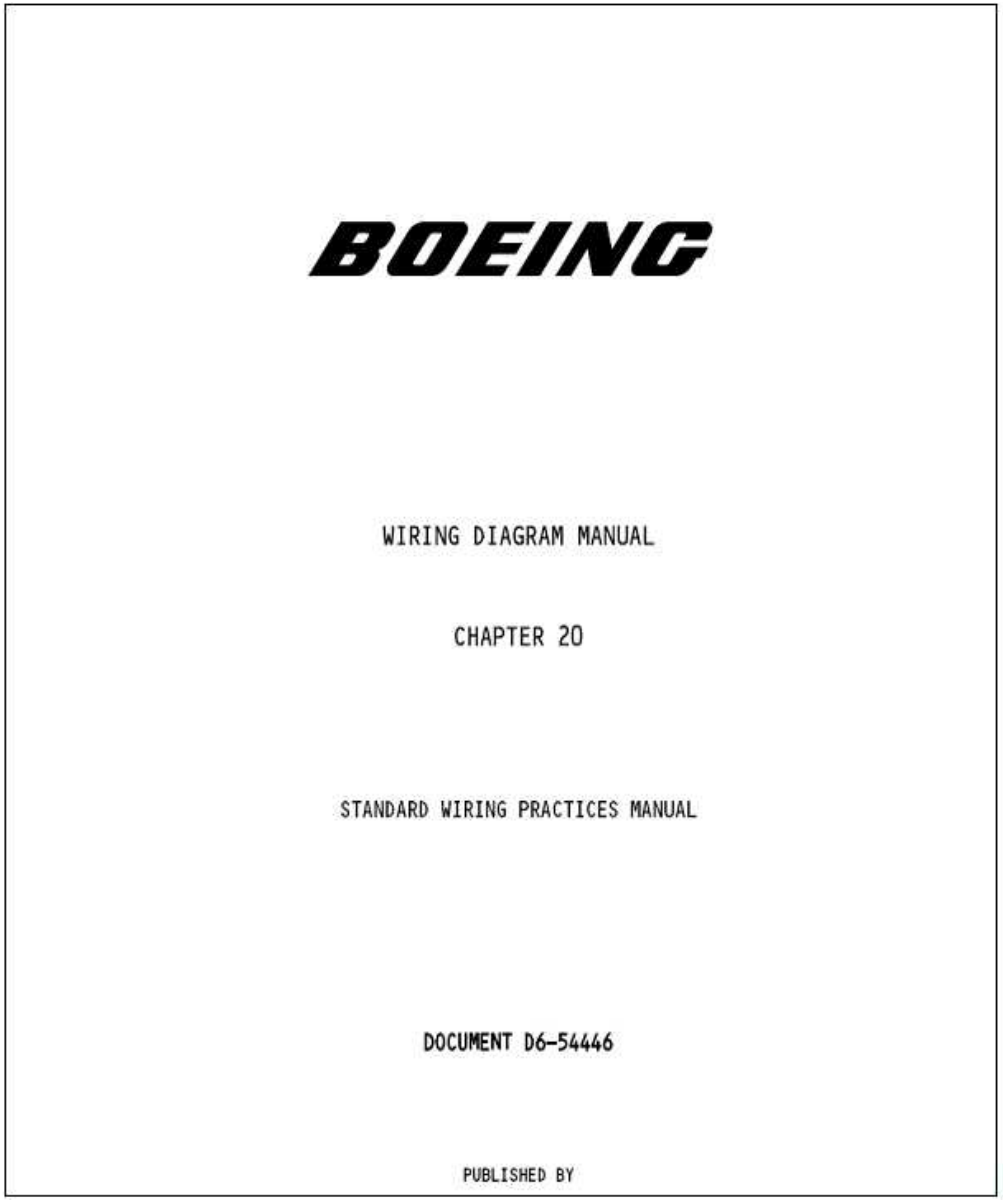
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WITH BAE SYSTEMS

Reference : ESPM

Issue : Apr 01



BOEING

WIRING DIAGRAM MANUAL

CHAPTER 20

STANDARD WIRING PRACTICES MANUAL

DOCUMENT D6-54446

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Figure 1 Front Pages of ESPM and SWPM

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Identification of Airbus Wires

ESPM 20–32–22/PMS 01–07–16

There are three different identification categories of Airbus cables

- printable cables
- non–printable cables
- cables without printing

Printable cables are cables longer than 75 mm and with an AWG from 6 to 24.

Printable cables are identified directly on the insulation, either with an impact printer or a laser printer; this depends on the coating or the code of the cable. Shielded cables are only identified with a laser printer.

-PRINTABLE CABLES:

HOT STAMP	CO^2 LASER
-SINGLE WIRE CABLE: E0261 CF GAUGE 24 TO 14 (ALSO GAUGE 12 TO 10 IF CABLE LENGTH IS MORE THAN 2500mm (98.43in.)) E0262 DK GAUGE 24 TO 14 (ALSO GAUGE 12 TO 6 IF CABLE LENGTH IS MORE THAN 2500mm (98.43in.))	-SINGLE WIRE CABLE: E0261 CF GAUGE 24 TO 10 E0262 DK GAUGE 24 TO 10 E0270 SJ GAUGE 26 TO 14 E0272 TK GAUGE 26 TO 16 E0274 UD GAUGE 26 TO 16 -SCREENED CABLES

Figure 2 Printable Cables

The identification of the cables is required along their entire length.

For cables shorter than two meters, the maximum distance between the printings is 75 mm.

For cables longer than two meters, identification within 1000 mm on both ends of the cable with a distance of 75 mm between the printings is required; for the rest of the cable a distance of 380 mm between the printings is required.

Additionally to the cable identification, cables connected to operating equipment or displays apart from the operating panel must have a cable marking on the side of the connection with the number of the connection.

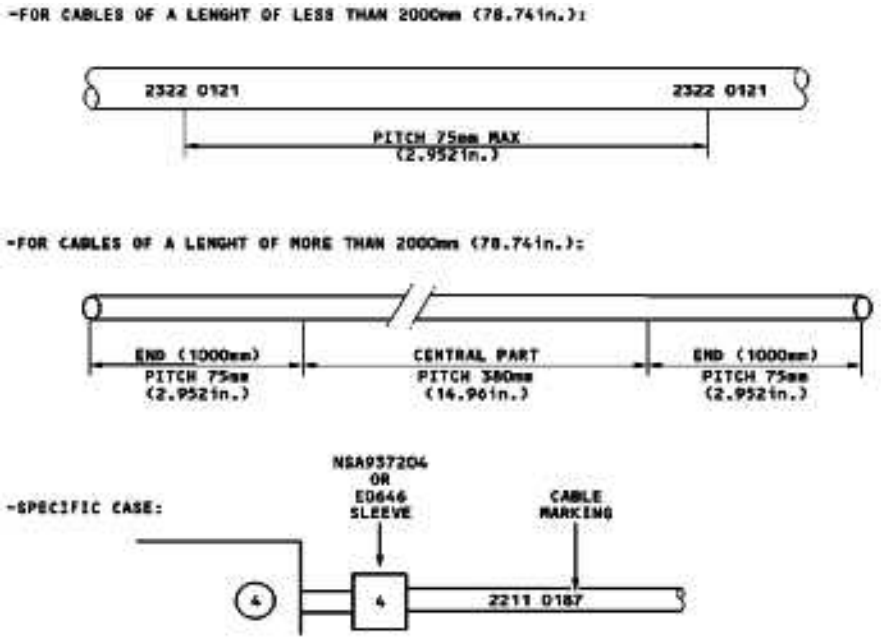


Figure 3 Rules for Printing

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Non−printable cables are cables which, due to the type of insulation, may not be marked in order to avoid damages on the insulation (e.g. coaxial−cables). This category includes

- cables with large gauge (AWG 14 and larger, except laser printing, see table on last page)
- wider cables in an electronic rack, shorter than 2.5 meters
- wires at least on one end connected to a Skydrol zone.

These cables are identified by white sleeves with black printing as close as possible to the connections.

- Sensitive cables marked with an ”S”.

These cables are identified by pink sleeves with black printing.

Cables without printing are:

- very short cables (no longer than 150 mm)
- cables used for circuit breaker monitoring
- ground connection wiring for shielding and grounding jumpers
- cables within small panels

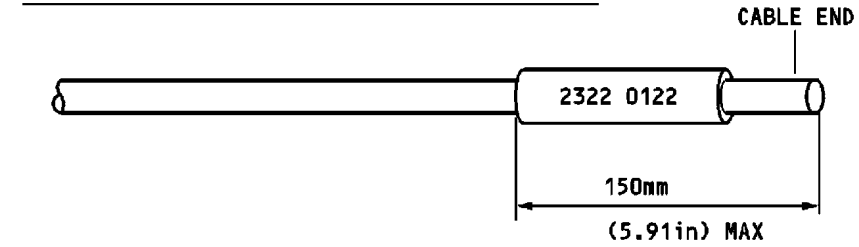


Figure 4 Identification Sleeves 1

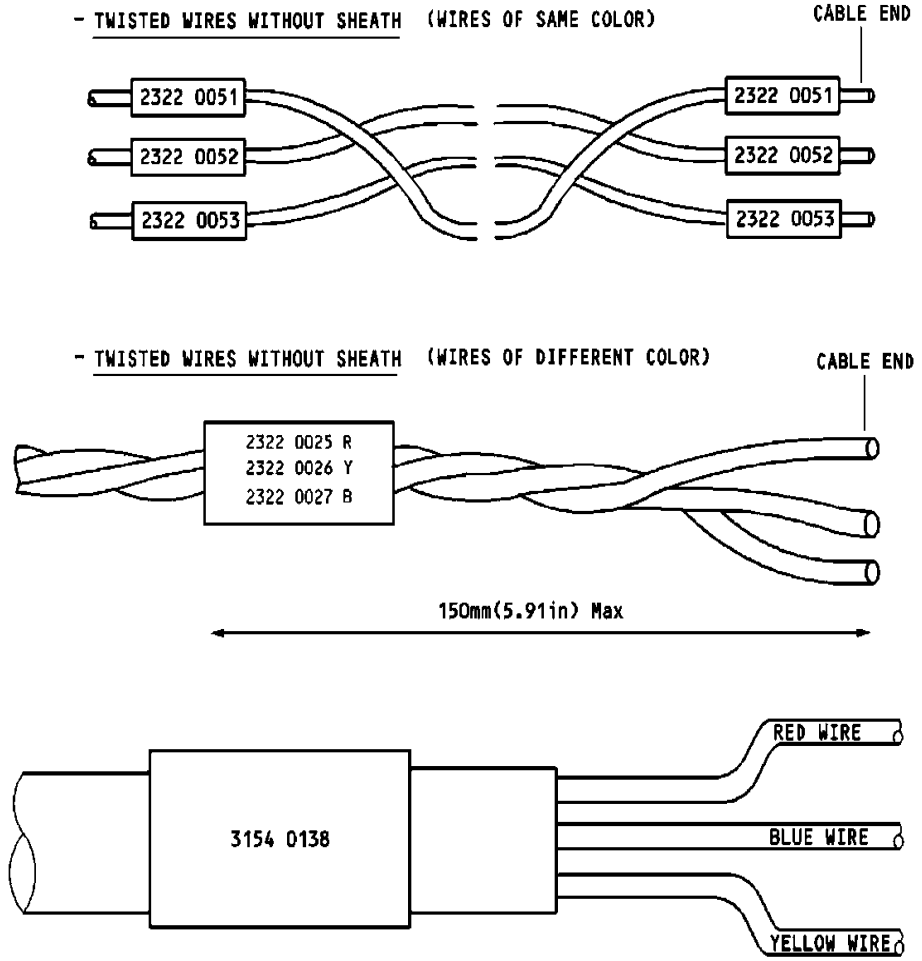


Figure 5 Identification Sleeves 2

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Wiring Damage Classification and Repair Procedures according to Boeing SWPM 20–10–13

The following pages detail the repair procedures for shielded and unshielded wires and cables according to SWPM.

The SWPM chapter 20–10–13 contains the following information:

- The damage conditions of wire, cable, coax cable, and cable assemblies
- The repair conditions for damaged wire, cable, coax cable, and cable assemblies
- The repair procedures for damaged wire, cable, and coax cable.

A distinction is made between:

1. The repair of unshielded wire
2. The repair of shielded wire

GENERAL CONDITIONS FOR WIRE AND CABLE REPAIR

The following conditions apply to all repair procedures:

- The cause of damage must be eliminated in order to prevent this damage from reoccurring.
- To keep the wires clean, any repair work must be done with clean hands and tools.
- This could otherwise lead to corrosion on the conductor and worsened insulation values.
- The repair is considered permanent unless stated otherwise in the repair procedure.
- Repair work in a ”fuel vapor area” must be approved for this area.

The following conditions are dependent on the repair area:

- Repairs may never be carried out in the protection sleeve
- Repairs may never be carried out in a connectors strain relief
- Repairs may never be carried out in a bend of the wire
- Repairs may never be carried out on parts of the wire/cable which often are subject to bending, e.g. at an instrument panel or in areas with movable doors.

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General selection criteria for parts and materials:

Following are the prerequisite conditions for the selection of parts and materials

- The temperature class of the insulation materials must be equal or higher than the temperature class of the wire or cable to be repaired.
- The temperature class of the metal parts must be equal or higher than the temperature class of the conductor to be repaired.
- For repairs in ”high temperature areas”, the temperature class of the material must be class ”D”. (20–02–20)
- If part of a wire or cable needs to be replaced, it must be done with wire or cable with the same part number.

General selection criteria for repair work with a splice

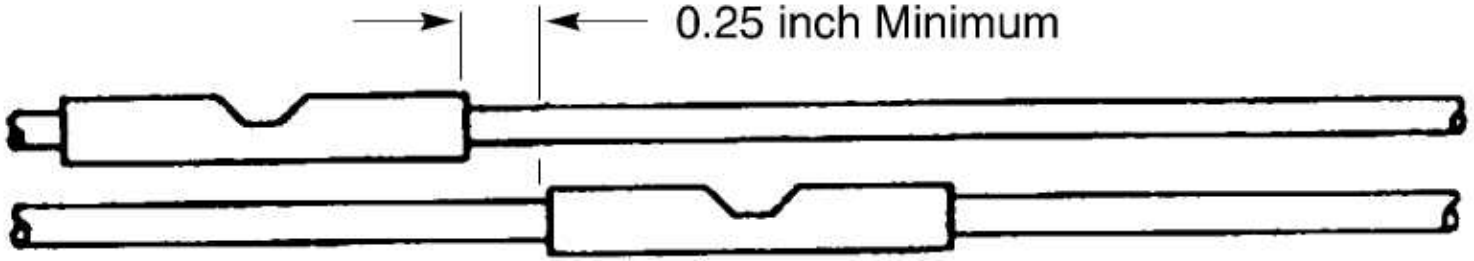
As a general rule, replacement should always be preferred to repair.

The following requirements must be met:

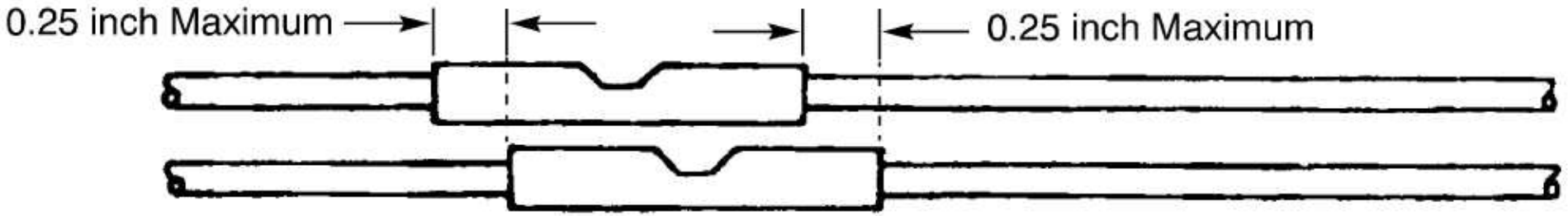
- Splices must be insulated
- A maximum of three repair splices are permitted in one wire, the ones mounted during aircraft construction are not relevant.
- Whenever more than one splice assembly is necessary during repair, the separation minimum of the splices is 0.25 inches.
- If this requirement can not be met due to the number of splices or insufficient length of the wire, the splices have to be assembled as shown in figure 2.

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RECOMMENDED SEPARATION OF SPLICES
Figure 1



ALTERNATIVE SEPARATION OF SPLICES
Figure 2

Figure 6 Separation of Splices

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SELECTION OF REPAIR PROCEDURES

Possible repair conditions for wires and cables:

- The repair of wire and cable, refer to Paragraph 1.B.
- The repair of Airworthiness Limitation wiring, refer to Paragraph 1.C.
- The repair of Fuel System wiring that has Airworthiness Limitations, refer to Paragraph 1.C.
- The repair of wiring that is adjacent to a fuel tank, refer to Paragraph 1.C.
- The selection of parts and materials for a repair, refer to Paragraph 1.D.
- The repair of wire and cable with a splice, refer to Paragraph 1.E.

For the applicable damage and repair conditions of:

- Wire and cable in special systems, refer to Table I
- Special wire and cable, refer to Table II
- Other types of wire and cable, refer to Table III.

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REPAIR OF ELECTRICAL WIRE AND CABLE

TABLE I
WIRE AND CABLE IN SPECIAL SYSTEMS

System Wire and Cable	Damage and Repair Conditions
Engine Wire Harness	Paragraph 2.T.
Fuel Quantity Indicator System that is in the Fuel Tank	Paragraph 2.V.
Fuel Quantity Indicator System that is not in the Fuel Tank	Paragraph 2.W.
Other Fuel System Wiring	Paragraph 2.U.
777 Primary Flight Control System	Subject 20-14-11

TABLE II
SPECIAL WIRE AND CABLE

Special Wire or Cable	Damage and Repair Conditions
Aluminum Wire	Paragraph 2.J.
Bond and Ground Jumper Assembly	Paragraph 2.L.
Coax Cable	Paragraph 2.M.
Copper Power Feeder Wire	Paragraph 2.K.
Fire Resistant Wire	Paragraph 2.N.
Flat Conductor Cable Assembly	Paragraph 2.O.
S280W502-1 ARINC 629 Stanchion to LRU Stub Cable	Paragraph 2.P.
S280W502-4 ARINC 629 Panel to Stanchion Stub Cable	Paragraph 2.P.
S280W651-() ARINC 629 Data Bus Cable Assembly	Paragraph 2.Q.
Shield Pull Through Shield Ground Wire	Paragraph 2.R.
Thermocouple Wire	Paragraph 2.S.

TABLE III
WIRE AND CABLE TYPES

Wire or Cable Type	Damage and Repair Conditions
Unshielded Wire	Paragraph 2.A.
Unshielded Cable	Paragraph 2.B.
Shielded Wire	Paragraph 2.C.
Shielded Wire - Two Adjacent Shields	Paragraph 2.D.
Shielded Wire - Two Shields That Are Not Adjacent	Paragraph 2.E.

REPAIR OF ELECTRICAL WIRE AND CABLE

Wire or Cable Type	Damage and Repair Conditions
Shielded Cable	Paragraph 2.F.
Shielded Cable - Two Adjacent Shields	Paragraph 2.G.
Shielded Cable - Two Shields That Are Not Adjacent	Paragraph 2.H.
Wire or Cable with a Non-Metallic Braid	Paragraph 2.I.

Figure 7 General Data (Paragraph 1)

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DAMAGES AND CORRESPONDING SELECTION OF REPAIR PROCEDURES OF UNSHIELDED WIRES

For the conditions that are applicable to the data in this paragraph, refer to Paragraph 1.A.

Repair **is necessary** when these types of damage occur:

- Damage to the conductor; refer to Paragraph 4.A.
- Damage that goes through the primary insulation; refer to Paragraph 3.A.
- Damage that goes into the primary insulation; refer to Paragraph 3.A.
- The bond between the overlaps of the tape of the insulation is broken for a length more than 50 percent of the diameter of the wire; refer to Figure 3 and Paragraph 3.C.
- Damage that goes into or through the insulation of a splice assembly when the conductor splice does not have damage; refer to Figure 4 and Paragraph 3.F.

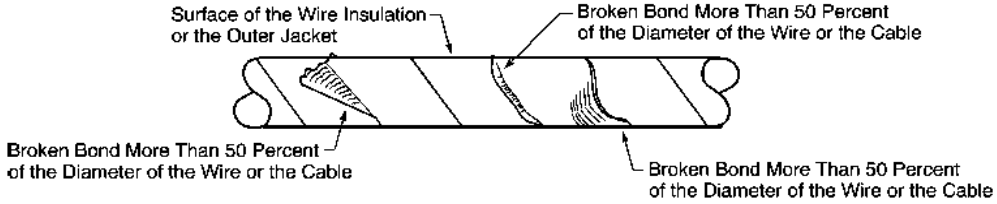
Repair **is not necessary** when these types of damage occur:

- A fold in the insulation at a bend
- A small scratch on the surface of the insulation
- Abrasion that makes the surface of the insulation rough
- The bond between the overlaps of the tape of the insulation is broken for a length that is less than 50 percent of the diameter of the wire.

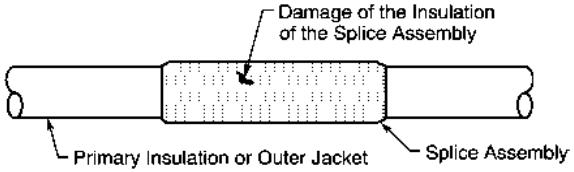
Refer to Figure 5 and Figure 6.

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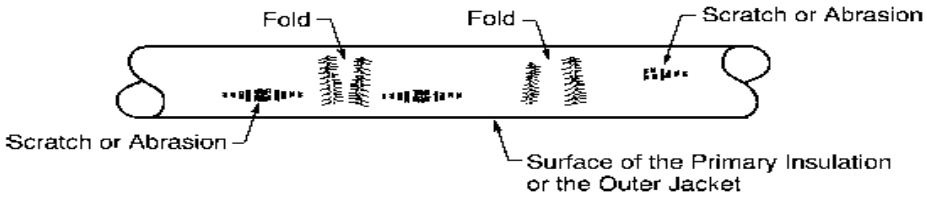
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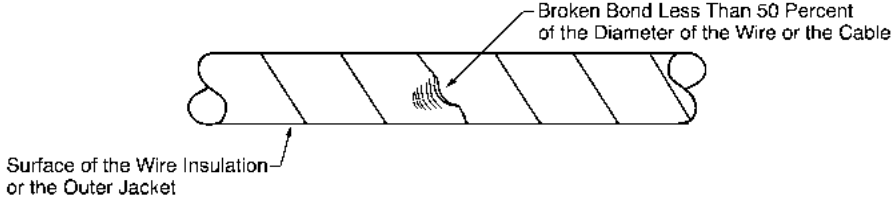
UNSERVICEABLE BROKEN BONDS
Figure 3



UNSERVICEABLE DAMAGE OF THE INSULATION OF A SPLICE ASSEMBLY
Figure 4



SERVICEABLE SCRATCHES, FOLDS, AND ABRASION
Figure 5



SERVICEABLE BROKEN BONDS
Figure 6

Figure 8 Types of Damage

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REPAIR OF UNSHIELDED WIRING

4.Repair of Unshielded Wire and Unshielded Cable with a Splice Assembly

Example given:

- Damage to the conductor; refer to Paragraph 4.A.

A. Repair of a Wire

Refer to Paragraph 1.E. for the applicable conditions for the repair of wire with a splice.

3. Remove the damaged length of the wire.

   (a) On one side of the damage, cut the wire. Make sure that the end of the wire is perpendicular to the longitudinal axis of the wire.

   (b) On the other side of the damage, cut the wire. Make sure that the end of the wire is perpendicular to the longitudinal axis of the wire.

4. Clean the insulation with isopropyl alcohol.
   Make sure:

- To clean the area of the insulation from the end of each wire to a minimum of 3 inches from the end
- That the cleaned area is dry.

5. Assemble a sealed splice.
   For the splice of:

- An AWG 8 or larger high temperature wire, refer to Subject 20–30–13
- All other wires, refer to Subject 20–30–12 for the selection of a sealed splice configuration.

Make sure that the configuration is applicable for the wire.

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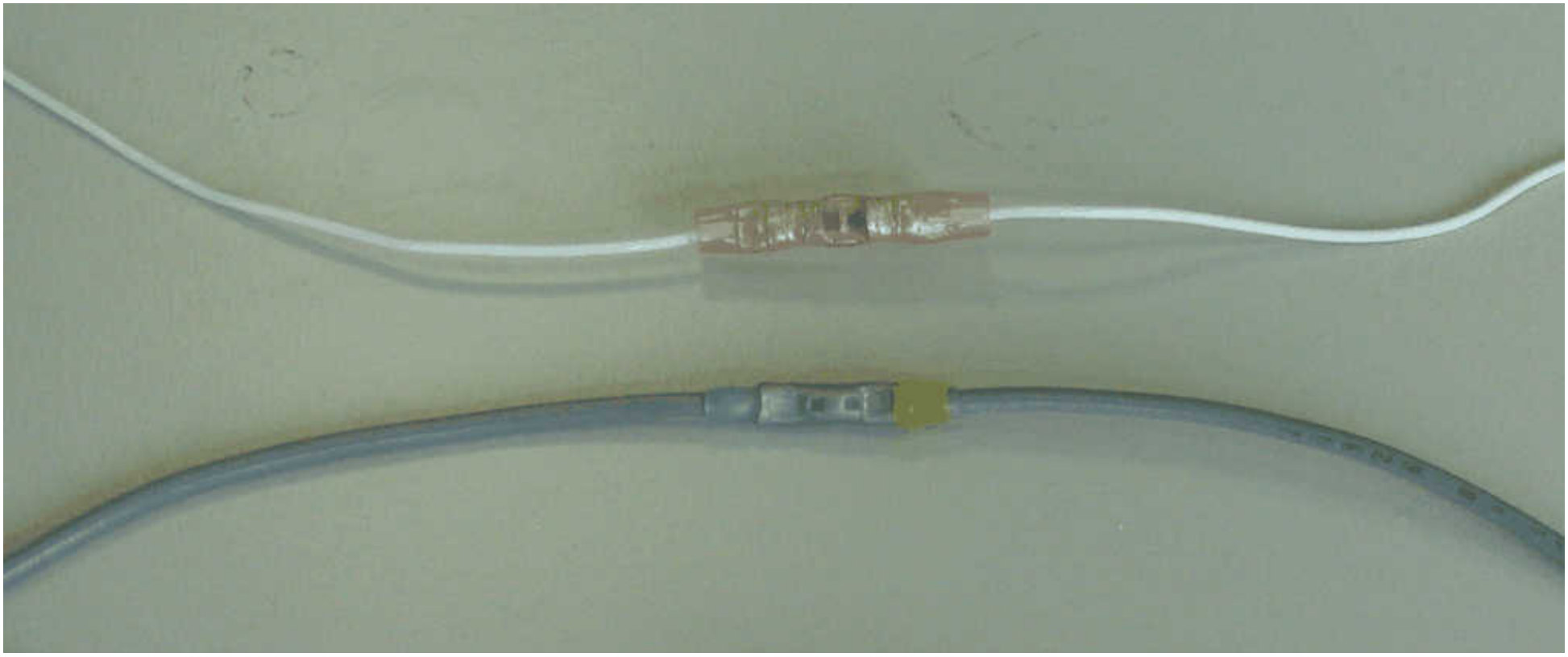


Figure 9 Examples of Splices

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DAMAGES AND CORRESPONDING SELECTION OF REPAIR PROCEDURES OF SHIELDED WIRES

Shielded Wire

For the conditions that are applicable to the data in this paragraph, refer to Paragraph 1.A.

Repair is necessary when these types of damage occur:

- Damage to the conductor; refer to Paragraph 5.A.
- Damage to the primary insulation; refer to Paragraph 5.A.
- Damage to the shield is more than 1 inch in length or more than 25 percent of the circumference of the shield, and near the end of the wire; refer to Paragraph 6.A.
- Damage to the shield is more than 1 inch in length or more than 25 percent of the circumference of the shield; refer to Paragraph 5.A.
- Damage to the shield is less than 1 inch in length and less than 25 percent of the circumference of the shield; refer to Paragraph 6.C.
- Damage that goes through the jacket, but the shield has no damage; refer to Paragraph 3.B.
- Damage that goes into the jacket; refer to Paragraph 3.B.
- The bond between the overlaps of the tape of a jacket is broken for a length more than 50 percent of the diameter of the wire; refer to Figure 12 and Paragraph 3.C.
- Damage that goes into the insulation of the shield splice assembly, but the shield has no damage; refer to Figure 13 and Paragraph 3.F.

Refer to Figure 11.

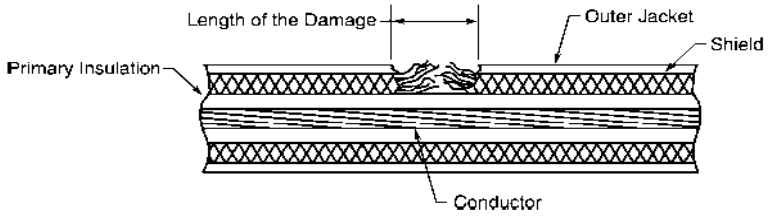
Repair is not necessary when these types of damage occur:

- A fold in the jacket or the primary insulation at a bend
- A small scratch on the surface of the jacket or the primary insulation
- Abrasion that makes the surface of the jacket or the primary insulation rough
- The bond between the overlaps of the tape of the jacket is broken for a length that is less than 50 percent of the diameter of the wire.

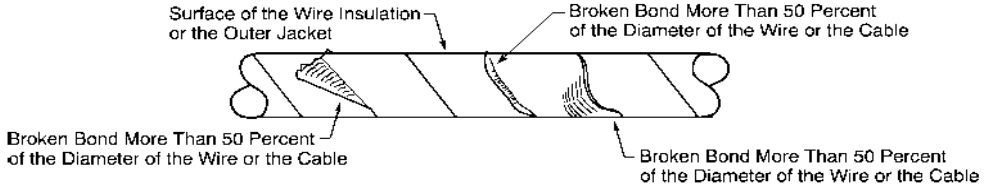
Refer to Figure 14 and Figure 15.

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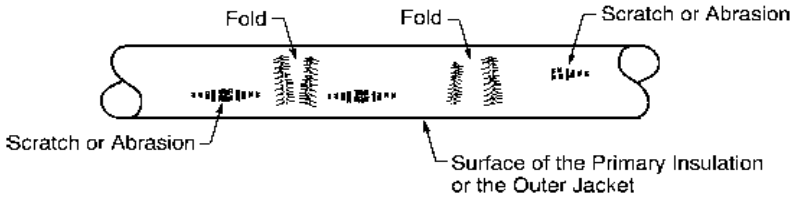
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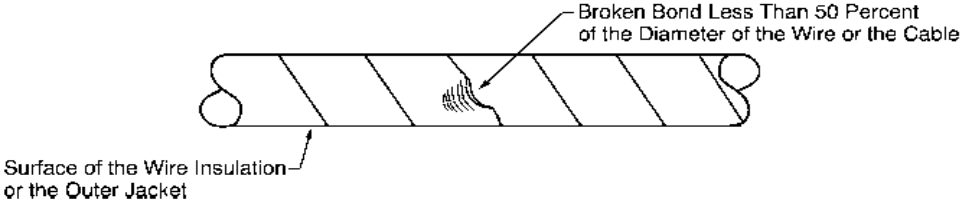
UNSERVICEABLE JACKET AND SHIELD DAMAGE
Figure 11



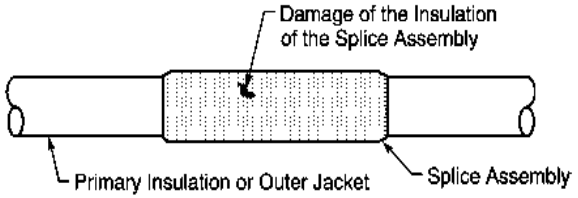
UNSERVICEABLE BROKEN BONDS
Figure 12



SERVICEABLE SCRATCHES, FOLDS, AND ABRASION
Figure 14



SERVICEABLE BROKEN BONDS
Figure 15



UNSERVICEABLE DAMAGE OF THE INSULATION OF A SHIELD SPLICE ASSEMBLY
Figure 13

Figure 10 Types of Damage

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REPAIR OF SHIELDED WIRING

Example given:

- Damage to the shield is more than 1 inch in length or more than 25 percent of the circumference of the shield, and near the end of the wire; refer to Paragraph 6.A.

6.Repair of the Shield of a Shielded Wire and a Shielded Cable

A. Selection of a Sealed Shield Splice Configuration

Refer to:

- Paragraph 2. for the damage and repair conditions of the applicable shielded wire or shielded cable
- Paragraph 1.E. for the applicable conditions for the repair of wire and cable with a splice.

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TABLE XIII
SEALED SHIELD SPLICE CONFIGURATIONS

Maximum Temperature Grade	Number of Shields	Shield Conductor	Applicable Condition	Shield Splice Assembly	
				Configuration	Procedure
B	1	Flat	No Fuel Vapor	Solder Shield Splice Sleeve	Paragraph 6.D.
				Solder Sleeves, Tape, Sleeve	Paragraph 6.E.
				Solder Sleeves, Tape, Ties	Paragraph 6.F.
		Round	No Fuel Vapor	Solder Shield Splice Sleeve	Paragraph 6.D.
				Solder Sleeves, Tape, Sleeve - No Shield Fold Back	Paragraph 6.E.
				Solder Sleeves, Tape, Ties - No Shield Fold Back	Paragraph 6.F.
				Solder Sleeves, Tape, Sleeve - Shield Fold Back	Paragraph 6.G.
				Solder Sleeves, Tape, Ties - Shield Fold Back	Paragraph 6.H.
B	2	Flat Round	No Fuel Vapor	Solder Shield Splice Sleeve	Paragraph 6.D.
B	2	Flat Round	No Fuel Vapor	Solder Sleeves, Tape, Sleeve	Paragraph 6.E.
B	2	Flat Round	No Fuel Vapor	Solder Sleeves, Tape, Ties	Paragraph 6.F.
B	2	Round Round	No Fuel Vapor	Solder Shield Splice Sleeve	Paragraph 6.D.
B	2	Round Round	No Fuel Vapor	Solder Sleeves, Tape, Sleeve - No Shield Fold Back	Paragraph 6.E.
B	2	Round Round	No Fuel Vapor	Solder Sleeves, Tape, Ties - No Shield Fold Back	Paragraph 6.F.
B	2	Round Round	No Fuel Vapor	Solder Sleeves, Tape, Sleeve - Shield Fold Back	Paragraph 6.G.
B	2	Round Round	No Fuel Vapor	Solder Sleeves, Tape, Ties - Shield Fold Back	Paragraph 6.H.
D	1	Round	Fuel Vapor	Mechanical Ferrules, Tape, Ties	Paragraph 6.J.
D	1	Round	Fuel Vapor	Shield-Kon, Tape, Ties	Paragraph 6.L.
D	1	Round	No Fuel Vapor	Mechanical Ferrules, Tape, Sleeve	Paragraph 6.I.
D	1	Round	No Fuel Vapor	Mechanical Ferrules, Tape, Ties	Paragraph 6.J.
D	1	Round	No Fuel Vapor	Shield-Kon, Tape, Sleeve	Paragraph 6.K.
D	1	Round	No Fuel Vapor	Shield-Kon, Tape, Ties	Paragraph 6.L.
D	2	Round Round	Fuel Vapor	Mechanical Ferrules, Tape, Ties	Paragraph 6.J.
D	2	Round Round	Fuel Vapor	Shield-Kon, Tape, Ties	Paragraph 6.L.
D	2	Round Round	No Fuel Vapor	Mechanical Ferrules, Tape, Sleeve	Paragraph 6.I.
D	2	Round Round	No Fuel Vapor	Mechanical Ferrules, Tape, Ties	Paragraph 6.J.
D	2	Round Round	No Fuel Vapor	Shield-Kon, Tape, Sleeve	Paragraph 6.K.
D	2	Round Round	No Fuel Vapor	Shield-Kon, Tape, Ties	Paragraph 6.L.

Figure 11 Repair Paragraphs

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E. Shield Repair – Solder Sleeves, Shield Material, Tape, and a Sleeve without Shield Folded Back

Refer to:

- Paragraph 1.E. for the applicable conditions for the repair of wire and cable with a splice
- Figure 94 for the configuration of the splice assembly.

For details how to do this kind of repair refere to SWPM 20–10–13 Page 86 and on.

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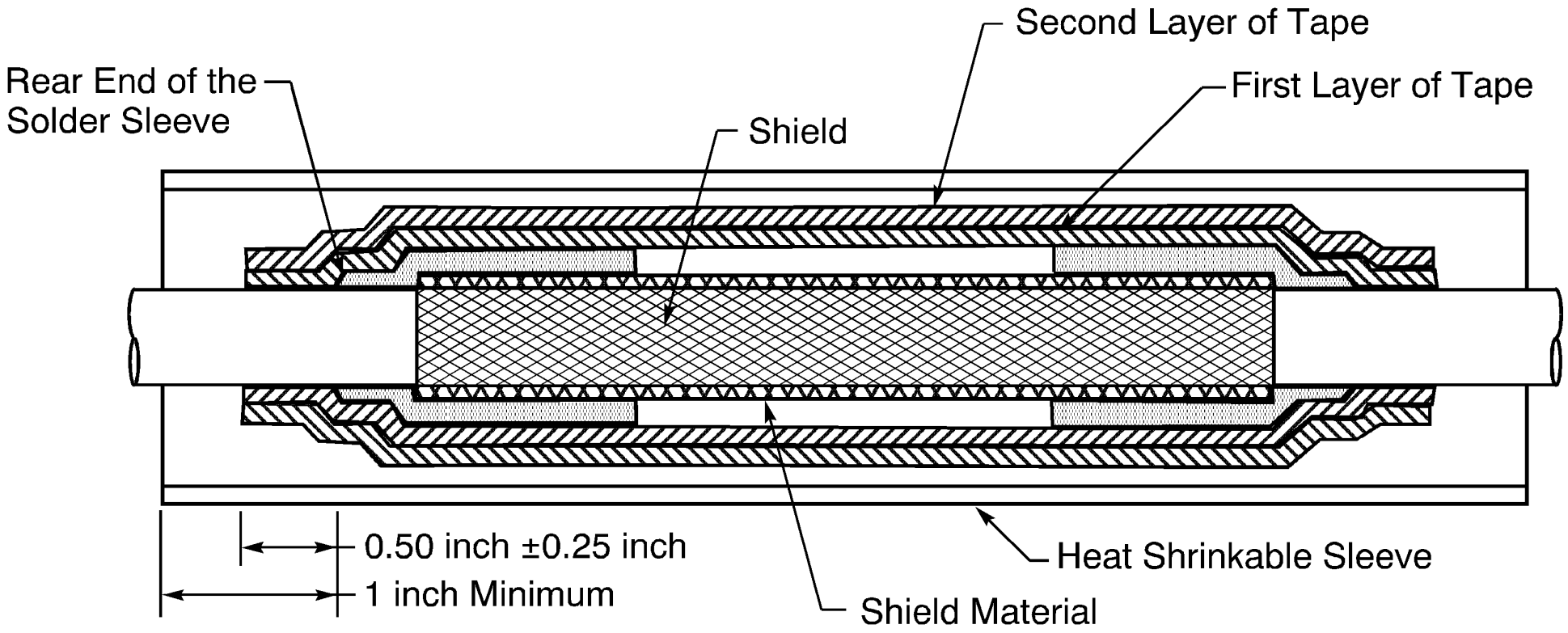


Figure 12 Shielded Wire Repair

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Wiring Repair acc. to Airbus ESPM 20–53–20

Whenever a wire is damaged or broken, the standard repair procedure is to replace it with a wire with the same part number.

DEFINITION

EFCS (Electrical Flight Control System) cables:

EFCS cables are cables which are part of the Flight Control System. One of the following ATA numbers is included in their wire number:

- A300, A300–600 and A310: not applicable.
- A320 family: ATA chapter 27–92/–93/–94/–95.
- A330/A340 family: ATA chapter 27–92/–97/–98.
- A380 family: ATA chapter 27–14/–24/–34/–44/–64/–92/–97/–99.
- EFCS cables are mounted in special EFCS routes.

Sensitive cables:

NOTE: Cables also called Safety cables.

Sensitive cables are important wires commonly used in all systems.

Sensitive cables are installed in EFCS equipment and:

- other ATA equipment
- or ATA27 equipment (high lift or flap and slat control).

these cables can be mounted in normal or special EFCS routes.

REPAIR STEPS

NOTE: Be careful, if the demand cable is a sensitive cable or an EFCS cable. The repair classification (grade) can be different.

If a standard wire is damaged, you must do the following:

- locate the damaged cable and identify it (P/N, type, sensitive/EFCS)
- locate and eliminate the cause for the damage.
- examine the cable to find out what type of damage occurred.

Refer to par. DAMAGE ASSESSMENT PROCEDURE and to fig. TABLE OF DAMAGE ASSESSMENT.

Carefully examine the wires. The insulation of many wires is transparent and thus the conductor is visible if there is no outer coating (see AP-wire). If this is the case, it does not affect the electrical functionality of the wire and repair work thus is not necessary.

Repair classes

There are several repair classes:

Refer to the repair classification and select the repair depending on the repair grade.

Grade 0:

- no repair is necessary (permitted damage).

Grade 1:

- permanent repair.

Grade 2:

- a check of the repair is necessary at each C–check. (Refer to chapter 20–52–10).

Grade 3:

- temporary repair only, replace with new wire in accordance with the basic definition within 20 months but preferably at subsequent C check.

Grade 4:

- no repair is permitted (replace the wire).

Repair types

The repair types are in the order of their priority. If it is not possible to do a specific repair due to missing parts, choose the next higher repair type.

- Refer to the applicable repair type. Refer to para. REPAIR PROCEDURE and to fig. REPAIR PROCEDURE TABLE.
- Do the applicable repair type. Refer to para. REPAIR PROCEDURE, to fig. REPAIR PROCEDURE TABLE and for more data refer to chapter 20–53–29 GENERAL REPAIR PROCEDURE.

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STRUCTURE OF REPAIR PROCEDURES

- Repair of Standard Cables (Ref. 20–53–21)
- Repair of Screened Cables (Ref. 20–53–22)
- Repair of Coaxial and Quad Cables (Ref. 20–53–23)
- Repair of Thermocouple Cables (Ref. 20–53–24)
- Repair of Aluminum Cables (Ref. 20–53–25)
- Repair of Fire–Resistant Cables (Ref. 20–53–26)
- Repair of EFCS and Sensitive Cables (Ref.20–53–27)
- Repair of Optical Fiber Cables (Ref.20–53–28)
- General Repair Procedure (Ref. 20–53–29)

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REPAIR SELECTION PROCESS USING THE EXAMPLE OF A CF−WIRE

Damage description

The alphabetical index is used to finding a repair procedure for a CF−wire. This search leads to 20−53−21 Page 5.

In our example, the conductor of the wire is damaged, which means it is damage grade 1.

As a result, this is Repair Type 1−C.

The asterisk behind the damage grade means that it is damage grade 3 for sensitive wires and cables in EFCS routes!

In this case, repair work is only permitted temporarily.

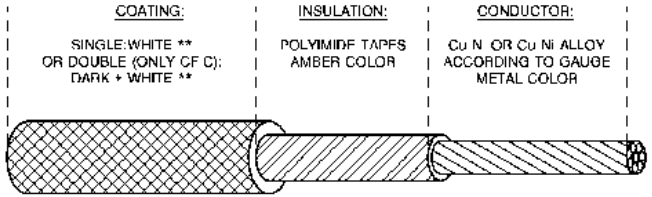
Repair Type

Repair type 1 C means that the wire has to be cut at the damaged part and an applicable splice has to be installed on the damage!

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TYPE: AKA, AKB, CF, CF C, CF U, PD, PF, QD, QF, RD, RF, AK(150°C/302°F)



**IN SOME CASES, THE COATING CAN HAVE A DIFFERENT COLOR

DAMAGE LOCATION	DAMAGE ASSESSMENT	GRADE	REPAIR TYPE (ORDER OF PRIORITY)
COATING:	SURFACE SCRATCHES ON OUTER COATING: YOU CAN SEE POLYIMIDE INSULATION BUT IT IS NOT DAMAGED. CASE OF CF C ONLY: YOU CAN SEE THE DARK COATING. YOU CAN SEE POLYIMIDE INSULATION THROUGH THE TRANSPARENT COATING BUT THE COATING IS NOT DAMAGED.	0	NO REPAIR (CABLE SATISFACTORY IN THIS CONDITION)
INSULATION:	SURFACE NICKS IN POLYIMIDE: YOU CANNOT SEE THE CONDUCTOR.	1	1 B
	DEEP NICKS IN POLYIMIDE: YOU CAN SEE THE CONDUCTOR BUT IT IS NOT DAMAGED.	1*	1 C 1 D 1 E
	MIDDLE OF CABLE: SEPARATION OF AMBER COLORED POLYIMIDE TAPE (CHEMICAL AGRESSION).	4 1*	REPLACE THE CABLE 1 E
	END OF CABLE: SEPARATION OF AMBER COLORED POLYIMIDE TAPE (CHEMICAL AGRESSION).	1	1-B
CONDUCTOR:	DAMAGED STRANDS OR CUT CONDUCTOR: YOU CAN SEE THE COPPER (NICKEL DAMAGED) OR THE STRANDS ARE CUT.	1*	1 C 1 E

* GRADE 3 FOR SENSITIVE CABLES AND EFCS ROUTE.

REPAIR CLASSIFICATION:
GRADE 0:NO REPAIR IS NECESSARY (PERMITTED DAMAGE).
GRADE 1:PERMANENT REPAIR
GRADE 2:A REGULAR CHECK OF THE REPAIR IS NECESSARY AT INTERVALS THAT MUST NOT BE MORE THAN 20 MONTHS (REFER CHAPTER 20 52 10).
GRADE 3:TEMPORARY REPAIR ONLY. REPLACE THE WIRE WITH A NEW WIRE AT A SUBSEQUENT MAINTENANCE CHECK. THE REPAIR MUST NOT STAY ON THE AIRCRAFT MORE THAN 20 MONTHS.
GRADE 4:NO REPAIR IS PERMITTED (CHANGE THE WIRE).

SI5 20 53 21 0 ADM0 03

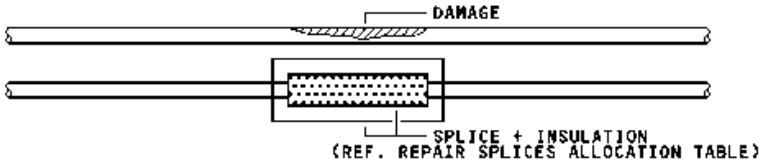
Layout and Table for Damage Assessment
AK, CF, PD, PF, QD, QF, RD, and RF
Figure 002

EFF : ALL

20-53-21

Page 5

REPAIR TYPE		GENERAL DESCRIPTION	CONDITIONS OF APPLICATION
1	A	-WRAP WITH PTFE TAPE MATERIAL No 05-116	-DAMAGE ≤ 300mm(11.8110in.)
	B	-DISCONNECT THE CABLE TERMINATION -INSTALL THE APPLICABLE HEAT-SHRINK SLEEVE ON THE DAMAGE (REF. SLEEVES ALLOCATION TABLE)	-LENGTH MUST BE EASY TO REMOVE -DAMAGE ≤ 300mm(11.8110in.)
	C	-CUT THE WIRE AT THE DAMAGE -ENGAGE THE APPLICABLE HEAT-SHRINK SLEEVE OR STANDARD SLEEVE ON THE CABLE (REF. REPAIR SPLICES ALLOCATION TABLE) -INSTALL THE APPLICABLE SPLICE ON THE DAMAGE (REF. REPAIR SPLICES ALLOCATION TABLE) -INSTALL THE SLEEVE ON THE SPLICE	-LENGTH OF DAMAGE IS LESS THAN LENGTH OF THE SPLICE -IF THERE ARE MORE THAN 3 REPAIR SPLICES ON THE SAME WIRE, REPLACE THE CABLE



MAKE SURE YOU USE THE CORRECT SLEEVE FOR THE AIRCRAFT TEMPERATURE ZONE.

Repair of Standard Cables - Repair Procedure Table
AK, CF, DE, DK, PD, PE, PF, PG, QD, QE, QF, QG, RD, RE, RF and RH
Figure 006

FF : ALL

20-53-21

Page 10

Figure 13 Damage Assessment and Repair Type

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Allocation table for low temperature sleeves

This table contains all the part numbers of insulation sleeves that may be used for this repair.

Allocation Table of Repair Splices

In correspondence to type and AWG of the wire that needs to be repaired, this table contains all the part numbers of splices that may be used for this repair.

(Refer to chapter 20−−43−−1X for SPLICE CRIMPING PROCEDURE).

NOTE: Make sure you use the correct sleeve for the aircraft temperature zone.

NOTE: For more data, refer to 20−53−29 GENERAL REPAIR PROCEDURE.

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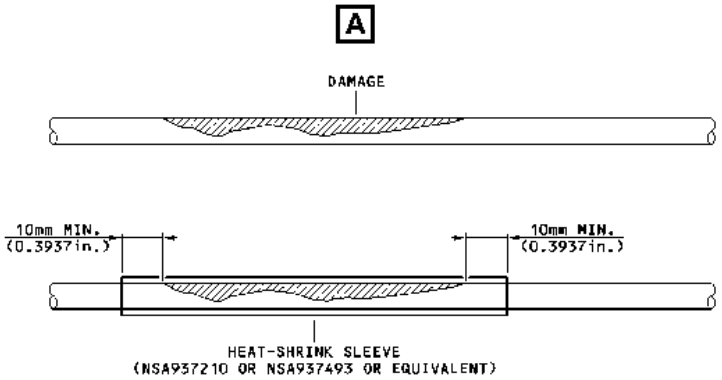
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LOW-TEMPERATURE CABLE TYPE:

SINGLE CORE: AK/AKA/AKB, CF, CF-C, CF-U
MULTI-CORE: PD, PF, QD, QF, RD, RF

CABLE GAUGE	SLEEVE NSA937210MBXX	SLEEVE NSA937493-XXX
26	01	001
24	01	001
22	01 OR 02	001
20	01 OR 02	001
18	01 OR 02	001
16	01 OR 02 OR 03	001 OR 002
14	02 OR 03	001 OR 002
12	02 OR 03 OR 04	001 OR 002
10	03 OR 04	001 OR 002 OR 003

NOTE: YOU CAN USE NSA937210MBXX (SEE DETAIL A)
OR NSA937493-XXX (SEE DETAIL A)
OR EQUIVALENT.



Repair Sleeves for Low-Temperature Cables - Allocation Table
Method 1B/1D only
Figure 010

ALL 20-53-21 Page 14

E0360RKXXXX
NSA936803RAXXXX

COPPER CABLE				WIRE GAUGE	SPLICE
LOW TEMPERATURE (200°C/392°F)		HIGH TEMPERATURE (260°C/500°F)			
WIRE	CABLE *	WIRE	CABLE *		
AK/AKA/AKB CF/CF-C/CF-U	PD/PF QD/QF RD/RF	DE/DG DK/DK-C/DK-U DM/DR	DRB/DRC/DRD PE/PG/PN QE/QG/QL RE/RH/RK	26-24	RA2324 RA2424 RK2424
				22-20	RA2322 RK2220
				18-16	RA1816 RK1816
				14	RA1314 RK1614
				12	RA1112 RK1210
				10	RA1210 RK1210
				8	RA0808 RK0808
				6	RA0606 RK0606

NSA936809RGXXXX

COPPER CABLE				WIRE SECTION ** (mm²)	SPLICE	SLEEVE NSA937493
LOW TEMPERATURE (200°C/392°F)		HIGH TEMPERATURE (260°C/500°F)				
WIRE	CABLE *	WIRE	CABLE *			
AK/AKA/AKB CF/CF-C/CF-U	PD/PF QD/QF RD/RF	DE DK/DK-C/DK-U DM/DR	DRB/DRC/DRD PE/PG/PN QE/QG/QL RE/RH/RK	0.24 TO 1.3	RG0001	001
				1.3 TO 2.6	RG0002	002
				2.6 TO 6.6	RG0003	
				6.6 TO 10.5	RG0004	003
				10.6 TO 16.7	RG0005	004

* THE SPLICE ARE GIVEN ONLY FOR THE REPAIR OF THE WIRE(S) INCLUDED IN THESE CABLES.

** THE WIRE SECTION IS THE SUM OF THE CORE SECTIONS OF THE WIRES TO CONNECT.
(e.g.: GAUGE 18 WIRE = 0.93mm2 GAUGE 20 WIRE = 0.6mm2
=> 0.93 + 0.6 = 1.53mm2 => USE RG0002)

Repair Splices - Allocation Table
Figure 013

FF : ALL 20-53-21 Page 18

Figure 14 Allocation Tables Sleeves and Splices

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REPAIR OF SHIELDED WIRES

As a basic principle:

In order to get the information that is needed for the repair, the same steps as with single wires are necessary.

With the wire code, the repair type can be looked up in the ”damage assessment”.

The table on the right shows the repair procedure for shielded wires; the inner wires have to be split and spliced.

In this example, a TK–wire consists of two CF–wires on the inside.

To repair them with a splice, refer to repair procedures for CF–wires.

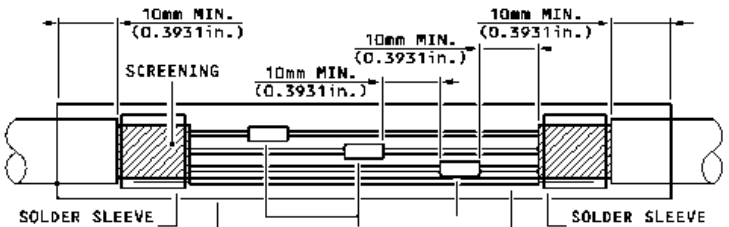
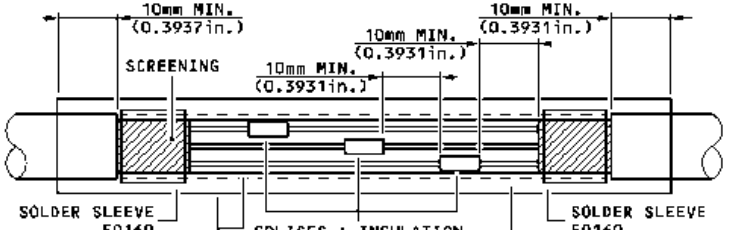
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TABLE 1-T

Cable Identification Coding
Pair Twisted, Shielded and Insulated

WIRE TYPE CODE	TYPE	INSULATOR	SPECIFICATION	STANDARD P/N
TC	600V-180°C (356°F)	XL-ETFE		ABS0824
TF	600V-260°C (500°F)	FIBER/PTFE	AIR 4524	E0818 or EN4608-003B
TG	600V-260°C (500°F)	KAPTON-PTFE KAPTON SHEATH	AIR 4524	NSA935211/213
TJ	600V-150°C (302°F)	KAPTON-FEP SHEATH	AIR 4524	NSA935212
TJA/TJB	600V-200°C (392°F)	2 AKB KAPTON-FEP SHEATH		NSA935214
TK	600V-200°C (392°F)	2 CF KAPTON-FEP		E0272 or
	Ink jet marking			EN2713-003B
	TK-B			EN2713-011B
	UV laser marking			
	TK-C			EN2713-005B
	CO2 laser marking			
	TK-U			EN2713-007B
	UV laser marking			
	TK-Y			EN2713-009B
	YAG-X3 laser marking			
TR	600V-150°C (302°F)	PI-FEP		EN2712-003B
TT	600V-260°C (500°F)	2 DK PI-PTFE		E0273 or
	Ink jet marking			EN2714-003B
	TT-C			EN2714-005B
	CO2 laser marking			
	TT-U			EN2714-007B
	UV laser marking			
	TT-Y			EN2714-009B
	YAG-X3 laser marking			

REPAIR	TYPE	GENERAL DESCRIPTION	CONDITIONS OF APPLICATION
2	E	REF. § 3. PROCEDURE REF. SOLDER REPAIR SLEEVES ALLOCATION TABLE	-DAMAGE ≤ 200mm(7.8740in.) -SINGLE-CORE CABLE REPAIRED BY SPLICE -DAMAGE NOT NEAR CABLE END
		 MAKE SURE YOU USE THE CORRECT SLEEVE FOR THE AIRCRAFT TEMPERATURE ZONE	
	F	REF. § 3. PROCEDURE REF. SOLDER REPAIR SLEEVES ALLOCATION TABLE	-SINGLE-CORE CABLE REPAIRED BY SPLICE -DAMAGE NOT NEAR CABLE END
		 MAKE SURE YOU USE THE CORRECT SLEEVE FOR THE AIRCRAFT TEMPERATURE ZONE	

NOTE: YOU CAN USE METHODS 2E AND 2F INSTEAD OF METHODS 2C AND 2D IF:
-AT LEAST ONE SINGLE-CORE CABLE IS REPAIRED BY SPLICE
(CUT THE OTHER SINGLE-CORE CABLE(S) AND INSTALL A SPLICE)
-NO SINGLE-CORE CABLE IS AFFECTED BUT THE DAMAGE IS
NOT LOCATED IN END ZONE(CUT AND INSTALL A SPLICE ON EACH
SINGLE-CORE CABLE.)

Repair of Screened Cables - Repair Procedure Table
Figure 011

Figure 15 Repair of Shielded/Screened Wire

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CONTINUITY, INSULATION AND BONDING TECHNIQUES

Stripping of Wires

To connect wires and cables in a professional manner, the insulation has to be separated from the conductor beforehand. This must be carried out with an approved wire stripper [e.g. Stripmaster] because it prevents damage on the wire if used properly.

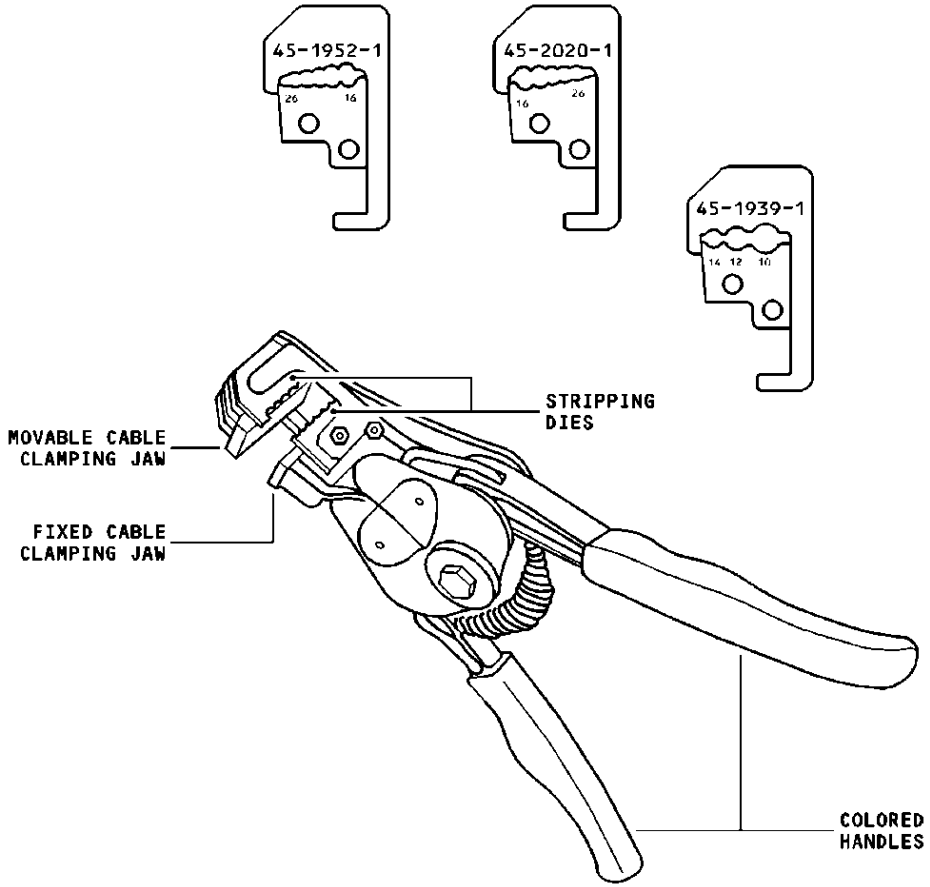


Figure 16 Stripping Tool with Blades



Figure 17 Stripping Tools

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Depending on the type of insulation and AWG standard of the wire (Metric or US), the blades of the stripping tool are exchangeable.

The different AWG standards are clearly detectable by means of green bars printed on AWG Metric Wires in intervals of approx. 20 cm. The cable clamping jaws are exchangeable as well.

Content of jaws set

JAWS SET P/N	MOVABLE JAW P/N	FIXED JAW P/N	CHARACTERISTICS
LB-721	LB-718	LB-719	specific for hard-to-grip Surfaces (eg Kapton, Teflon)
LB-722	LB-718	LB-720	
LB-197	L-5212	L-5215	standard for all products
LB-198	L-5212	L-5217	

Figure 18 Content of Jaws Set

Example of stripping tools

IDEAL-STRIPMASTER Tool P/N	STRIPPING DIES P/N	COLOR OF HANDLES	CABLE CLAMPING JAWS SET P/N	ADMISSIBLE WIRES SIZES	ADMISSIBLE WIRES TYPE
45-2020 *	45-2020-1	Blue	LB-722	26 to 16	METRIC
45-1952 *	45-1952-1	Blue	LB-722		
TMC-PCW1 **	TMCW1	Black	LB-722		
TMC-PCW3 **	TMCW3	Green	TMC-MP3		
45-1773	45-1773-1	Red	LB-198	24 to 16	
45-1774	45-1774-1	Black	LB-197	14 and 12	
45-1939	45-1939-1	Red	LB-721	14 to 10	
TMC-PCW2 **	TMCW2	Grey	LB-721		
TMC-PCW4 **	TMCW4	Green	TMC-MP4		
45-092	L-4421	Blue	LB-198	22 to 16	US
45-171	L-5211 or 45-1654-1	Blue	LB-198	26 to 16	
45-170	45-1608-1 or L-5210	Red	LB-197	14 to 10	

* the difference between these 2 stripping pliers is the position of the wire gauge cavities on the stripping dies.
** DAVUM - STRIPMASTER

Figure 19 Stripping Tools

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To strip the wire, it must be placed into the matching notch of the Stripmaster stripping tool; then the handles must be pressed until stop. When releasing the handles, the clamping jaws open first so that the wire can be removed smoothly.

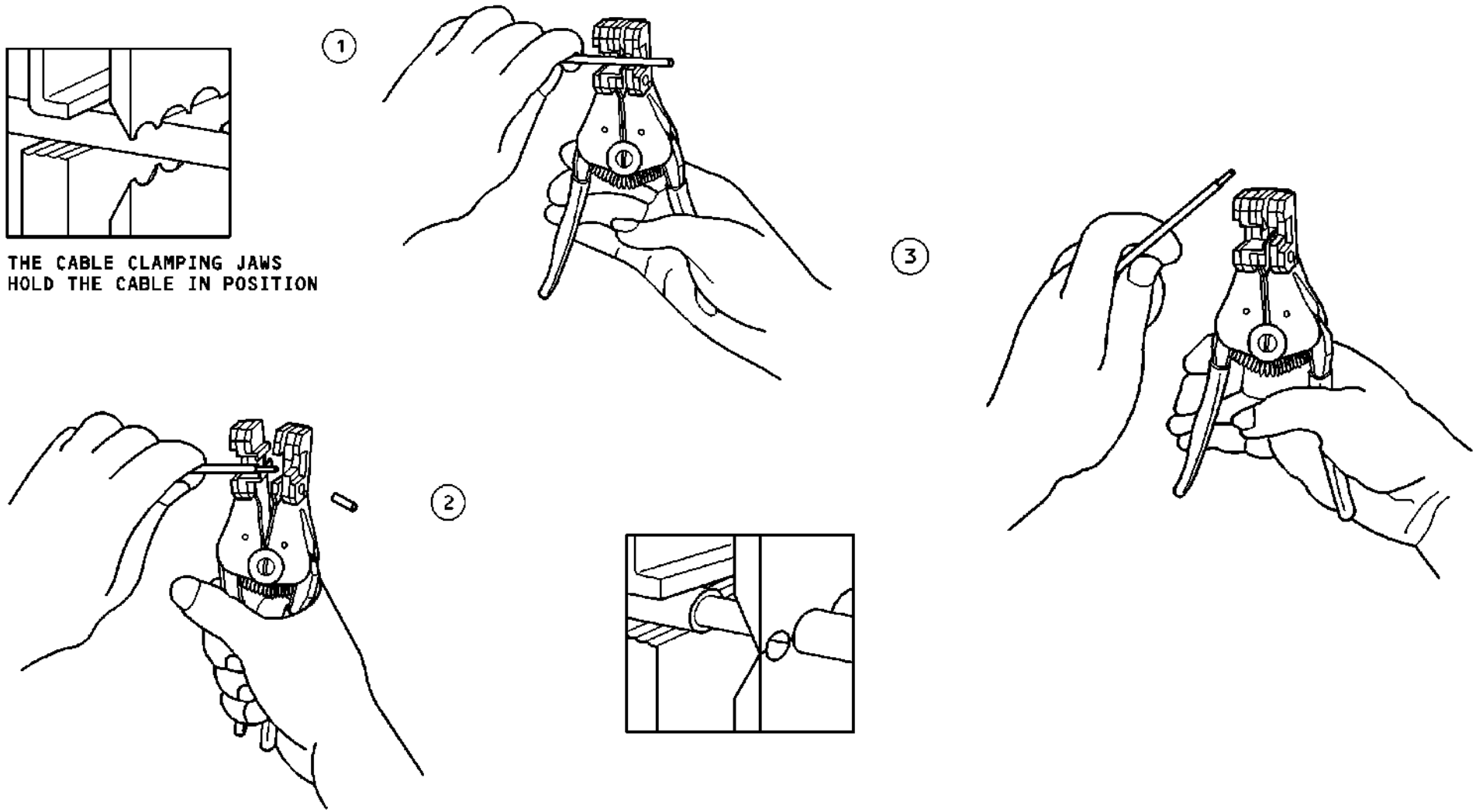


Figure 20 Stripping

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After the stripping process, inspect the wire for any signs of damage.

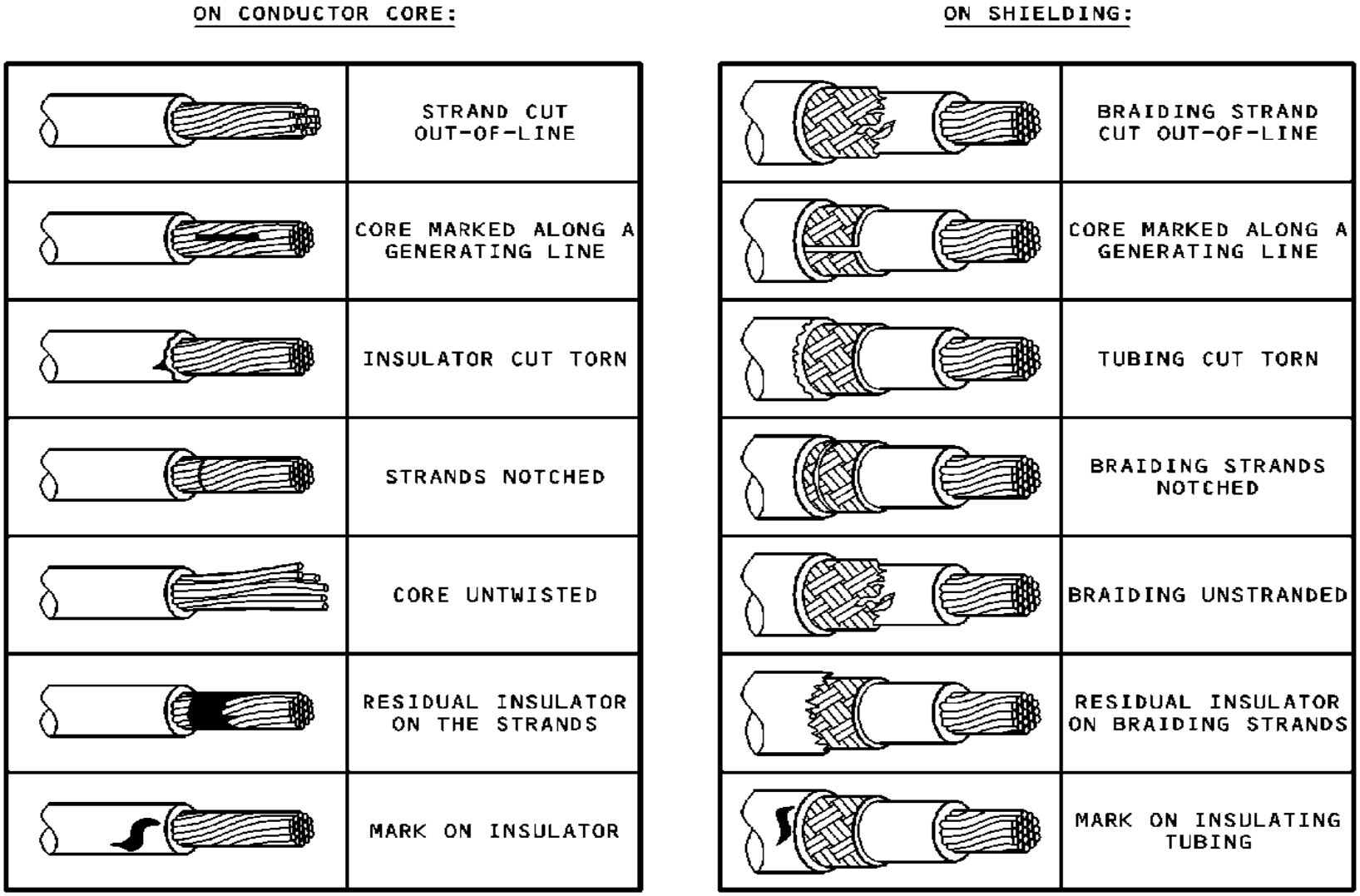


Figure 21 Damages caused by Stripping

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A cutter or scalpel is used to remove insulation from wires with AWG 10 or more or the sheath from a shielding.

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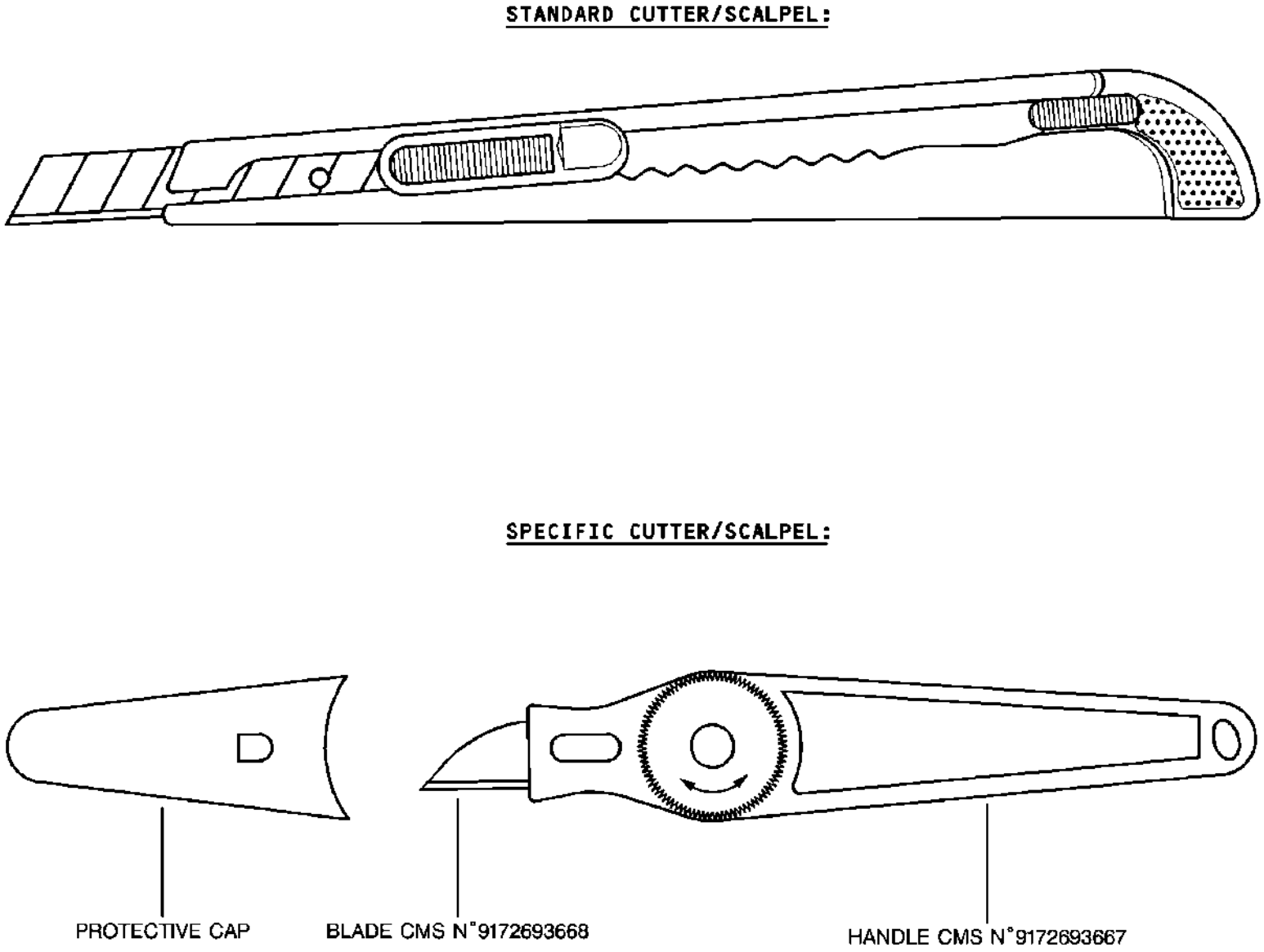


Figure 22 Cutter/Scalpel

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Connections

Soldered Connections

Soft soldering is a method used for joining wires and wide range of connectors.

The solder starts to melt at a temperature of approx. 300 degrees Celsius.

- a solder that contains an acid–free flux in the core is used for this purpose the parts to be soldered must be clean and most important: free from grease
- first, the wire strand must be tin–plated
- then, the tinned wire must be shortened to the desired length
- engage wire into the contact. Heat contact with soldering iron, add some solder and let run
- let soldering joint cool down; do not move joint during this phase
- quality check: the solder must be uniformly dispersed and the surface glossy.

Since the quality control for soldering with a soldering iron is difficult, there are legislations which limit soldered connections in an aircraft to a minimum (MIL – W 5088).

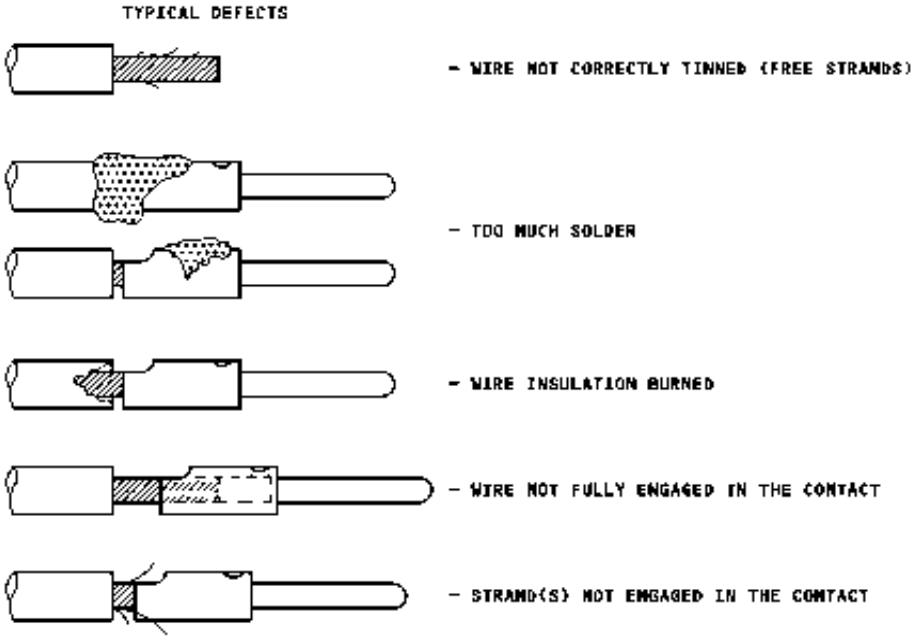


Figure 23 Typical Defects

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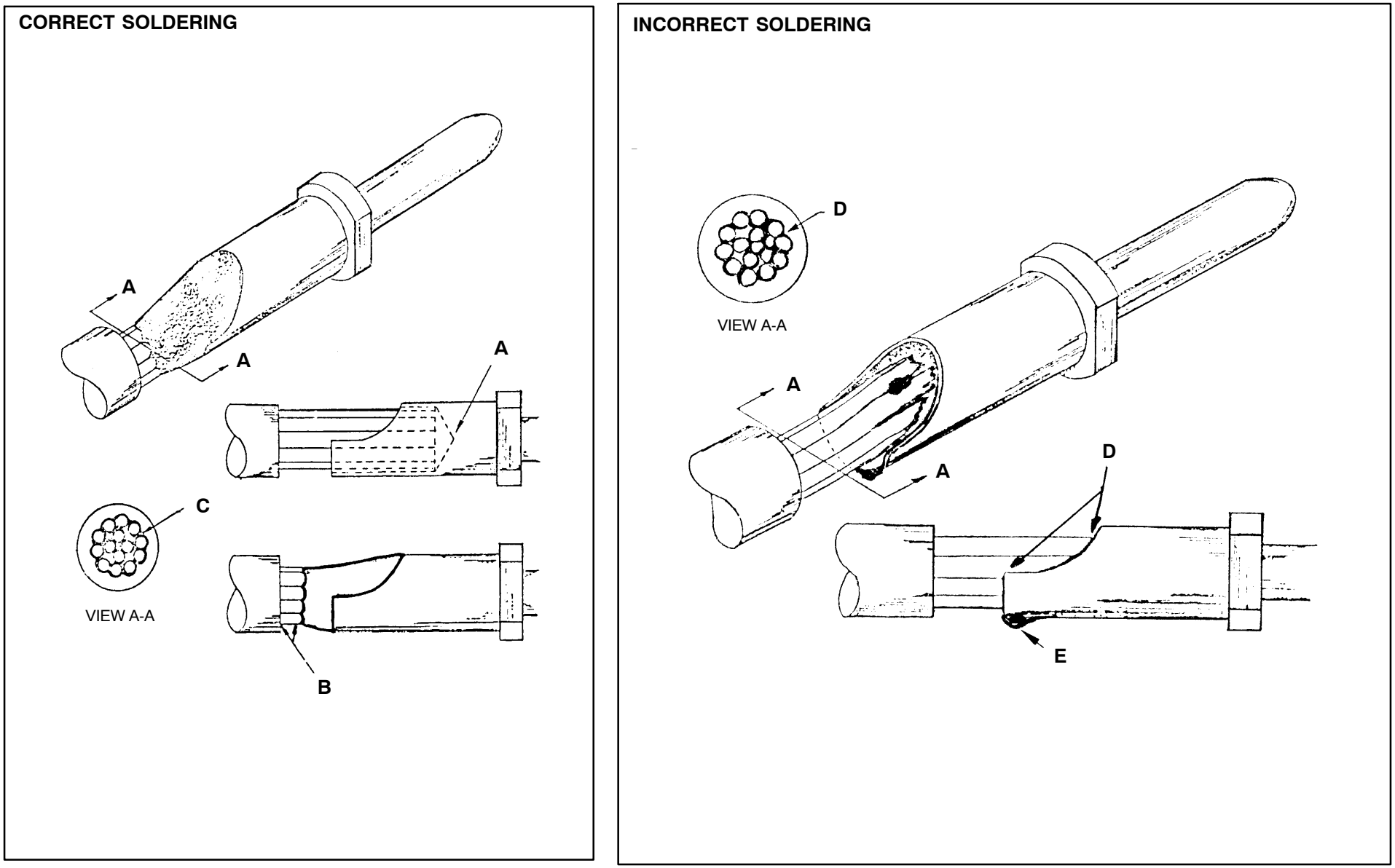


Figure 24 Soldering

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Solder sleeve

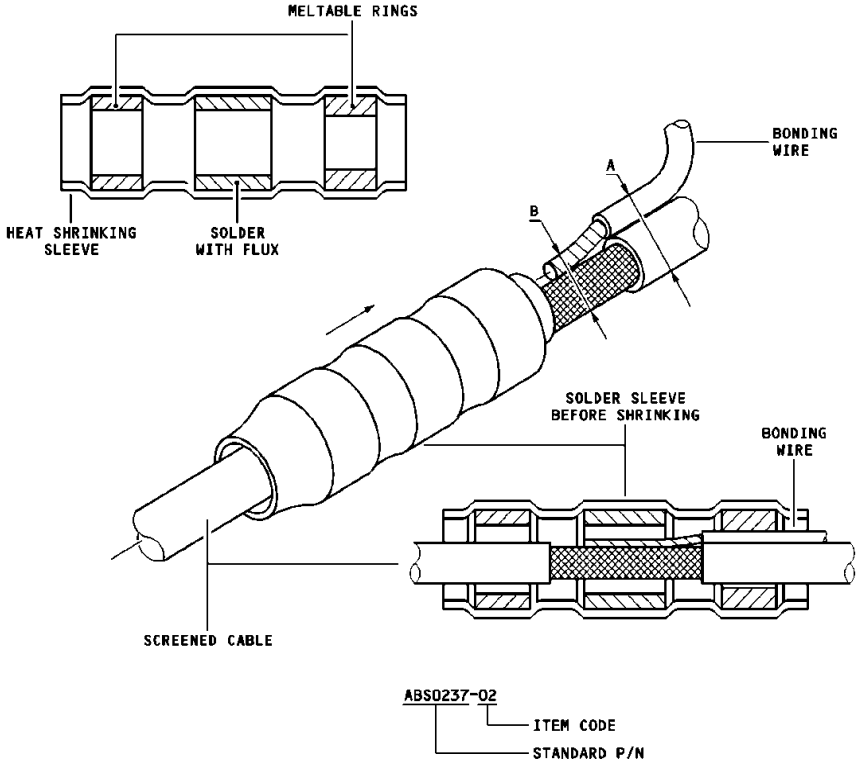
A different soldering technique can be realized with a solder sleeve; its main purpose is to connect a wire to a shielding.

This is described exemplary in the Airbus manual (ESPM 20–42–21).

Depending on the wire type, there are seven different techniques (see table)!

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WIRE TYPE*	WIRE P/N	WIRE GAUGE EN CABLE SIZE CODE								METHOD
		26	24	22	20	18	16	14	12	
		001	002	004	006	010	012	020	030	
HA (5 DK12)	E0287	1.3H								"F"
HD (4 CF24 + RG316)	E0299	1.1H								"C" OR "D" OR "E"
		1.0H 1.1H								
HE (2*24)	E0259	1.1H								
HG (UD24 + 4 XM24)	E0300	1.3H								"F"
HP (HM22 + HN22)	E0529	1.1H								"C" OR "D" OR "E"
KB	ABS0972	1.1H								"C"
KD	ABS1503	1.1H								"C" OR "D" OR "E"
MG (7 CF24)	ABS0682	1.1H								"C" OR "D" OR "E"
MH	EN 2714-011B	1.0H	1.0H	1.1H	1.1H	1.1H	1.2H	1.2H	1.2H	"A" OR "B"
MLA (1 DRA)	EN 2714-013A	1.0H	1.0H	1.0H	1.0H	1.0H	1.0H	1.1H	1.1H	"A" OR "B"
MLB (2 DRA)	EN 2714 013B	1.0H	1.0H	1.1H	1.1H	1.1H	1.1H	1.2H	1.2H	"A" OR "B"
MLC (3 DRA)	EN 2714 013C	1.0H	1.0H	1.1H	1.1H	1.1H	1.2H	1.2H	1.2H	"A" OR "B"
MLD (4 DRA)	EN 2714 013D		1.1H	1.1H	1.1H					"A" OR "B"
MME (5 DRA)	EN 2714 014E					1.2H	1.2H	1.3H	1.3H	"A" OR "B"
MMG (7 DRA)	EN 2714 014G		1.1H							"C" OR "D" OR "E"
SE SFB	NSA935171		1.0H	1.0H	1.0H	1.0H	1.0H			"C" OR "D" OR "E"
SF	NSA935172		1.0H	1.0H	1.0H	1.0H	1.1H			"A" OR "B"
SG	NSA935173	-	1.0H	-	-	-	-	-	-	"C" OR "D" OR "E"
SJ (1 CF)	E0270	1.0H	1.0H	1.0H	1.0H	1.0H	1.0H	1.0H	-	"A" OR "B"
ST (1 DK)	E0271	-	1.0H	1.0H	1.0H	1.0H	1.0H 1.1H	-	-	
SW	E0291	-	1.0H	-	-	-	-	-	-	"E"

* THE WIRE TYPE CODES BETWEEN BRACKETS ARE INNER COMPONENTS OF THE MAIN WIRE TYPE.

Figure 25 Soldering Sleeve Selection

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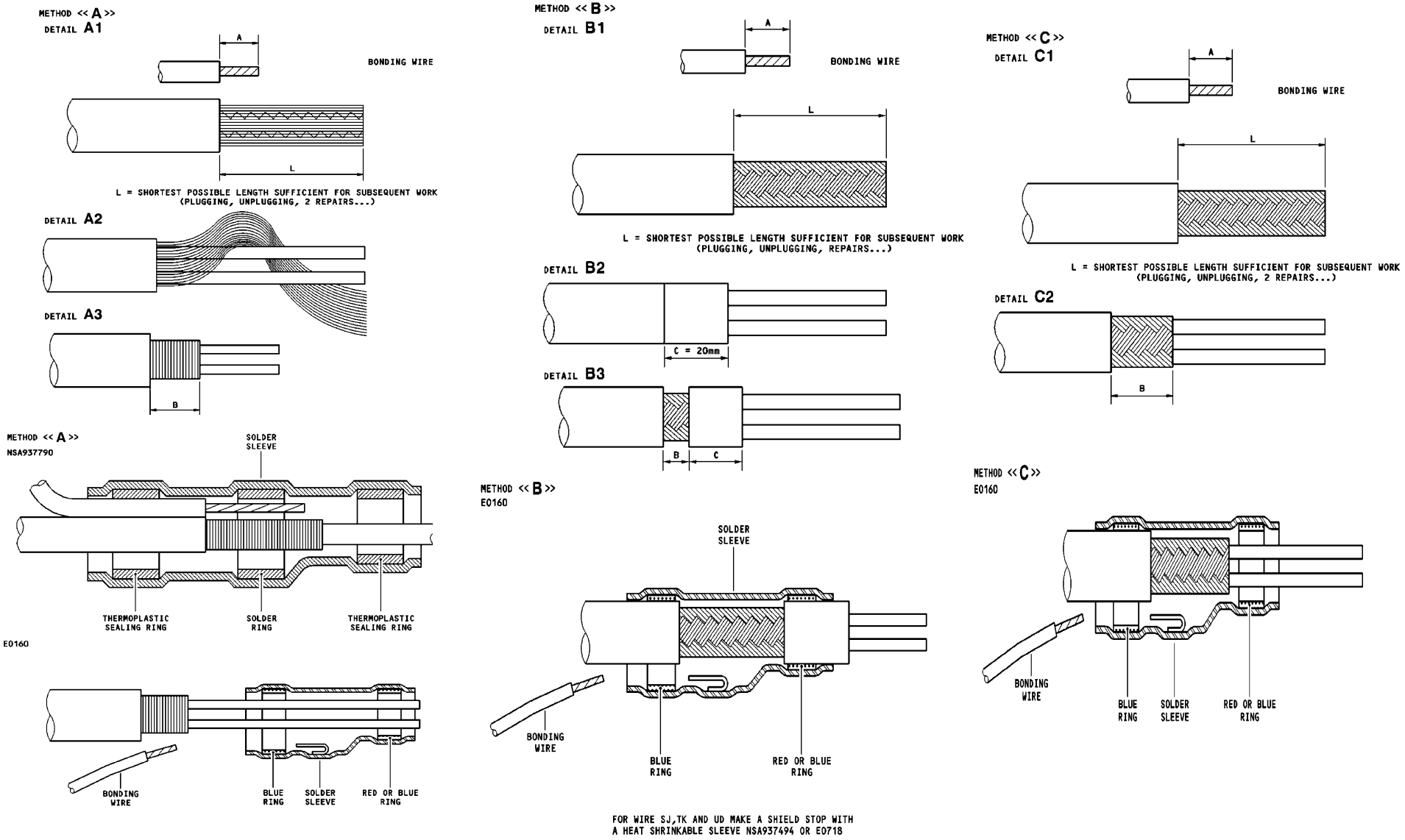


Figure 26 Soldering Sleeve Processing 1

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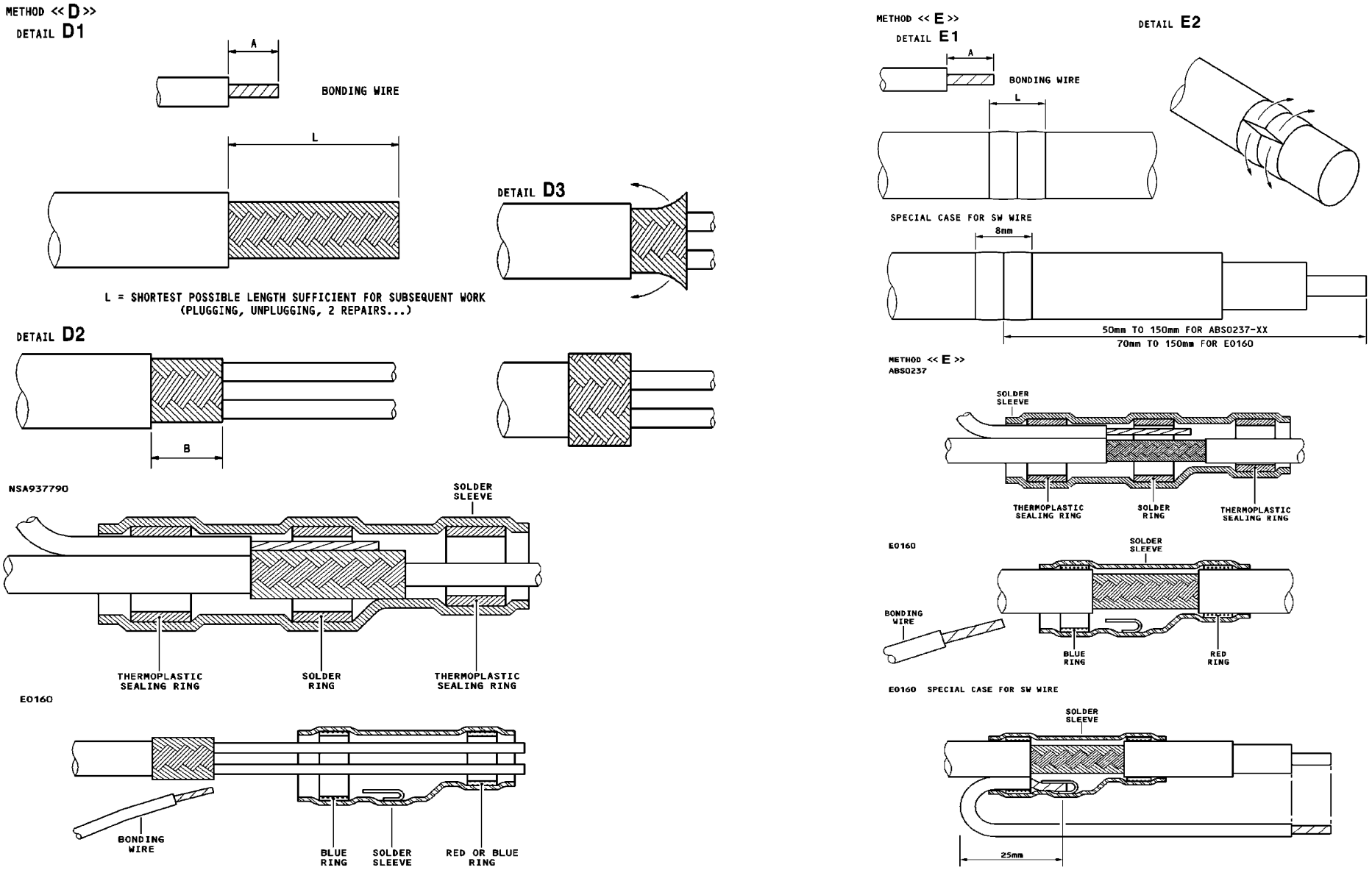


Figure 27 Soldering Sleeve Processing 2

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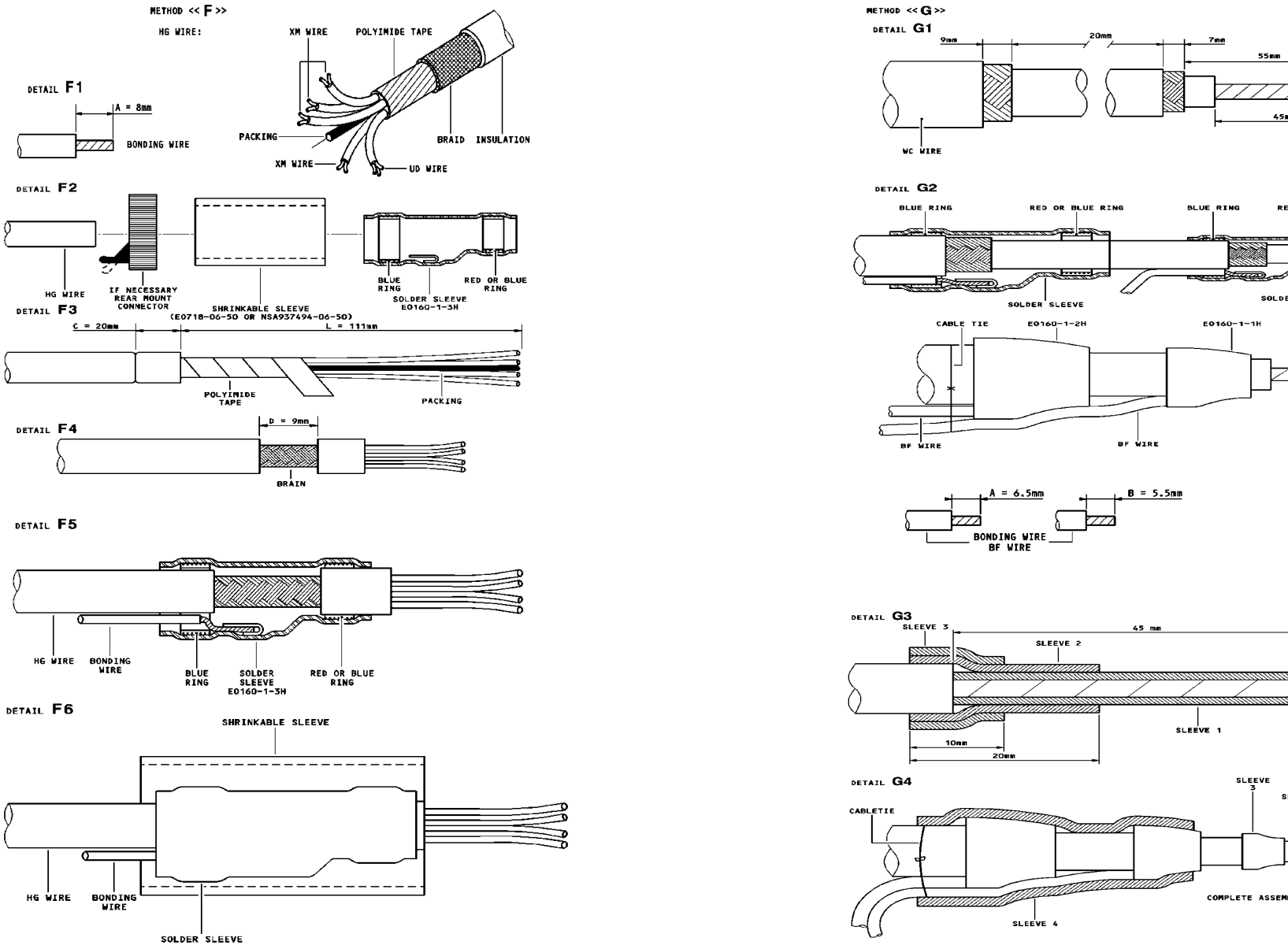


Figure 28 Soldering Sleeve Processing 3

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Figure 29 Picture Soldering Splice

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Once the individual components have been connected, the solder sleeve is heated with a hot air generator or an infrared heat gun until the solder ring starts to melt and flow along the individual wires.

After the cooling down process, a quality check is required:

- no balls of solder?
- solder evenly dispersed?
- have inserts melted and flowed along wires?
- no signs of overheating visible on solder sleeve?
- the thermal indicator (red color on solder ring) should be gone

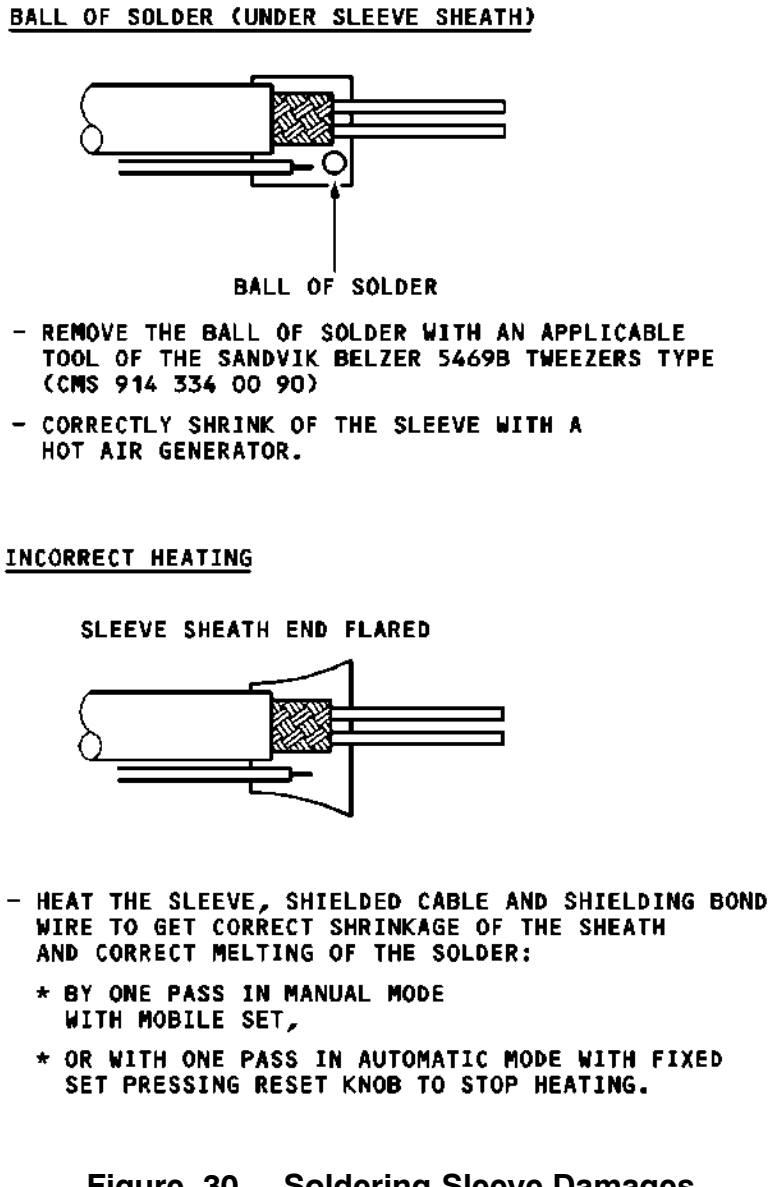


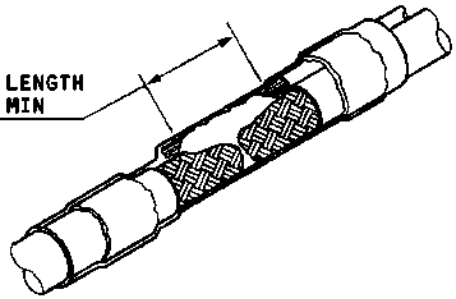
Figure 30 Soldering Sleeve Damages

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ACCEPTABLE TERMINATION (MINIMUM)

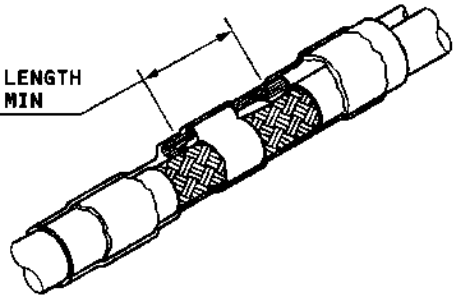
MINIMUM ACCEPTABLE SOLDER FLOW TERMINATION AS SHOWN IN FIGURE MUST HAVE TRACES OF THE THERMAL INDICATORS IN THE FILLET AREA.



NOTES: 1- LIGHT TRACES OF THERMAL INDICATOR MUST BE PRESENT.
2- SOLDER NO LONGER SHOWS PREFORM SHAPE.
3- INSERTS HAVE MELTED AND FLOWED ALONG WIRES.
4- SHIELD AND LEAD CONTOURS CAN BE SEEN.
5- YOU CAN SEE A FILLET ALONG THE LEAD AND SHIELD INTERFACE.

ACCEPTABLE TERMINATION (MAXIMUM)

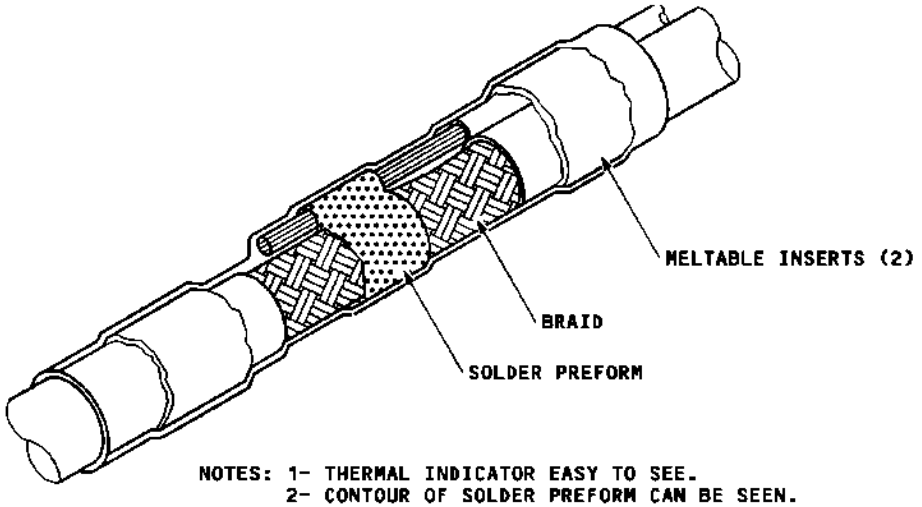
MAXIMUM ACCEPTABLE SOLDER FLOW TERMINATIONS AS SHOWN IN FIGURE MUST SHOW LITTLE OR NO SIGN OF THE THERMAL INDICATOR IN THE FILLET AREA.



NOTES: 1- THERMAL INDICATOR GOES OUT OF VIEW.
2- THERE MUST BE NO SIGNS OF THERMAL INDICATOR IN THE SOLDERED AREA.
LIGHT TRACES OF THE THERMAL INDICATOR IN THE INSERT AREA ARE PERMITTED.
3- YOU CAN CLEARLY SEE THE FILLET BETWEEN LEAD AND SHIELD.
4- YOU CAN SEE THE JOINT AREA ALTHOUGH THE SLEEVE IS BROWN.

UNACCEPTABLE TERMINATION (INSUFFICIENT HEAT)

INSUFFICIENTLY HEATED TERMINATION AS SHOWN IN FIGURE MUST SHOW SURE SIGNS OF THE THERMAL INDICATOR.



NOTES: 1- THERMAL INDICATOR EASY TO SEE.
2- CONTOUR OF SOLDER PREFORM CAN BE SEEN.
3- MELTABLE INSERTS HAVE NOT FLOWED.
4- CONTOUR OF BRAID AND/OR LEAD IS OBSCURED BY SOLDER.

Figure 31 Soldering Sleeve Quality Inspection

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USE OF CRIMP TOOLS

Crimped Connections

General

To connect a wire to a connecting element, one of the most common methods today is to crimp these elements onto a wire by means of a special crimping tool. This procedure is also called 'cold welding'; the connecting element is non−detachably connected to the wire. Design and requirements have been defined in order to ensure a proper connection.

- The wire strands must be pressed together without it leading to breakage or separation
- The connection may not reduce the electrical attributes of the wire
- The junction from the connecting element to a component must be equivalent to a direct connection to a corresponding copper wire
- There also are guidelines regarding tensile strength of crimped connections

To meet these guidelines, specially designed, tested and properly adjusted crimping tools have to be used for all crimped connections!

Before using a crimping tool, always check:

- did you choose the appropriate tool for the terminal?
- for cleanliness
- for damages
- for corrosion
- for abrasion

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Figure 32 Crimping Tool for PIDG

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Terminals and Splices

Terminals can be used to connect a single wire to components (switches, sensors, terminal strips/ terminal blocks, etc.). Splices are used for wire repairs.

Terminals come in different sizes for various wire sizes but also can have different shapes, can come with or without insulation and with or without strain relief.

PIDG

PIDG (Pre Insulated Diamond Grip) terminals and splices are a touch proof insulated connection, with protection against vibration by means of a crimped–on strain relief. The terminal is made of electrolytic copper and for protection against corrosion also is galvanically tin–plated. PIDG terminals and splices are heat–resistant up to 105°C.

Insulation

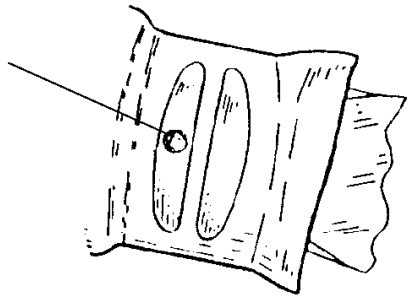
A PVC – or nylon sleeve is connected to a copper sleeve that also is tightly connected to the sleeve of the terminal. The copper sleeve ensures a uniform plastic deformation of the insulating sheath during crimping without affecting the original insulation thickness.

Crimping

In the crimping procedure both the conductor and the insulation are connected to the terminal. The insulation sleeve is also identified with dot coding (dot matrix). These dots indicate whether the terminal has been pressed with the correct matrix size.

Color Code

To avoid errors when selecting terminals and corresponding crimping tools, the terminals come with colored insulation sleeves and the crimping tools have colored handles, too. Different colors are assigned to corresponding wire sizes.



WIRE SIZE COLOR CODE		
26–24	YELLOW	0,1 - 0,4 mm²
22–18	RED	0,25 - 1,6 mm²
16–14	BLUE	1,0 - 2,6 mm²
12–10	YELLOW	2,7 - 6,6 mm²

Figure 33 Dot Code and Color Coding

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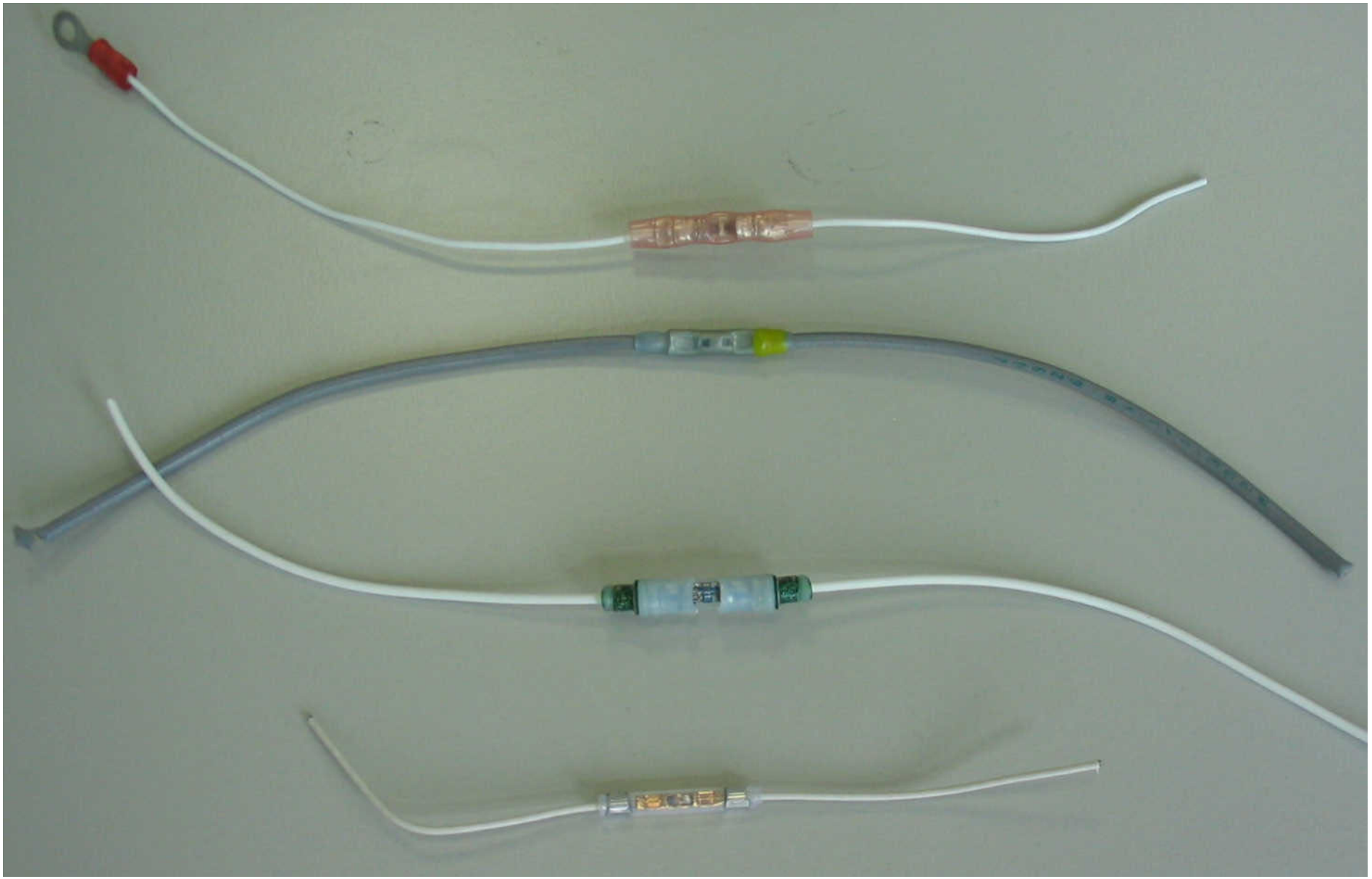


Figure 34 Several Splices

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Crimping of PIDG Terminals

After selecting the right crimping tool, the insulation crimp has to be adjusted to match the wire insulation.

- set insulation crimp to position 4, insert terminal, insert non–stripped wire into the insulation crimping jaws, crimp.
- examine whether the wire is held well by the insulation crimp, as a test bend the wire 90 degrees at the terminal twice.
- If this isn't the case, choose the next smaller position and repeat the procedure until the desired insulation support is achieved (the smaller the position/ number, the stronger the crimp of the insulation).
- strip wire to desired length
- insert terminal into tool until stop and insert the stripped end of the wire. The strand should stick out approx. 1 mm from the terminal barrel.
- Crimp tool until security ratchet is unblocked.
- Finally, check if:
  - the crimping is on the correct position of the terminal
  - all strands have been included
  - the imprinted dots are visible
  - the insulation crimp is as desired
  - the strands are visible at the side with the terminal

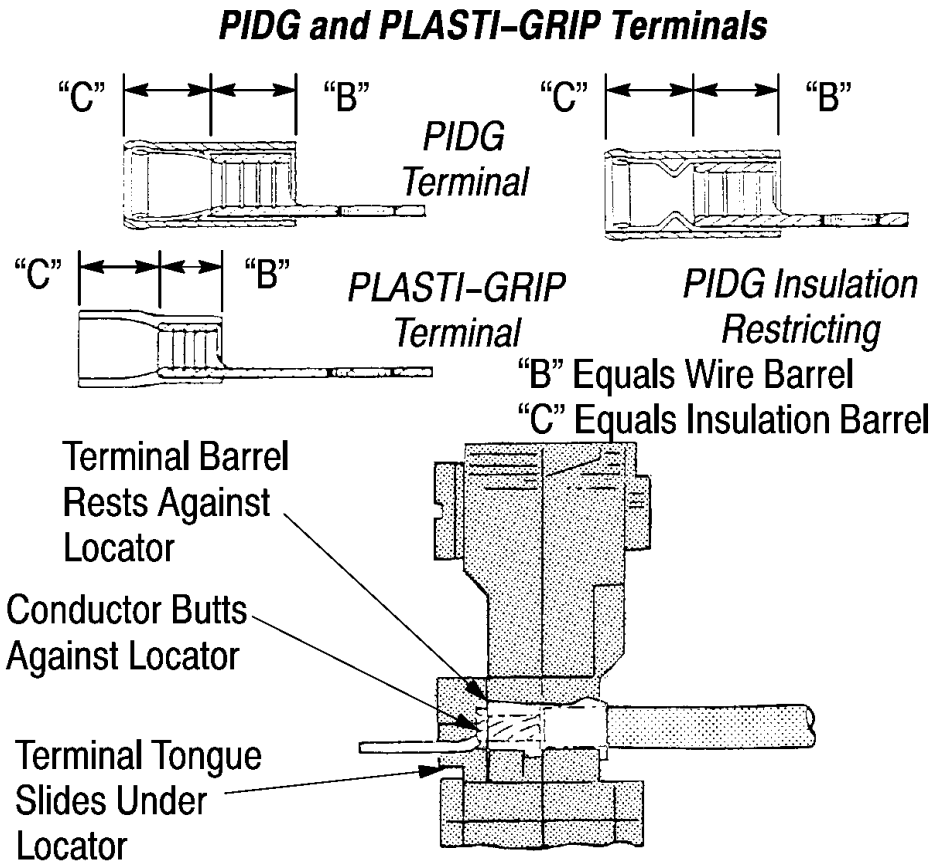


Figure 35 Crimping PIDG

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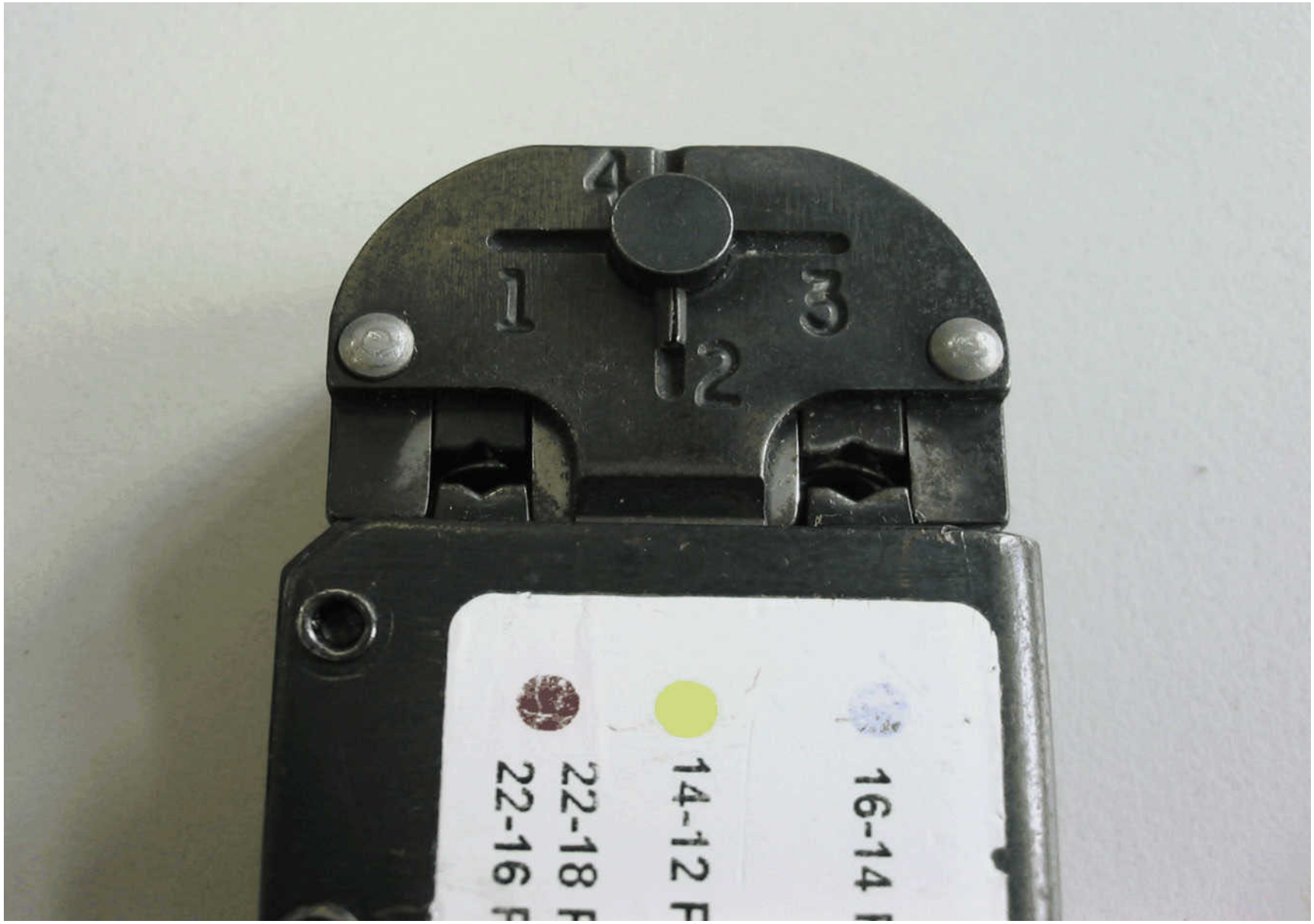


Figure 36 Strain Relief Adjustment

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Crimping of PIDG Splices

The same crimping tool as described for terminals is used.

The adjustment process is identical, too. For inserting the splice, see the illustration (window under the locator).

Insert stripped wire into splice and begin with first crimping procedure. When finished, check if done properly. Insert other side of the splice into the tool for the second crimping procedure. Second check as described for terminals.

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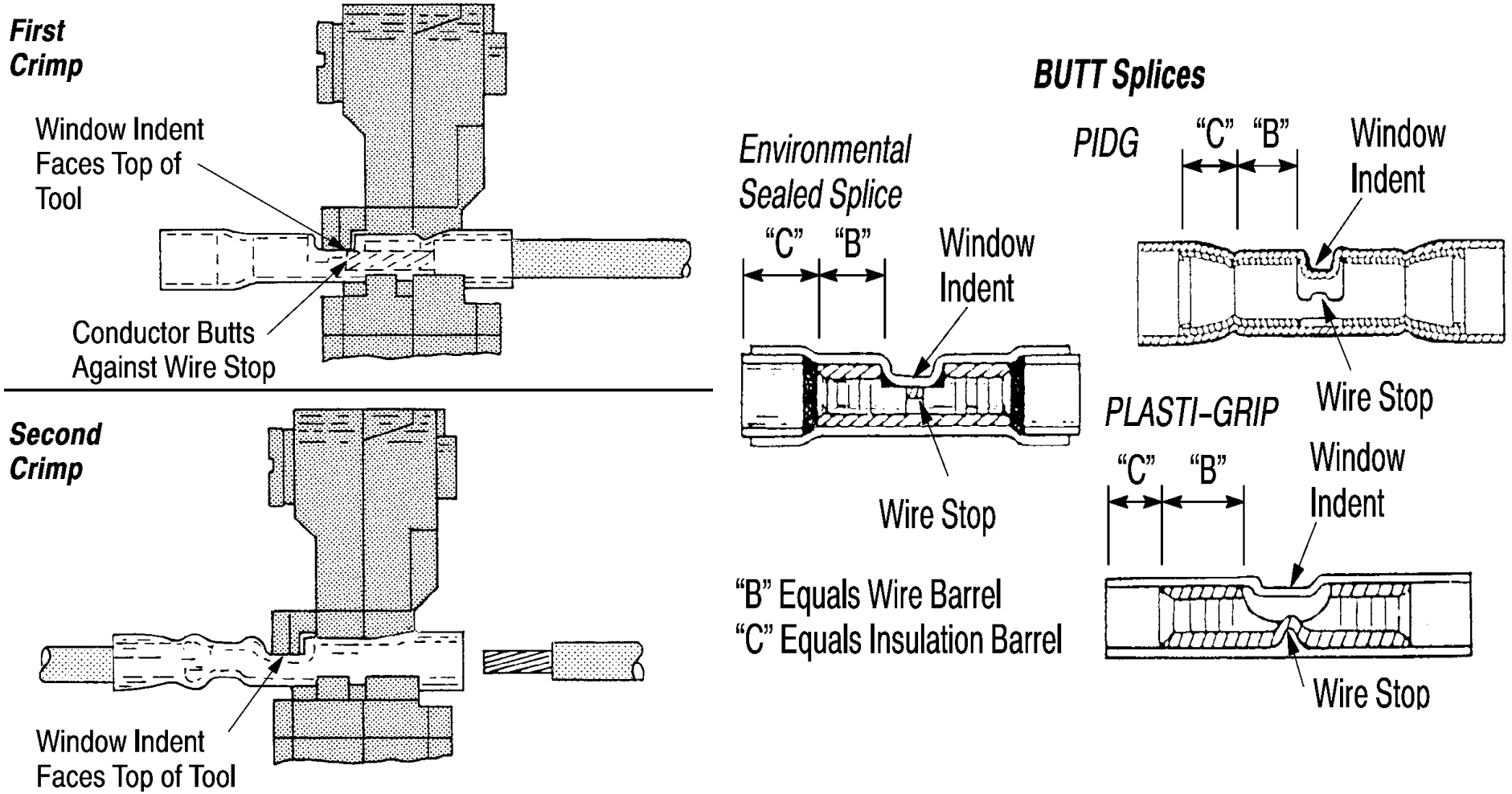


Figure 37 PIDG Splice Crimping

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TESTING OF CRIMP JOINTS

Possible Crimping Mistakes

1. Insulation barrel is in firm contact with wire insulation.
2. Correct color code, dot code, and tool combination.
3. Wire size is within wire range stamped under terminal tongue or on center of splice.
4. Crimp centered on wire barrel.
5. End of conductor is flush with, or extends beyond end of terminal wire barrel.
6. End of conductor against wire stop of splice, or at least flush with, or extended slightly beyond wire barrel.
7. Wire insulation does not enter wire barrel.
8. No nicked or missing conductor strands.

1. Wire insulation extruded. (Insulation crimp too tight on PIDG terminals and splices) See Section 5.
2. Wrong dot code and color code combination. See Figure 2.
3. Wire size is not within wire range stamped on terminal tongue or splice.
4. Crimp not centered on wire barrel. (Terminal was not butted against locator. See Figure 3.)
5. End of conductor is not flush with or extending beyond end of wire barrel. (Check for correct strip length.)
6. Excessive flash or extruded insulation, (wrong tool, terminal, or splice combination, or damaged dies).
7. Wire insulation entered wire barrel.
8. Nicked or missing conductor strands.
9. Splice was reversed in dies (tool's locator was not seated in window indent of splice).

Figure 38 Possible Damages in Crimping Procedures

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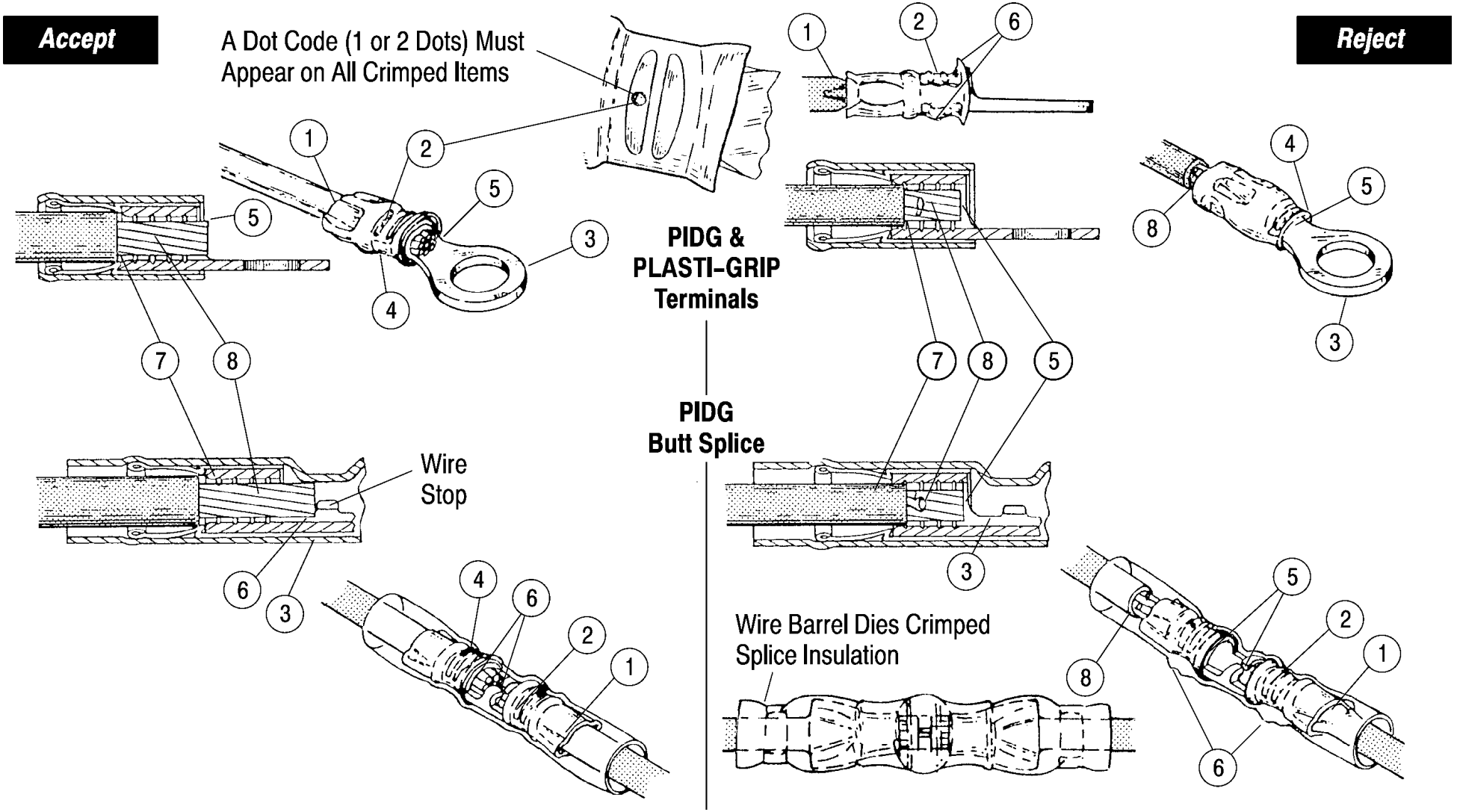


Figure 39 Crimping Damages

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CONTINUITY, INSULATION AND BONDING TECHNIQUES

Closed End Splice

Closed end splices are another category of splices: all wires are inserted stripped and then are electrically connected by crimping with the crimping tool.

Closed end splice must always be arranged so that they stick out of the wire harness.

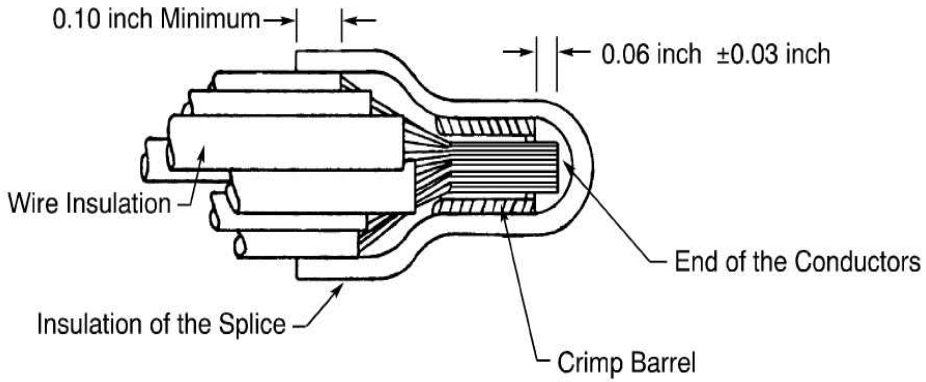
The splices should always be arranged as shown in the illustration.



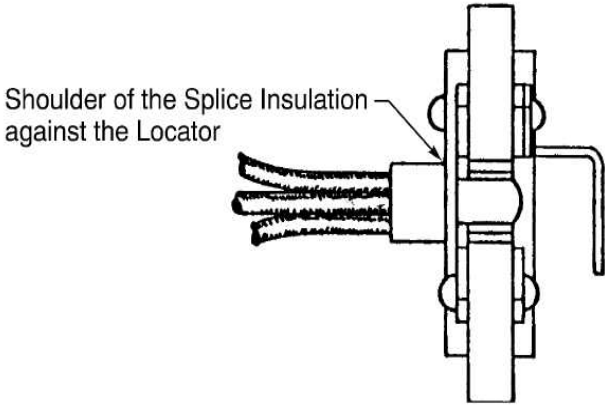
Figure 40 Close End Splice

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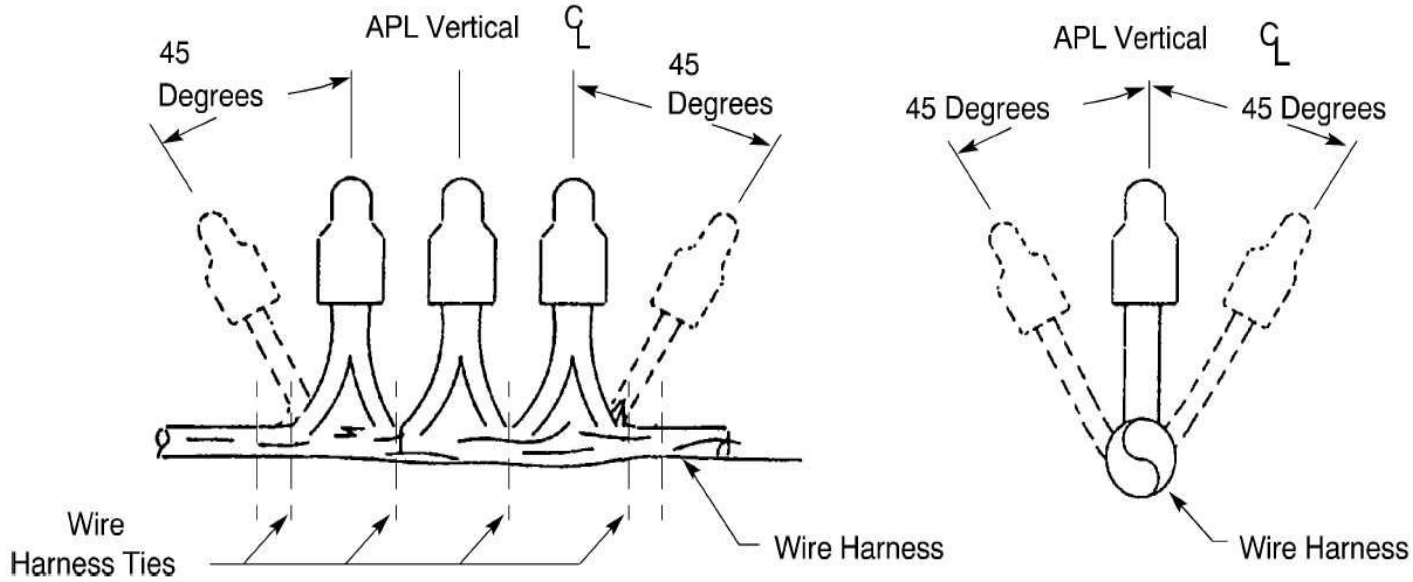
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POSITION OF EACH WIRE IN THE SPLICE



POSITION OF THE SPLICE IN THE CRIMP TOOL



CONFIGURATION OF THE CLOSED END SPLICES

Figure 41 Closed End Splices

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Connection of Wires under Special Circumstances

Under special circumstances, e.g.:

- the wire is too thin for the crimp barrel
- the diameter of the insulation is too thin for strain relief pressing
- more than one wire is to be inserted into the terminal or splice

there are specific aircraft manufacturer regulations how to handle special cases.

For example Boeing:

Boeing has developed the Circular Area Units (CAU) for cases like these; they are measurements for the area of crimp barrels and wires.

There is a ”Minimum” and a ”Maximum CAU range” for each crimp sleeve in a splice or a terminal. As long as the value of the wire is within these values, it can be crimped without any problems. The CAU–value of wires can be found in corresponding tables in the SWPM or can be calculated with the following formula:

$$CAU = \frac{CMA}{100} = \frac{(1000 \times StrandDiameter)^2}{100} \times NumberofStrands$$

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Wire Size (AWG)	Circular Area Units (CAU)
20	12
18	19
16	24
14	38
12	59
10	99
8	170
6	268
4	426
2	665
1	837
1/0	1045
2/0	1330
3/0	1665
4/0	2109

Figure 42 CAU of Wires

CAU von Terminals

Crimp Barrel Size	CAU		Terminal		
	Minimum	Maximum	Type	Specification or Standard	Description
26	2	3	Insulated	BACT12AR()	With Insulation Grip
26-22	3	8	Insulated	BACT12AC()	With Insulation Grip
24	4	5	Insulated	BACT12AR()	With Insulation Grip
22	6	8	Insulated	BACT12AR()	With Insulation Grip
22-18	7	24	Insulated	BACT12AC()	With Insulation Grip
	5	20	Uninsulated	BACT12E()	No Insulation Grip
				BACT12G()	No Insulation Grip
				MS20659-()	With Insulation Grip
20	8	11	Insulated	BACT12AR()	With Insulation Grip

CAU von Splice

CAU Range		Part Number	Crimp Barrel Size	Description	Insulation Color	Supplier
Minimum	Maximum					
3	8	NAS1388-5	26-22	Insulation Grip	Yellow	QPL
4	12	NAS1388-4	24-20	Insulation Grip	White	QPL
7	24	NAS1388-1	22-18	Insulation Grip	Red	QPL
15	51	NAS1388-2	16-14	Insulation Grip	Blue	QPL
59	138	NAS1388-3	12-10	Insulation Grip	Yellow	QPL
132	208	NAS1389-1	8	No Insulation Grip	Red	QPL
209	331	NAS1389-4	6	No Insulation Grip	Blue	QPL
332	526	NAS1389-7	4	No Insulation Grip	Yellow	QPL
527	837	NAS1389-10	2	No Insulation Grip	Red	QPL

Figure 43 CAU of Terminals and Splices

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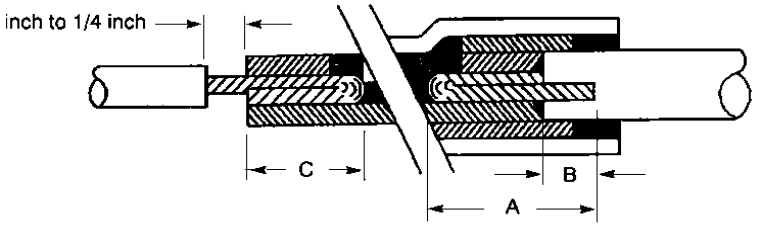
If the CAU–value of the wire is below the value of the crimping sleeve, there are several procedures to increase the CAU–value, see following illustration.

There also is the possibility, to increase the CAU–number by using an appropriate sleeve adapter.

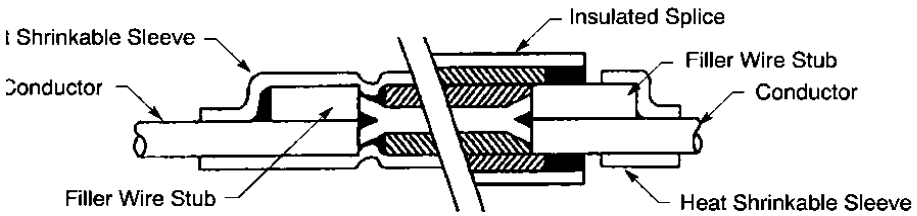
In case the insulation of a wire is too thin, the size can be doubled by using a heat shrinkable sleeve.

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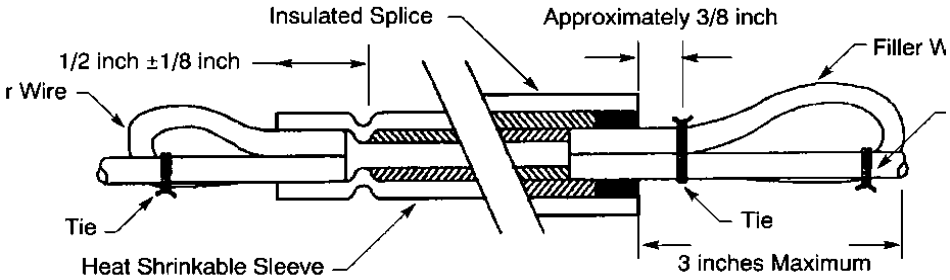
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DIMENSIONS FOR A CONDUCTOR THAT IS FOLDED BACK



CONFIGURATION OF AN ASSEMBLY WITH FILLER WIRE STUBS

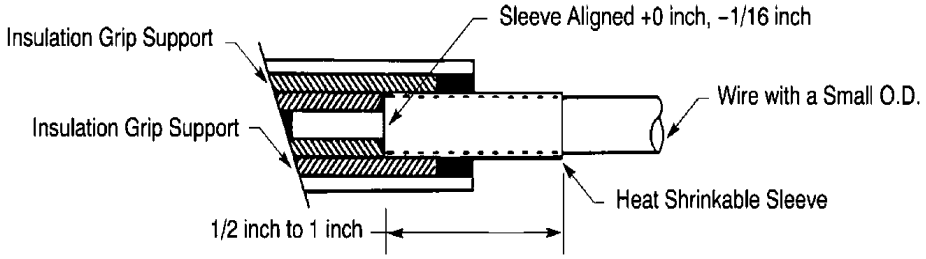


CONFIGURATION OF AN ASSEMBLY WITH FILLER WIRE LOOPS

Figure 44 CAU–Value Increase 1



BACS13S() SLEEVE ADAPTER INSTALLED ON TWO CONDUCTORS



POSITION OF THE HEAT SHRINKABLE SLEEVE ON THE WIRE

Figure 45 CAU–Value Increase 2

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Bending Angle of Terminals

All insulated terminals may be bent if needed for the connection: however, only once and a maximum of 90° degrees on the even side and a maximum of 30 ° degrees on the side with the wire.

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Uninsulated and preinsulated terminals can be bent:

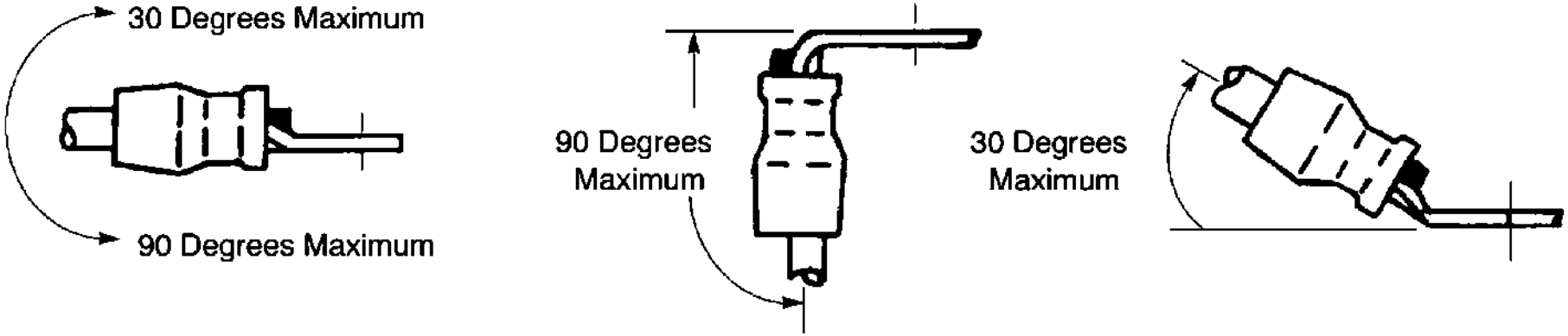
- A maximum of 90 degrees for installation in restricted spaces
- A maximum of 30 degrees for installation on a terminal block.

Refer to Figure 1.

CAUTION: A TERMINAL CAN BE BENT ONLY ONCE AND ONLY IN EITHER DIRECTION THAT IS SHOWN IN FIGURE 1. DO NOT USE TERMINALS THAT HAVE BEEN BENT BEFORE.

Make sure that:

- The bend radius is not greater than 5/32 inch ±1/32 inch
- There are no cracks in the bend area.



PERMITTED DIRECTION AND ANGLE OF THE BEND OF A TERMINAL

Figure 46 Terminal Bending Angle

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Color Identification of Terminals

All terminals AWG 8 or larger have to be identified with a colored heat shrinkable sleeve.

For three−phase wiring:

- Phase A = RED
- Phase B = YELLOW
- Phase C = BLUE

Single−phase wiring and direct current lines have a YELLOW identification.

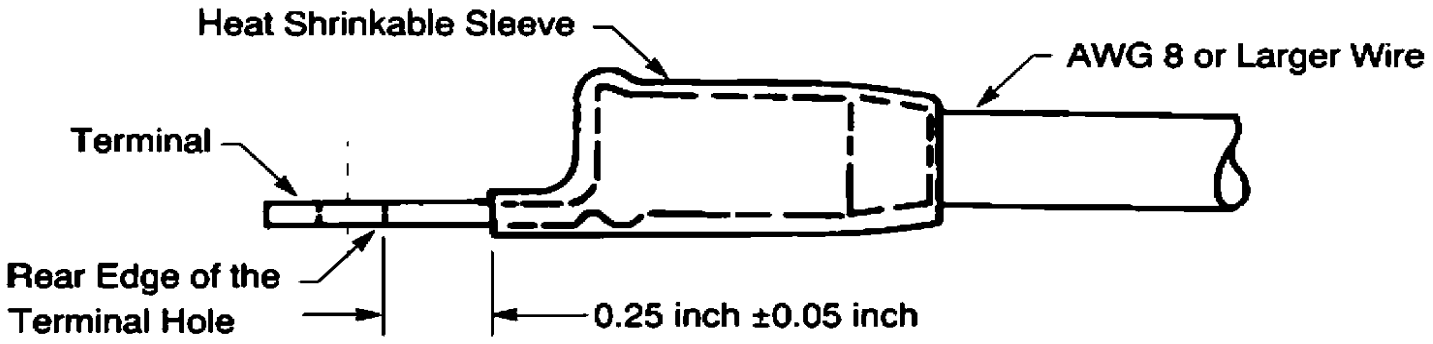


Figure 47 Identification of Terminals with Heat Shrinkable Sleeve

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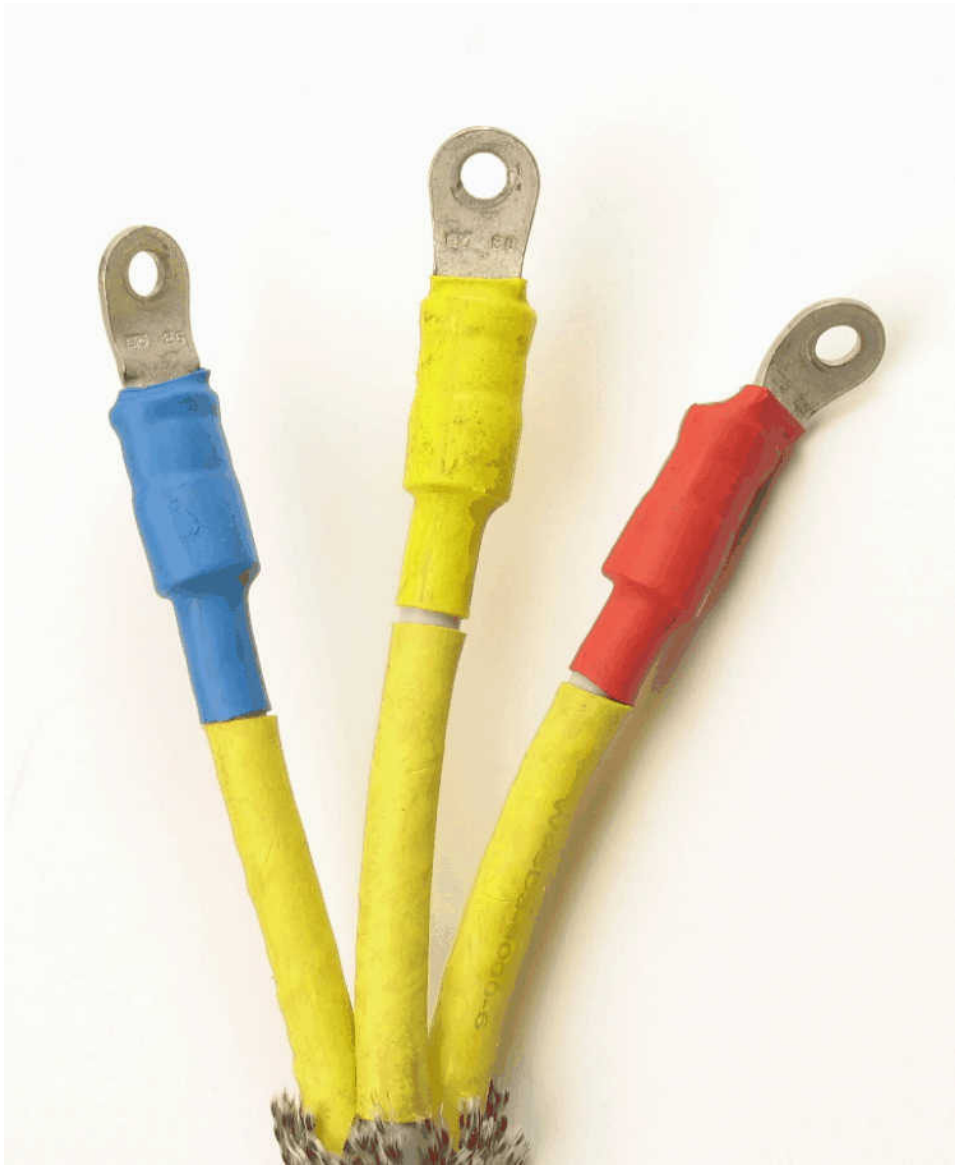




Figure 48 Phase Colors

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Terminalblocks for Terminals

Terminal blocks help to interconnect several terminals.

It is important to make sure that

- the size of the hole at the end of the terminal matches the size of the stud bolt
- a total maximum of 4 terminals are mounted on one bolt
- the largest terminal is on the bottom
- the rest of the terminals are installed decreasing in size
- the top terminal is installed on the right stop side
- terminals are installed according to guidelines in the manufacturers documents (e.g. Boeing)
- nuts are tightened with the right torque value

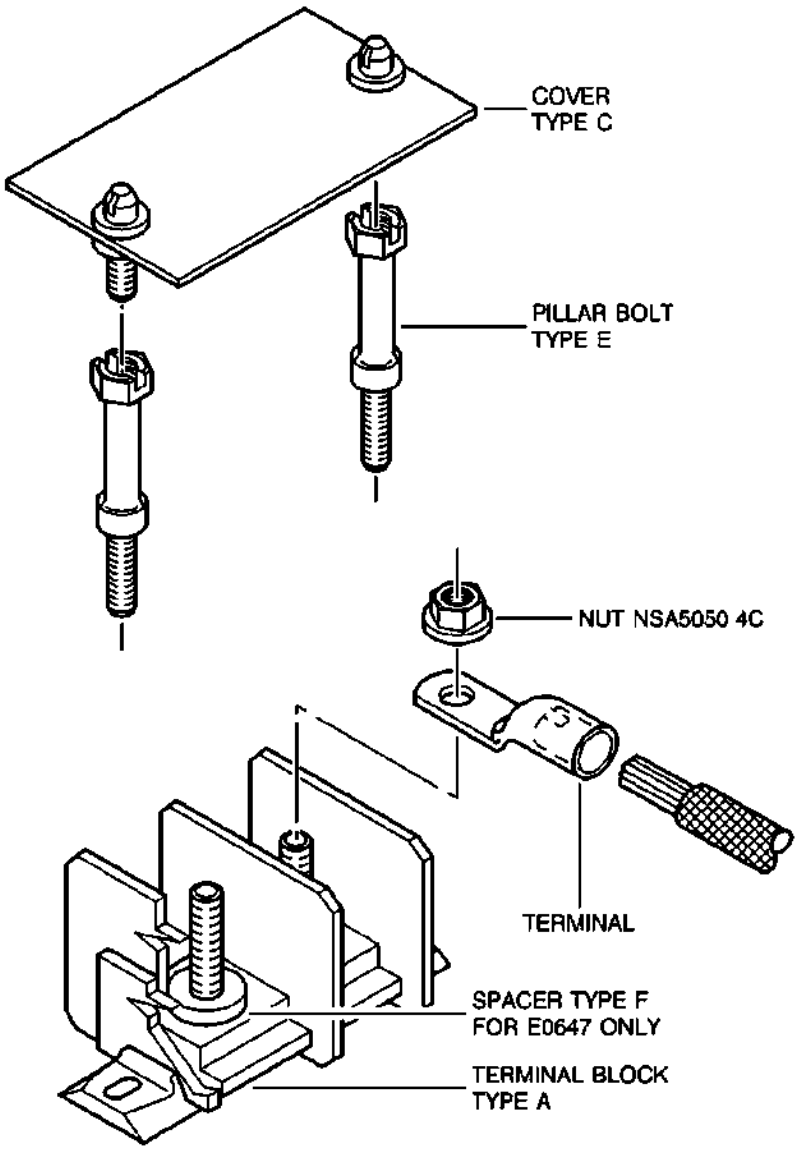


Figure 49 Terminal Block for Terminals

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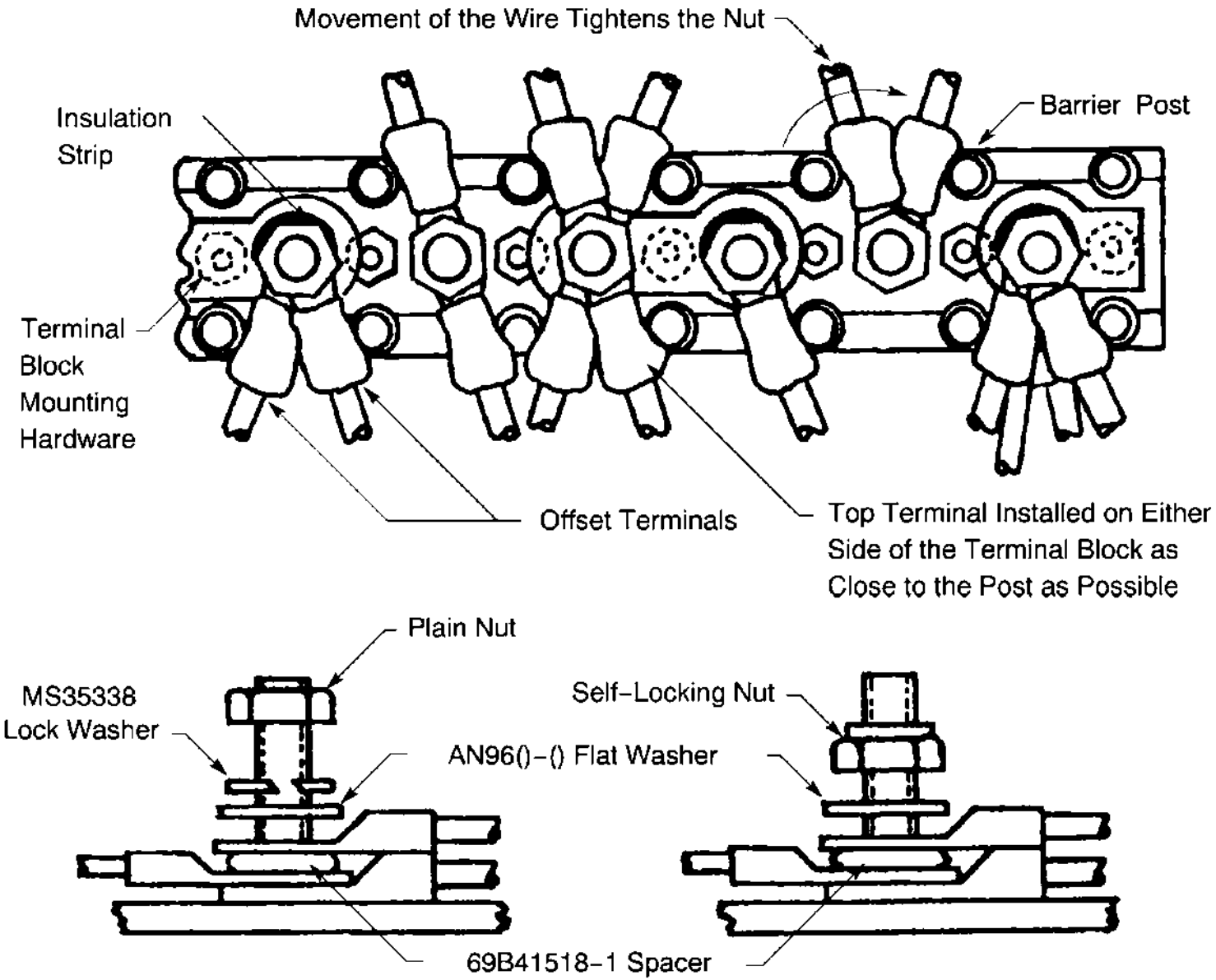


Figure 50 Connection of Terminals

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Connecting Aluminum and Copper Wires

Particular attention is required whenever aluminum and copper wiring shall be clamped together on a terminal block. The different wires must not come into direct contact. In combination with the atmospheric humidity, an electrochemical element would form, which would lead to dissolution of the base metal and thus contact resistance due to corrosion.

Therefore, non−magnetic washers placed between the different terminals must always be used in order to prevent this.

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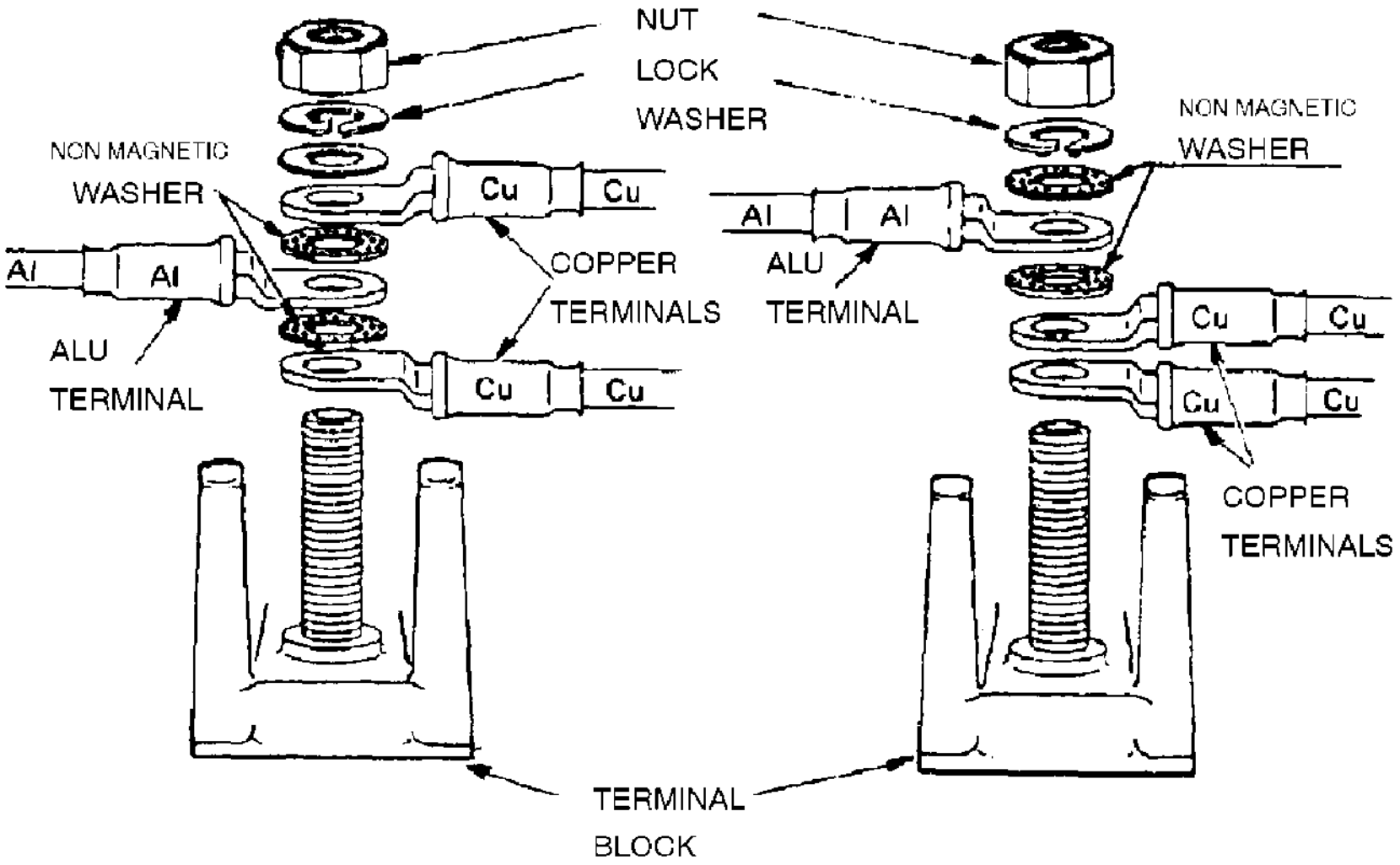


Figure 51 AL/CU Connections

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USE OF CRIMP TOOLS

CONNECT AND INSTALL CONNECTORS

There are special crimping tools for connecting a connector to a wire. At present, three different models are approved by the aircraft manufacturers.

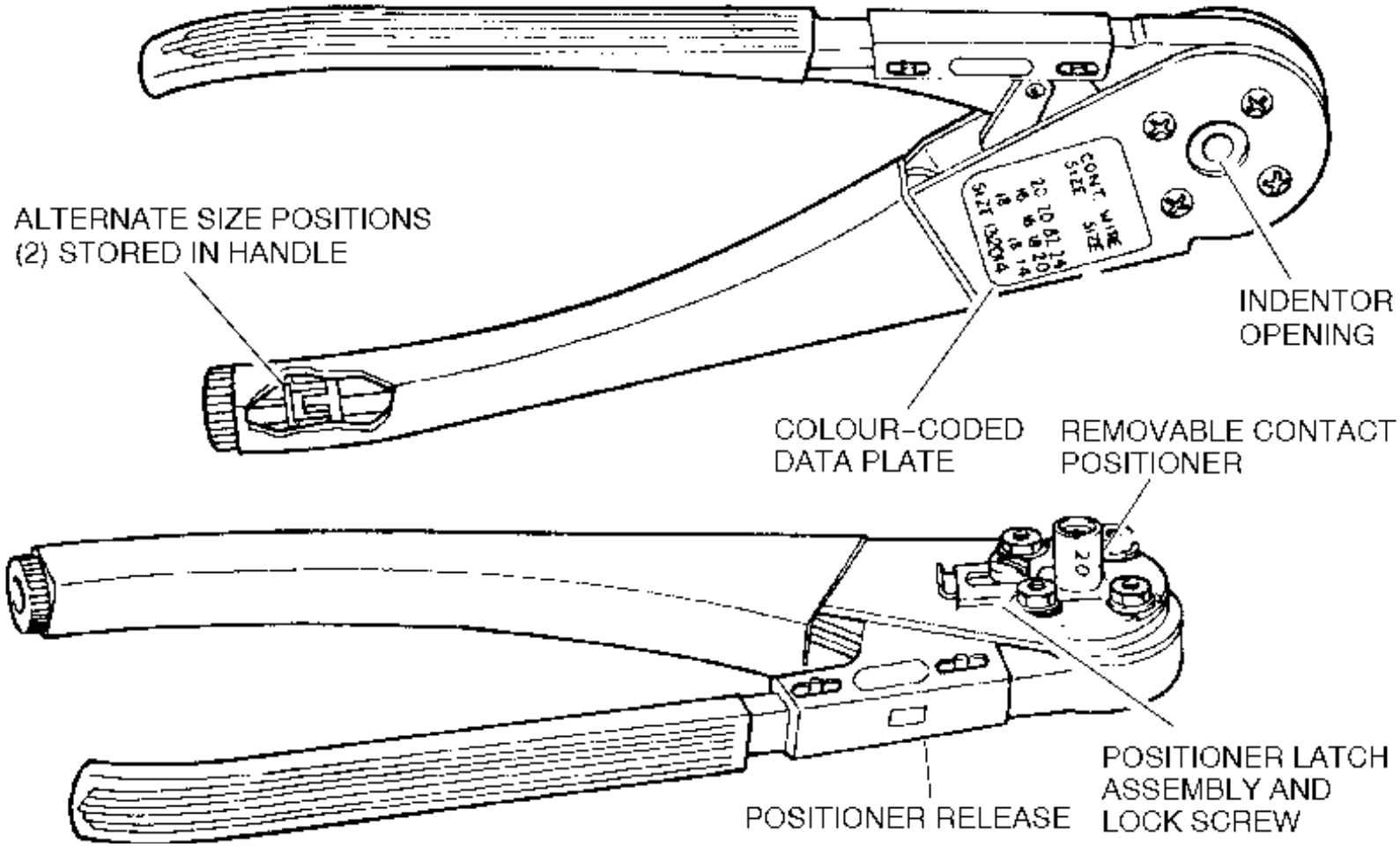


Figure 52 Crimping Tool MS3191-1

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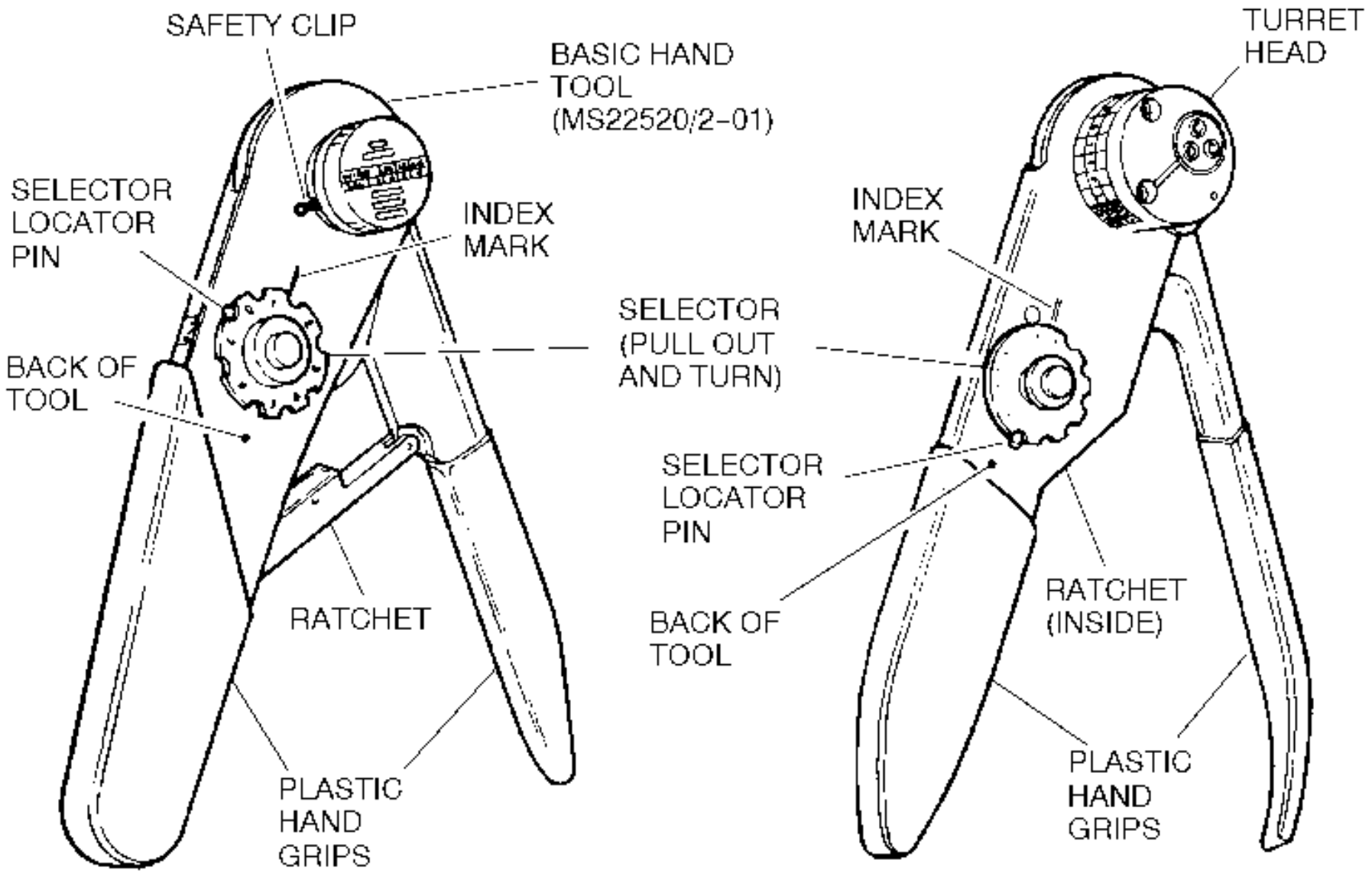


Figure 53 Crimping Tools MS22520/2-01 and MS22520/1-01

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Additionally, for very large electrical contacts, there also are hydraulic or pneumatic crimping tools in various designs.

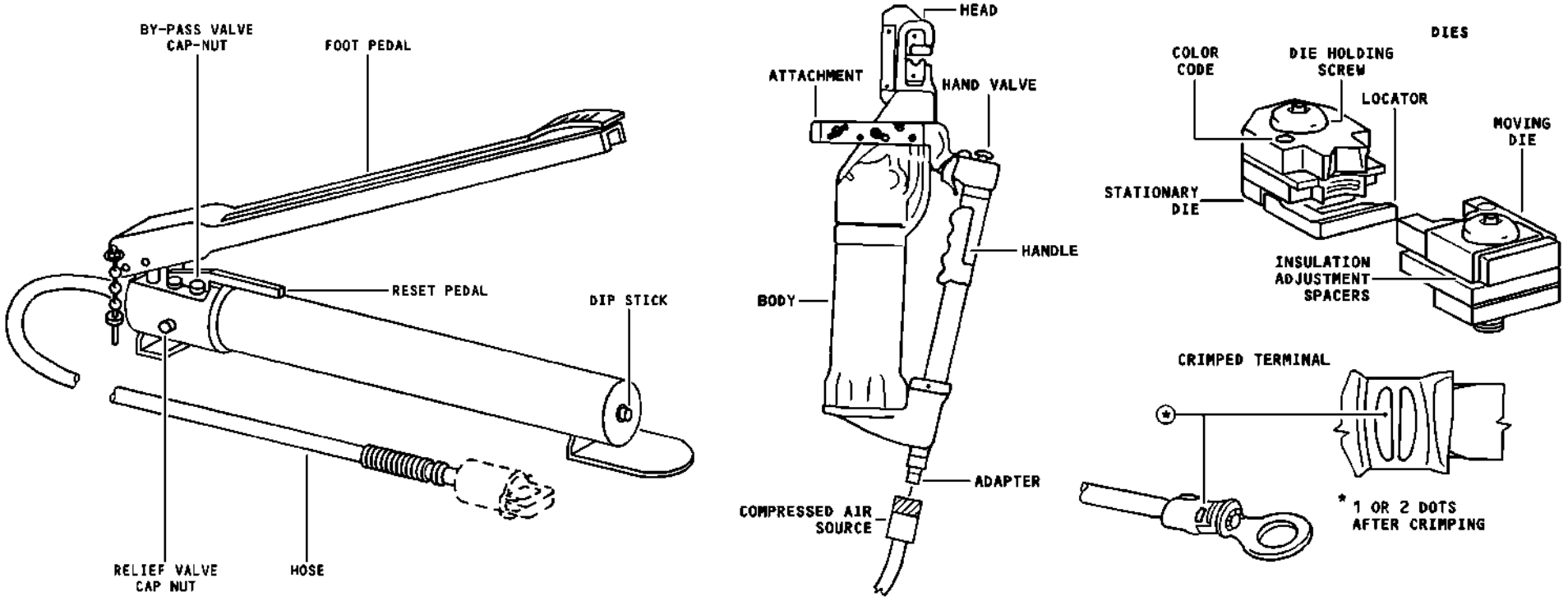


Figure 54 Hydraulic Crimping Tools

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Figure 55 Hydraulic Tool

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PICO CRIMPING TOOL MODEL 500D1

The Pico Model 500D1 crimping tool is used for crimping of Flight Connector contacts, gauge 8 to 4/0.

This is a full−cycling pneumatic tool which cannot be opened until a full crimping cycle has been completed.

This tool operates on a supply of clean dry air or inert gas within a pressure range of 6 to 9 bars, depending on the size of contact to be crimped.

With the tool in full operating condition, insert contact and wire.

Press trigger.

Note that indentors cannot be opened until full crimping cycle is completed.

ESPM 20−25−24

AMP HYDRAULIC FOOT PUMP P/N 781019 (EX 69064) OR 523199−3

Hydraulic foot pumps P/N 781019 (ex 69064) or 523199−3 are used for crimping of splices, connections and terminals listed below:

- High temperature parallel splices,
- High temperature wire splices,
- Termalum butt splices, for aluminum RB wire
- Stratotherm flag terminals,
- Copalum terminals

Preparation of Tool

- Put foot pump in a vertical position with dipstick nut up.
- Remove dipstick.
- Make sure that oil level is at the notch on dipstick, add oil if necessary.
- If necessary, connect the hose.
- Install dipstick and put tool in horizontal position.

Example of Crimping

Always use tool in horizontal position.

- Remove cap from crimping head adapter.
- Slowly operate foot pedal until oil comes into view at end of hose.
- Connect the applicable crimping head to hose adapter
- Install the applicable dies in the head.
- Put terminal or splice in dies.
- Lift reset pedal then return to down position.

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Figure 56 Pneumatic and Hydraulic Crimp Tools

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The crimping tools are subject to a periodic inspection during which they are checked for sufficient pressure and any signs of wear or damage. Before using a crimping tool, always make sure that it is not damaged and check the date on the test badge.

If the crimping tool is not subject to periodic inspections, a check with a GO/NO GO testing tool is required before each crimping procedure.



Figure 57 Crimping Tool Inspection

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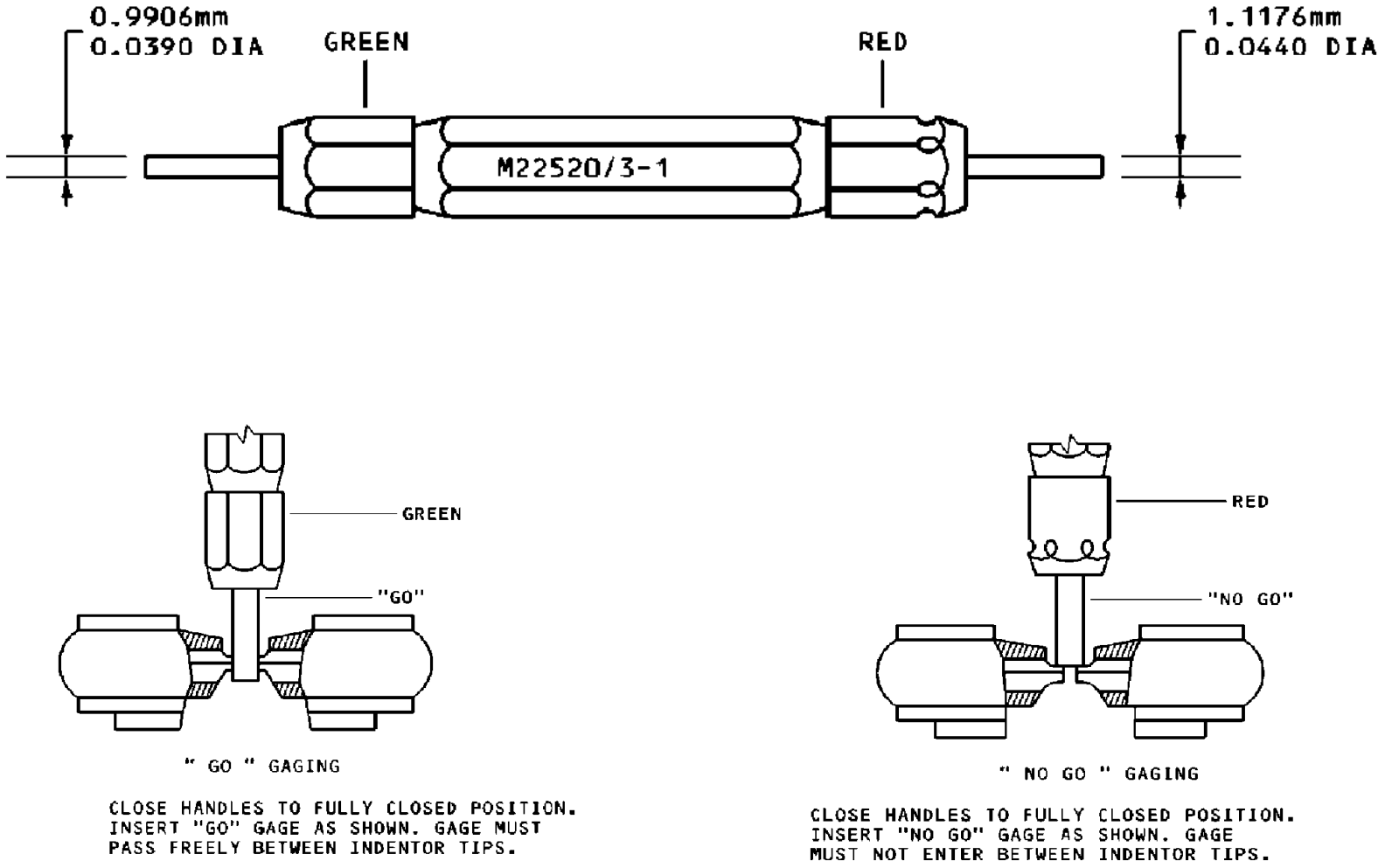


Figure 58 Testing of Crimping Tools

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All these crimping tools have in common that depending on the contact to be crimped, the locator, turret or positioner (which determines the position of the contact in the tool) are exchangeable.

In most models, the depth−stop can also be adjusted to match the corresponding wire−size.



Figure 59 Crimping Tool Adjustment

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Figure 60 Adjusting the Crimping Strength

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Contact Crimping Procedure

Before start, the corresponding locator for the contact has to be selected and then inserted into the crimping tool. Then the pressure of the tool must be adjusted according to the size of the wire on the selector knob.

After these preparations, the contact is placed into the tool, the stripped wire inserted, and then the tool has to be pressed until the security ratchet releases the opening.

The crimping procedure is finished after an inspection of the contact.

- If the contact has no insulation support barrel, the insulation may not touch the contact.
- The insulation has to be inserted into the support barrel if there is one.
- The strands must be visible through the inspection hole.
- All strands must be located in the contact.
- The crimp must be precisely on the correct spot.

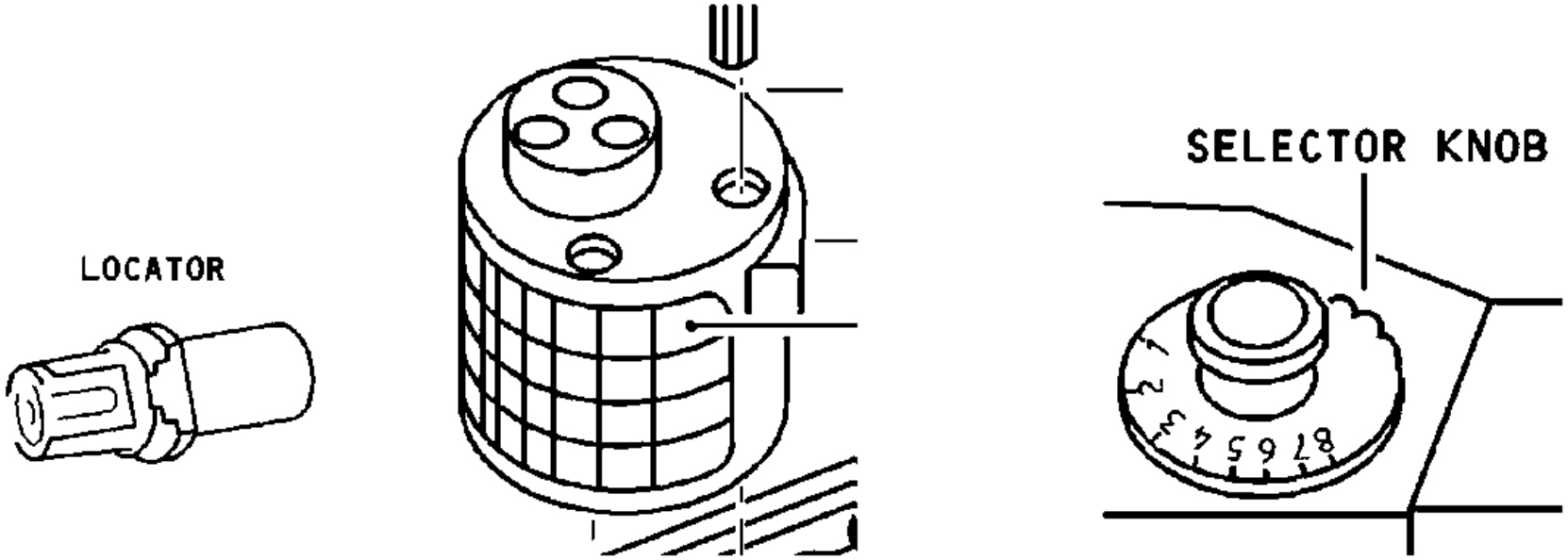


Figure 61 Adjusting the Crimping Tool

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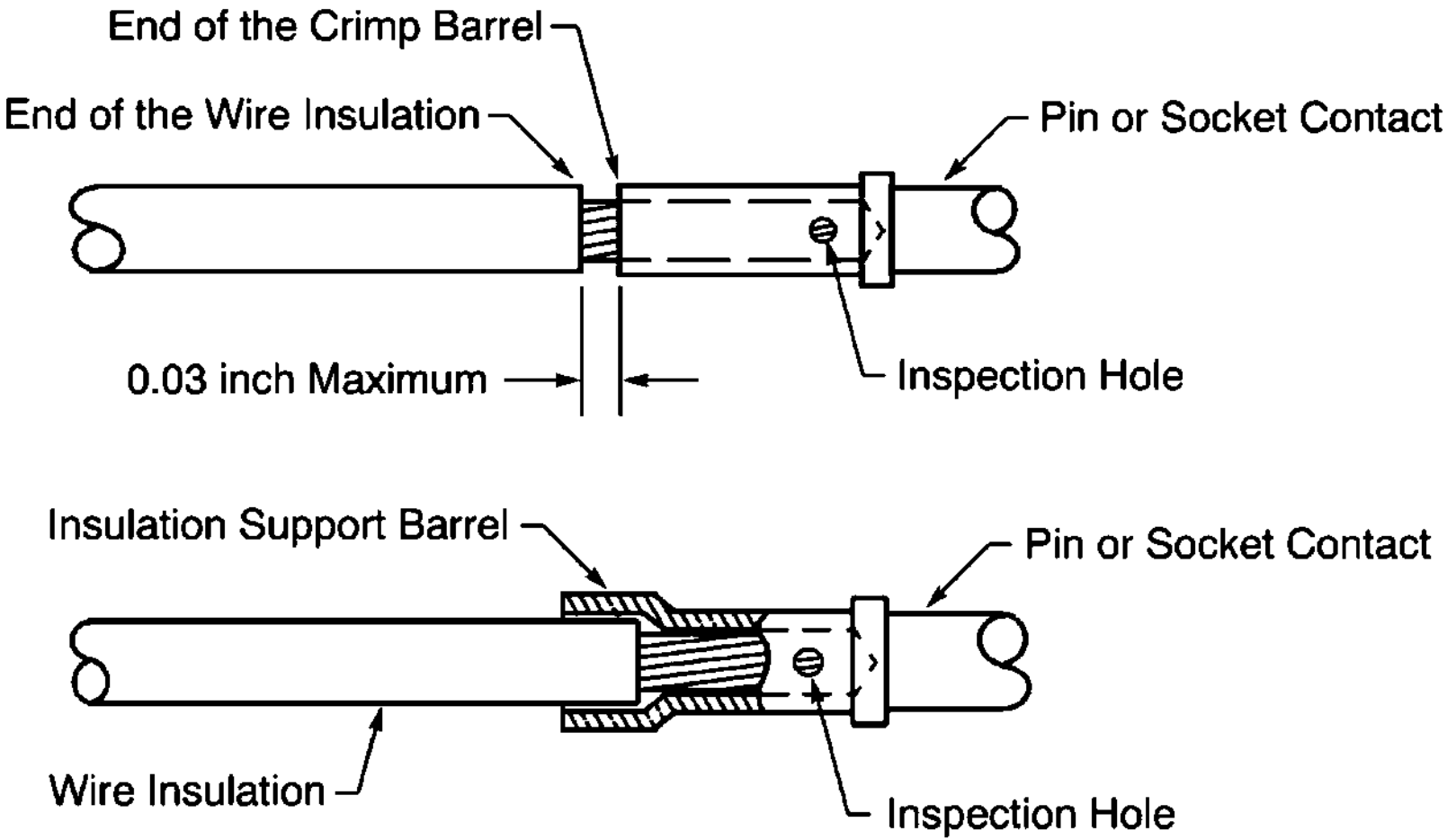


Figure 62 Contact Crimping Testing

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CONNECTOR CONTACTS REMOVAL AND INSTALLATION

Insertion and Removal of Contacts

Contacts are always inserted at the rear by means of a special insertion tool until they snap into place in the contact cavity.

It is important to insert it straight into the hole to prevent any damages on the insert.

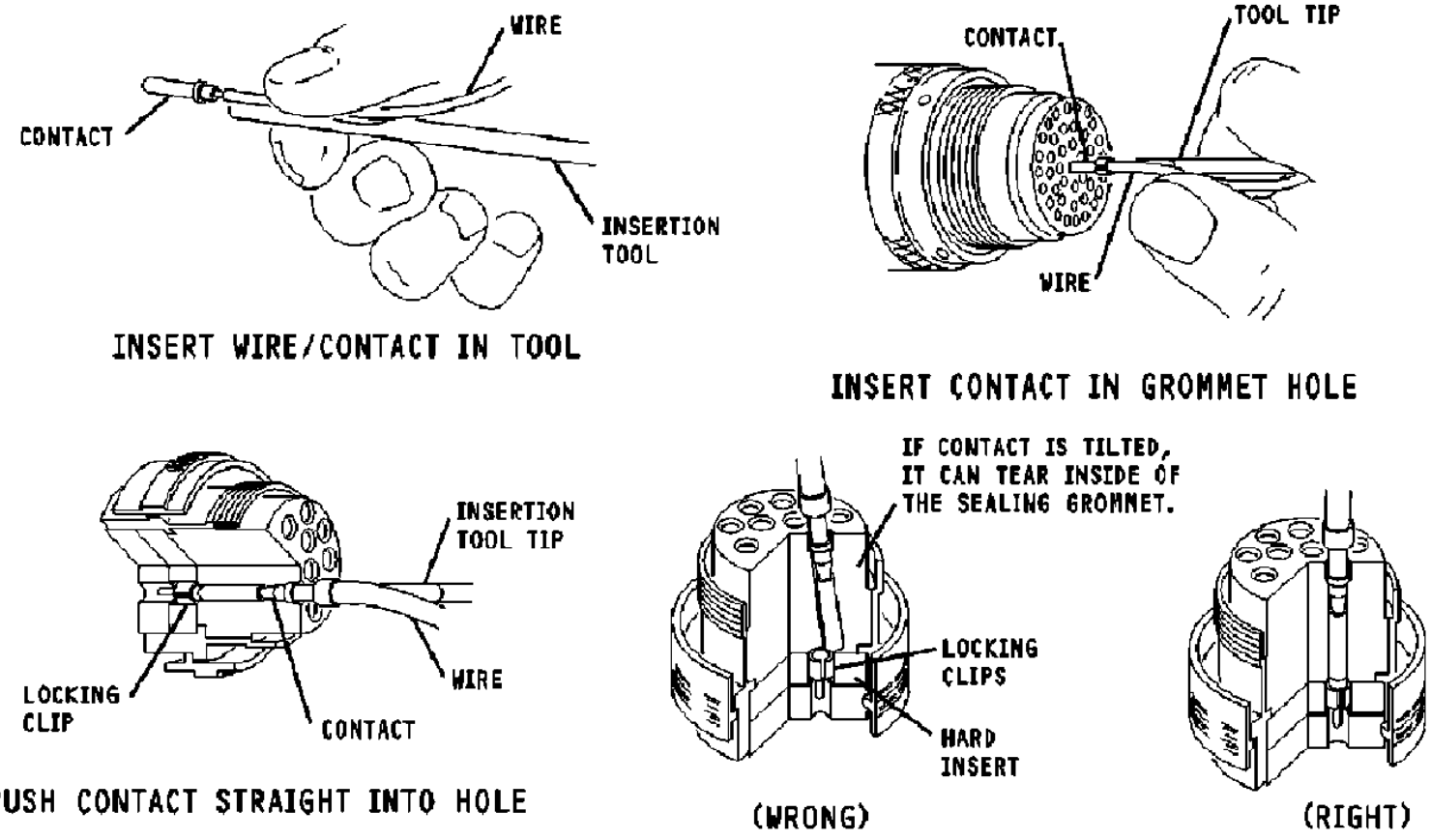


Figure 63 Insertion of Contacts

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Figure 64 Front Release Tools

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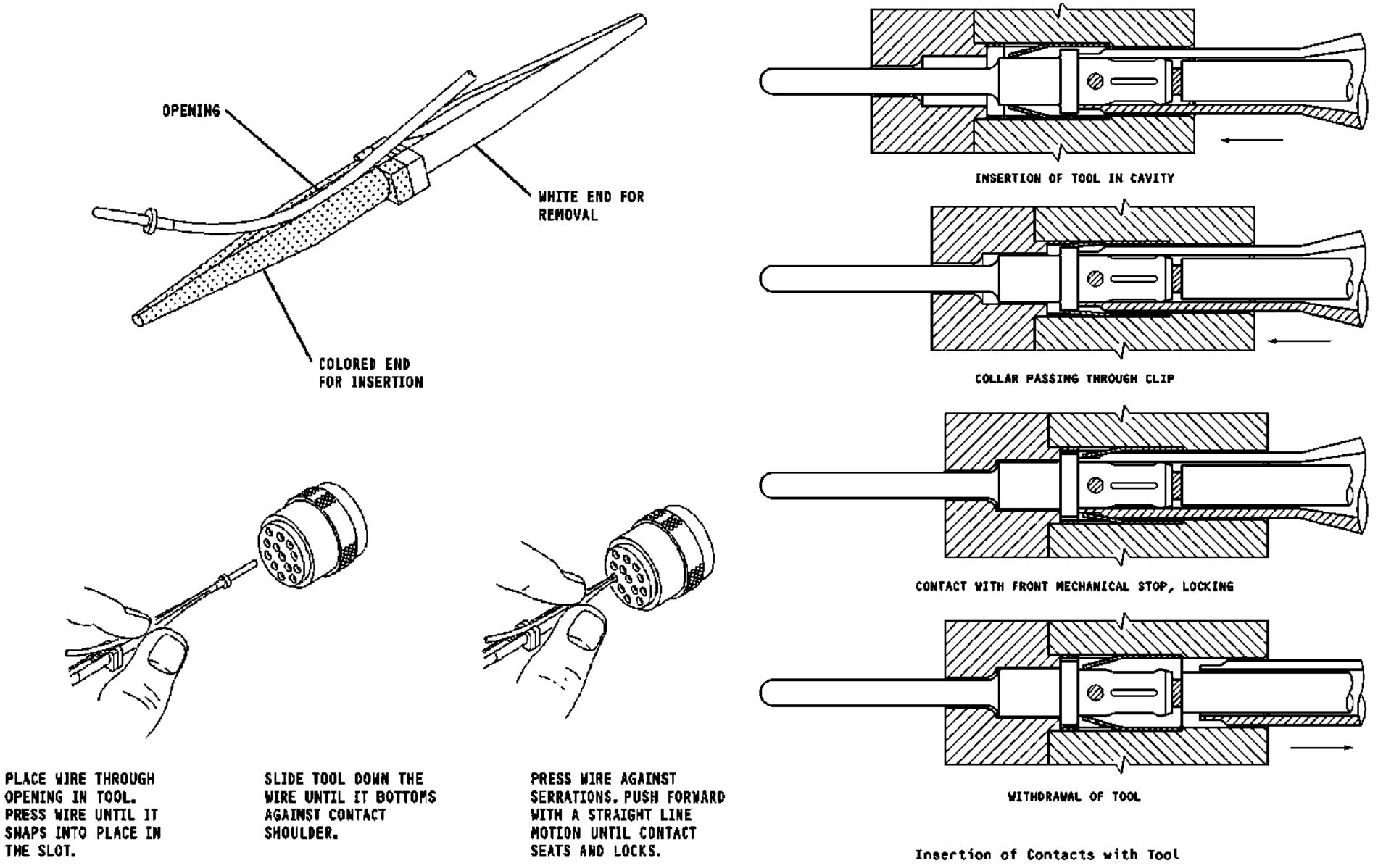


Figure 65 Insertion of Contacts

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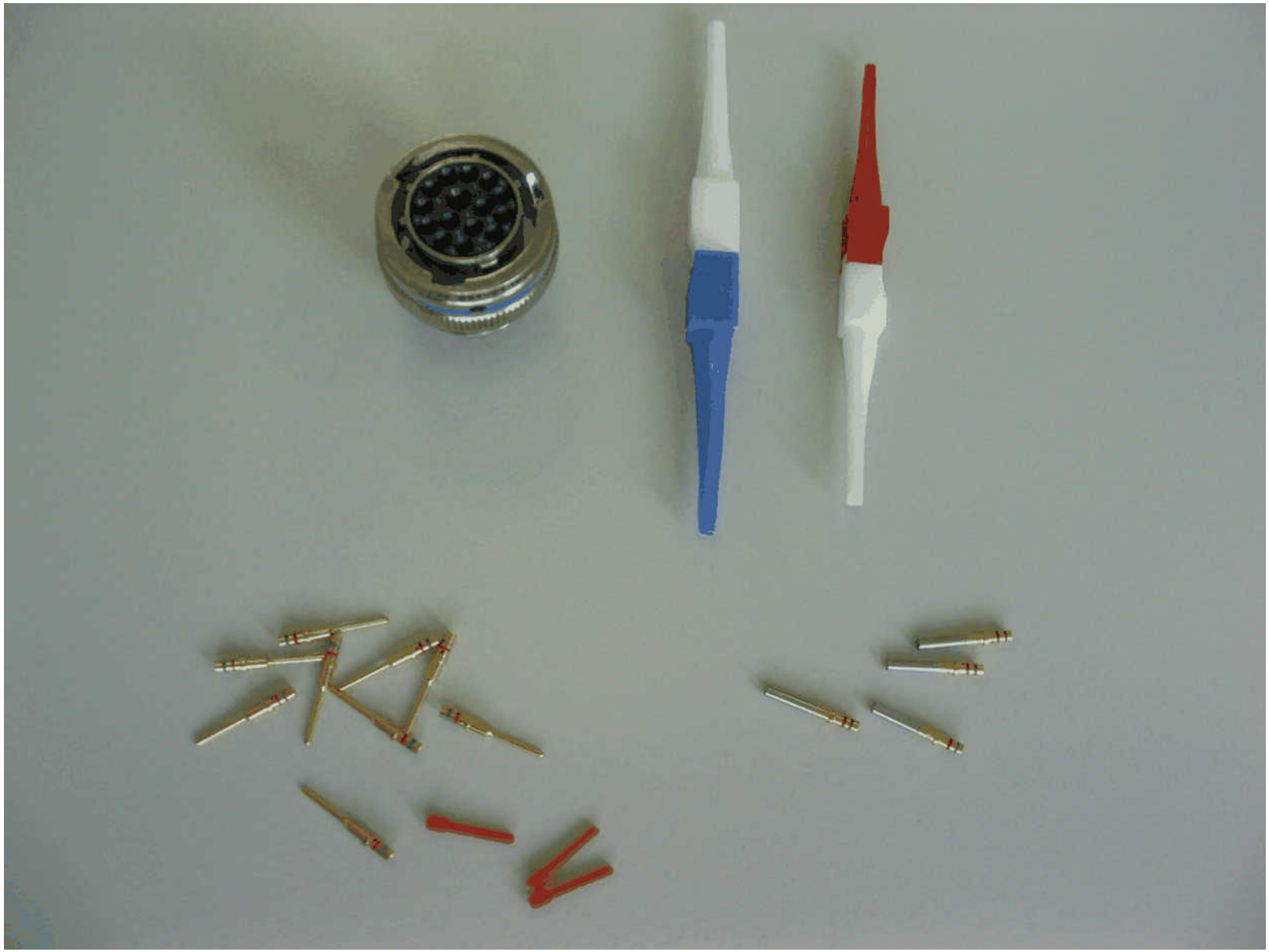


Figure 66 Rear Release Tools

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For the removal of contacts, a difference is made between connector series that have contacts to be removed from the front and connector series with contacts that have to be removed from the rear.

Contact removal from front of connector

When removing the contact from the front of the connector, the tool is inserted above the contact until the locking clip releases the contact. This activates the plunger which then pushes the contact out of the cavity.

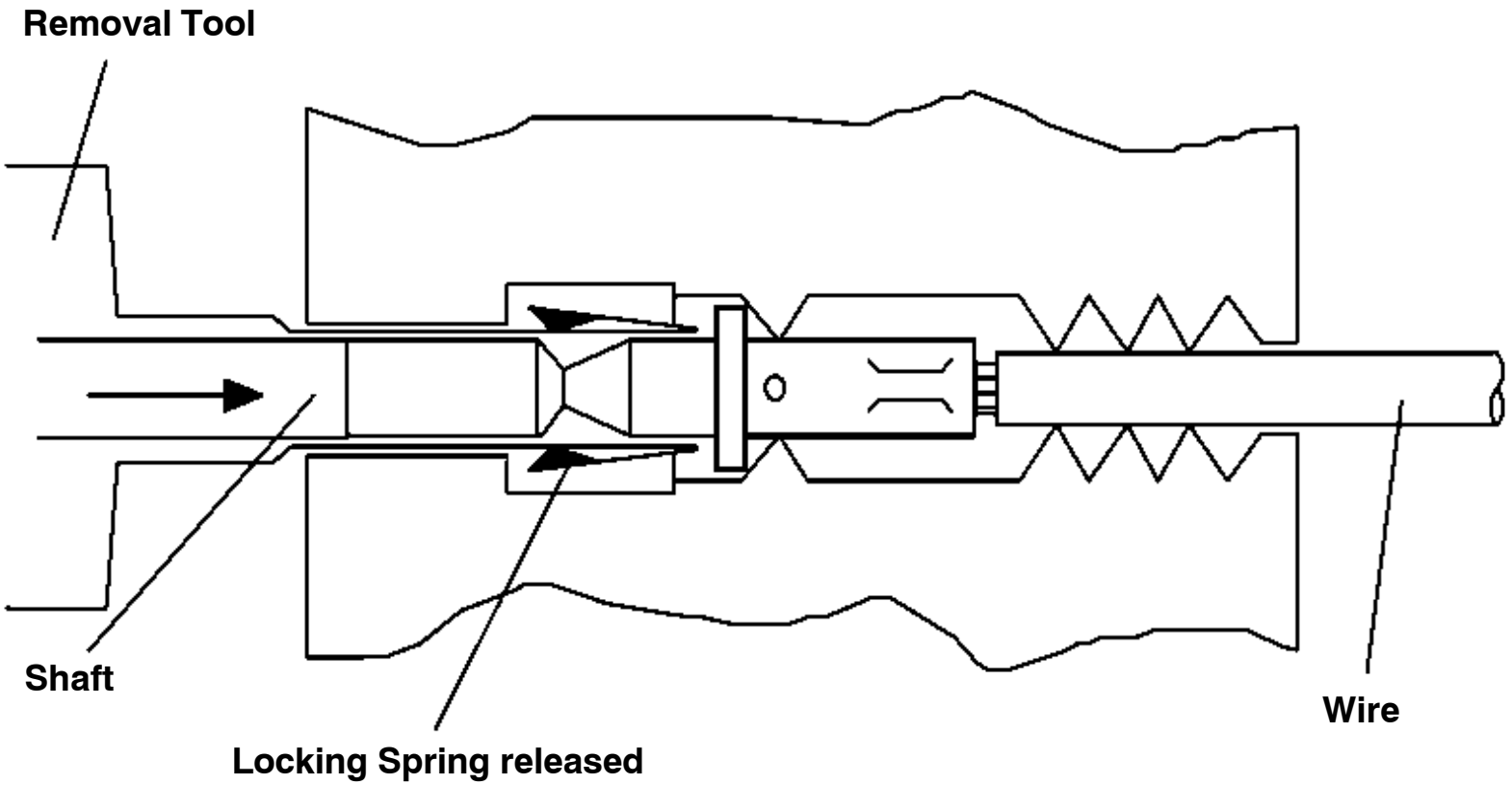


Figure 67 Contact Removal Form

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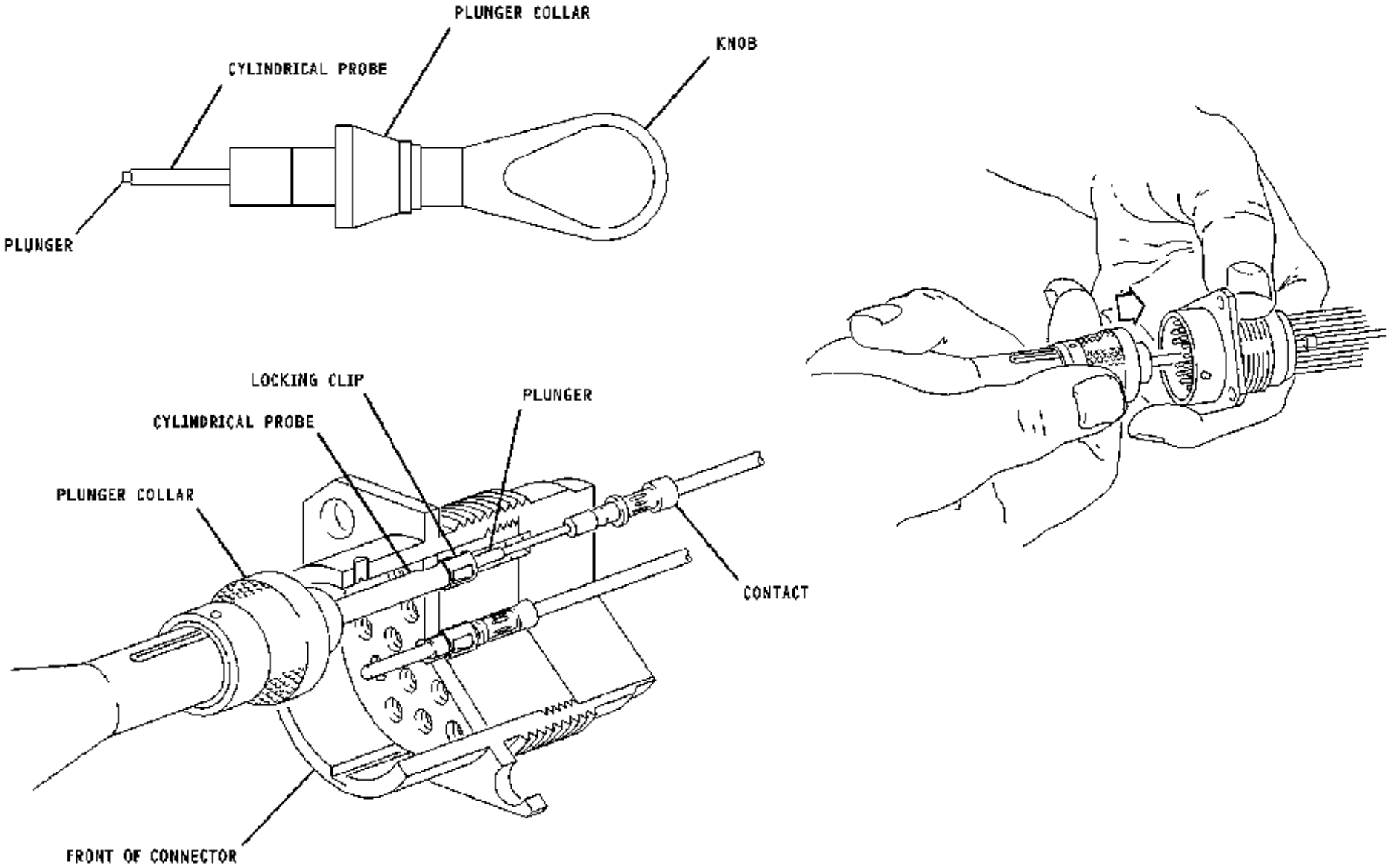


Figure 68 Front Removal of Contacts

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Contact Removal from the Rear End

When removing contacts from the rear, the tool is inserted above the wire and then into the connector until the locking clip releases the contact. Then, together with the tool, the wire is removed from the contact cavity.

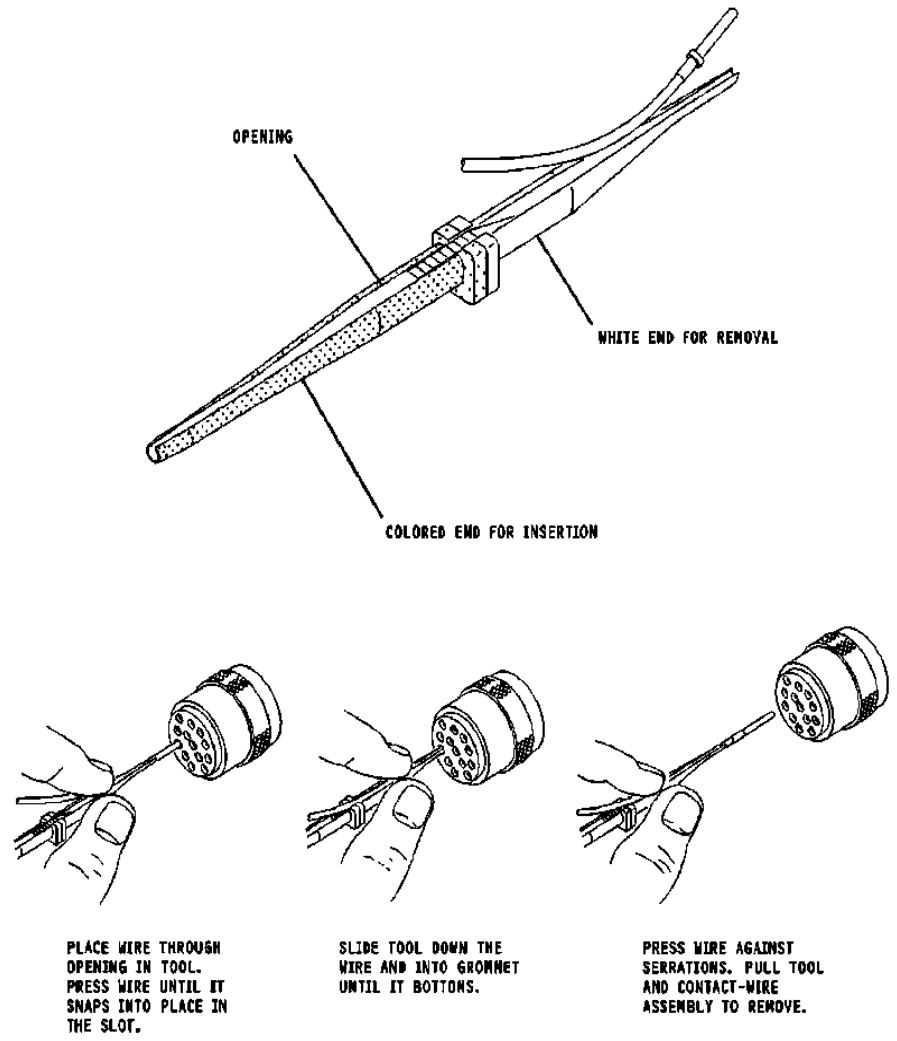


Figure 69 Rear Removal of Contacts

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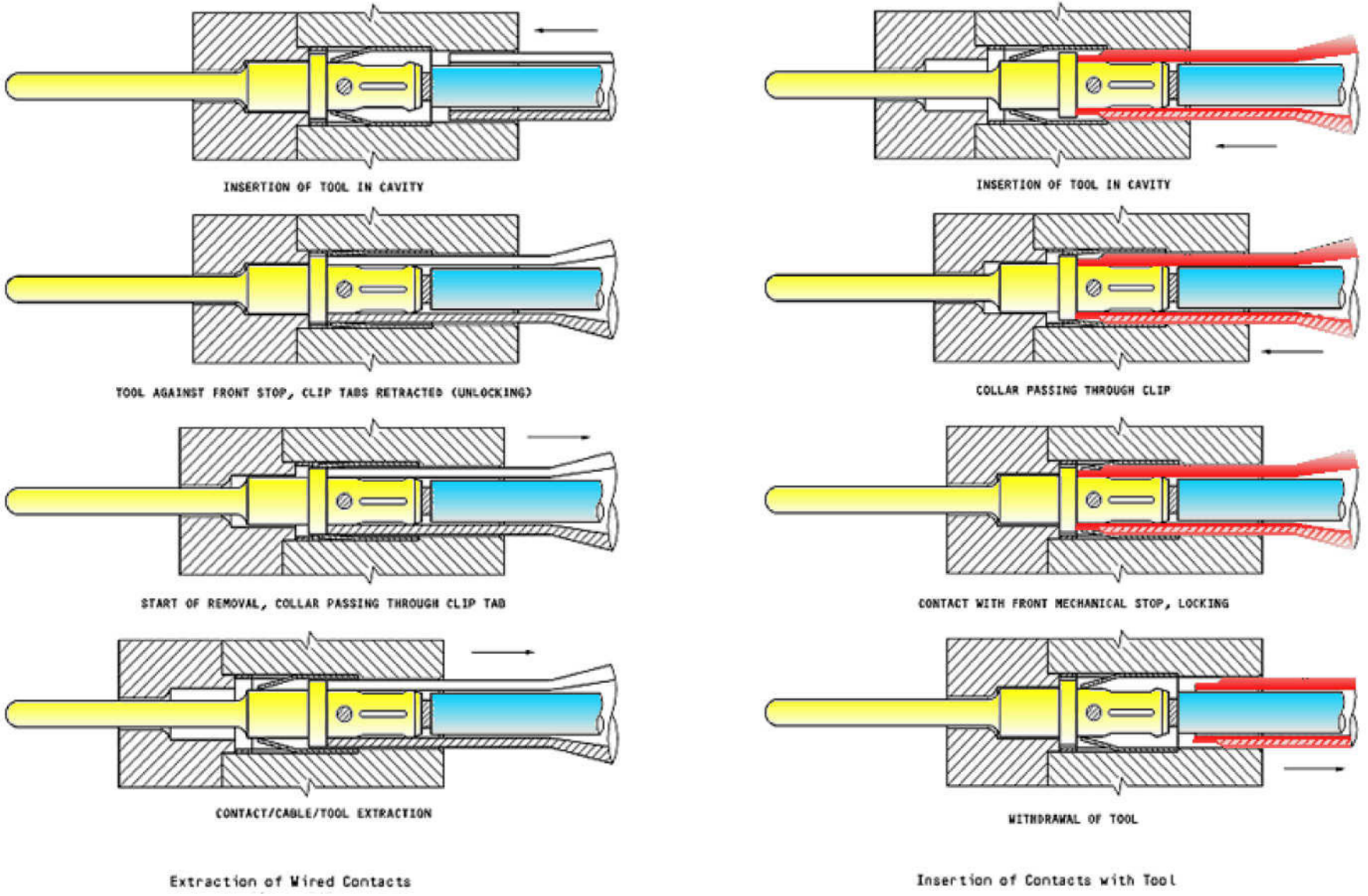


Figure 70 Front– and Rear Contact Removal

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CONTINUITY, INSULATION AND BONDING TECHNIQUES

Block Terminal Systems

A different method for the connection of wires are block terminals. They are usually mounted on U–rails and are used as an alternative to the conventional terminal blocks. Two different types are currently used by the manufacturers.

Boeing Block Terminals

Boeing uses block connectors with 2 x 2, 1 x 4 or 1 x 8 contacts bussed together. In addition, there are models with integrated resistors or diodes.

The contacts are pressed onto the wire by means of a special crimping tool; a contact tool is used for final installation or for removal.

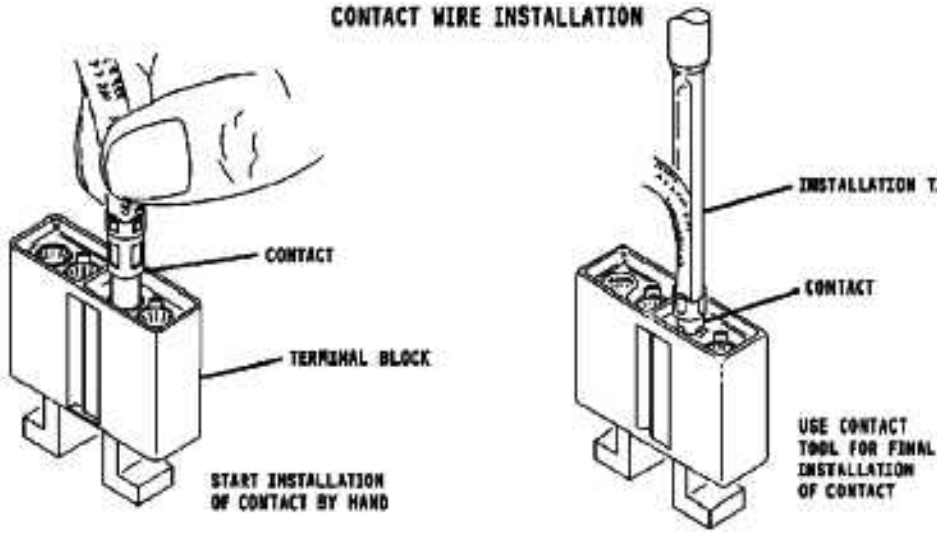


Figure 71 Insertion and Removal of Contacts

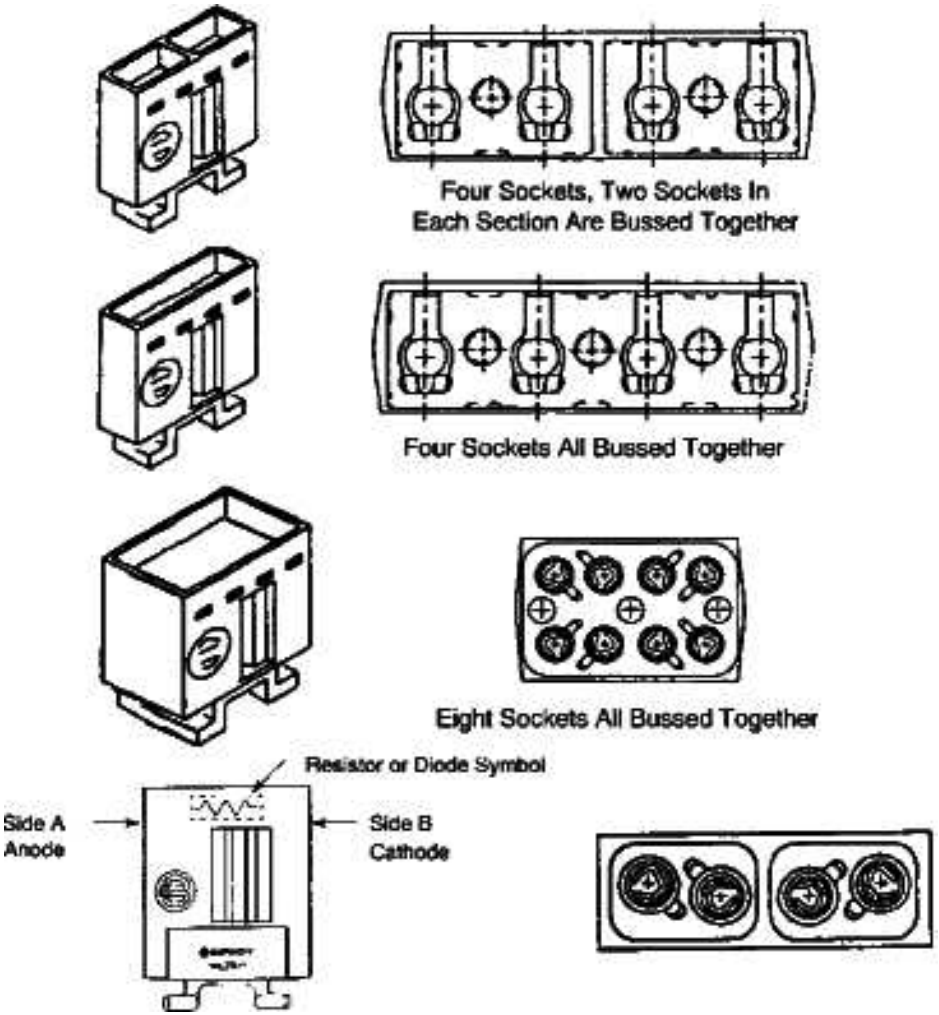


Figure 72 Boeing Block Connectors

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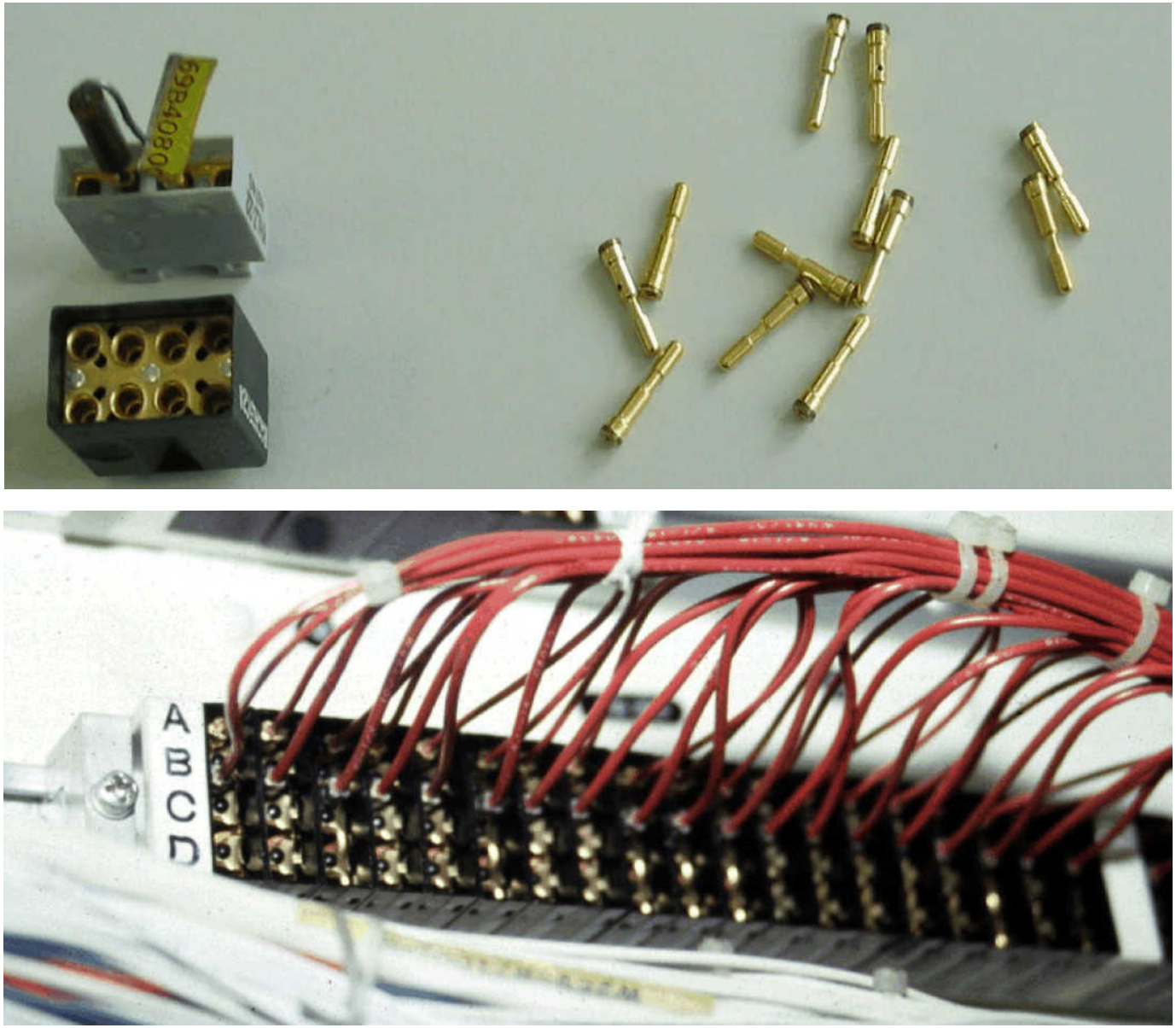


Figure 73 Block Connector

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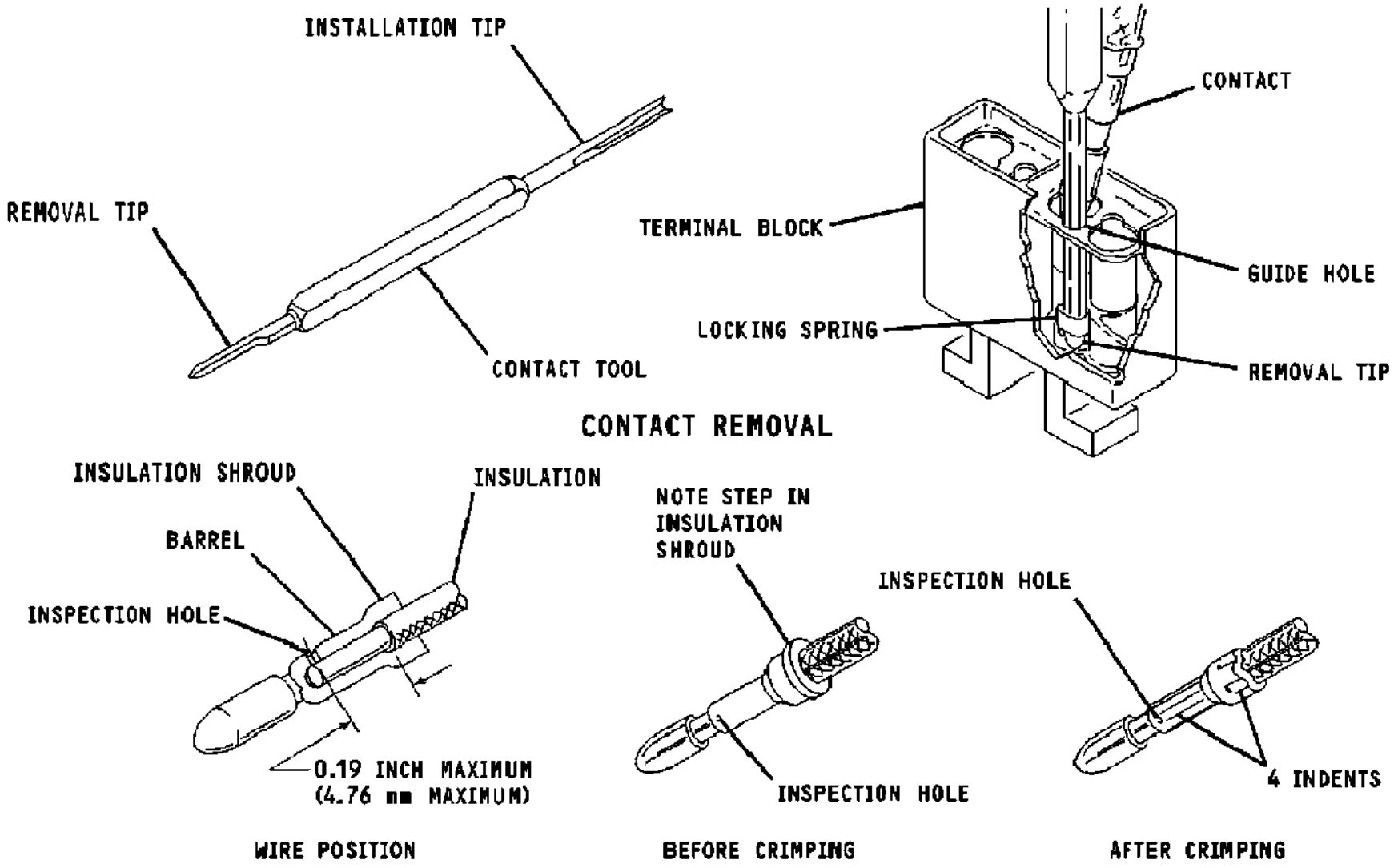


Figure 74 Processing of Burndy–Contacts

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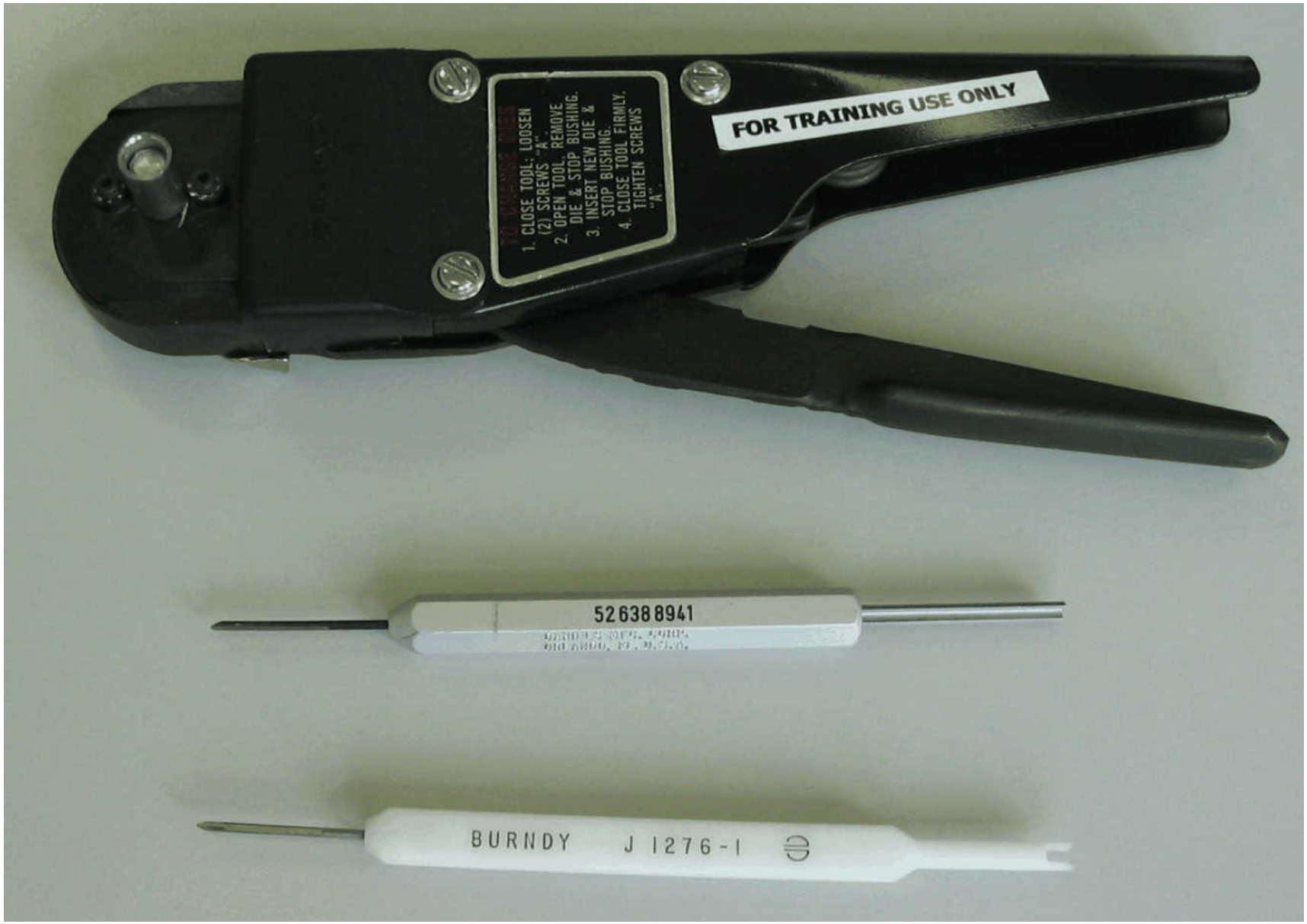


Figure 75 Tools for Block Connectors

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Airbus Block Terminal System (NSA–Standard)

Airbus uses block terminals according to the NSA standard. In this system, modules with 10 contacts are used as standard. There are 12 different contact arrangements. For very small or very large contacts, there are modules with different contact numbers. Airbus also uses special modules with integrated resistors.

The contacts of these block terminals are connected by means of standard crimping tools and integrated into the modules by means of standard installation– and removal tools.

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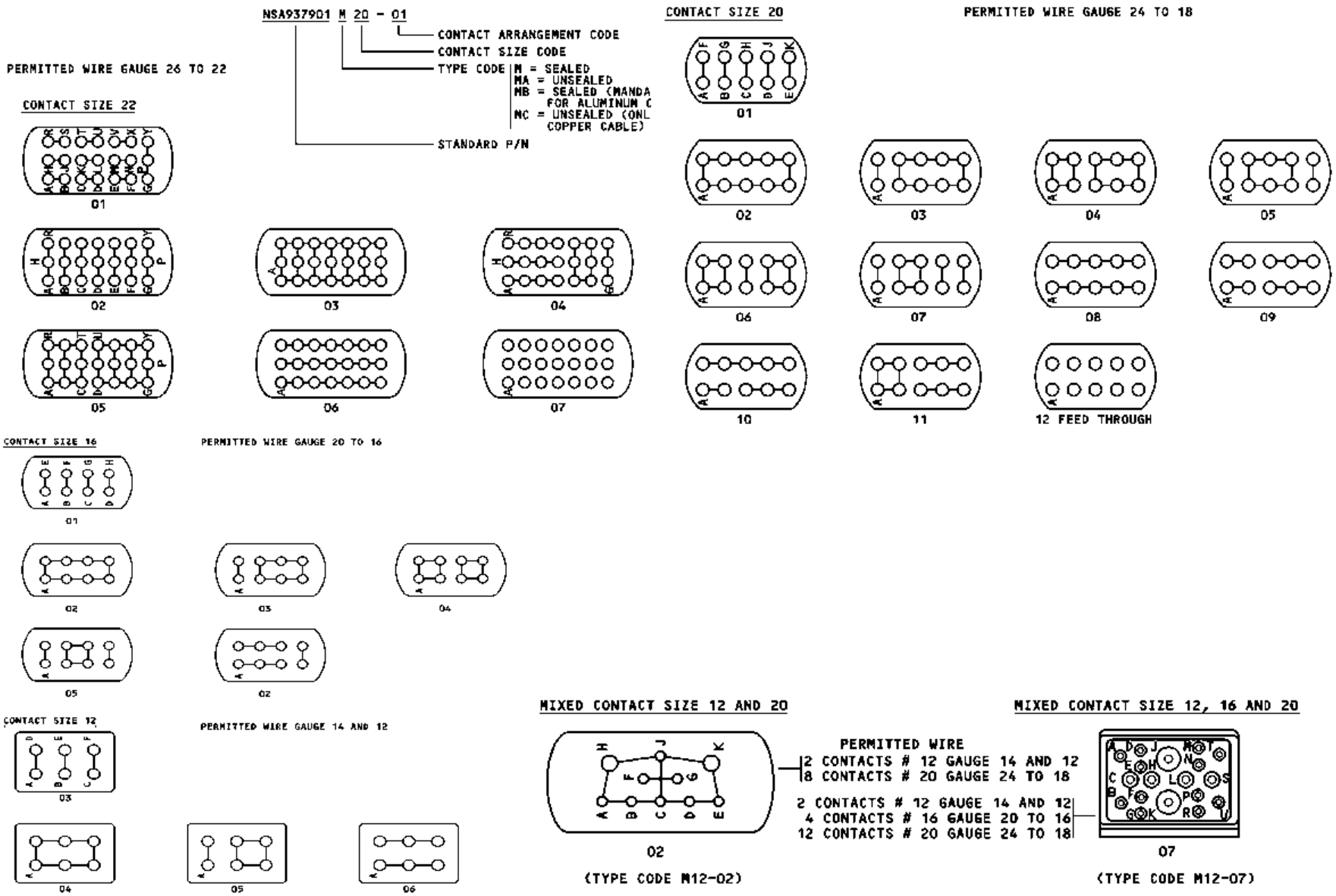


Figure 76 NSA Standard Block Connectors

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EWIS INST.,INSP.,REP.,MAINT. AND CLEANING STANDARDS

Installation

Safety instructions

Before carrying out any work on electrical systems on an aircraft, the power supply must be disconnected in an accident–proof way, and a safeguard must be provided to prevent unintentional restart.

Ideally, the entire aircraft should be disconnected from the power supply and the battery should be disconnected.

If this is not possible due to operational circumstances (e.g. several groups work on the aircraft at the same time) the circuit to be worked on must be disconnected from the power network.

1. **Pull the circuit breaker**
2. **Secure the circuit breaker by using a respective (locking collar) against reactivation.**
3. **Attach the warning tag or sticker to the circuit breaker and the switch.**
4. **Cover open clamps of adjoining systems to avoid accidental touching.**
5. **Implement a voltage test before stating the work.**

If possible, a second person should supervise the work.

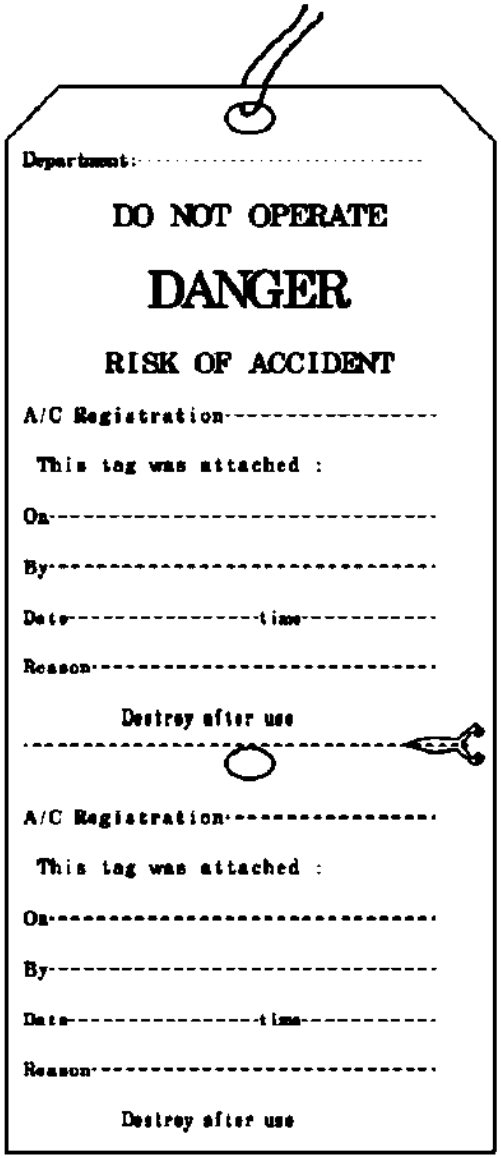


Figure 77 Warning Sign

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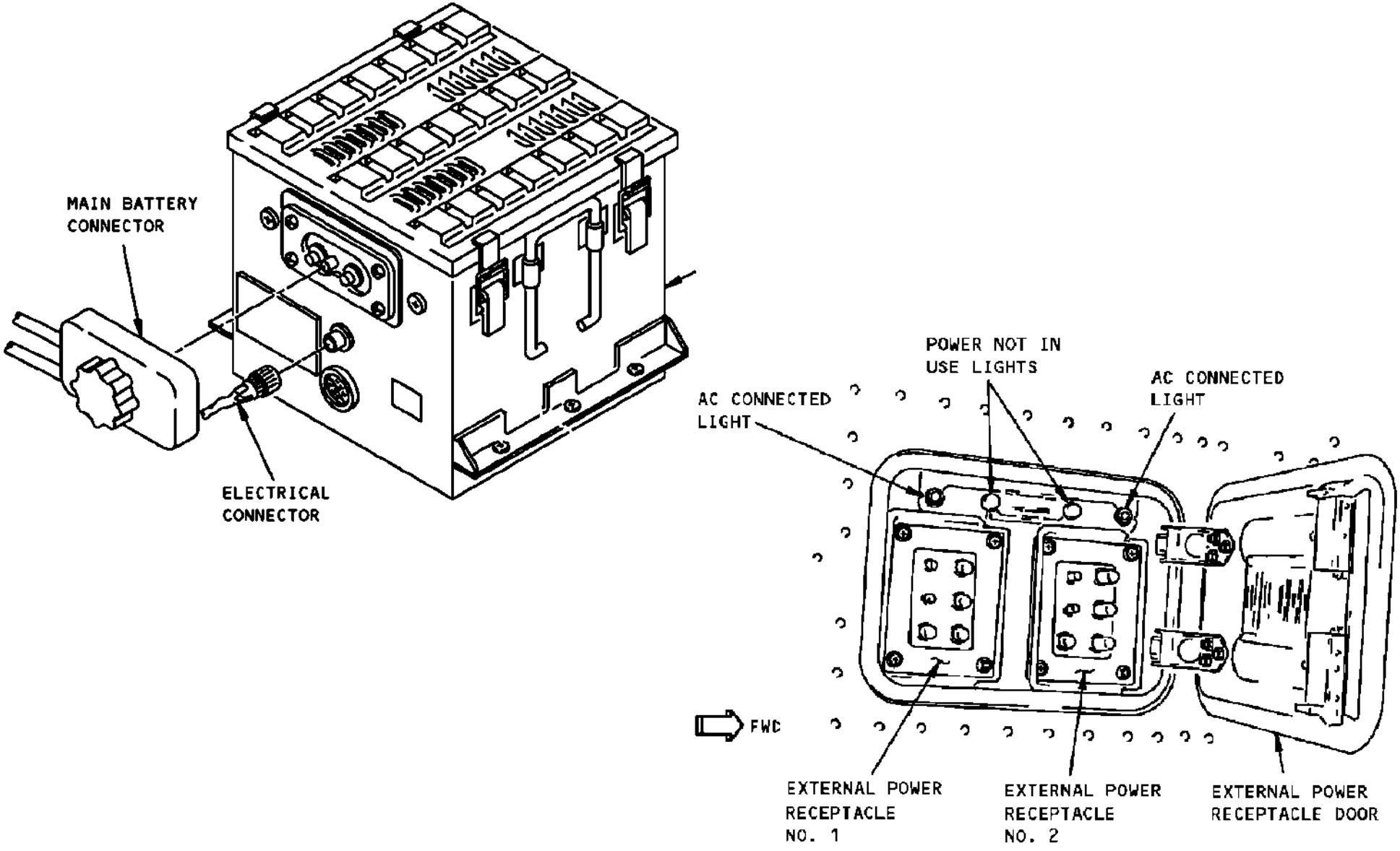


Figure 78 Separating Connections

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General Guidelines

All work on electrical lines and cables should be carried out according to the following criteria, in this order:

- security of the aircraft during flight time
- no time pressure during maintenance and repair work
- working cost–efficient

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Harness Separation

In case of damage on the aircraft, the damage should not affect redundant systems, which is why harnesses of systems important for the flight should be separated from each other and should be installed with as few connectors as possible.

The harnesses are to be installed according to the following specifications:

- avoid interference of the different power sources.
- occuring errors in the individual systems must not effect other systems
- avoid electromagnetic interference (EMI).

To assure this, keep the following points in mind:

- separate independent current courses.
- separate identical multiple systems.
- separate circuits causing EMI and circuits sensitive to EMI.

Circuits which need to be separated are to be installed in different harnesses.

Example: Airbus Segregation Rules

The wires are categorized in six different groups:

- Generator G
- Power Supply P
- Radio/Audio R
- Coaxial routes T/U/V
- Sensitive wires S
- Miscellaneous Wires M

Within these categories, redundant systems are installed on routes 1 or 2, separated from eachother, e.g.: Airbus A 340.

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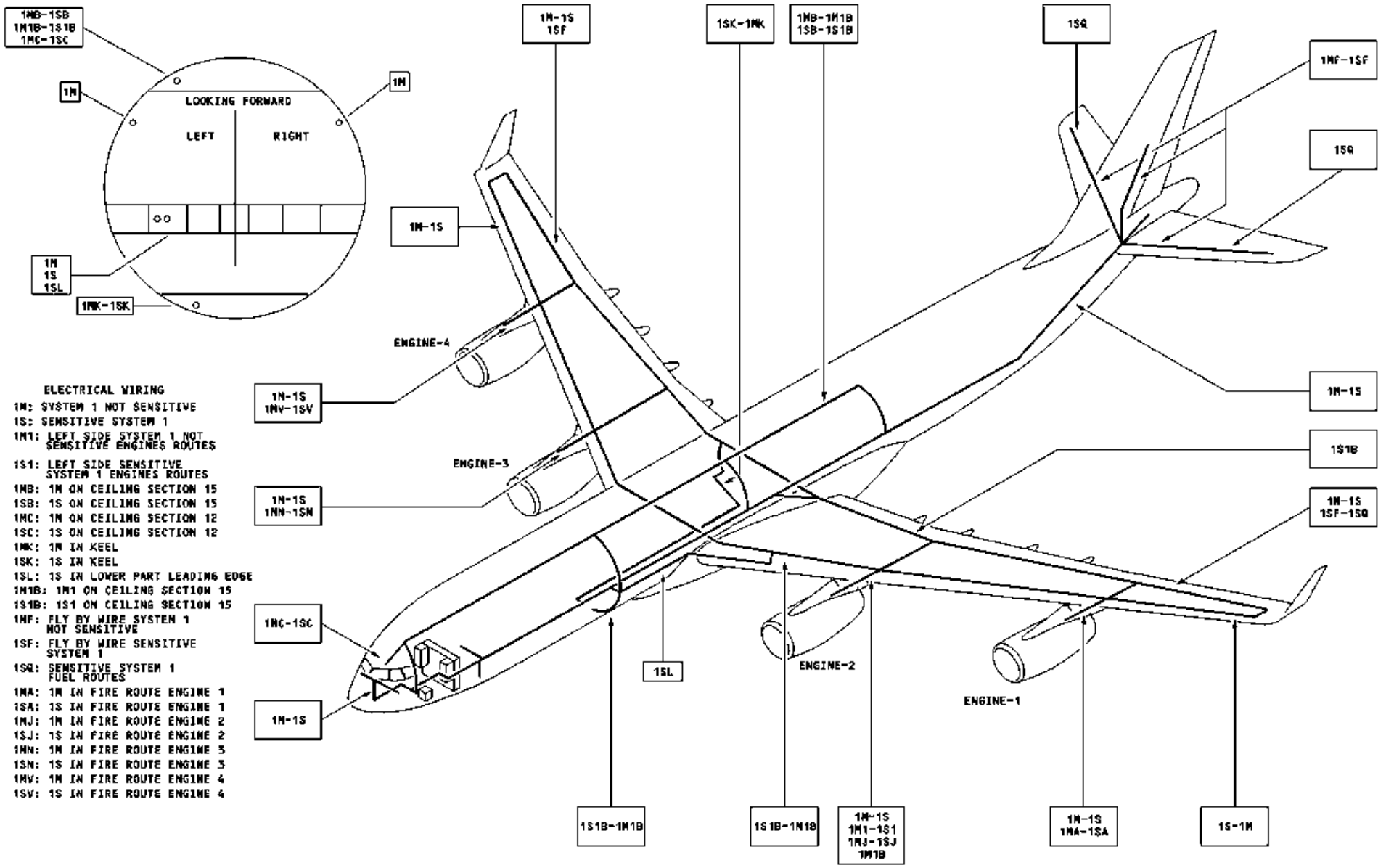


Figure 79 Separation 1

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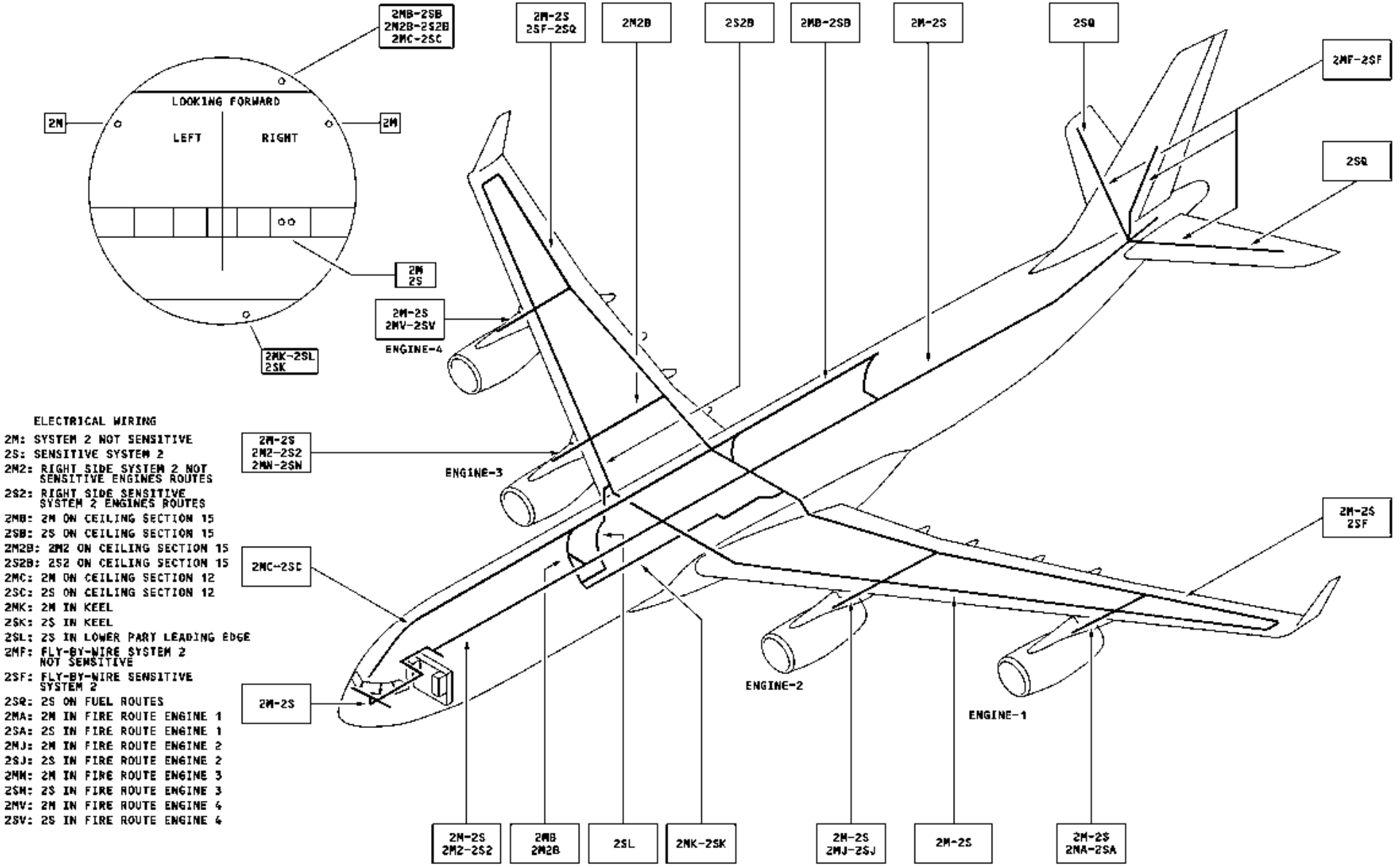


Figure 80 Separation 2

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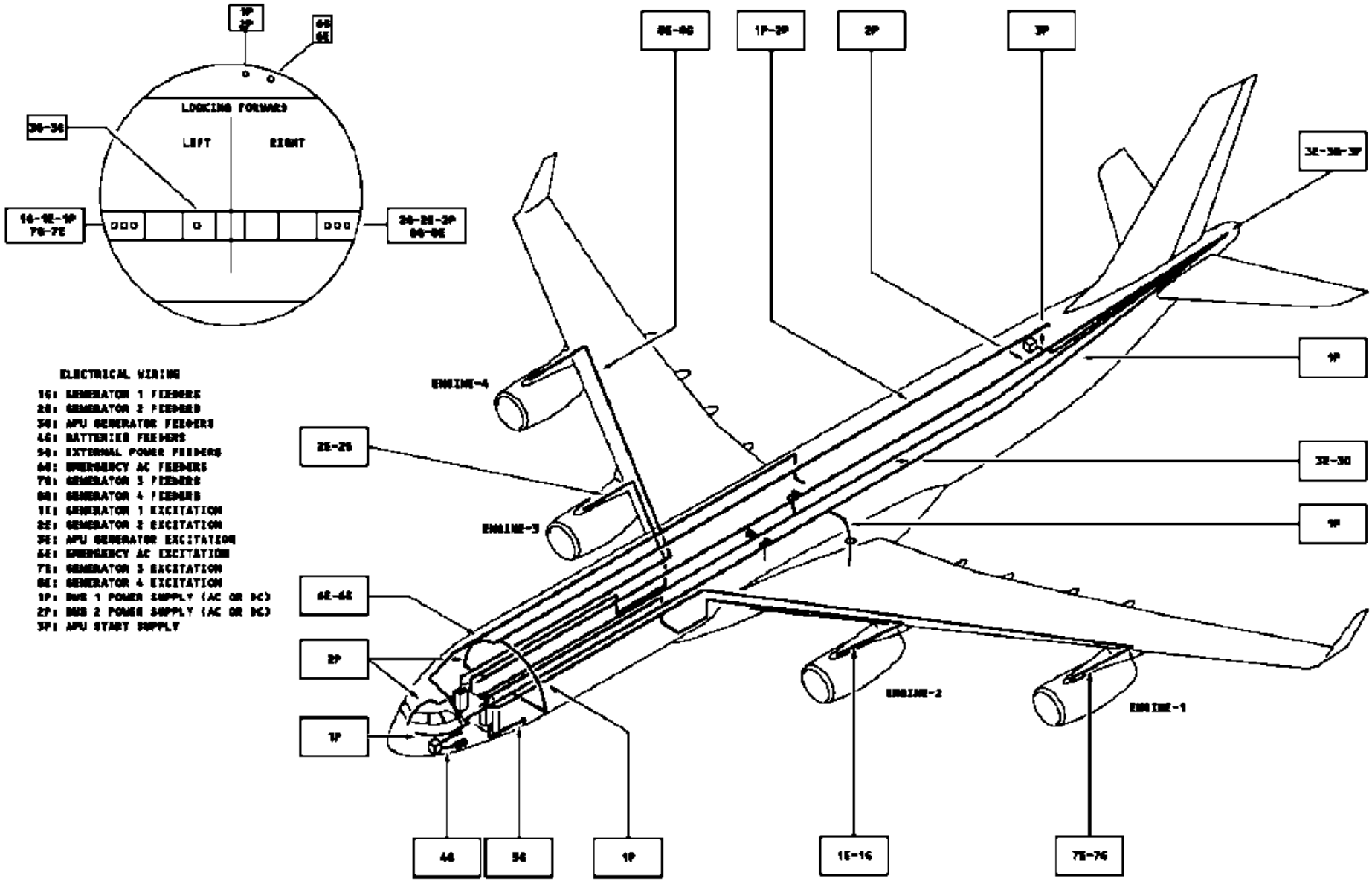


Figure 81 Separation 3

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WIRING PROTECTION TECHNIQUES

Installation of Harnesses and Wires on the Aircraft

For better–quality installations, wires and cables are tied up to harnesses.

This is done using either cable straps or special cable tie.

Tying off cables with cable straps

Tying off cables with cable straps is a fast method to create harnesses, and is therefore used by many aircraft manufacturers.

However, the field of application of cable straps is limited:

- not with ambient temperatures over 135 deg. C
- not for coaxial cables
- not inside of harnesses
- not outside the pressurized cabin (only permitted for aircraft manufacturers at the first installation)
- not in high vibration areas
- not inside the fuel tank

There are different types of cable straps, and they come in different lengths.

They are tightened and cut with a tool approved by the manufacturer.

These cable strap tools can bet set to a tightening torque value which is suitable for the type of cable strap. This prevents damage on the cable strap due to a tightening torque which is too high, but also assures that the cable strap is not too loose on the harness and can slip.

The required tightening torque can be found in the manufacturer's information manual.

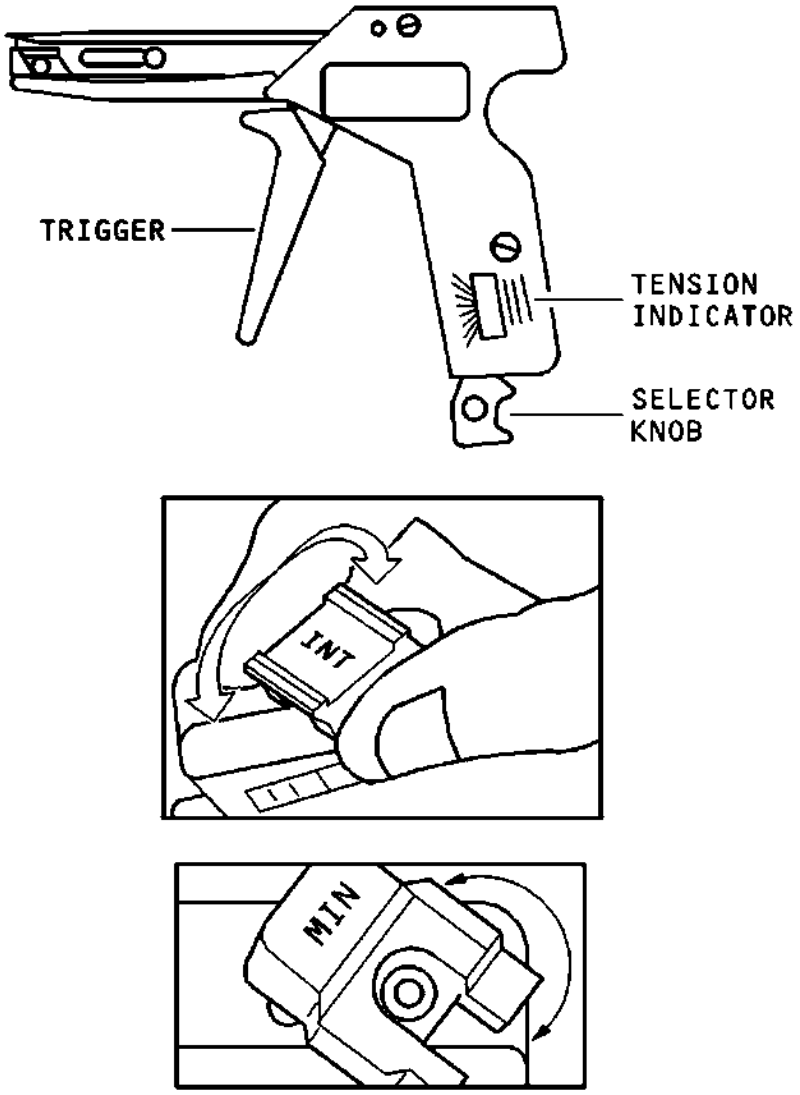


Figure 82 Panduit Clamp Tool

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Figure 83 Assembling of Cable Ties

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Tying off cables with cable tie

When tying off cables with cable tie, it has to be assured that only cable tie appropriate for the application range is used. Also, the temperature range and potentially occurring fluids have to be considered, when choosing the cable tie.

Generally, two different knots are used for tying up harnesses. Knot 1 is the standard knot and can be used anywhere, knot 2 is used in areas which are not easily accessible.

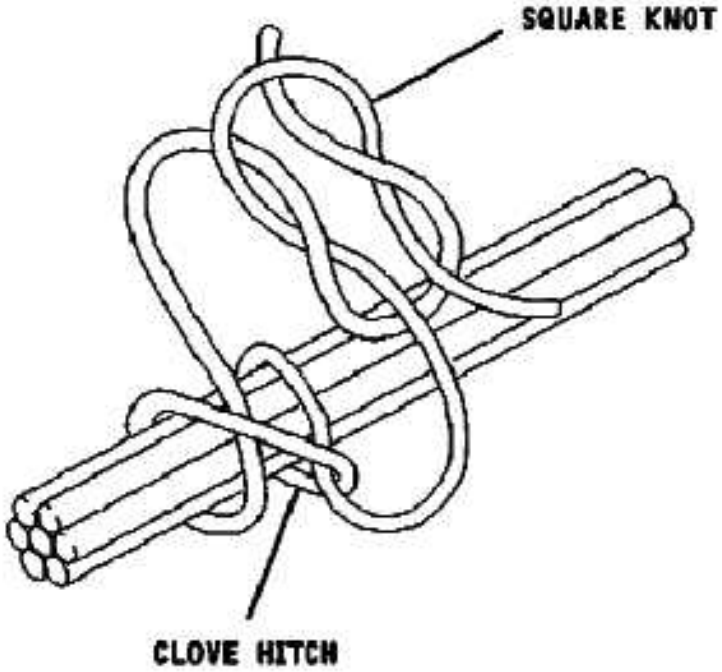


Figure 84 Knot Number 1 Tying Sequence A

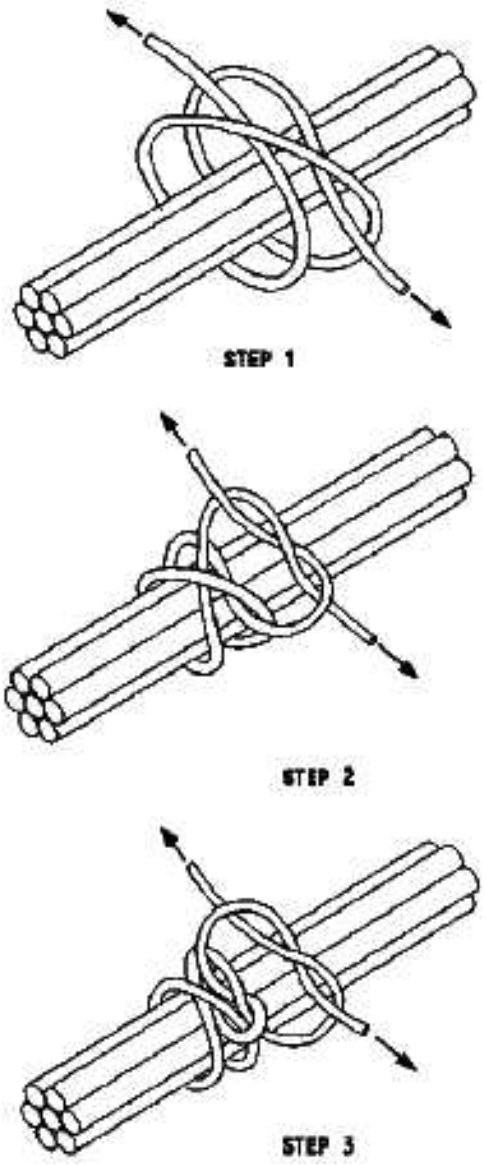
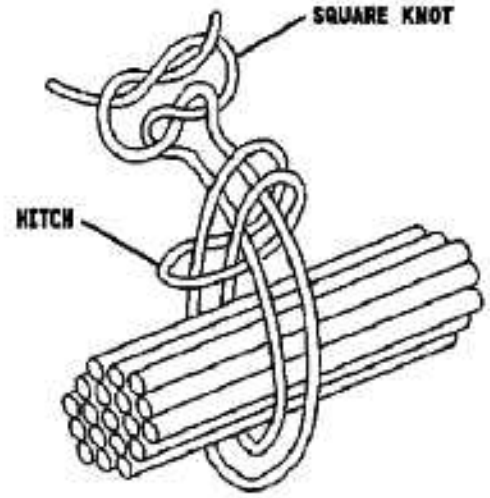
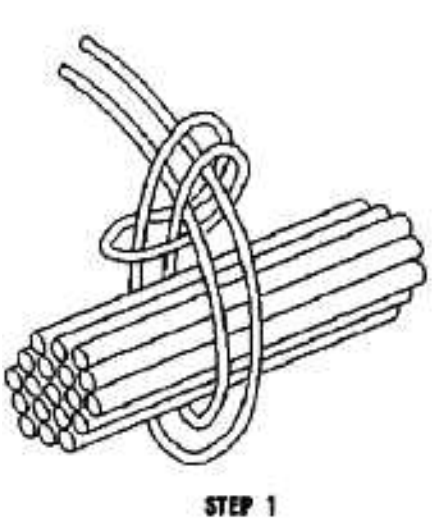


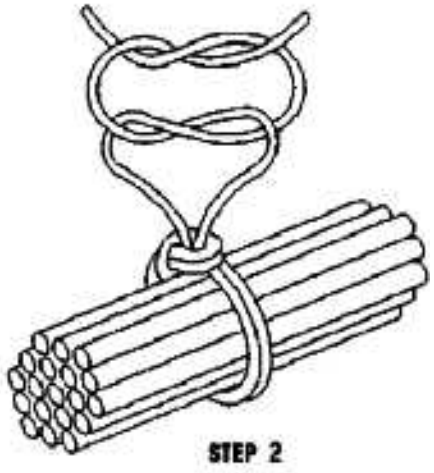
Figure 85 Knot Number 1 Tying Sequence B

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The following conditions must be met:

The tie may not deform the wires.

The gaps between ties should be between 20 and 25 cm, cm in high vib. areas.

Wires should lie parallel and close to eachother.

No ties under clamps and protective condiuts.

Splice and spare wires must be outside the harness.

Protection against abrasion must be provided for intersect

No ties are allowed in the tank (with the exception of A34(

Pay particular care with coaxial cables and AP–wires.

Figure 86 Knot Number 2 Tying Sequence

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Installations of Harnesses Inside the Aircraft

Harnesses and individual wires must be installed on the aircraft in a stable way and must be protected against abrasion. This can be done using several components and procedures.

CLAMPS ESPM 20–33–42 SWPM 20–10–12

The components used most often for the installation are clamps, which come in different types and sizes. There are nylon and metal clamps.

Nylon clamps are used mainly inside the pressurized cabin, and are only used outside of it if the clamp can withstand the environmental conditions occurring there. Nylon clamps only come in sizes up to a bore diameter of 1.5 inches. They have different colors depending on the size.

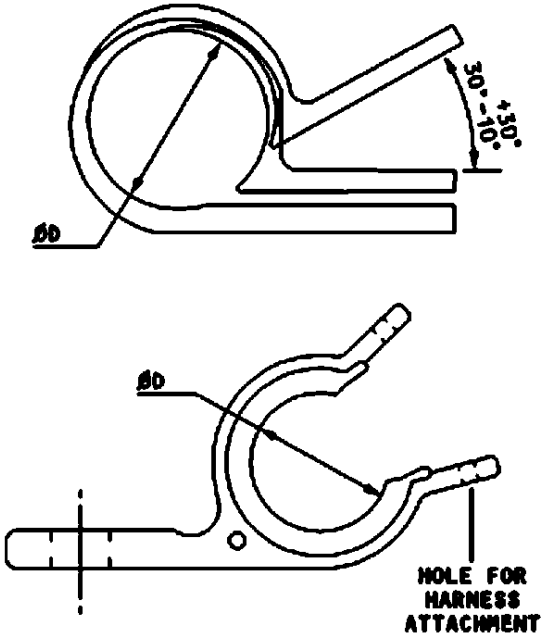


Figure 87 Clamps 1



Figure 88 Clamps 2

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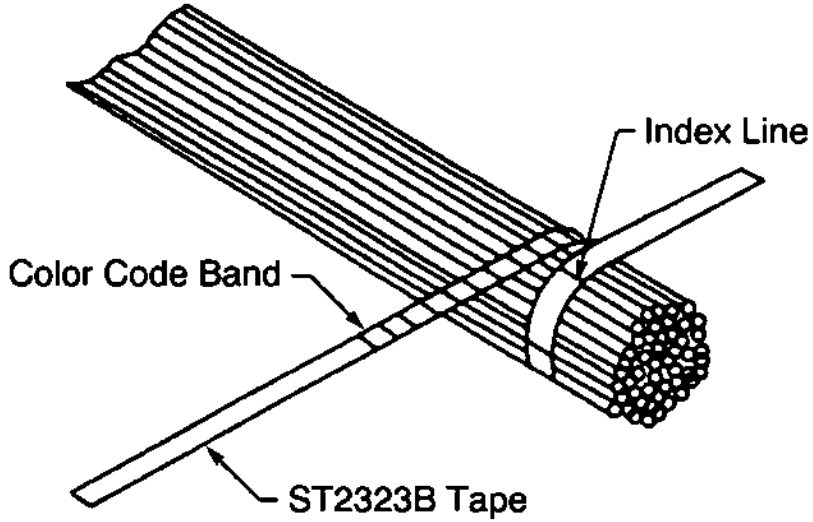
Inner Diameter (inch)	Boeing Standard	Color
0.125	BACC10DK2	Brown
0.187	BACC10DK3	Orange
0.250	BACC10DK4	Pink
0.312	BACC10DK5	Natural
0.375	BACC10DK6	Gray
0.437	BACC10DK7	Blue
0.500	BACC10DK8A	Yellow
0.562	BACC10DK9A	Brown
0.625	BACC10DK10	Orange
0.687	BACC10DK11	Pink
0.750	BACC10DK12	Natural
0.812	BACC10DK13	Gray
0.875	BACC10DK14	Blue
0.973	BACC10DK15	Yellow
1.000	BACC10DK16	Brown
1.062	BACC10DK17	Orange
1.125	BACC10DK18	Pink
1.187	BACC10DK19	Natural
1.250	BACC10DK20	Gray
1.500	BACC10DK24	Blue

Figure 89 List of Nylon Clamp Sizes

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To determine the correct size, a special tool is used.



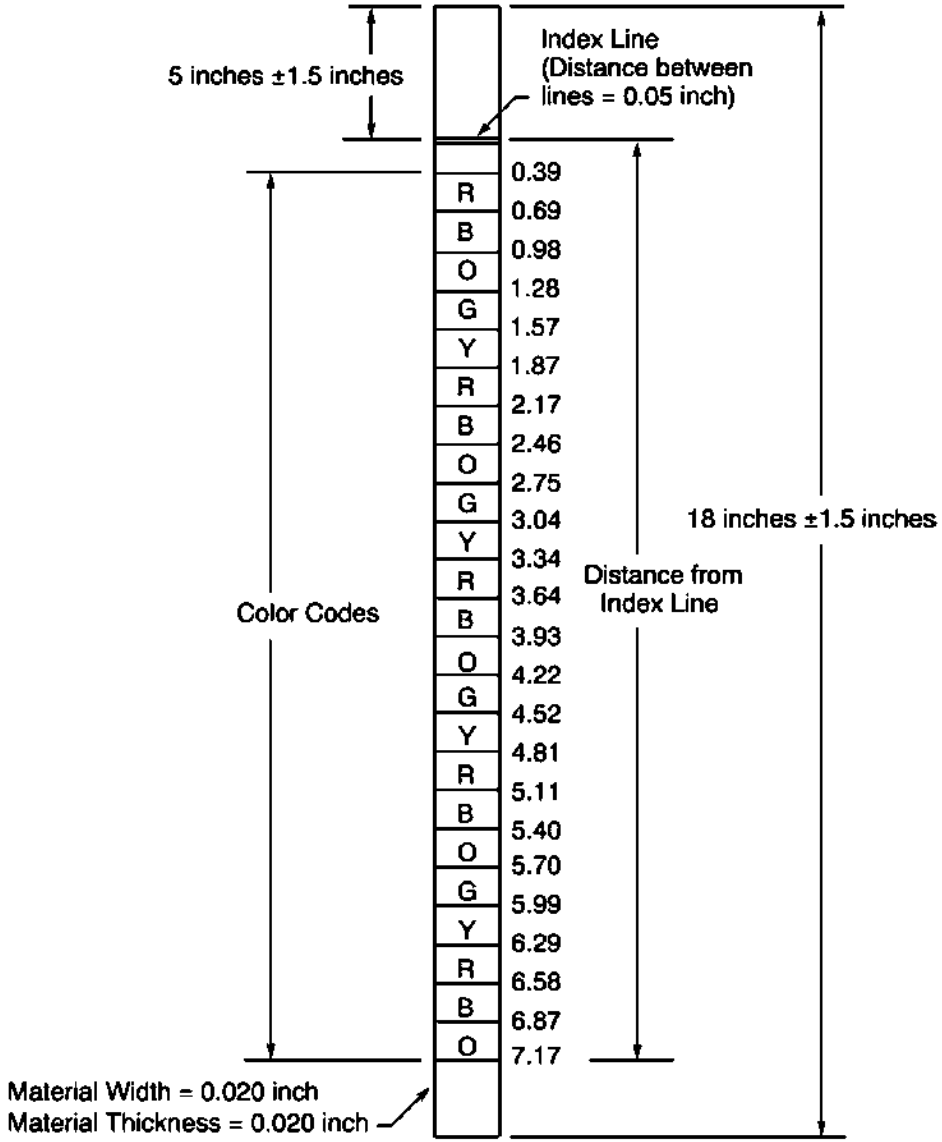
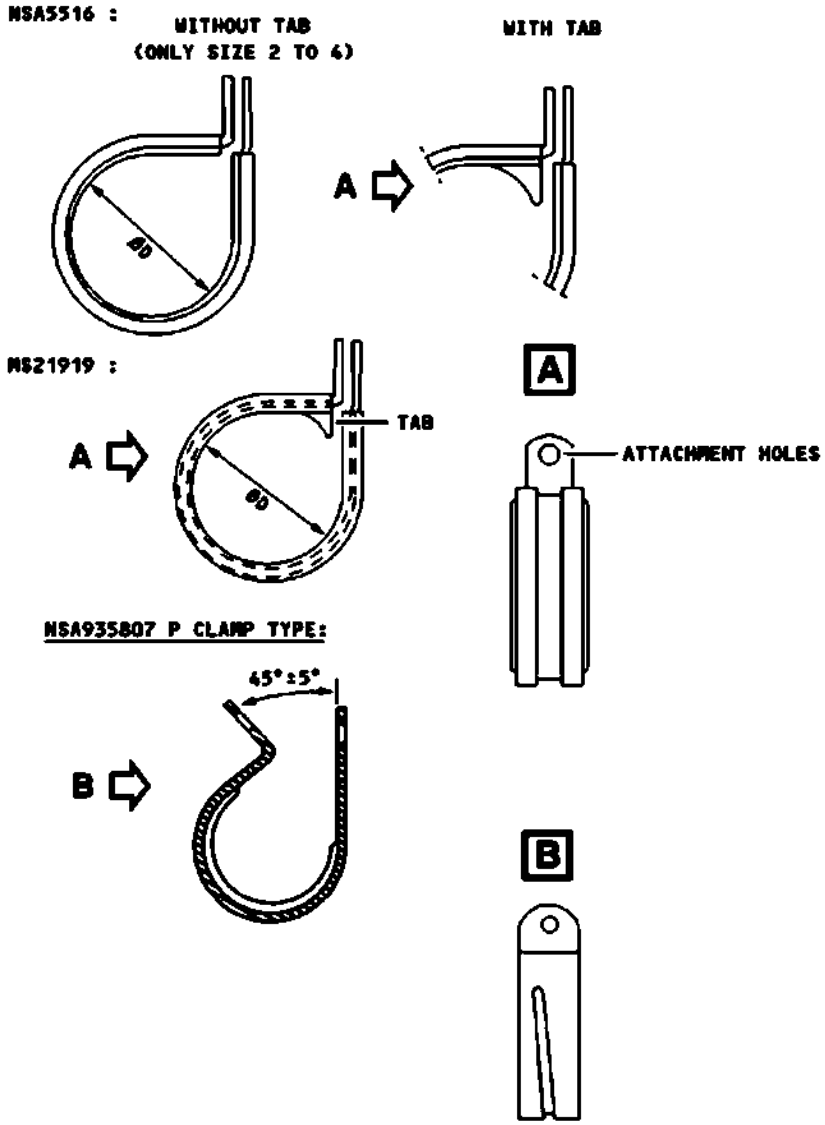


Figure 90 Determining the Clamp Size

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Metal clamps are mainly used for hot areas on the aircraft, the choice of clamp depends on the existing condition of the place of installation.



Material code		Color	Material		Max operating temp °C(°F)	Installation area
Clamp	Coating		Clamp	Coating		
D	E	Purple	Aluminum	Ethylene propylene	100(212)	Phosphate ester hydraulic fluid
	F	Yellow		Nitrile		Fuel + fuel vapor
	G	Black		Chloroprene		Petroleum based hydraulic fluids
C	E	Purple	Cres	Ethylene propylene	136(275)	Phosphate ester hydraulic fluid
	F	Yellow		Nitrile	100(212)	Fuel + fuel vapor
	G	Black		Chloroprene		Petroleum based hydraulic fluids
	H	Natural		Silicone	204.44(400)	Phosphate ester based fluid
	J	Blue		Fluorosili-cone	232.22(450)	High temp and petroleum based fluids
-	F	Yellow	Low carbon steel	Nitrile	100(212)	Fuel + fuel vapor
	G	Black		Chloroprene		Petroleum based hydraulic fluids
	H	Natural		Silicone	204.44(400)	Phosphate ester based fluid

Figure 91 Metal Clamp Selection

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Installation of Clamps

When installing clamps, several rules have to be observed:

- Do not pinch wires in the clamp.
- The clamp should be closed after tightening the clamping bolt (max.0.8 mm/0.03 inch open).
- Clamps should always be installed overhead.
- When installing nylon clamps on spacers, washers must be used to avoid extruding of the clamp.
- Clamps may not be installed onto pipes or lines carrying fluids or gases.
- Exception: when clamps are not holding the harness but only prevent abrasion.
- The clamp should be installed at right angles tot he harness.
- Clamps may not be installed over splices, ties and shielding connections.
- If the harness is not big enough to fasten the clamp appropriately, the diameter can be extended with ”Filler Plugs”, ”Filler Rods” or with suitable tape.
- Harnesses may only be extended with special ”Seal Rings” inside fuel tanks.

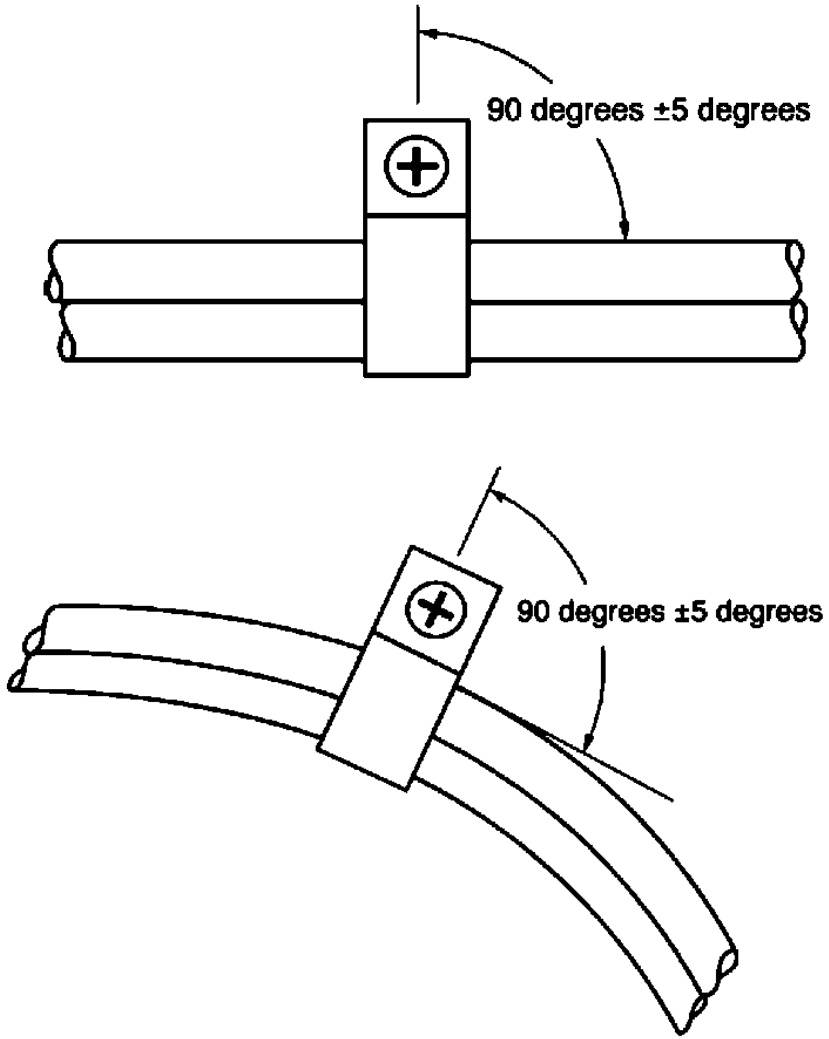


Figure 92 At Right Angles to Wire Harness

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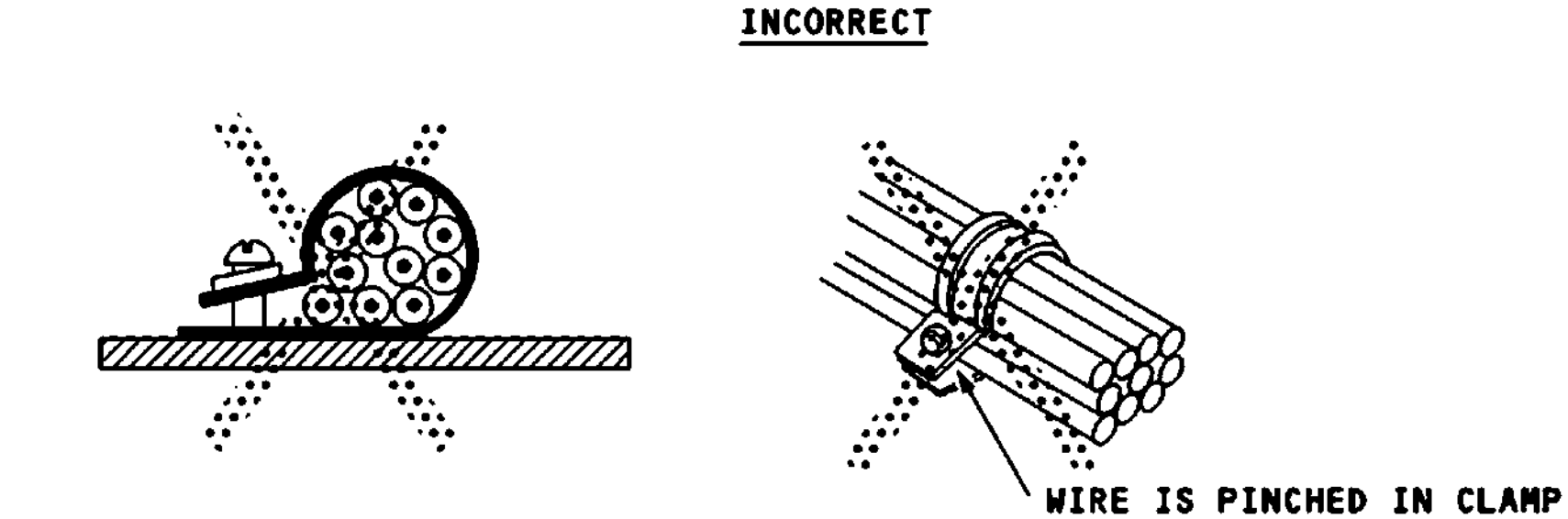


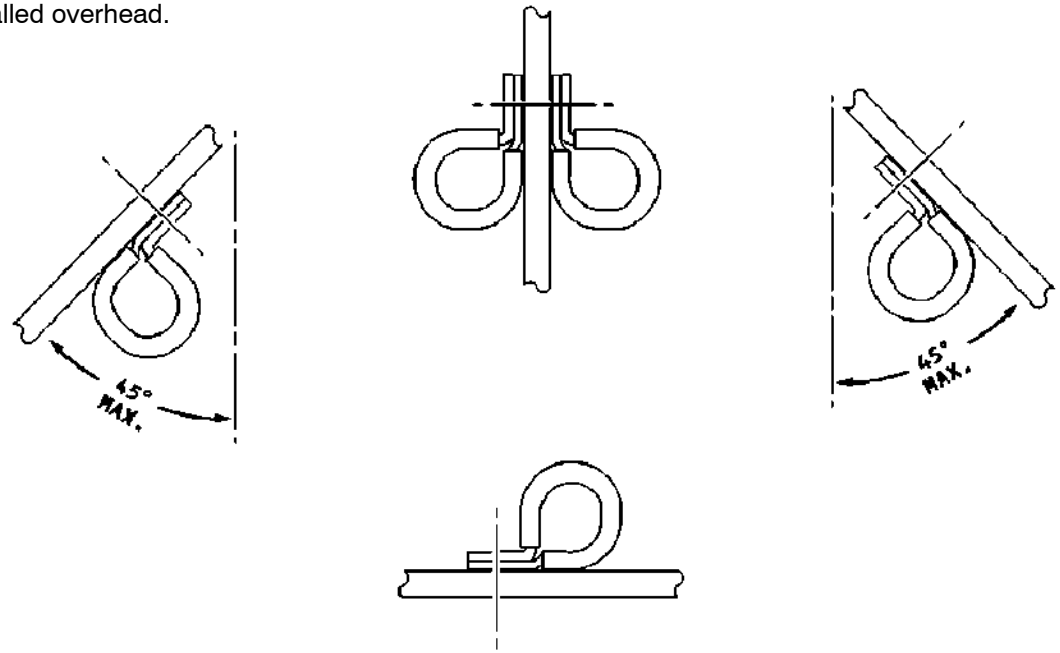
Figure 93 Installation of Clamps

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CORRECT

Clamps should always be installed overhead.



INCORRECT

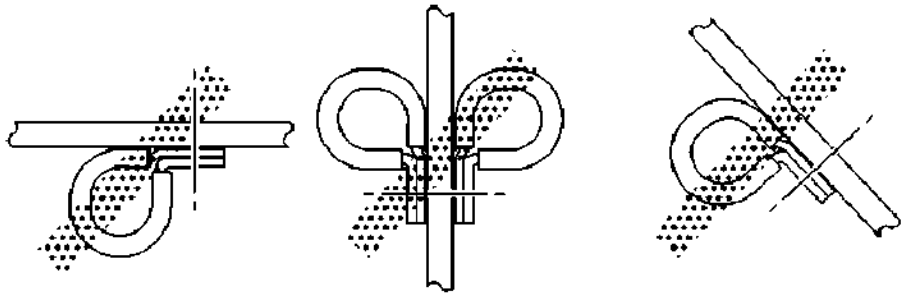


Figure 94 Installation of Clamps

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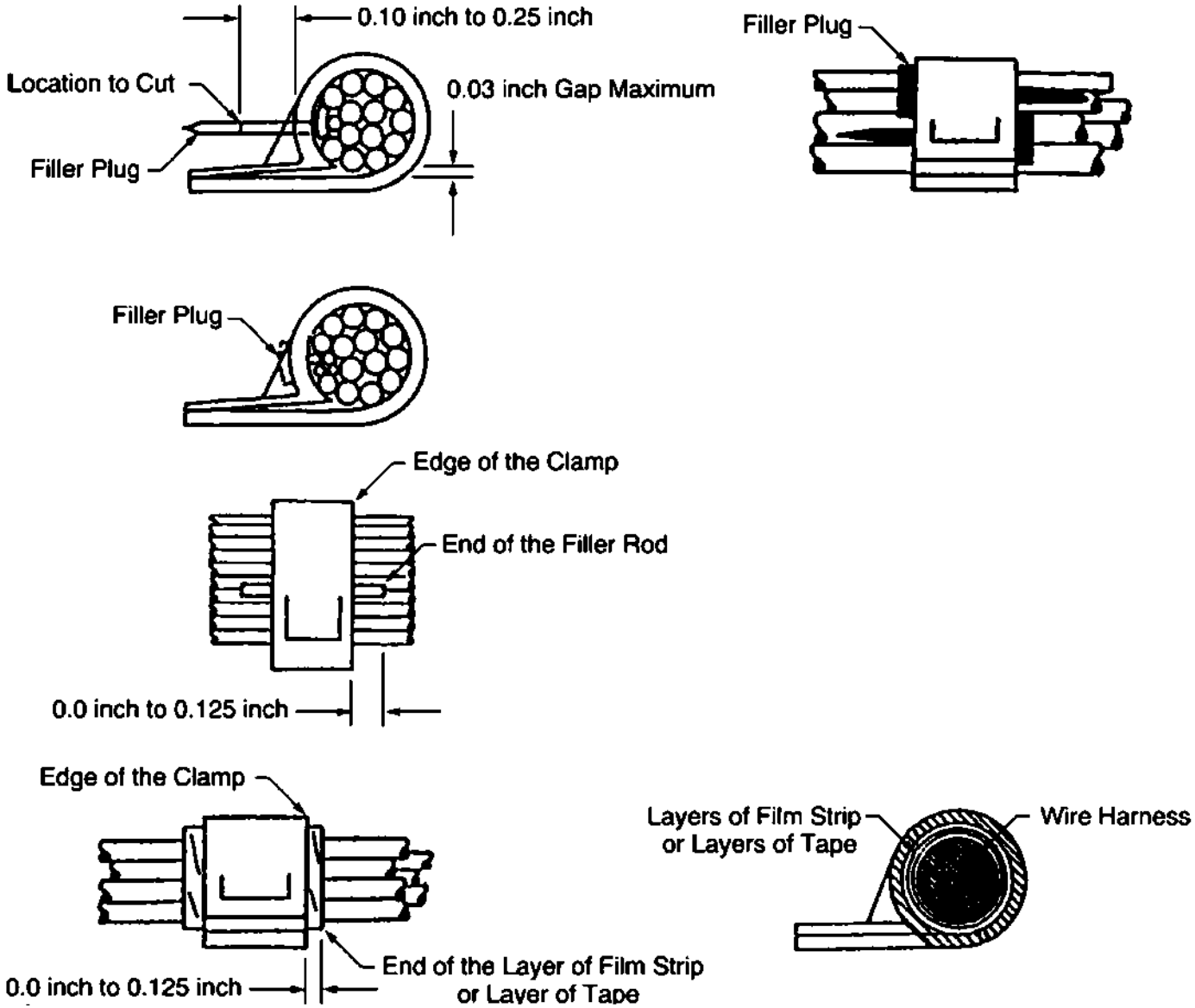


Figure 95 Adjusting Clamps to Wire Harnesses

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Cable Bearers

Another way to install wires or cables is by using raceway – or U–clamps.

For this type of installation, the following rules have to be followed:

- all harnesses must be installed in parallel inside the cable bearer.
- the biggest harness may only compress the cushion up to a preset value.
- when using coaxial cables, the cushion may only be compressed up to a respectively smaller value.
- the harnesses may not be able to move inside the cable bearer.
- a wire is not permitted between the end of the cushion and the side of the channel.



Figure 96 Cable Bearer

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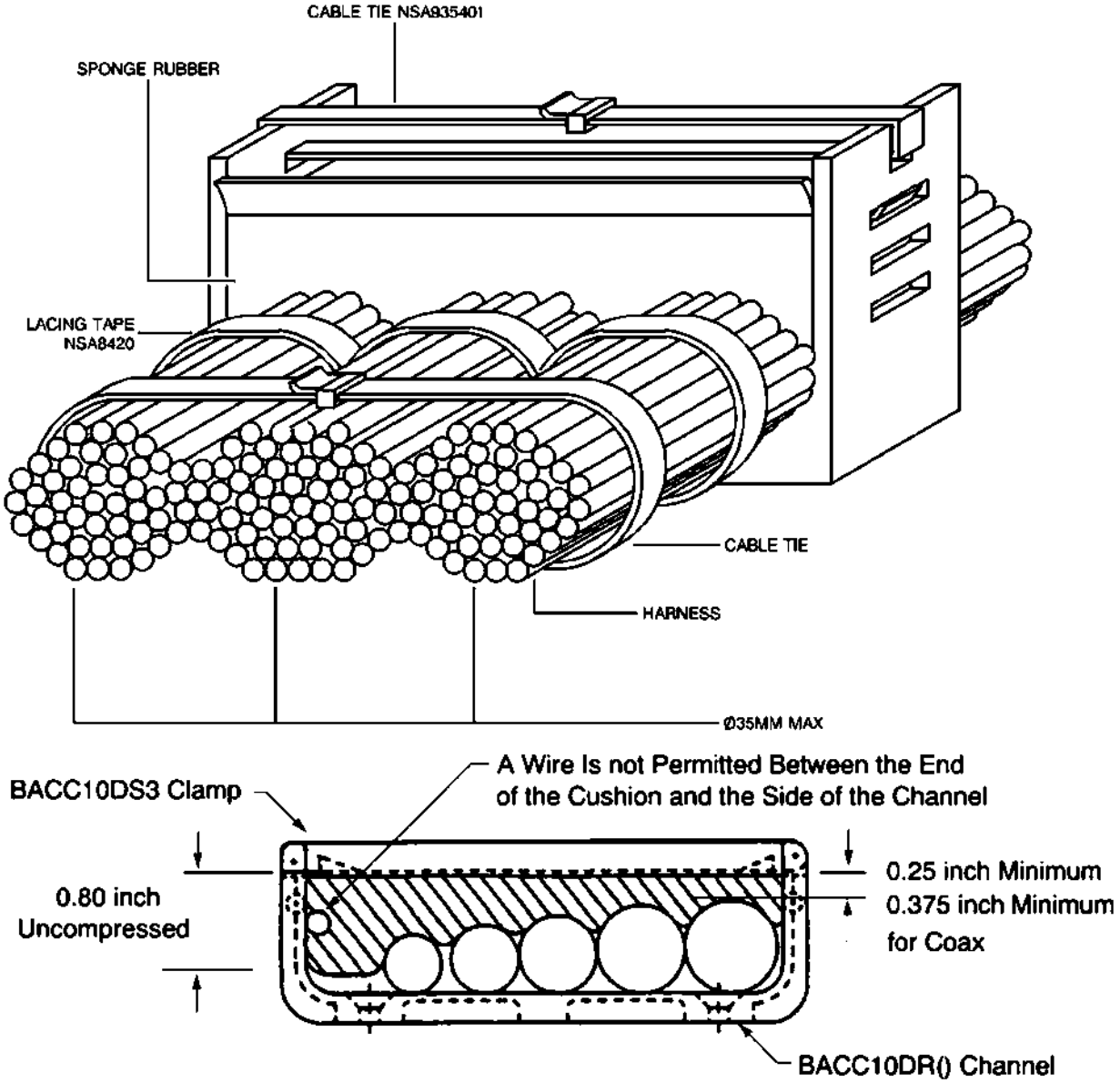


Figure 97 Cable Bearer Construction

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Cable Conduits

For the installation of cables along the wings on the A320 and A340, AIRBUS uses cable conduits in which the harnesses are fixed with harpoon tie, fairlead and retainer.

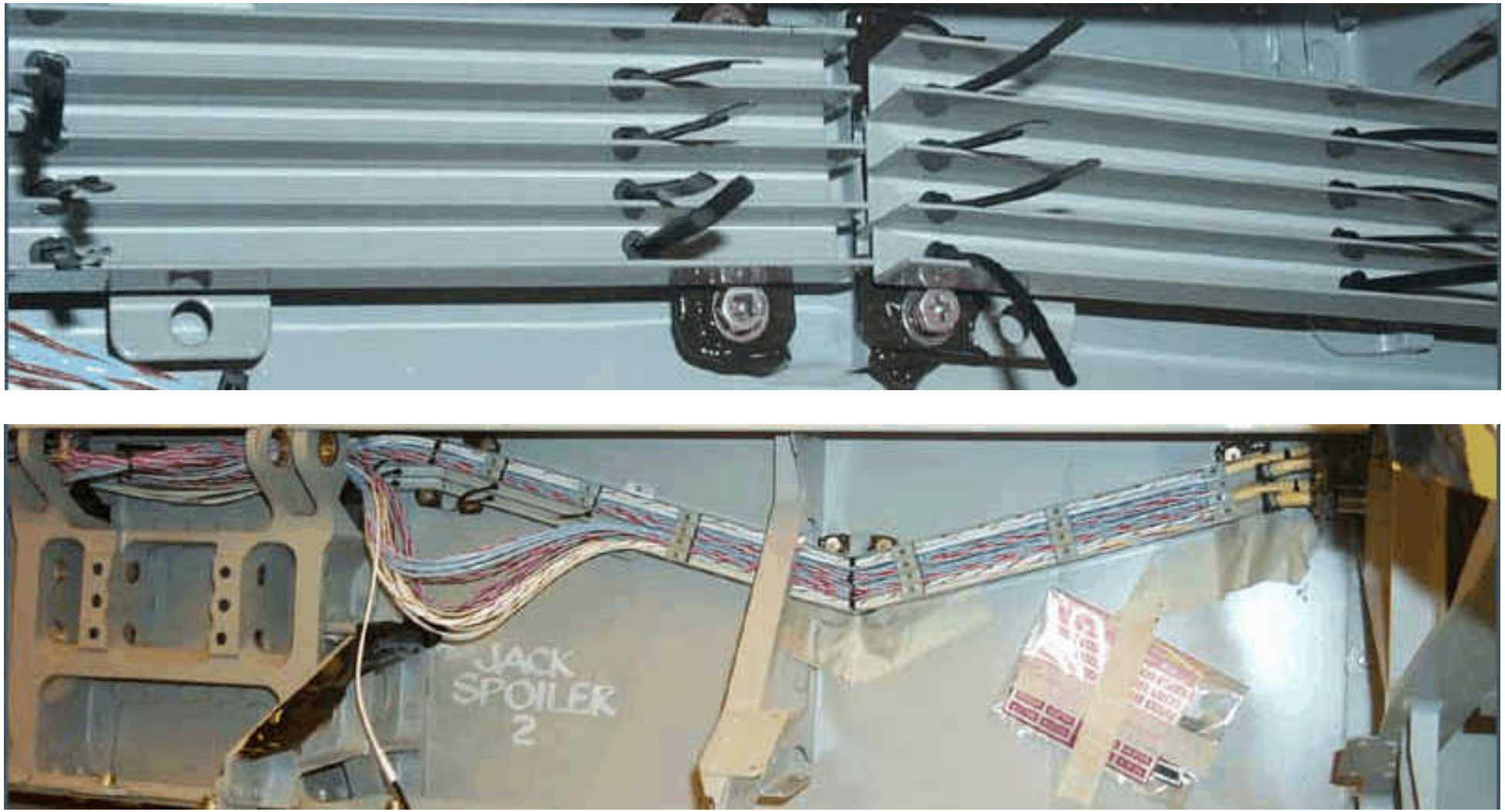


Figure 98 Cable Conduits

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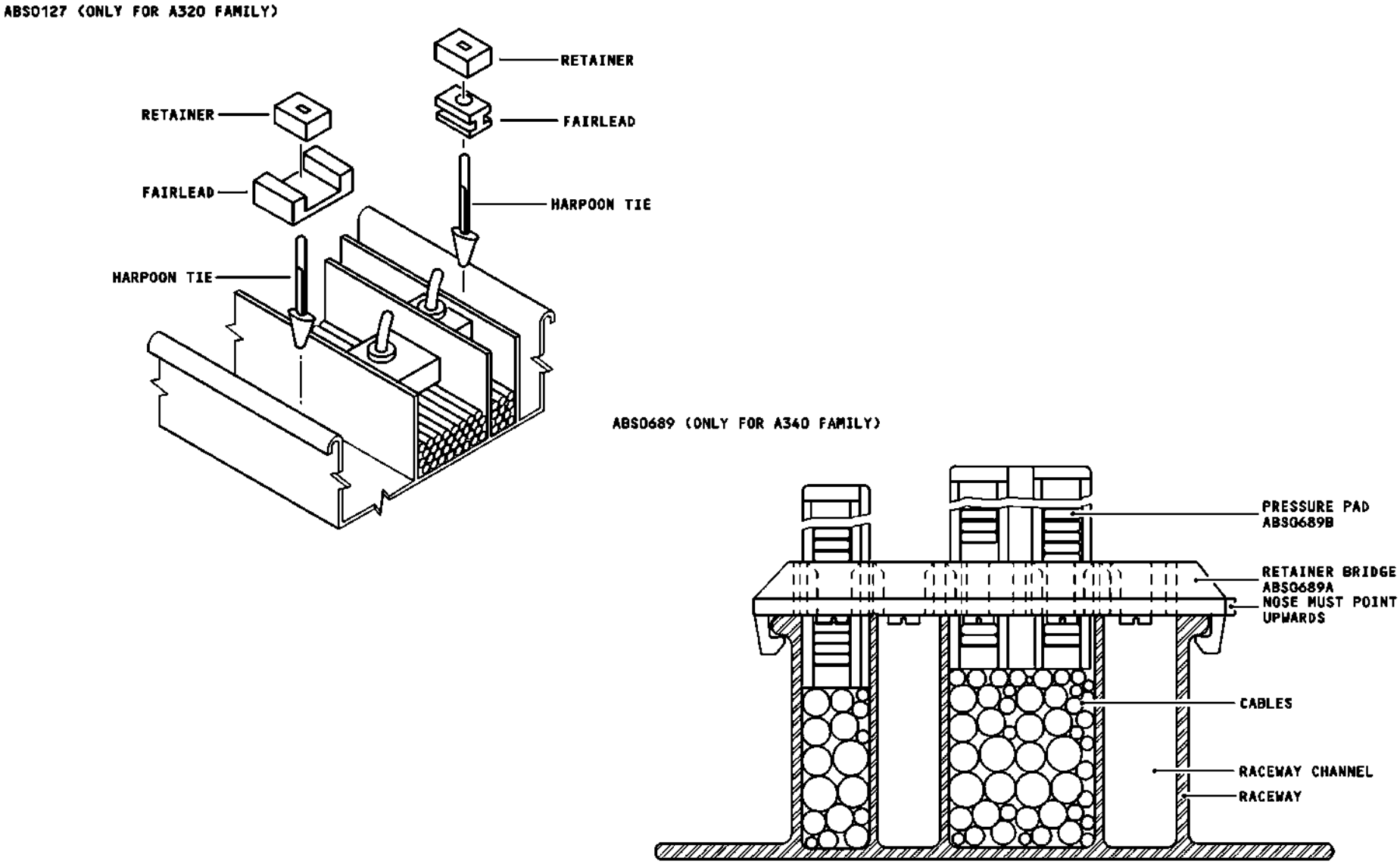


Figure 99 Cable Conduit Construction

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Installation of Harnesses

When installing a harness in a clamp, consider that the harness does not have to be installed fixedly, a potential longitudinal movement as well as a clockwise and counterclockwise movement is permitted.

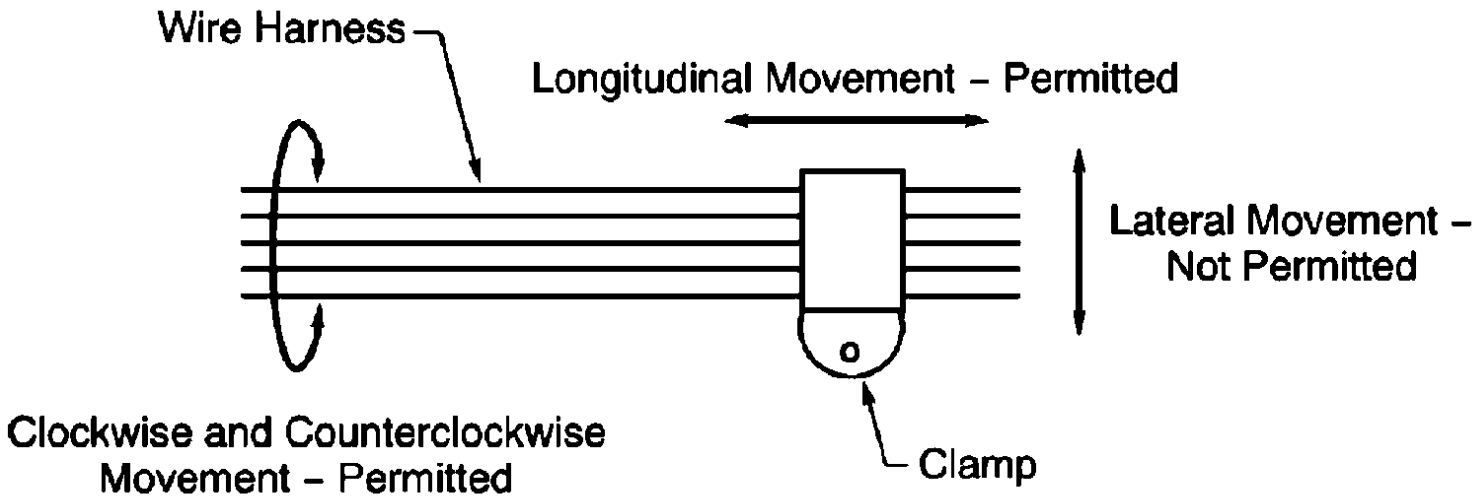


Figure 100 Wire Harness Assembly 1

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For longitudinal mounting of wire harnesses, they must be clamped to every frame avoiding any tension.

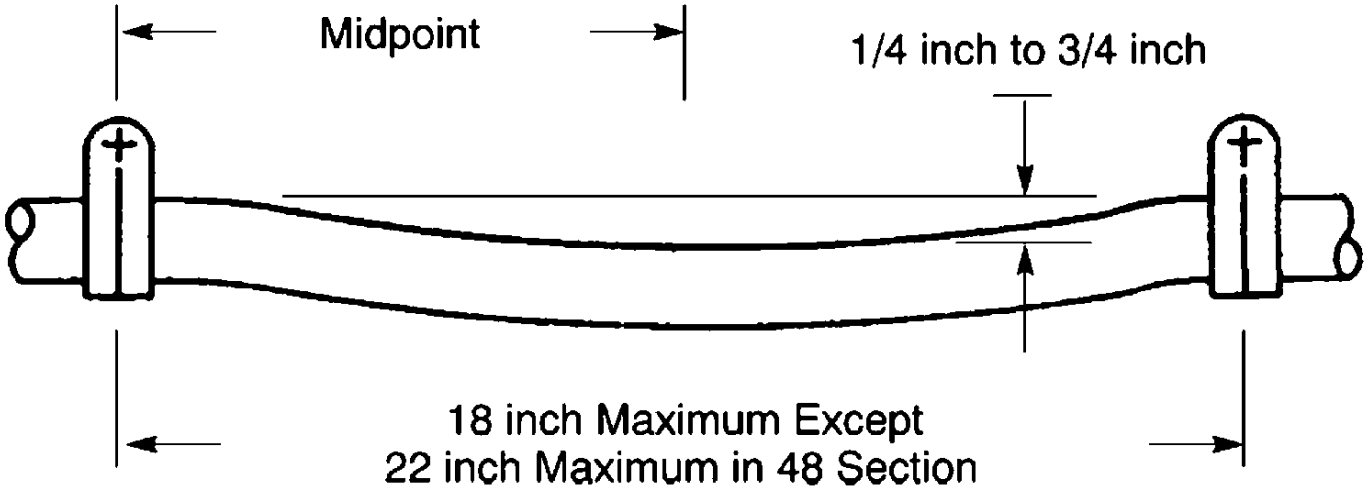


Figure 101 Wire Harness Assembly 2

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A drip−off loop is required before component connections or plug connectors in order to avoid water penetration.

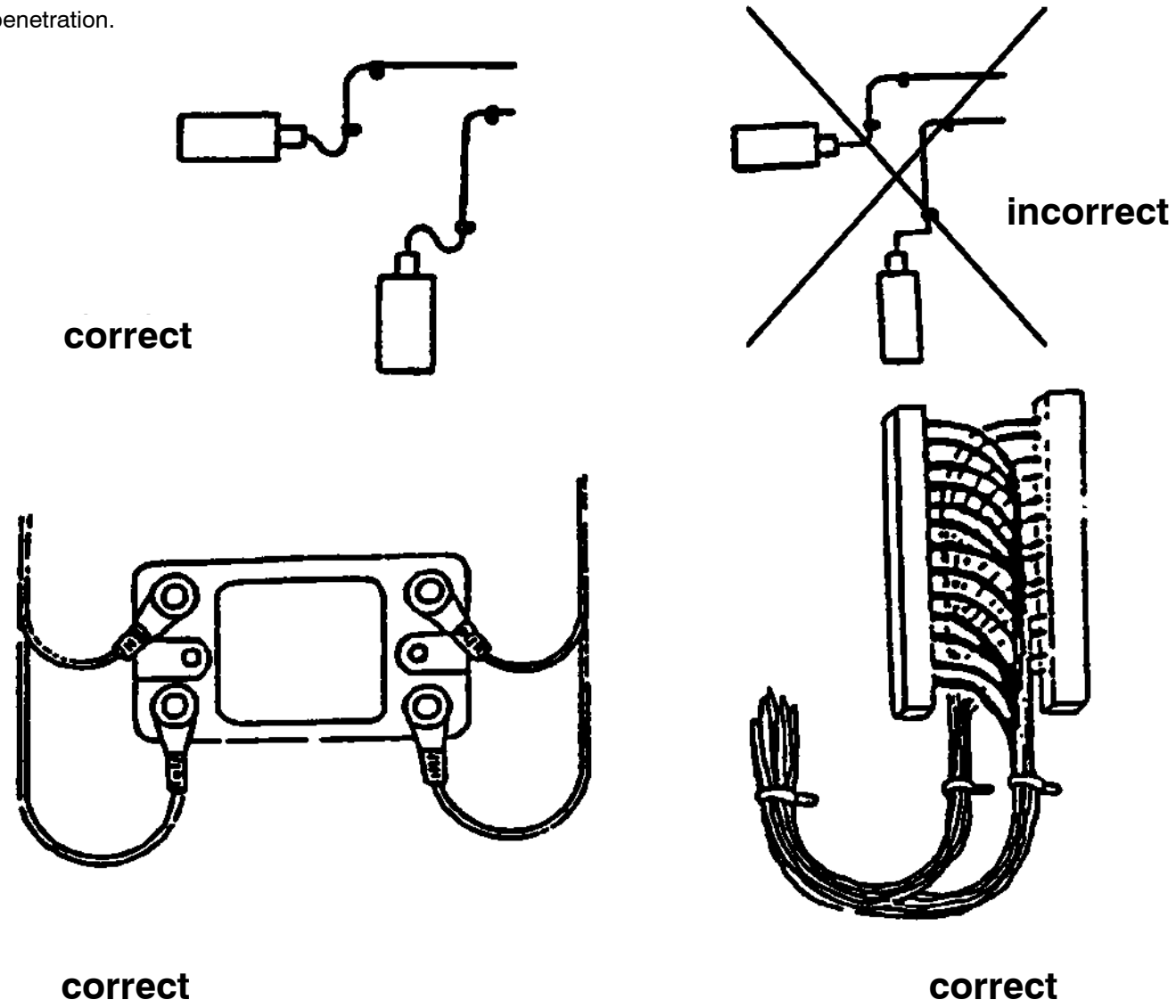


Figure 102 Drip−Off Loop

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The minimum bending radius must be taken into account during installation for it is crucial that there are no kinks in wire harnesses.

Minimum bending radii are dependent on wire type and the mounting conditions; please refer to ESPM 20–33–11 and SWPM 20–10–11 for specific regulations.

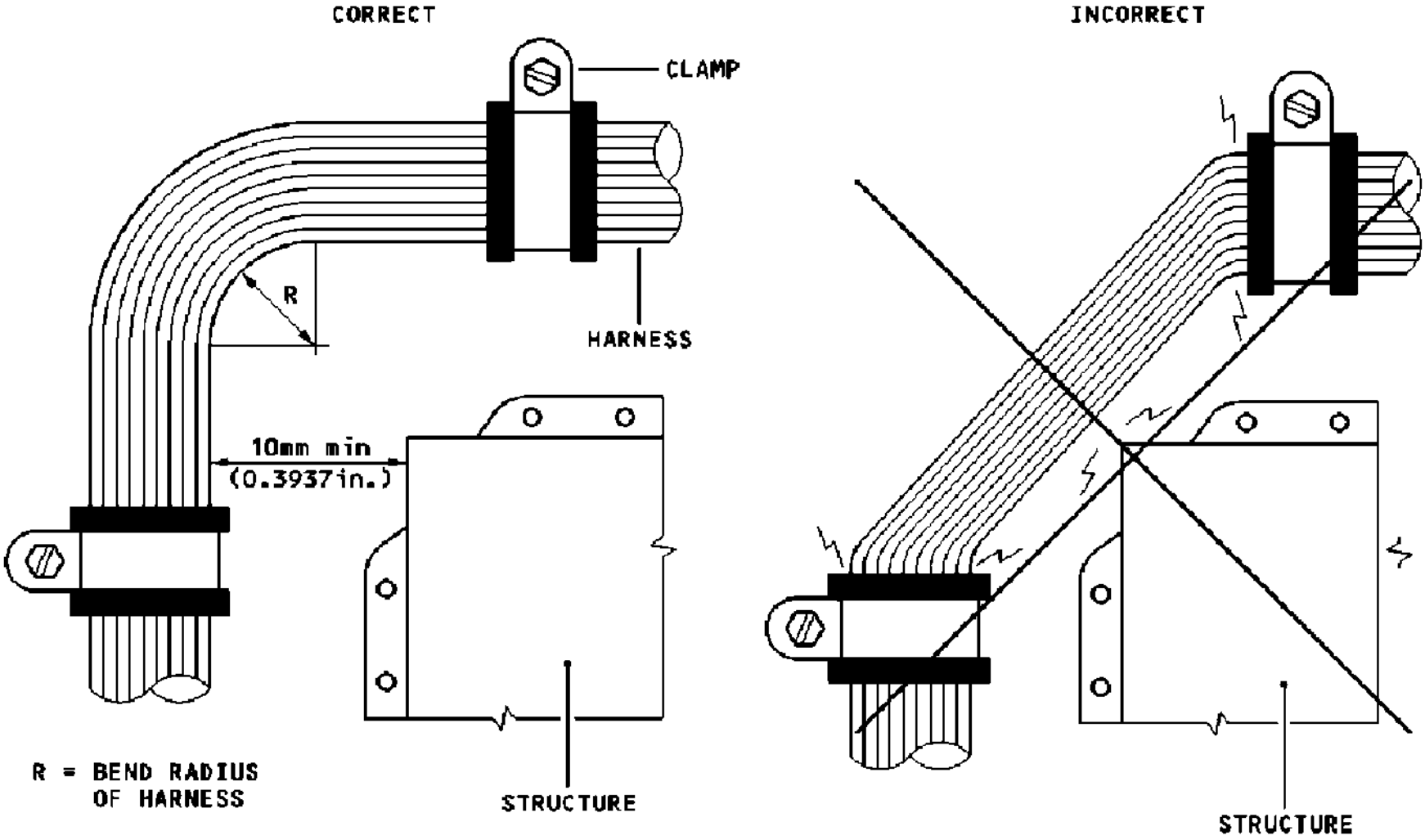


Figure 103 Wire Harness Bending Radius

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To prevent possible damages on other airplane components, the table below lists the corresponding minimum clearance in inches.

Airplane Component	Minimum Clearance (inch)	Special Instructions
Side of Bleed Air Duct	1	None
Top of Bleed Air Duct	2	None
Control Cable	2	If positive separation is made sure by mechanical support, the minimum clearance can be decreased.
Fuel Line	2	If positive separation is made sure by mechanical support, the minimum clearance can be decreased. Refer to Figure 16.
Heat Equipment	0.2	Fiberglass conduit must have the minimum clearance specified.
Hydraulic Fluid Line	0.5	If positive separation is made sure by mechanical support, the minimum clearance can be decreased. Refer to Figure 16.
Oxygen Line	2	If positive separation is made sure by mechanical support, the minimum clearance can be decreased. Refer to Figure 16.
Pitot Static Line	0.5	If positive separation is made sure by mechanical support, the minimum clearance can be decreased. Refer to Figure 16.
Sharp Edge of Structure and Equipment	0.13	As an alternative to the minimum clearance, use a continuous Teflon or Expando sleeve for protection.
Smooth Metal or Plastic with 0.13 inch minimum radius	0.0	In pressurized areas only, the length of the wire harnesses between clamps can touch smooth flat surfaces and smooth 0.13 inch minimum radius.
Water Line	0.5	If positive separation is made sure by mechanical support, the minimum clearance can be decreased. Refer to Figure 16.

Figure 104 Mounting Clearance

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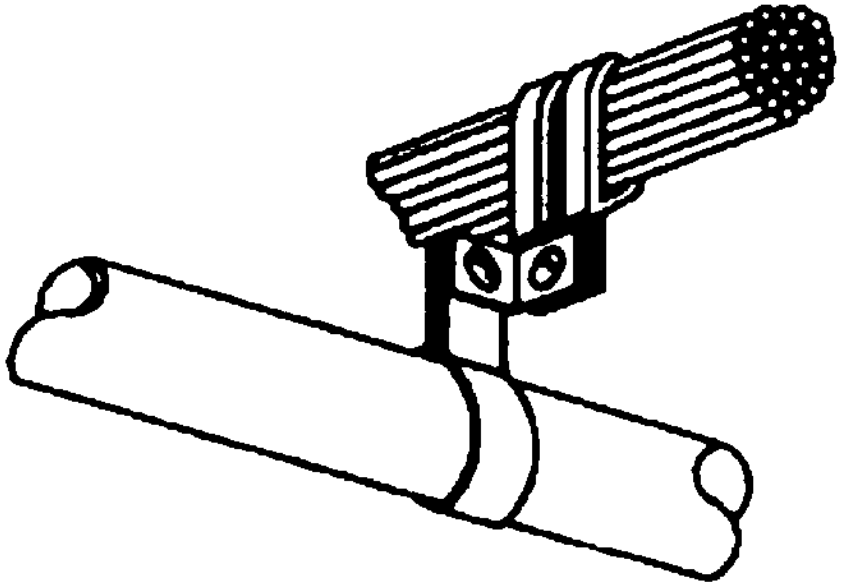


Figure 105 Positive Separation

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PROTECTIVE TUBES

If a contact with other components can not be avoided, the wire harness must be protected against abrasion by means of an appropriate protective tube.

They are also used to protect the wires against contamination, for example water, fuel or hydraulic fluid.

A distinction is made between:

- rolled protective tubes
- metallic protective tubes
- protective tubes made of various elastic materials (textiles, elastomers, rubber)
- heat shrinkable sleeves

The appropriate sleeve or tube is chosen based on the environmental conditions (ESPM 20–33–30).

Important – during the assembly:

- no lacing within protective tubes
- protective tubes must not be extended; the connection of two protective tubes is prohibited
- all protective tubes longer than 50 mm require a cable with AWG 18 with insulating caps on both ends and then connected to the protective tube
- protective sleeves with a cross section larger than 10 mm require drain holes on the low points



Figure 106 Protective Tube 1

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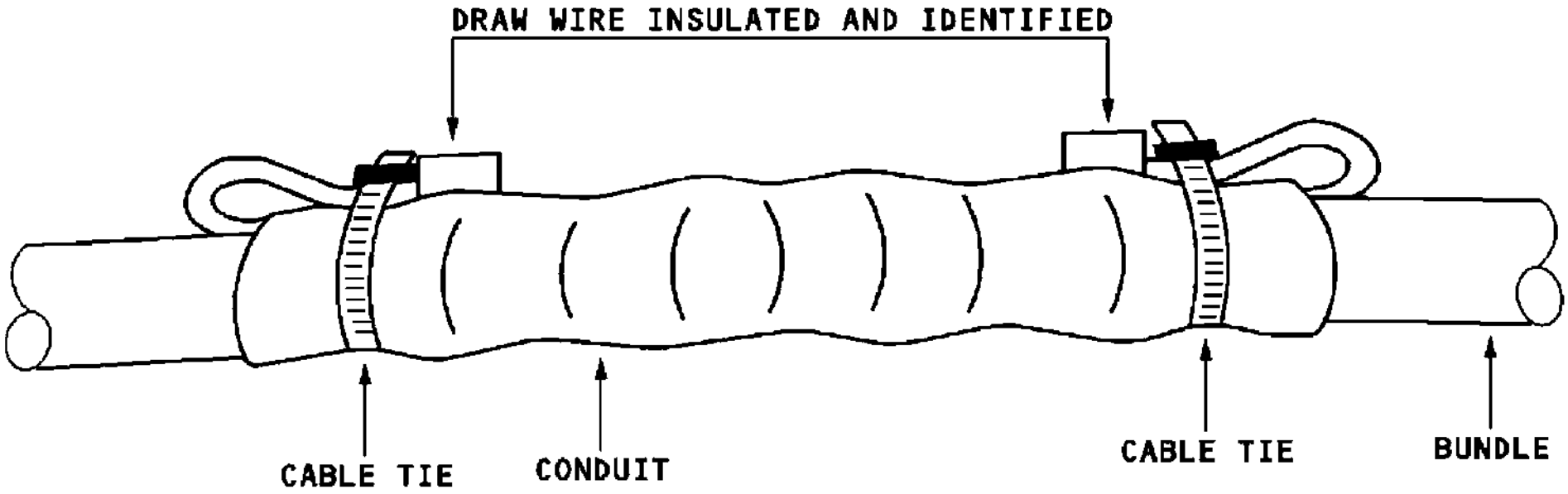


Figure 107 Protective Tube 2

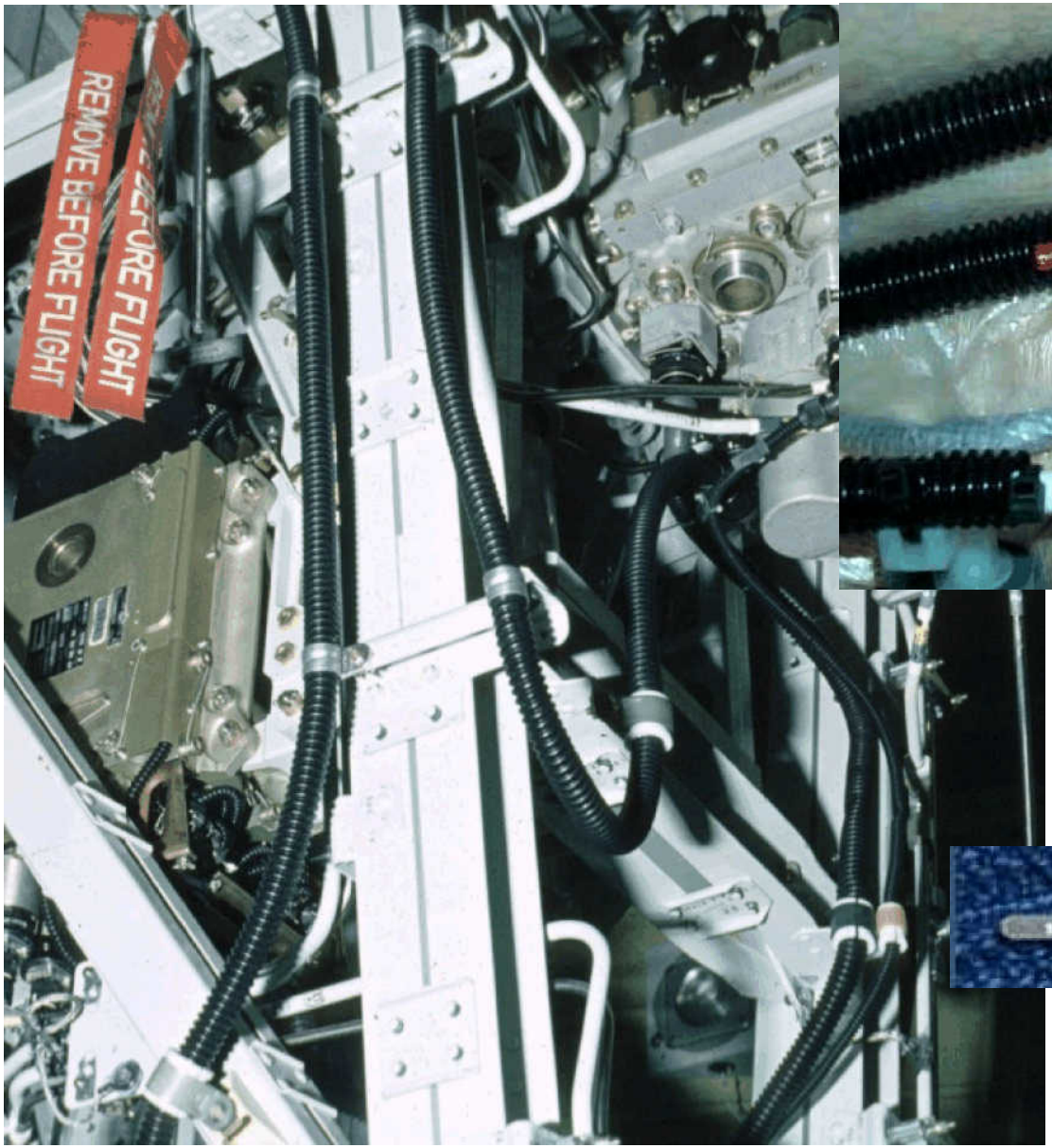
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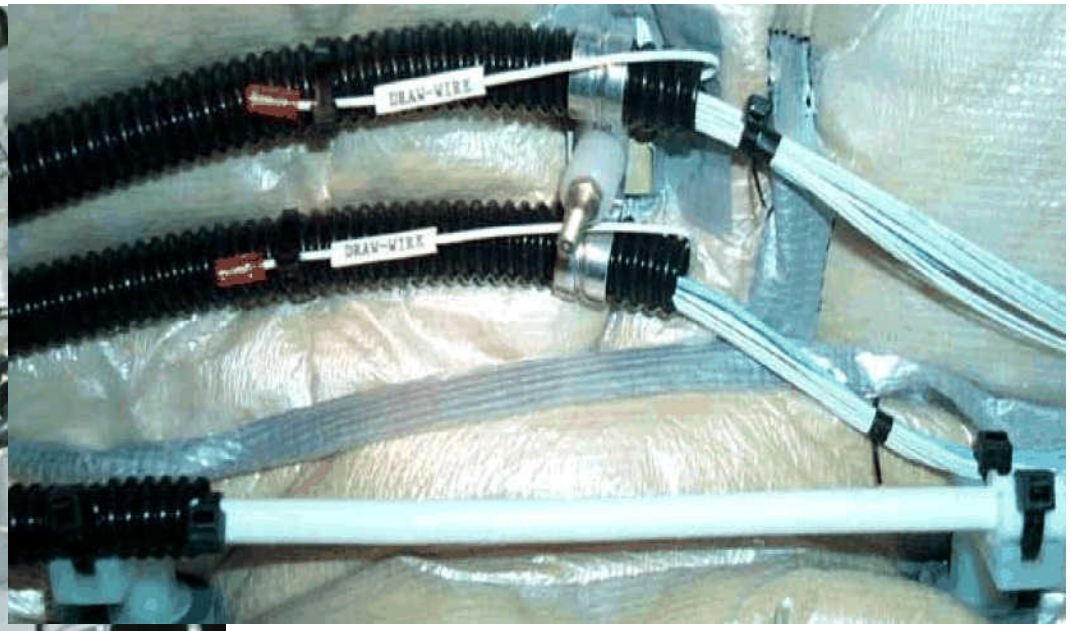
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Convoluted Conduits



SUPERFLEXIT Cutter No. 27672

Figure 108 Convoluted Conduits

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SHRINKING TUBES

Using of shinking tubes

Acc. ESPM and SWPM shrinking tubes could be used for repair and for protection of wires and cables.

Shrinking tubes are produced with diameters form 1 mm to 1100 mm.

The possible shinking depends on the material. It's between 2:1 and 6:1.

For very good sealing some shrinking tubes are inside coated with adhesive.

The producers recommend a ratio of 4:5 between the diameter of the wire or cable and the shrinking tube to achieve the best result.

The shrinking tube have to be shrinked only with a hot air gun!

The material of the colored shrinking tubes are thermoplastics. These are only for use in low-temperature-areas.

In high-temperature-areas teflon is used. This tubes needs a very higher temperatur for shrinking!

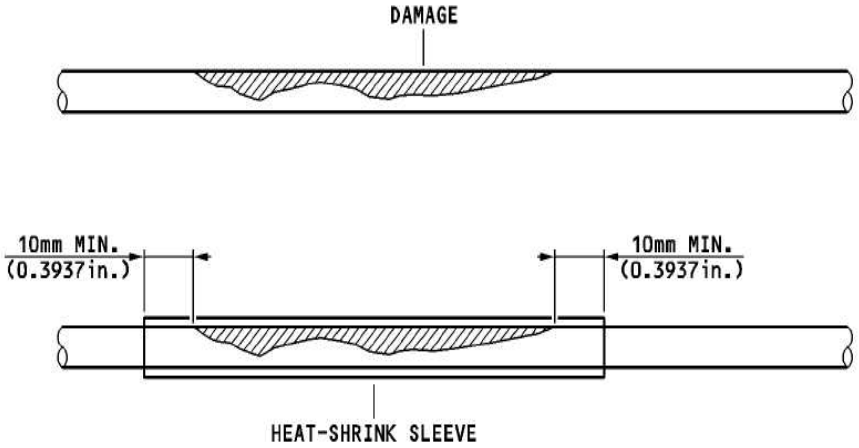
WARNING: THE WIRES AND CABLES SHOULD NOT BE HEATED TO MUCH (LOOK FOR DISCOLOURATIONS)!

WARNING: NO OPEN FLAME ALLOWED FOR SHRINKING!

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Repair of a wire with a shrinking tube



shrinking with an open flame is strictly forbidden



Repair of a shielded wire

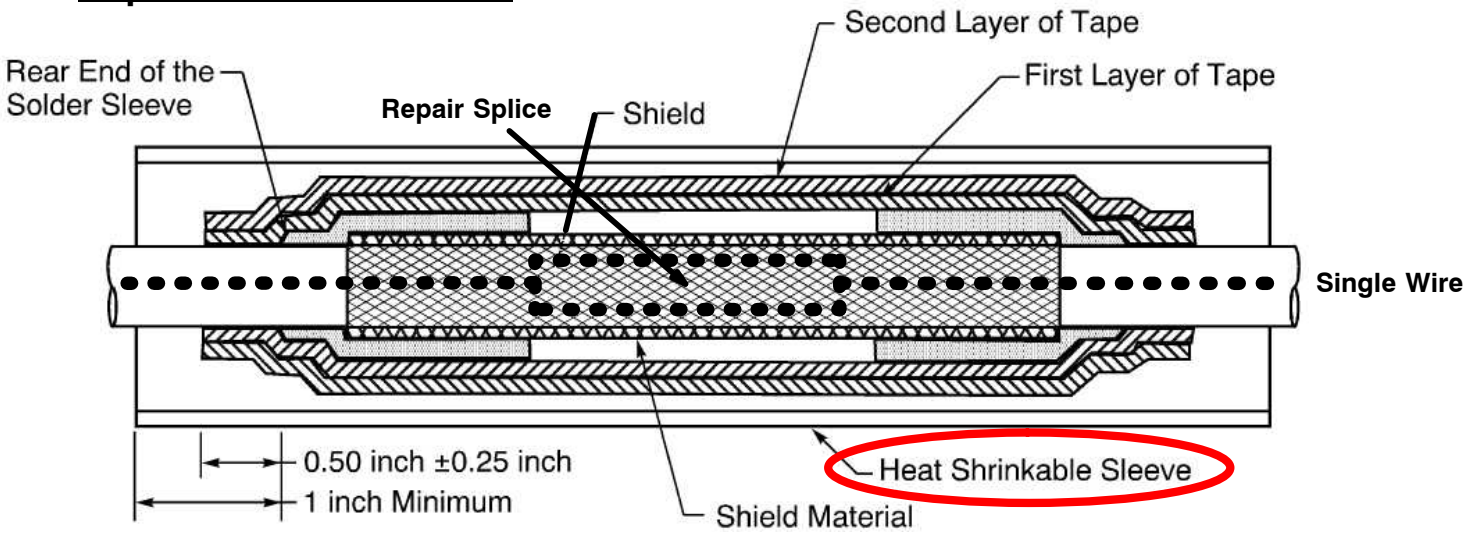


Figure 109 Usages of Shrinking Tubes

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Pressure Seals

Wire harnesses sticking out of the pressurized cabin into non−−pressurized areas have to be sealed with a pressure seal in order to prevent loss of pressure during a flight.

Two different types of pressure seals are used:

- grommet type pressure seals
- compound filled pressure seals

Grommet Type Pressure Seal

This type of pressure seal seals the gap between wires by means of pressed rubber.

The wires are inserted into holes in the rubber separately; the remaining holes are sealed with caps.

Then, the cap nut must be tightened so the rubber can be pressed together which completes the pressure seal.

This method is particularly suitable for large wire sizes.

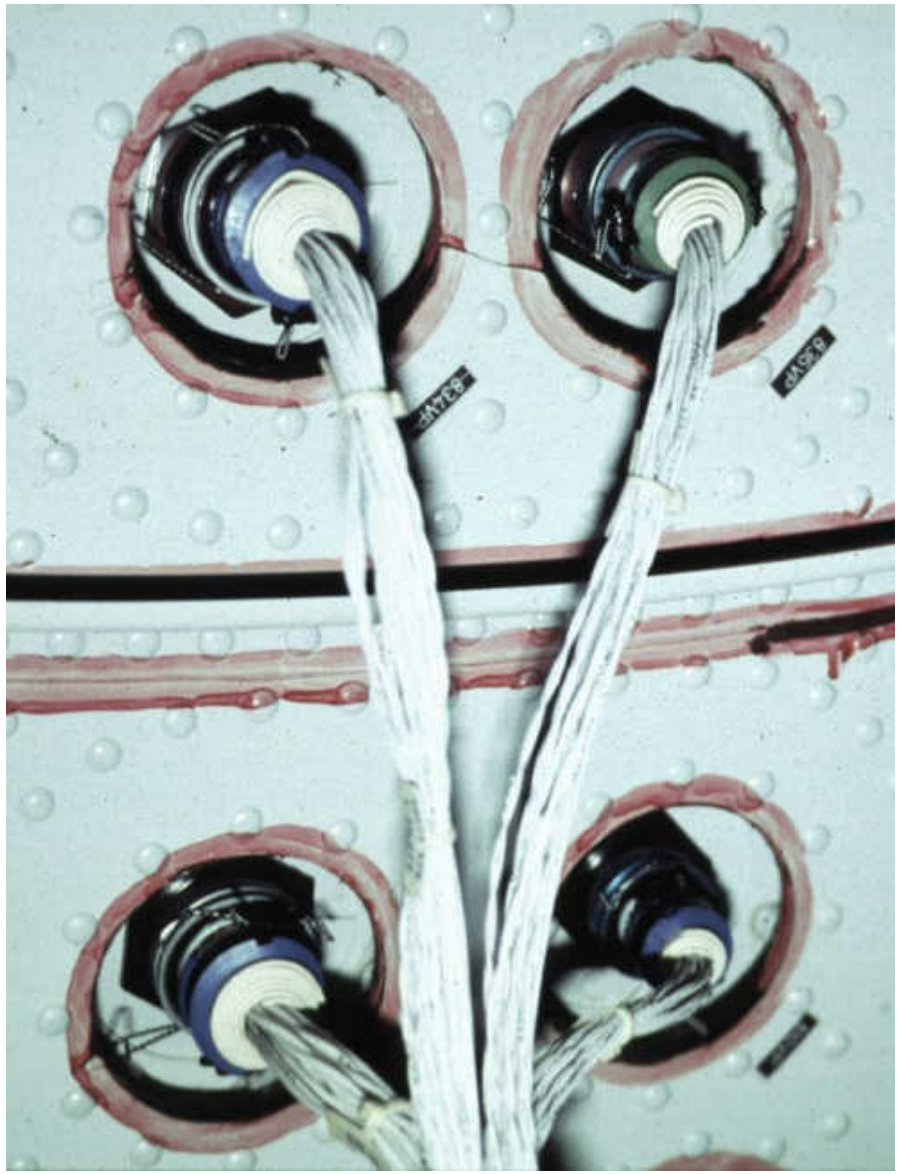


Figure 110 Pressure Seals

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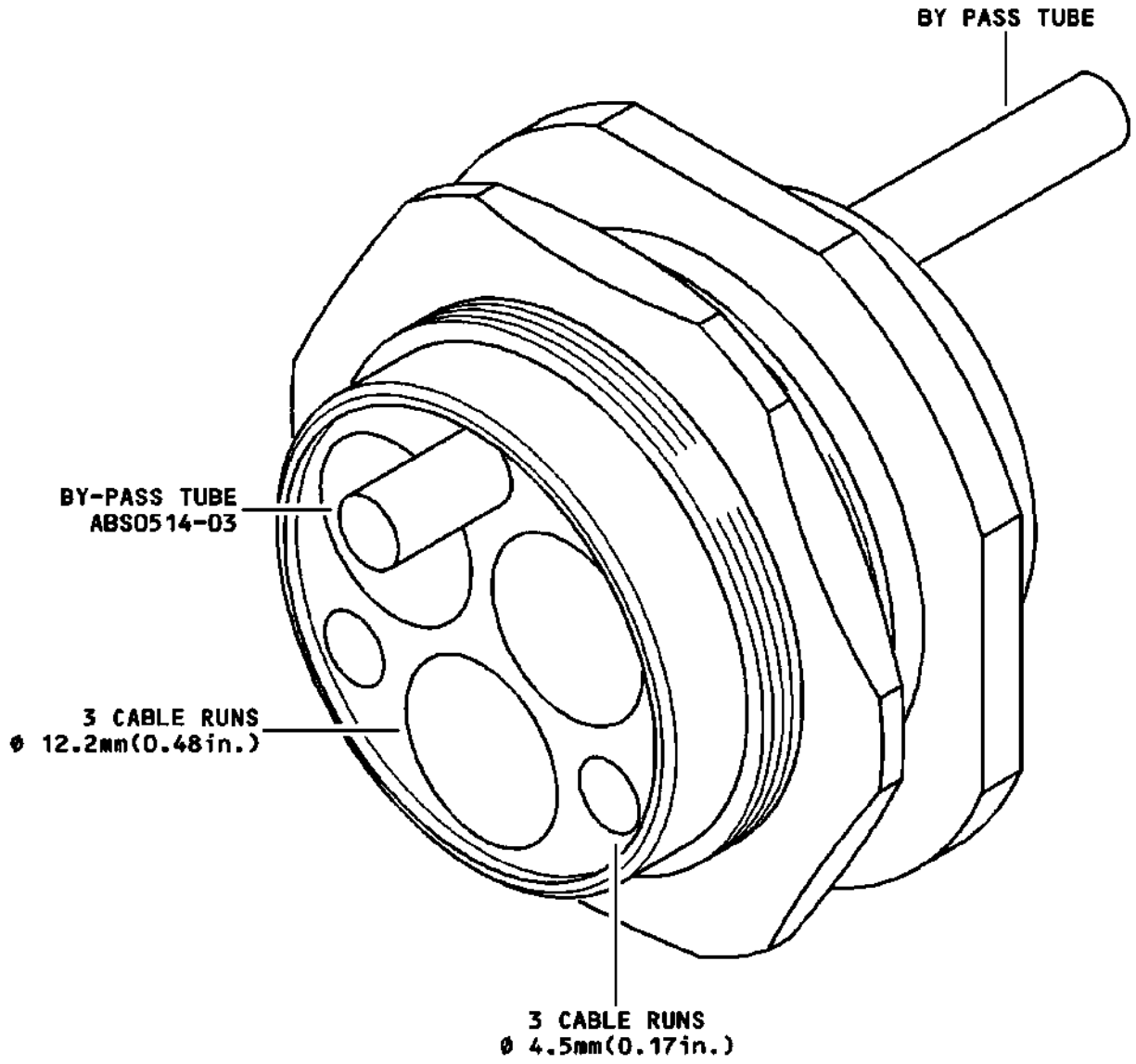


Figure 111 Grommet Type Pressure Seal

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Compound filled Pressure Seal

These pressure seals consist of a one– or two–part housing which is mounted into the bulkhead.

Large single wires or cables (e.g. generator combination cable) are kept apart with a spacer so that the filling compound can enter all the gaps.

Additionally, a string is added on both ends of the wire harness. Thus if necessary, the filling compound can later be removed easily.

A cone made from tape is then formed on both ends; these cones are then filled with filling compound.

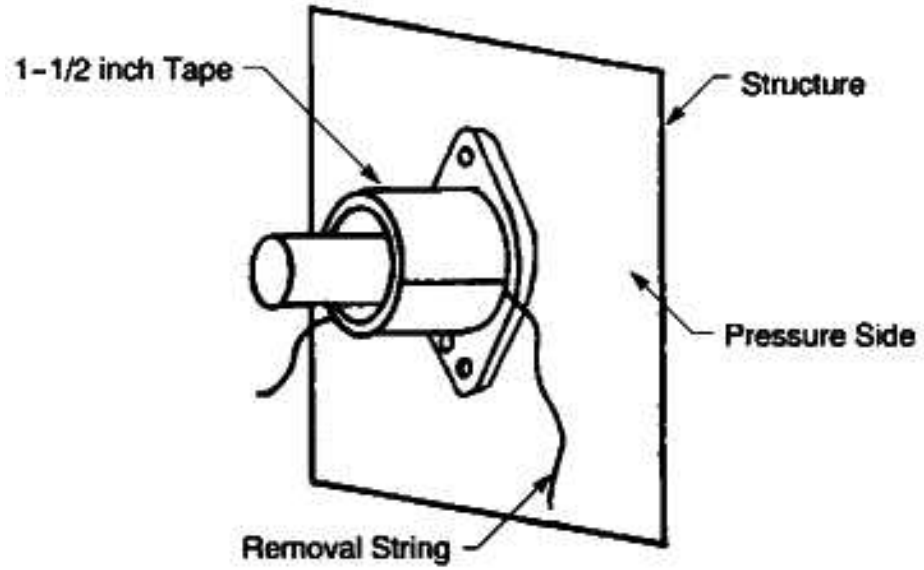


Figure 112 Compound Filled Pressure Seal

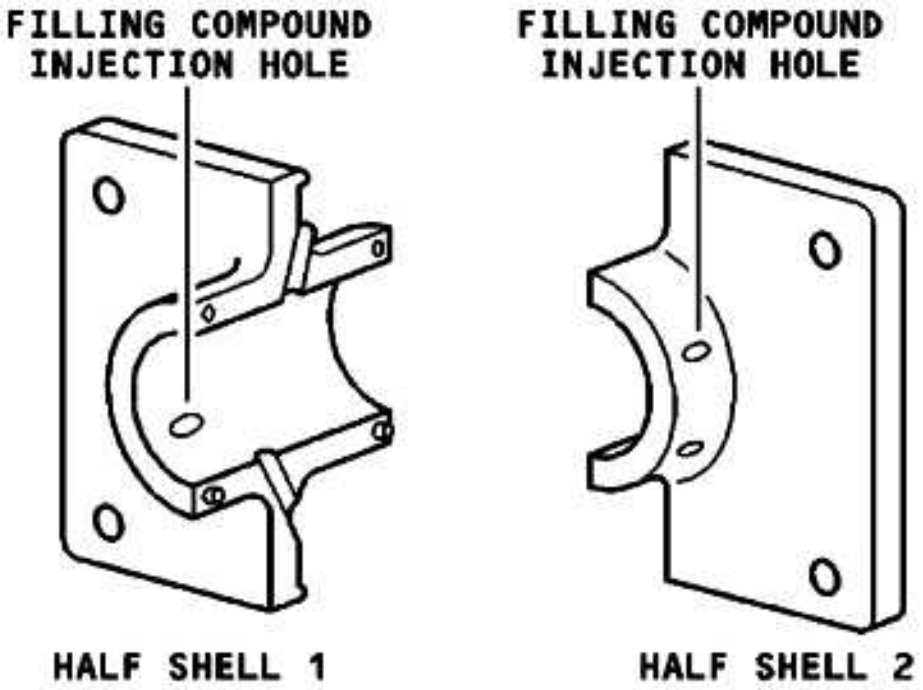


Figure 113 Seal Shells

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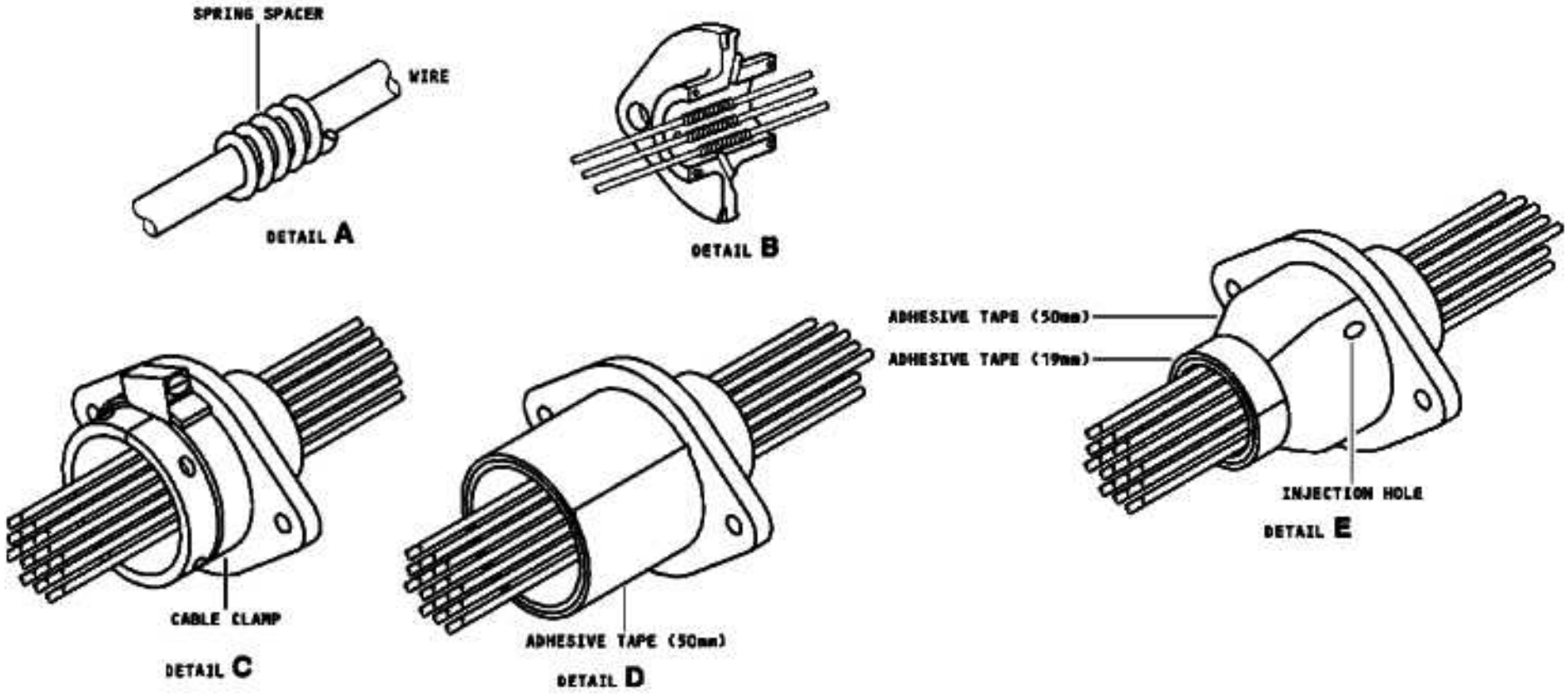


Figure 114 Pressure Seal Preparation

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Instead of tape cones, there also are plastic housings which can be used as a pressure seal; they also require a filling compound for sealing.



Figure 115 Pressure Seal with Housing

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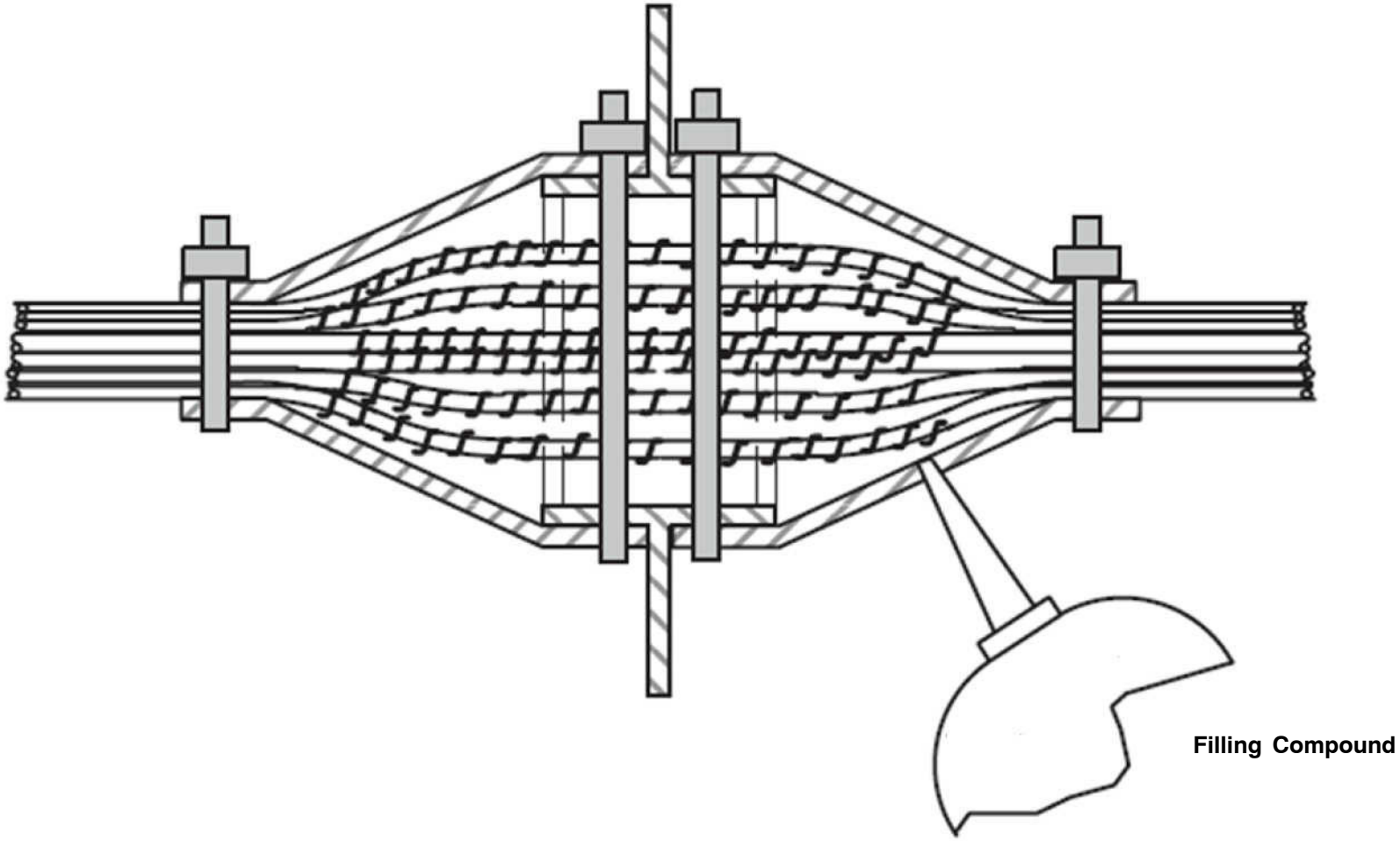


Figure 116 Pressure Seal with Plastic Housing

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Spare Wires

Spare wires in wire harnesses are insulated at the wire ends and attached on the outer part of a wire harness. Depending on the purpose of the wire, different methods are used for insulation.



Figure 117 Spare Caps

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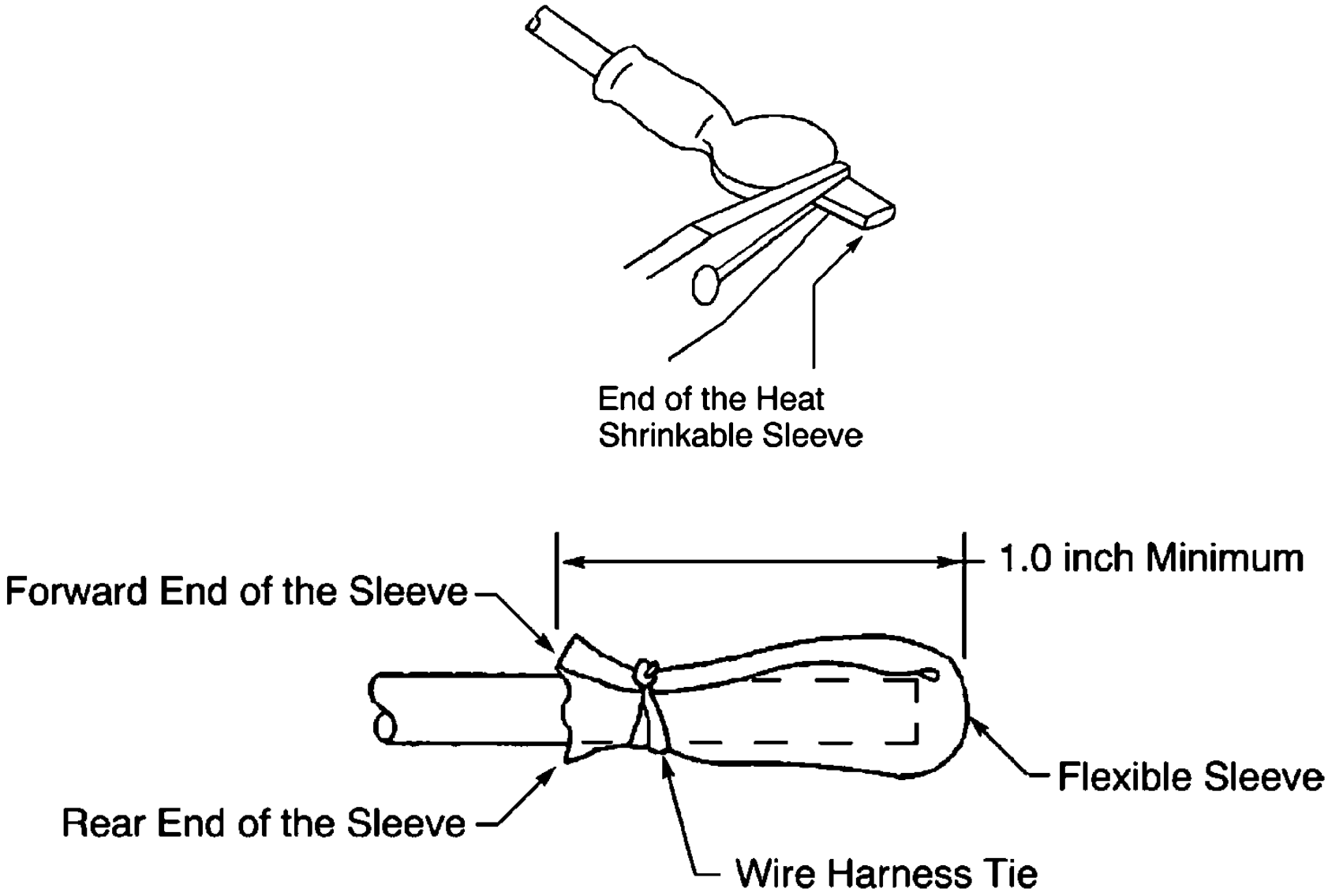


Figure 118 End Cap Insulation

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In contrast to end splices, wires with end caps are usually not stripped.

For special wires there are some exceptions, as shown in the following illustration.

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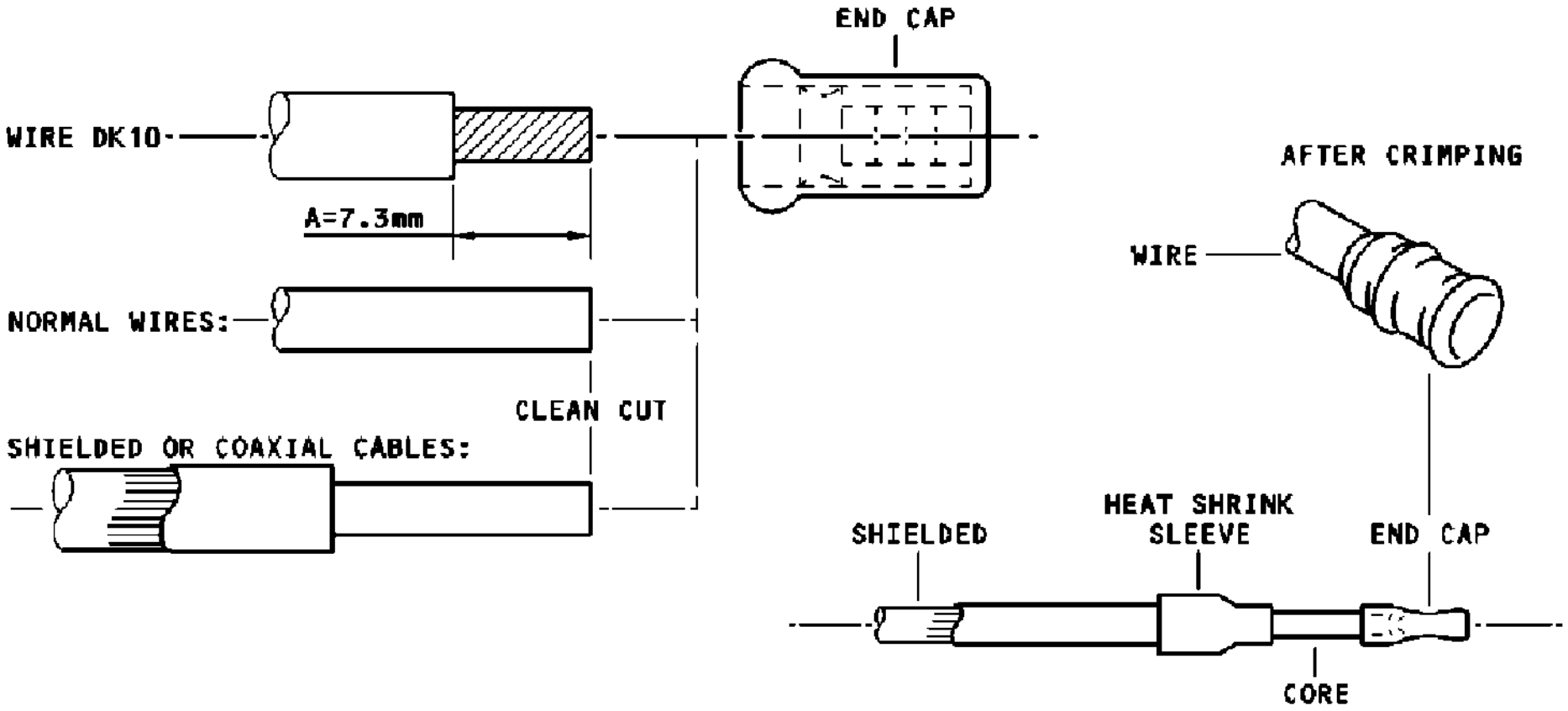


Figure 119 End Cap Insulation

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Depending on AWG–size and type, there are different methods for the attachment of spare wires.



Figure 120 Spare Wires

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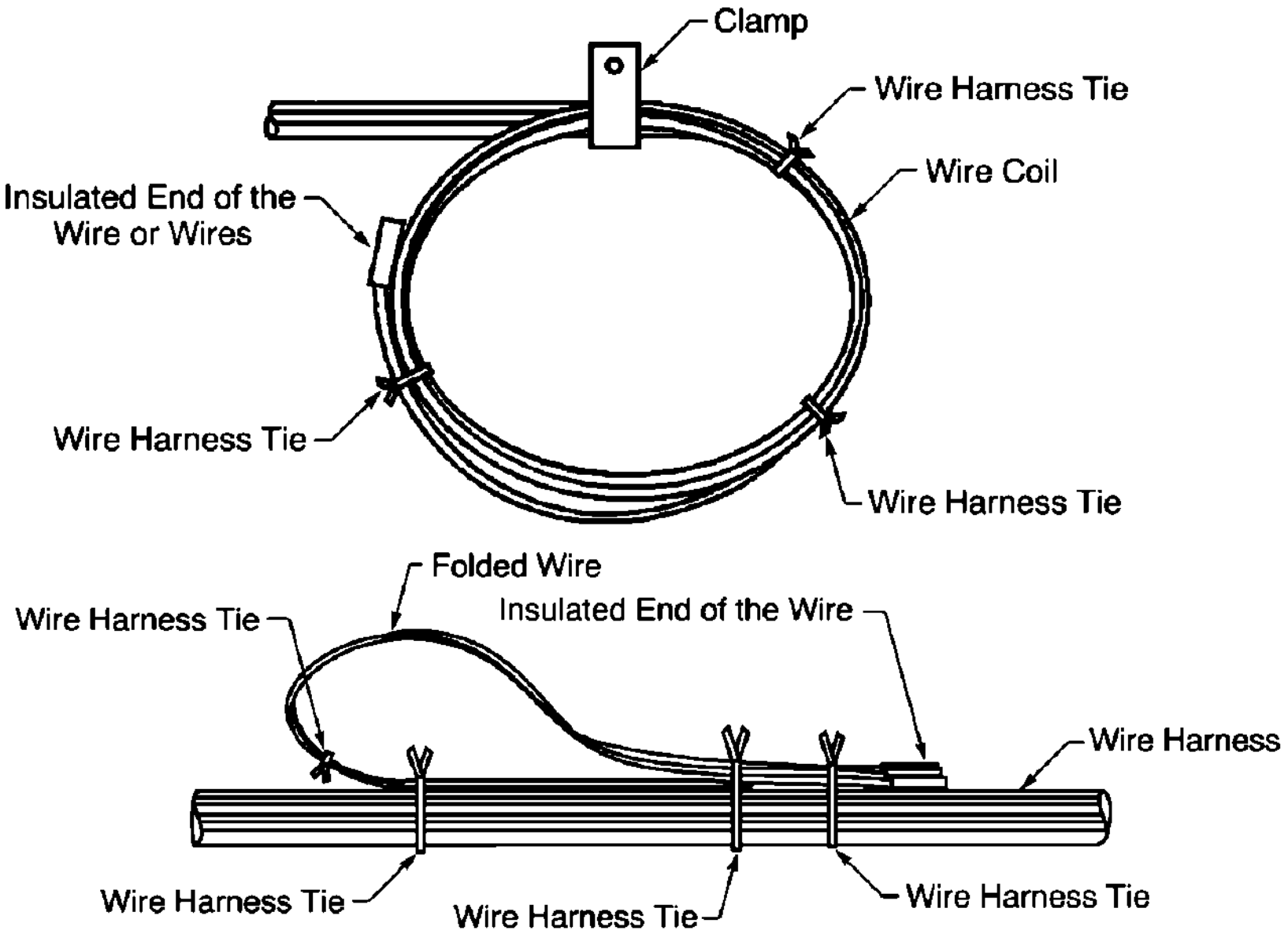


Figure 121 Attachment of Spare Wires

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EWIS INST.,INSP.,REP.,MAINT. AND CLEANING STANDARDS

Inspection

SPECIAL INSPECTIONS

General Visual Inspections (GVI)

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.

Detailed Inspection (DET)

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.

Common Sense Surface cleaning and elaborate access procedures may be required.

Not the same as DVI!

DET allows tactile examination to determine condition.

Zonal Inspection

A collective term comprising selected General Visual Inspections and visual checks that are applied to each zone, defined by access and area, to check system and power plant installations and structure for security and general condition.

Enhanced Zonal Analysis Procedure (EZAP)

An analytical logic procedure specifically designed to identify applicable and effective tasks that:

6. minimize accumulation of combustible materials,
7. address wiring discrepancies,
8. address installations where wiring is in close proximity to both primary and backup flight controls.

Common Sense

„...“Clean and protect as you go“

References:

Airbus: ESPM 20–52–11 Page 1 and on

Boeing: SWPM 20–10–06 Page 1 and on

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Guidance for GVI/Zonal Inspection of EWIS

EWIS DISCREPANCIES DETECTABLE BY GVI/ZONAL INSPECTION

Wiring/Wire Bundles

- Wire–to–wire or wire–to–structure contact/chafing
- Wire bundle sagging or improperly secured
- Wires damaged (obvious damage due to mechanical impact, overheat, localized chafing, etc.)
- Lacing tape and/or ties missing/incorrectly installed
- Wiring protection sheath/conduit deformity or incorrectly installed
- End of sheath rubbing on end attachment device
- Grommet missing or damaged
- Dust and lint accumulation
- Surface contamination by metal shavings/swarf
- Contamination by liquids
- Deterioration of previous repairs (e.g., splices)
- Deterioration of production splices
- Inappropriate repairs (e.g., incorrect splice)
- Inappropriate attachments to or separation from fluid lines

Connectors

- External corrosion on receptacles
- Backshell broken
- Rubber pad or packing on backshell missing
- No backshell wire securing device
- Fool–proofing chain broken
- Missing or broken safety wire
- Discoloration/evidence of overheat on terminal lugs/blocks
- Torque stripe misalignment

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Damages

WIRING SYSTEM DAMAGE

Swarf/FOD/Metal Shavings

Wires and cables could be damaged by FODs like washers, srews, screw bits a.s.o.

The pictures show pulluted wirebundles by drill chips and swarf.

How to clean these wires will be discussed in the module housekeeping.

FODs and drillchips damage the wires when vibrations or movement of the bundles are present.

Dust and swarf are flame catalysts in case of fire.

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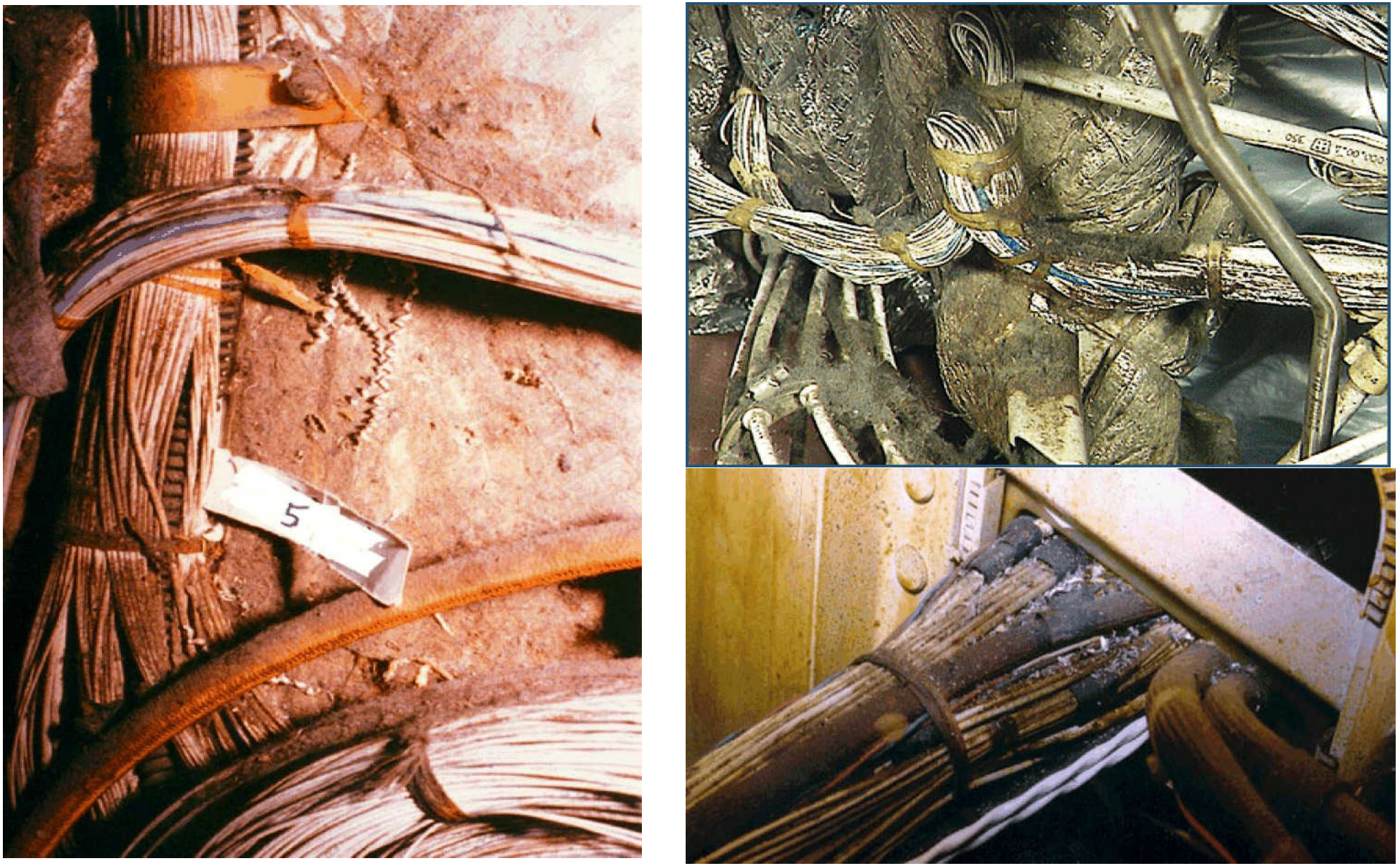


Figure 122 Drill Chips and Swarf

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EXTERNAL MECHANICALLY INDUCED DAMAGE

Wire bundles have to be separated from moving parts in the aircraft.

This could be done by clamping or protecting the bundle with tapes, sleeves or tubes.

Chafing wires could cause a short circuit in the electrical systems.

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Figure 123 External mechanically induced Damage

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HOT GAS

Hot gas areas are:

- Engines
- Pylons/Struts
- APU Compartments
- Aircondition Bay
- Front Spar and everywhere where bleed ducts are located

In these areas the bundles have to be separeted from the hot air sources.

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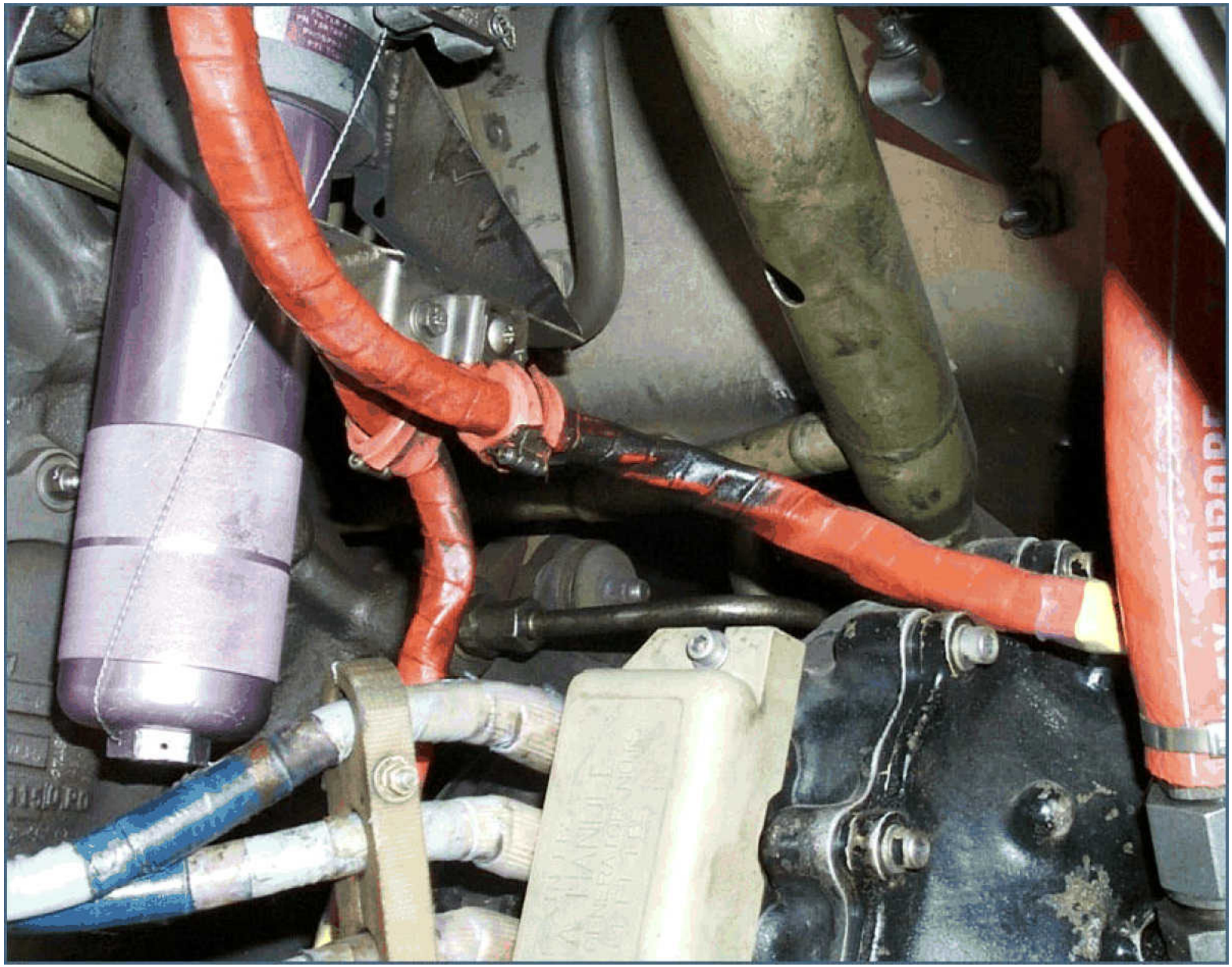


Figure 124 Hot Gas Damage

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FLUID CONTAMINATION

Aggessive fluids could destroy the insulation of wires and cables.

Coductive fluids can cause short circuits in electrical systems.

Here are some examples of fluids you will find in aircraft:

- Hydlaulic fluid
- Fuel
- Motor oil
- Corrosion prevention, like Dinol
- Water from outside and salt water (aircraft landing on aircraft carriers)
- Toilet fluids
- Beverages, alcoholic drinks, Coffee, water, even food

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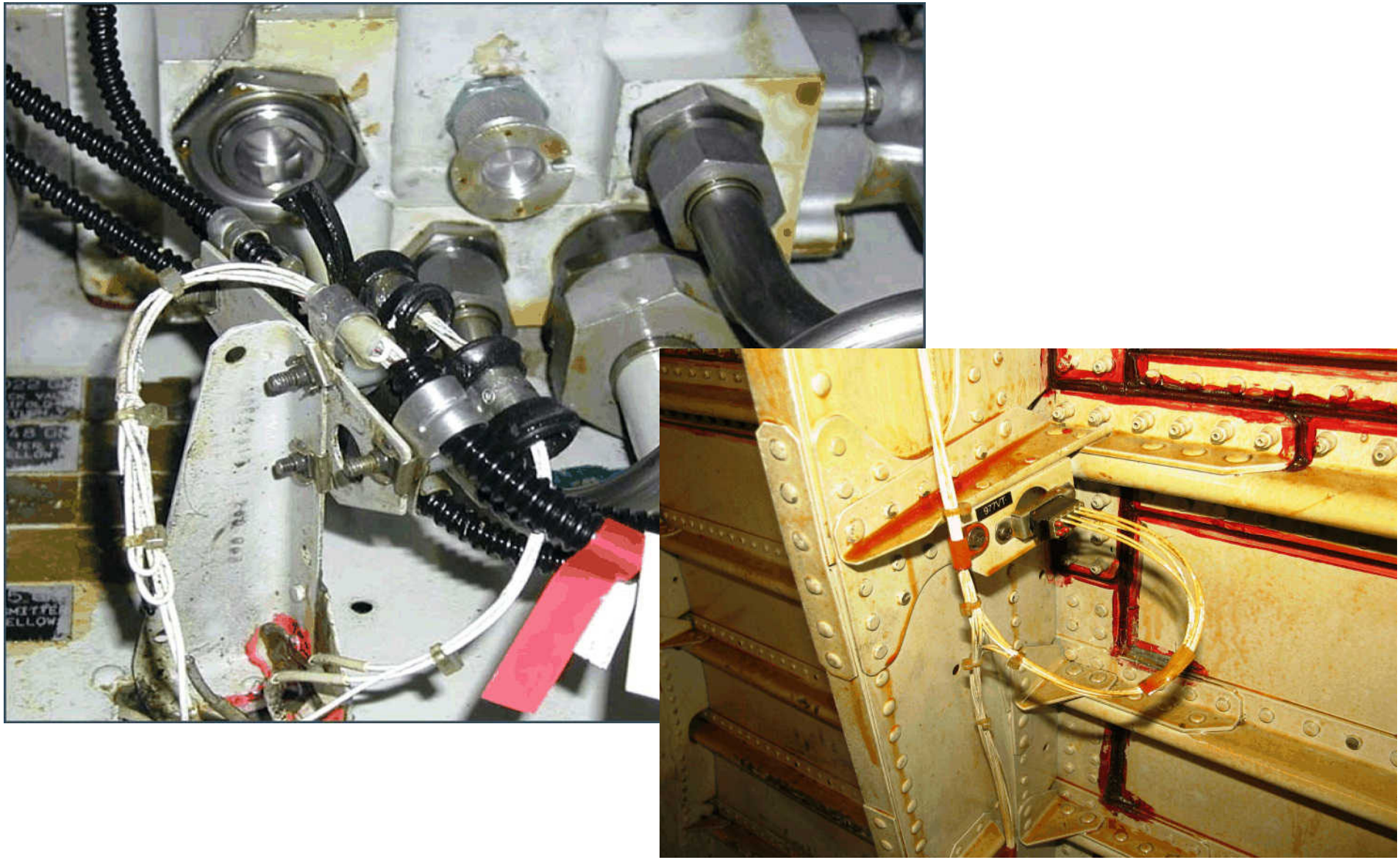


Figure 125 Fluid Contamination

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VIBRATION/CHAFING

Here are 2 examples:

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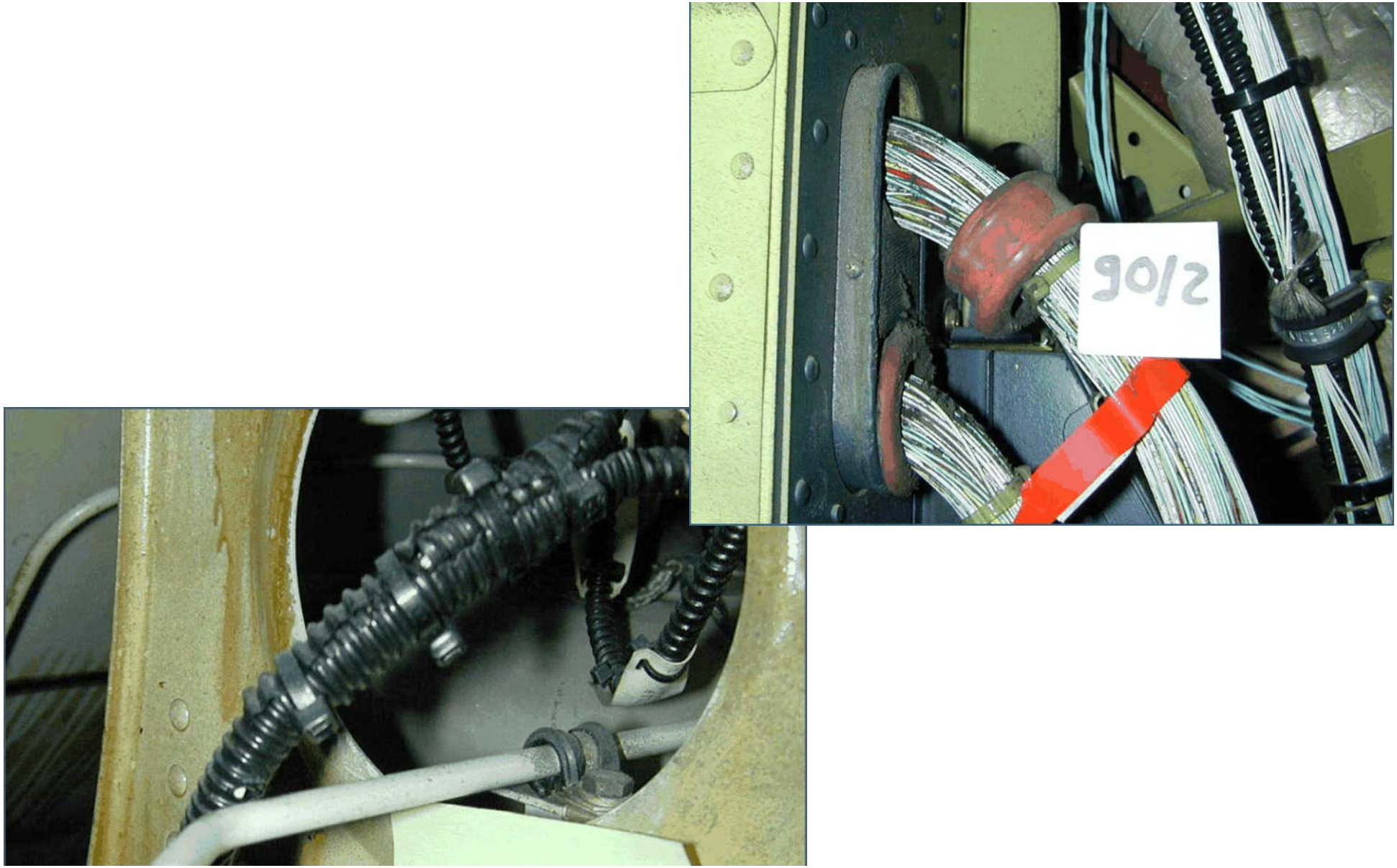


Figure 126 Vibration/Chafing

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CORROSION

Corrosion of wires, cables, grounds, connectors and connections could occur, when there is a leak of water, acid or leach.

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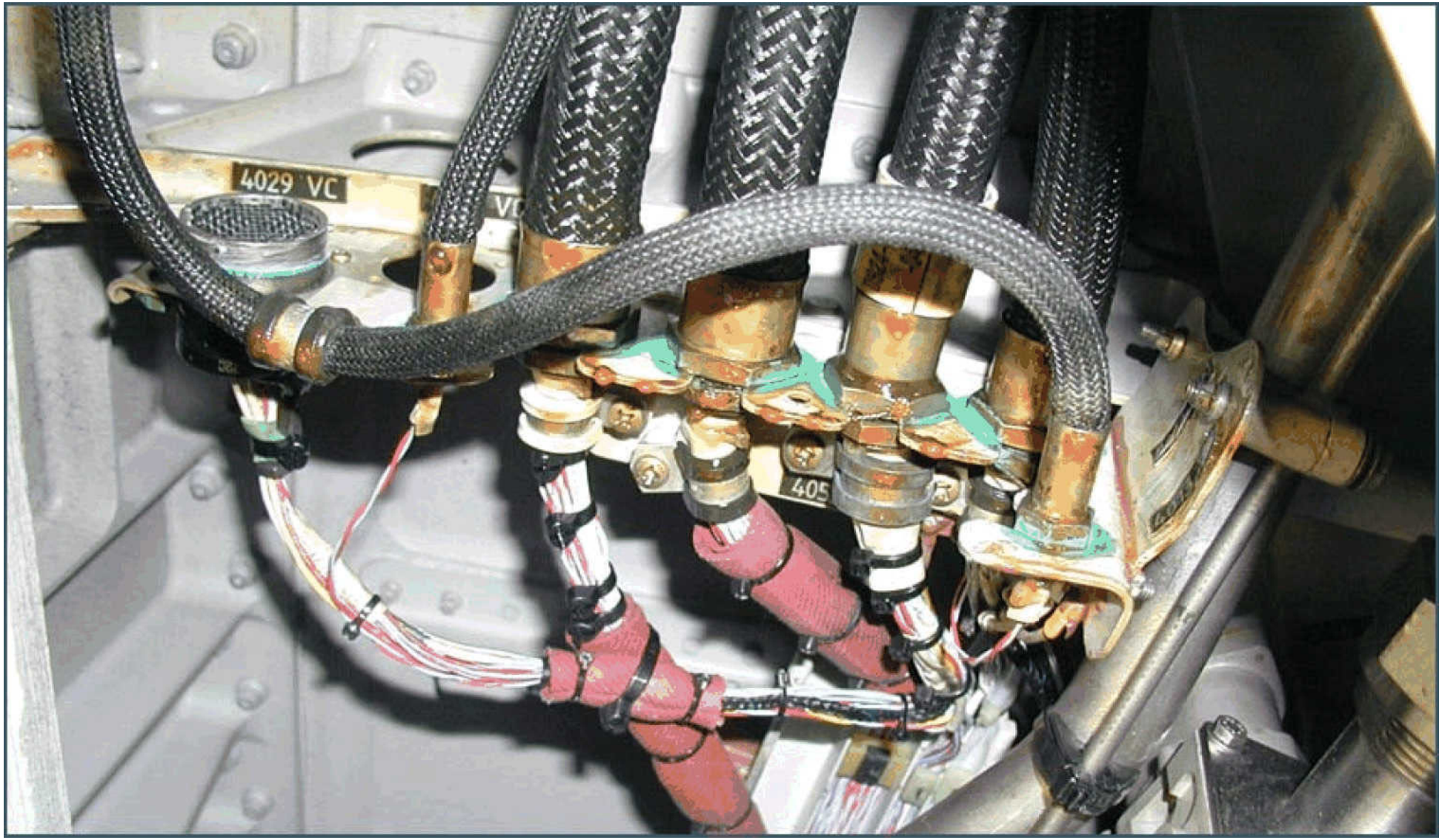


Figure 127 Corrosion

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SIGNS OF OVERHEATING

Wires could show a result of overheating in case of a bleed leak or fire in the aircraft.

The same effect will occur in case of overcurrent or too much heated up wires when a pig tail was made with a solder sleeve.

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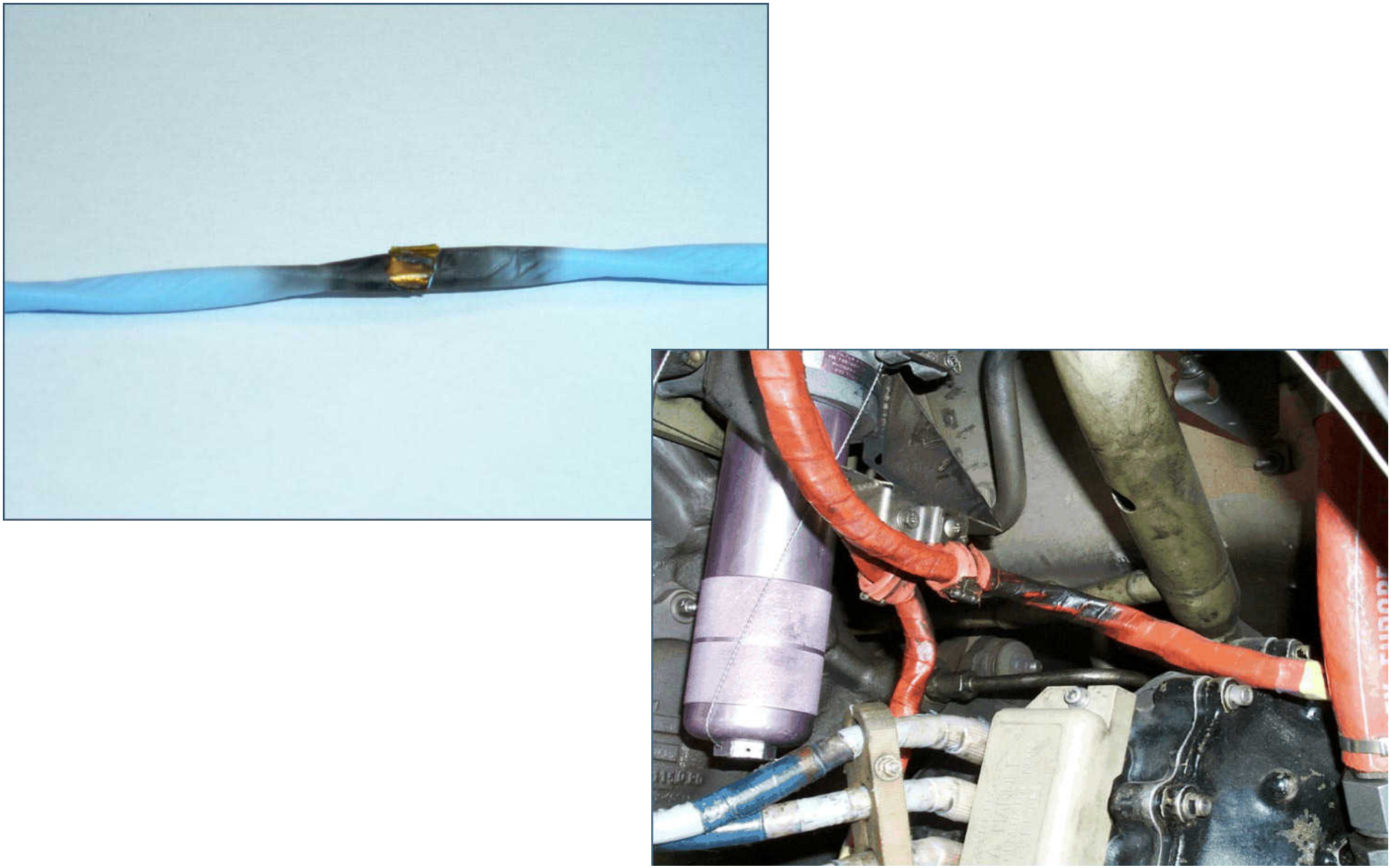


Figure 128 Signs of Overheating

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WIRE DAMAGES CAUSED BY ANIMALS

Interesting New Failure Mechanism

Following are pictures of damage inflicted on an American Airlines B757.

The Crew had to make an emergency landing after losing all:

- TCAS,
- ATC Transponder,
- DME/VOR functions as well as
- VHF communications during the flight.

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Figure 129 Wire Damage caused by a Pit Bull

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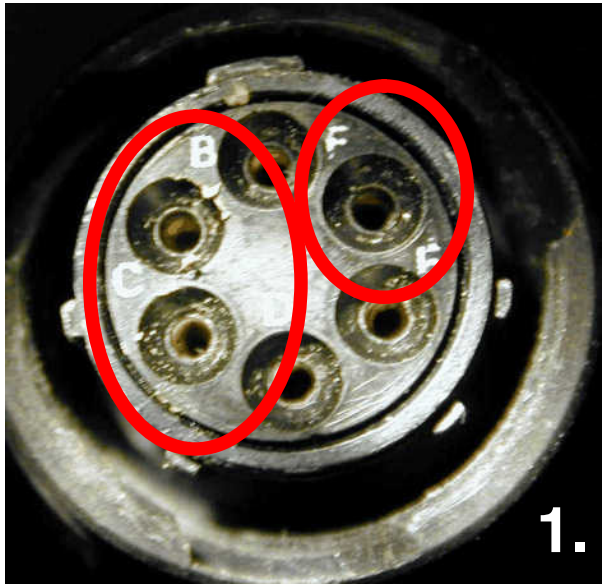
TYPICAL DAMAGE FOUND

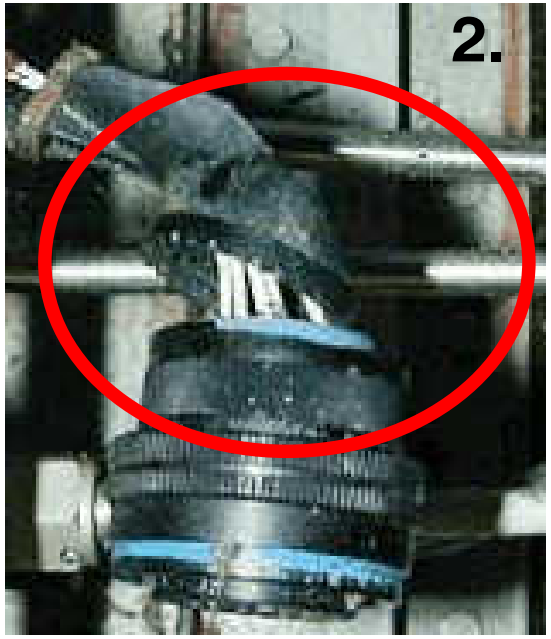
Contamination and Damage of connectors

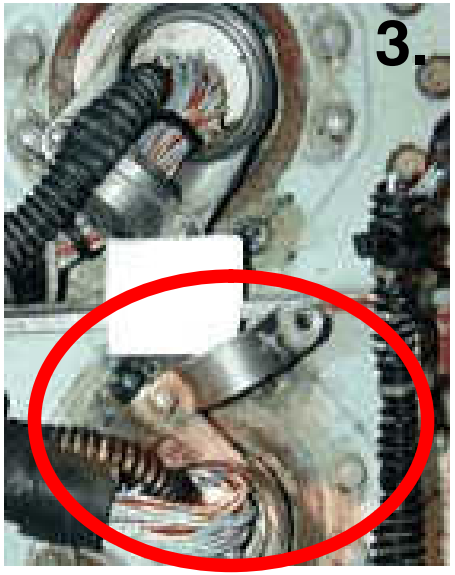
1. **Sockets are contaminated by Dinitrol, Socket -F- is not correct inserted.**
2. **Back shell is broken.**
3. **Screw of back shell is missing, no function!**
4. **Wire bundle is not fixed at strain relief.**
5. **Wire bundle is not fixed at strain relief.**

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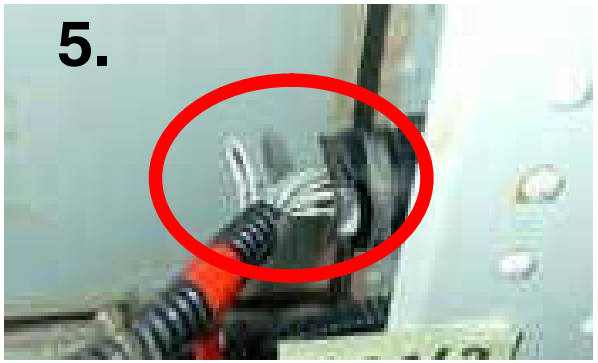


Figure 130 Connector Damages 1

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CONTAMINATION AND DAMAGE OF CONNECTORS (CONT.)

(6) **Connectors contaminated by Dinitrol**

(7) **Wrong protection used for plugs! Use caps!**

(8) **Connectors contaminated by Dinitrol**

(9) **Do not use paper tape to protect connectors, use caps!**

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Figure 131 Connector Damages 2

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Housekeeping

AEROPLANE EXTERNAL CONTAMINATION FLUIDS

External contamination sources are:

- De-ice fluids
- Water and rain
- Snow and ice
- Miscellaneous (e.g. cargo/beverage spillage)
- Air corrosion

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Figure 132 External Contamination Sources

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AEROPLANE INTERNAL CONTAMINATION SOURCES

Internal contamination sources are:

- Hydraulic oils
- Engine and APU oils
- Fuel
- Greases
- Galleys and toilets
- Lint/Dust
- Bleed air and hot areas
- Hazardous materials

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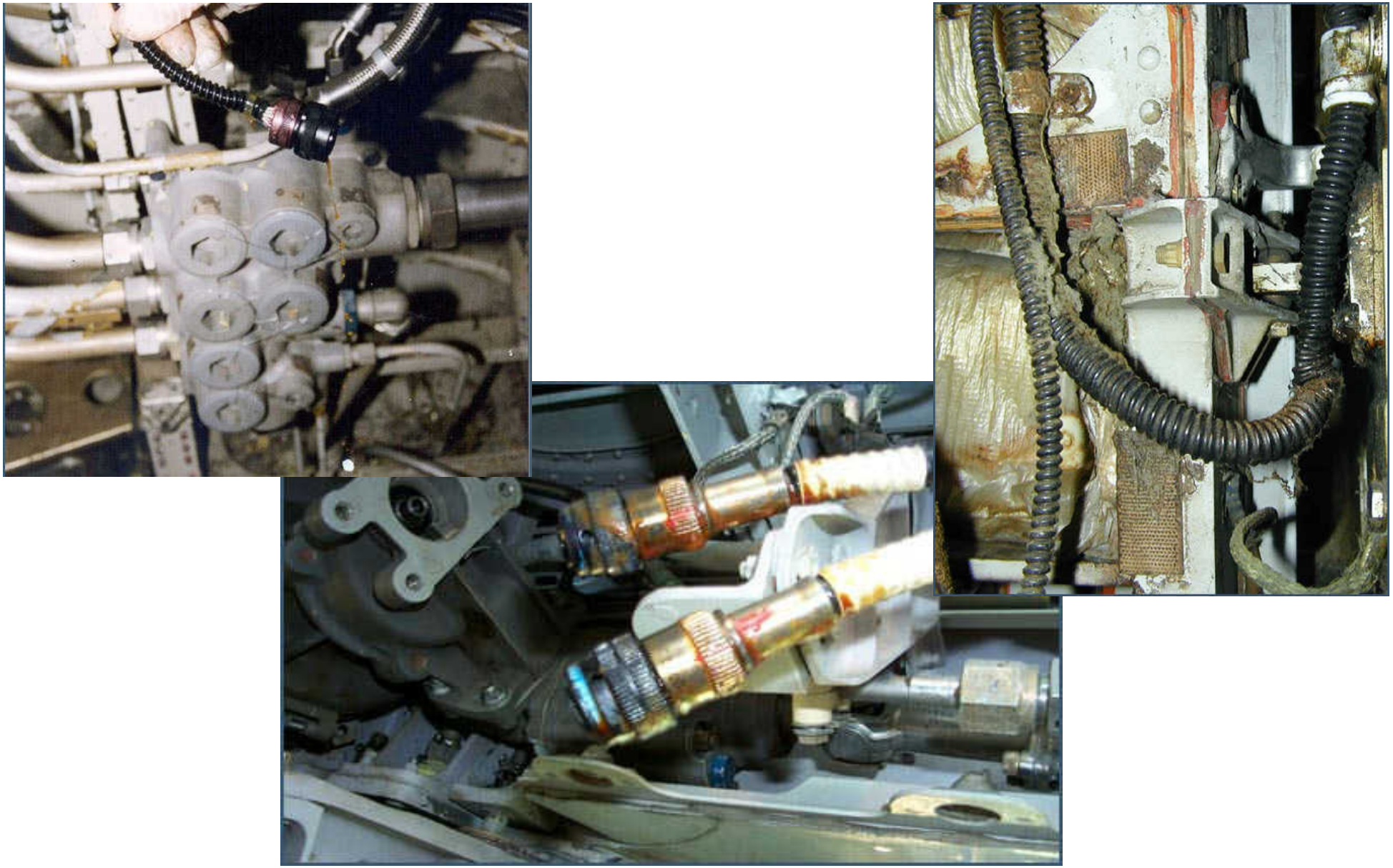


Figure 133 Internal Contamination Sources

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OTHER CONTAMINATION SOURCES

These are for example:

- Paint
- Corrosion Inhibitor
- Drill shavings/Swarf
- Foreign Objects (srews, washers, rivets, tools, etc.)

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Figure 134 Other Contamination Sources

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Contamination Protection Planning

It is very important to:

9. Protect yourself
10. Protect the aircraft (e.g plastic foils)
11. Perform the maintenance work
12. Clean the protection first
13. Remove the protection
14. Clean again the adjacent area (clean as you go philosophy)

General Recommendations

- An annual cleaning of electrical equipment to remove dust, dirt and grime is recommended.
- To clean areas correctly it is recommended to have a proper lighting.
- Cleaning is a very important operation because you can detect a damage in progress!

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Figure 135 Contamination Protection Planning

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Cleaning Process

GENERAL SEQUENCE OF ACTION

1. Identify the contamination source.
2. Stop or contain the source of contamination.
3. After this opereation clean the area. Do not hesitate to clean first a small area to test the efficiency of the cleaning product.
4. After you cleaning operation check the enviroment. Check the drain holes of the aircraft as necessary.(e.g. under floor area, cargo belly)
5. When your cleaning operation is fully performed check that you did not forget a tool used and that there are no foreign objects in the area.
6. Apply clean as you go philosophy.

There are three groups of contamination:

Fluid contamination

- Snow and Ice
- De-Ice fluid
- Cargo spillage
- Water and rain
- Galleys
- Toilets water and waste
- Oils and greases
- Pressure washing

Solid contamination

- Drill shavings/Swarf
- Foreign objects (Screws, washers, rivets, tools, etc.)

Enviromental contamination

- Lint and dust
- Paint
- Corrosion inhibitor
- Animal waste

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Figure 136 Cleaning Process

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Cleaning Regulations for Airbus Aircraft

Structure of this chapter

1. General Cleaning (Ref. 20–55–10).
2. Cleaning of Wires (Ref. 20–55–20).
3. Cleaning of Conduits (Ref. 20–55–30).
4. Cleaning of Standard Electrical Items (Ref. 20–55–50).
5. Cleaning of Bundle Attachments (Ref. 20–55–40).

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ELECTRICAL STANDARD PRACTICES MANUAL

GENERAL CLEANING - DESCRIPTION AND OPERATION

1. General

This chapter gives the general instructions related to the cleaning of electrical components that have contamination.
The contamination can be:
- natural: the contamination agent is an identified material used in the aircraft systems (hydraulic fluid, fuel, ect.),
- accidental: the contamination agent comes from an external source (cleaning agent, etc.),
- the effect of ageing: the contamination agent is dust.

2. Safety Practices

WARNING : BEFORE YOU USE A MATERIAL REFERRED TO IN THIS PUBLICATION, YOU MUST KNOW ALL OF THE APPLICABLE PRECAUTIONS.
THESE PRECAUTIONS TELL YOU HOW TO:
- USE THE MATERIAL SAFELY,
- KEEP THE MATERIAL SAFELY,
READ THE SAFETY DATA SHEETS FROM THE MANUFACTURER OR THE SUPPLIER OF THE MATERIAL TO LEARN THE RECOMMENDED PRECAUTIONS. OBEY YOUR LOCAL REGULATIONS.

WARNING : USE SOLVENTS/CLEANING AGENTS, SEALANTS AND OTHER SPECIAL MATERIALS ONLY WITH A GOOD FLOW OF AIR THROUGH THE WORK AREA.
THESE MATERIALS ARE POISONOUS AND FLAMMABLE AND SKIN IRRITANTS.
OBEY THE MANUFACTURERS INSTRUCTIONS.
PUT ON PROTECTIVE CLOTHING.
DO NOT GET THEM IN YOUR MOUTH.
DO NOT SMOKE.
DO NOT BREATHE THE GAS.
GET MEDICAL HELP IF YOUR SKIN OR EYES BECOME IRRITATED.

3. Procedure

A. Sequence of Actions
In relation to the type of contamination, do these steps:
- stop the contamination source.
- keep the area that has contamination to a minimum.
- find the applicable cleaning procedure.

EFF : ALL

20-55-10

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ELECTRICAL STANDARD PRACTICES MANUAL

B. Type of Contamination

(1) Liquid contamination:
- stop the contamination source.
- make a sealed barrier, usually with cloth, to stop the liquid and prevent contamination of the adjacent areas.
- remove the contamination with cloth or a vacuum cleaner for liquids.

(2) Powder, granular or dust contamination:
- make sure that there are no draughts.
- remove the contamination with a vacuum cleaner.

C. Analysis of Accidental Contamination
If the contamination is accidental, find the characteristics of the contamination agent (Refer to the material manufacturer's documentation).
You must make an estimate of the risk of deterioration of the electrical items.
Some contamination agents can cause damage to the polymers used in the electrical items.
There can be a change in the electrical performance (insulation resistance, dielectric strength.).
Refer to the table to know if:
- you can clean the items.
- you must replace the items.

(1) Visually examine the area that has contamination
Examine the electrical items that have contamination for traces of damage.

Type of Damage	Procedure
- Discoloration (connectors, terminal blocks, modules, bases, etc.). - Cracks.	Replace the electrical item.
- Expansion of the sealing grommets (module, connectors, etc.).	Replace the electrical item.
- Supplier marks erased.	Replace the electrical item.
- Loss of label adhesion.	Replace the electrical item.
- Functional Item Number erased	Replace the electrical item

EFF : ALL

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Figure 137 General Cleaning

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Type of Damage	Procedure
on placards, sleeves or labels	(Put indentification on the item).

NOTE : Examine the painted surfaces, the composite surfaces, the insulation blankets, etc.. The contamination agent can have an effect on these parts.

D. General Cleaning Principle

R

R (1) You must clean only the areas and items that have contamination.
R Before you clean, make sure that the cleaning materials and methods will not cause more contamination.

NOTE : Basic cleaning materials (pH>11) are not permitted.

R (2) In case of contamination with Temporary Corrosion Protection (TCP)
R compounds:
R We recommend protection of the wires from accidental contamination
R during application of TCP. Dust and fluff can collect on the wire if
R the surface stays tacky.
R However, if you accidentally apply TCP on wiring, it is not necessary
R to remove it as this material has no effect on the integrity of the
R wire insulation.
R If the presence of dust or fluff makes it necessary to clean the
R wires, you must be very careful not to cause damage to the wires
R (Ref. ESPM 20-55-20 for wire cleaning procedures).

4. Cleaning Method

A. Precautions

(1) Always start from the top to the bottom and from the periphery to the center of the area that has contamination.

(2) If you use cleaning agents:
- First, do a test with the cleaning agents and methods in a low-risk area or on a small surface.
- Examine the results immediately to make sure that they are satisfactory for the task. If the results are not satisfactory, adapt the methods and/or the materials as necessary.

(3) If you use a cloth, make sure that it is clean, dry and lint-free.

(4) If you use a vacuum cleaner, make sure that:
- the filters are in position.
- its outlet is out of the aircraft to prevent contamination of a different area.

B. Clean with Cloth and Solvent

WARNING : USE SOLVENTS/CLEANING AGENTS, SEALANTS AND OTHER SPECIAL MATERIALS ONLY WITH A GOOD FLOW OF AIR THROUGH THE WORK AREA.
THESE MATERIALS ARE POISONOUS AND FLAMMABLE AND SKIN IRRITANTS.
OBEY THE MANUFACTURERS INSTRUCTIONS.
PUT ON PROTECTIVE CLOTHING.
DO NOT GET THEM IN YOUR MOUTH.
DO NOT SMOKE.
DO NOT BREATHE THE GAS.
GET MEDICAL HELP IF YOUR SKIN OR EYES BECOME IRRITATED.

- Do not get more solvent than is necessary for the task.
- Out of the aircraft, transfer only the necessary quantity of solvent from its initial container to small capacity cans (less than 1/2 liter).
- Never put the cloth in the liquid but always put the liquid on the cloth.

5. Types of Solvent

R

You can use these materials only if there is a natural contamination. If these is an accidental contamination and you do not know the material that caused the contamination, you must not use solvents.

Natural Contamination	Recommended Cleaning Material
Aircraft hydraulic fluid Fuel and Oil/Grease De-icing fluids	Isopropyl Alcohol (Material No. 11-010) or equivalent.(Refer to the local regulations)
Anti-corrosion material Dust	
Accidental contamination	To be treated on a case-by-case basis dependent on the chemical nature of the material

Figure 138 Cleaning Methods

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ELECTRICAL STANDARD PRACTICES MANUAL

CLEANING OF WIRES - DESCRIPTION AND OPERATION

1. General
This chapter gives the instructions related to the cleaning of cables that have surface contamination or in-depth contamination. The CML codes of the cleaning products are given in 20-55-10.

2. Cleaning
- Use suction to remove the particles or a sponge to remove the liquids from the surface of the bundles.
- Locally remove the ties in the area that has contamination (300 mm (11.8110 in.) approx). Estimate if the contamination is on the surface or deeper (the contamination agent goes deep in the bundle).

A. Surface Contamination
- Do not remove the cable ties.
- Clean the bundles with a dry cloth or with a cloth moist with solvent. If you use a solvent, let it operate during 10 mn then clean again with a dry cloth.
- Install new cable ties in the cleaned area.
- Remove the old ties and clean their location.

NOTE : When the ties hold the bundle on supports, do not remove all the ties at the same time.
Replace the ties support by support.
Install a new cable tie at the same location.
Clean the support or replace it if necessary.

B. Deep Contamination
- Do the procedure on one bundle only at a time and on a small length.
- Remove the support ties first, then the others.
- Clean the cables one by one on the prepared length.
- Install the cable ties (maximum pitch: 150 mm (5.9055 in.); 100 mm (3.9370 in.) on the last 500 mm (19.6850 in.)).
- Install the bundle at its original location except at the two ends of the cleaned length. This is to make an overlap when you clean the subsequent section.
- Make new identification if necessary.

C. Special Conditions
Aluminum cables NSA935308YU and E0438YV.
The Polyamid Aromatic (NOMEX) braid can operate like a wick. Make sure that the drying operation is correct.
If basic materials (pH>11) caused the contamination, the polyimide insulation can have damage.

ELECTRICAL STANDARD PRACTICES MANUAL

If there is this type of damage, it is better to fully replace the feeder.

EFF : ALL

20-55-20

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Figure 139 Cleaning of Wires

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Cleaning Regulations for Boeing Aircraft

Structure of this chapter

This Subject gives the procedures to the remove the contamination from these wire harness components:

- A wire
- A cable
- A wire harness support
- The external surface of a connector
- A connector backshell
- A strain relief clamp.

BOEING

STANDARD WIRING PRACTICES MANUAL

CLEANING OF WIRE HARNESSES

PARAGRAPH	DESCRIPTION	PAGE
1.	General Data	1
1.A.	Necessary Conditions for Fire Safety	1
1.B.	Necessary Conditions for Personnel Safety	2
1.C.	General Conditions for Cleaning a Wire Harness	3
1.D.	General Conditions for Cleaning with a Solvent	3
1.E.	General Conditions for Cleaning with an Aqueous Cleaner	3
1.F.	Necessary Materials and Tools	4
2.	Selection of a Cleaning Procedure	5
2.A.	Selection of an Applicable Cleaning Procedure	5
3.	Cleaning of a Wire Harness That Has Contamination on the Internal Surfaces	9
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3.C.	Removal of Solid Contamination	14
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4.B.	Removal of Contamination on or near Environmentally Sealed Connectors	18
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1.General Data

A. Necessary Conditions for Fire Safety

Refer to Subject 20-00-10 for more safety conditions.

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Figure 140 Cleaning of Wire Harnesses 1

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STANDARD WIRING PRACTICES MANUAL

CLEANING OF WIRE HARNESSES

These conditions are applicable for a solvent or a flammable aqueous cleaner:

- The conditions for fire safety specified by the manufacturer must be obeyed
- The necessary local conditions for fire safety must be obeyed
- The airplane must be electrostatically grounded; refer to the Aircraft Maintenance Manual
- The material must be kept in an approved closed container
- Only the quantity of material that is necessary to clean the wire harness or wire harness components must be kept near the airplane
- A wiper or a cloth that is made from a synthetic material is not permitted.

WARNING: CAREFULLY READ THE INSTRUCTIONS AND CAUTIONS FROM THE MANUFACTURER OF THE MATERIAL FOR MORE SAFETY CONDITIONS. IF ALL OF THE SPECIFIED CONDITIONS ARE NOT OBEYED, INJURY TO PERSONNEL CAN OCCUR.

CAUTION: CAREFULLY READ THE INSTRUCTIONS AND CAUTIONS FROM THE MANUFACTURER OF THE MATERIAL FOR MORE SAFETY CONDITIONS. IF ALL OF THE SPECIFIED CONDITIONS ARE NOT OBEYED, DAMAGE TO EQUIPMENT CAN OCCUR.

B. Necessary Conditions for Personnel Safety

These conditions are applicable for a cleaning material:

- The conditions for personnel safety specified by the manufacturer must be obeyed
- The necessary local conditions for personnel safety must be obeyed
- A cleaner must not touch the skin or the eyes
- The vapors from a cleaner must not be breathed.

WARNING: CAREFULLY READ THE INSTRUCTIONS AND CAUTIONS FROM THE MANUFACTURER OF THE MATERIAL FOR MORE SAFETY CONDITIONS. IF ALL OF THE SPECIFIED CONDITIONS ARE NOT OBEYED, INJURY TO PERSONNEL CAN OCCUR.

These equipment are recommended for protection:

- An apron
- Boots
- Coveralls
- Rubber gloves
- Chemical goggles
- An approved eye protection.

To make sure that fumes are not breathed, one of these conditions must occur:

- The area has a good airflow
- The personnel have sufficient respiratory protection.

STANDARD WIRING PRACTICES MANUAL

CLEANING OF WIRE HARNESSES

C. General Conditions for Cleaning a Wire Harness

These conditions are applicable:

- Equipment or a component that is sensitive to contamination, solvents, or water and that is near the area that must be cleaned, must have satisfactory protection
- All disconnected connectors in the area must have protection
- A solvent, a cleaner, contamination, or water must not go into a connector
- A paint, a plastic, a polymeric material, or an adhesive must be fully cured before it can be cleaned.

CAUTION: FLUID OR CONTAMINATION IN A CONNECTOR CAN CAUSE UNSATISFACTORY PERFORMANCE OF THE CONNECTOR.

D. General Conditions for Cleaning with a Solvent

These conditions are applicable:

- The mixture of the solvent and the contamination must be a safe mixture
- Different solvents must not be mixed
- A solvent must not be mixed with an aqueous cleaner
- The solvent must be a permitted cleaner for the materials in a wire harness
- The local environmental laws must be obeyed
- The solvent must be applied only with the procedure that is permitted or specified.

WARNING: IT CAN BE DANGEROUS TO MIX SOME TYPES OF SOLVENTS WITH SOME TYPES OF CONTAMINATION. MAKE SURE THAT THE MIXTURE OF THE SOLVENT AND THE CONTAMINATION IS PERMITTED. INJURY TO PERSONNEL CAN OCCUR.

CAUTION: A SOLVENT THAT IS NOT SPECIFIED FOR THE MATERIALS AND THE COMPONENTS IN A WIRE HARNESS MUST NOT BE APPLIED TO THE WIRE HARNESS. DAMAGE TO THE WIRE HARNESS CAN OCCUR.

E. General Conditions for Cleaning with an Aqueous Cleaner

These conditions are applicable:

- The mixture of the aqueous cleaner and the contamination must be a safe mixture
- The maximum permitted pH of a cleaner is 9.0
- Different cleaners must not be mixed
- An aqueous cleaner must not be mixed with a solvent
- The cleaner must be a permitted cleaner for the materials in a wire harness
- The area that must be cleaned must sufficiently drain large volumes of liquid
- The sensitive components in the area must have satisfactory protection; refer to the Aircraft Maintenance Manual
- The local environmental laws must be obeyed
- The cleaner must be applied only with the procedure that is permitted or specified.

WARNING: IT CAN BE DANGEROUS TO MIX SOME TYPES OF AQUEOUS CLEANERS WITH SOME TYPES OF CONTAMINATION. MAKE SURE THAT THE MIXTURE OF THE CLEANER AND THE CONTAMINATION IS PERMITTED. INJURY TO PERSONNEL CAN OCCUR.

Figure 141 Cleaning of Wire Harnesses 2

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STANDARD WIRING PRACTICES MANUAL

CLEANING OF WIRE HARNESSES

CAUTION: AN AQUEOUS CLEANER THAT HAS A PH MORE THAN 9.0 MUST NOT BE APPLIED TO THE WIRE HARNESS. DAMAGE TO THE WIRE HARNESS AND OTHER EQUIPMENT CAN OCCUR.

CAUTION: AN AQUEOUS CLEANER THAT IS NOT SPECIFIED FOR THE MATERIALS AND THE COMPONENTS IN A WIRE HARNESS MUST NOT BE APPLIED TO THE WIRE HARNESS. DAMAGE TO THE WIRE HARNESS CAN OCCUR.

CAUTION: A HIGH VOLUME OF AQUEOUS CLEANER MUST NOT BE APPLIED TO AN AREA UNLESS THE LIQUID CAN DRAIN SUFFICIENTLY. IF THE LIQUID DOES NOT DRAIN SUFFICIENTLY, DAMAGE TO THE EQUIPMENT OR A STRUCTURE CAN OCCUR.

F. Necessary Materials and Tools

TABLE I
RECOMMENDED SOLVENTS

Solvent	Specification	Supplier
Alcohol, Isopropyl	TT-I-735 Grade A	Any Source
	TT-I-735 Grade B	Any Source
Alcohol, Denatured, Ethyl	O-E-760	Any Source
Naphtha, Aliphatic	TT-N-95, Type II	Any Source

TABLE II
NECESSARY TOOLS

Material or Tool	Description	Part Number or Specification	Supplier
Brush	1. The bristles are soft and not abrasive; 2. The bristle retainer is not metal; 3. The cleaners do not cause damage to the brush materials	Specified by supplier	Any Source
Cloth, Cleaning	Cotton, non-woven	CCC-C-46	Any Source
Compressed Gas	Air, Clean and dry	Specified by supplier	Any Source
	Nitrogen, Clean and dry	Specified by supplier	Any Source
Swabs	Cotton, lint free	Specified by supplier	Any Source
Vacuum	The brush has soft bristles	Specified by supplier	Any Source

STANDARD WIRING PRACTICES MANUAL

CLEANING OF WIRE HARNESSES

Material or Tool	Description	Part Number or Specification	Supplier
Wiper	Cotton, low lint	Specified by supplier	Any Source
	Cotton, non-woven Grade 142951	BMS15-5 Class A	BBA Nonwovens Walpole
	Cotton, cheesecloth No. 10, 20, 40	BMS15-5 Class A	American Fiber & Finishing
	Cotton, cheesecloth No. 9017	BMS15-5 Class A	DeRoyal Textiles
	Cotton, gauze sponge No. 582556	BMS15-5 Class A	American Fiber & Finishing
	Cotton, gauze sponge No. 9405	BMS15-5 Class A	DeRoyal Textiles
	Cotton, HAN SIN SANG SA Fabric Code No. 3D30	BMS15-5 Class A	HO CHANG Medical Company
	Cotton, Hermitex No. 300, 400	BMS15-5 Class A	DeRoyal Textiles
	Cotton, Rymplecloth No. 201, 300, 301	BMS15-5 Class A	American Fiber & Finishing
	Cotton, Weston cloth No. 8000	BMS15-5 Class A	Nippon Weston Company

2. Selection of a Cleaning Procedure

A. Selection of an Applicable Cleaning Procedure

NOTE: Connectors can be environmentally sealed or unsealed. Each type has a different cleaning procedure. Environmentally sealed connectors are identified in Subject 20-60-08.

Figure 142 Cleaning of Wire Harnesses 3

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STANDARD WIRING PRACTICES MANUAL

CLEANING OF WIRE HARNESSES

CAUTION: A SOLVENT THAT IS NOT SPECIFIED FOR THE MATERIALS AND THE COMPONENTS IN A WIRE HARNESS MUST NOT BE APPLIED. DAMAGE TO THE WIRE HARNESS CAN OCCUR.

(6) Disassemble a short length of the wire harness:

(a) Remove the necessary wire harness supports to get access to the contamination.

Make sure that the wire harness has sufficient support after the supports are removed.

(b) Remove the wire harness ties along the free length.

(c) Move the wires apart.

CAUTION: A WIRE OR A CABLE MUST NOT BE MOVED MORE THAN IT IS NECESSARY TO CLEAN IT. DAMAGE TO THE WIRE OR THE CABLE CAN OCCUR.

(7) Remove the contamination.

Refer to Paragraph 4. for the procedure to remove the contamination from:

- A backshell
- The external surface of the connector
- An area of a wire that is less than 6 inches from the end of a connector.

CAUTION: MAKE SURE TO PREVENT THE MOVEMENT OF THE CONTAMINATION TO A DIFFERENT WIRE HARNESS COMPONENT. DAMAGE TO THE COMPONENT CAN OCCUR.

CAUTION: A WIRE MARK OR AN IDENTIFICATION TAPE MUST NOT BE CLEANED WITH TOO MUCH FORCE. DAMAGE TO THE WIRE IDENTIFICATION CAN OCCUR.

CAUTION: SURFACES WITH PROTECTIVE FINISHES MUST BE CLEANED CAREFULLY. REMOVAL OF THE PROTECTIVE FINISH CAN CAUSE UNSATISFACTORY PERFORMANCE OF THE EQUIPMENT OR THE STRUCTURE.

(a) Put the sufficient quantity of aliphatic naphtha on the wiper to make it moist.

CAUTION: THE WIPER MUST NOT HAVE TOO MUCH ALIPHATIC NAPHTHA. THE NAPHTHA CAN GET INTO A WIRE HARNESS COMPONENT AND DAMAGE TO THE COMPONENT CAN OCCUR.

(b) Carefully remove the contamination from each component with the wiper.

NOTE: A moist brush can help loosen the particles.

CAUTION: ALIPHATIC NAPHTHA MUST NOT BE APPLIED ON CONTROL CABLES, ACRYLIC SURFACES, DECALS, OR FINISHES THAT ARE NOT MADE FROM CLASS 1 MATERIALS. DAMAGE TO THE COMPONENT CAN OCCUR.

CAUTION: ALIPHATIC NAPHTHA MUST NOT BE APPLIED ON A SURFACE THAT HAS A CORROSION INHIBITING COMPOUND UNLESS THE CORROSION INHIBITING COMPOUND MUST BE REMOVED AND THEN APPLIED AGAIN.

CAUTION: ALIPHATIC NAPHTHA MUST NOT STAY ON A WIRE HARNESS COMPONENT. REMAINING NAPTHA CAN CAUSE UNSATISFACTORY PERFORMANCE OF THE WIRE HARNESS COMPONENT.

(c) Dry the cleaned area with a new wiper.

STANDARD WIRING PRACTICES MANUAL

CLEANING OF WIRE HARNESSES

NOTE: As an alternative, compressed gas at 30 PSI can be applied to remove the remaining naptha. Refer to Table II.

WARNING: COMPRESSED GAS CAN BE DANGEROUS. TO PREVENT AN INJURY, CAREFULLY APPLY THE GAS IN A DIRECTION AWAY FROM THE EYES, THE FACE, AND OTHER PERSONNEL.

(d) Do Step (a) through Step (c) again until all of the contamination is removed.

(e) Put the sufficient quantity of isopropyl alcohol on the wiper to make it moist.

(f) Carefully clean the areas where the naptha was applied.

(g) Dry the cleaned area with a new wiper.

NOTE: As an alternative, compressed gas at 30 PSI can be applied to remove the remaining naptha. Refer to Table II.

WARNING: COMPRESSED GAS CAN BE DANGEROUS. TO PREVENT AN INJURY, CAREFULLY APPLY THE GAS IN A DIRECTION AWAY FROM THE EYES, THE FACE, AND OTHER PERSONNEL.

(8) Examine the wire harness components and supports.

Make sure that the components and supports are clean and fully dry.

(9) Assemble the wire harness to make it the same as the initial configuration.

(10) Install the wire harness supports.

(11) Do Step (6) through Step (10) again until all of the contamination on the wire harness is removed.

B. Removal of Heavy Contamination with an Aqueous Cleaner

This procedure is recommended for the unpressurized areas where a high volume of liquid can drain sufficiently. Refer to Paragraph 2.A.

CAUTION: A HIGH VOLUME OF AQUEOUS CLEANER MUST NOT BE APPLIED TO AN AREA UNLESS THE LIQUID CAN DRAIN SUFFICIENTLY. IF THE LIQUID DOES NOT DRAIN SUFFICIENTLY, DAMAGE TO THE EQUIPMENT OR A STRUCTURE CAN OCCUR.

Heav contamination can be:

- A petroleum based material
- A hydraulic fluid
- A wet or dried mixture of a fluid and a solid
- A wet or dried semi-solid.

(1) Identify the electrical system that must be cleaned.

(2) Open all circuit breakers and all switches for the wire harness and the equipment in the area that must be cleaned. Refer to Subject 20-00-10.

Make sure that the applicable wire harness or wire harnesses are de-energized.

(3) Electrostatically ground the airplane. Refer to the Aircraft Maintenance Manual.

(4) Install the necessary protection for all equipment and the components that are sensitive to contamination and cleaners. Refer to the Aircraft Maintenance Manual.

Figure 143 Cleaning of Wire Harnesses 4

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CONTINUITY, INSULATION AND BONDING TECHNIQUES

Bondings

Aircrafts are constructed in such way that lightning strikes and static discharge can not lead to damages or errors in electrical systems. Therefore all equipment parts and the structure must be permanently and electrically conductively connected to one another. This is ensured by means of bondings.

Bondings are required for the following tasks:

- protecting crew and passengers against electric shocks in the event of potential differences
- protection of the aircraft and all the installed systems as well as the occupants against lightning
- protection against irregular electrical static charge which could lead to radio errors as well as discharge sparks
- trouble−free current backflow from the consumer to the power source

Different types of copper strands are used for the bondings which are connected by means of various connection methods (clamps, terminals, etc.).

It is especially important to connect all tubing carrying flammable liquids to the structure in order to prevent explosions due to static electrical charge.

A new installation of a bonding or of one of its connecting elements requires the lowest possible contact resistance.

This has to be measured and documented after completion of a connection.

The SWPM and ESPM list the maximum values for respective connections.



Figure 144 Bonding

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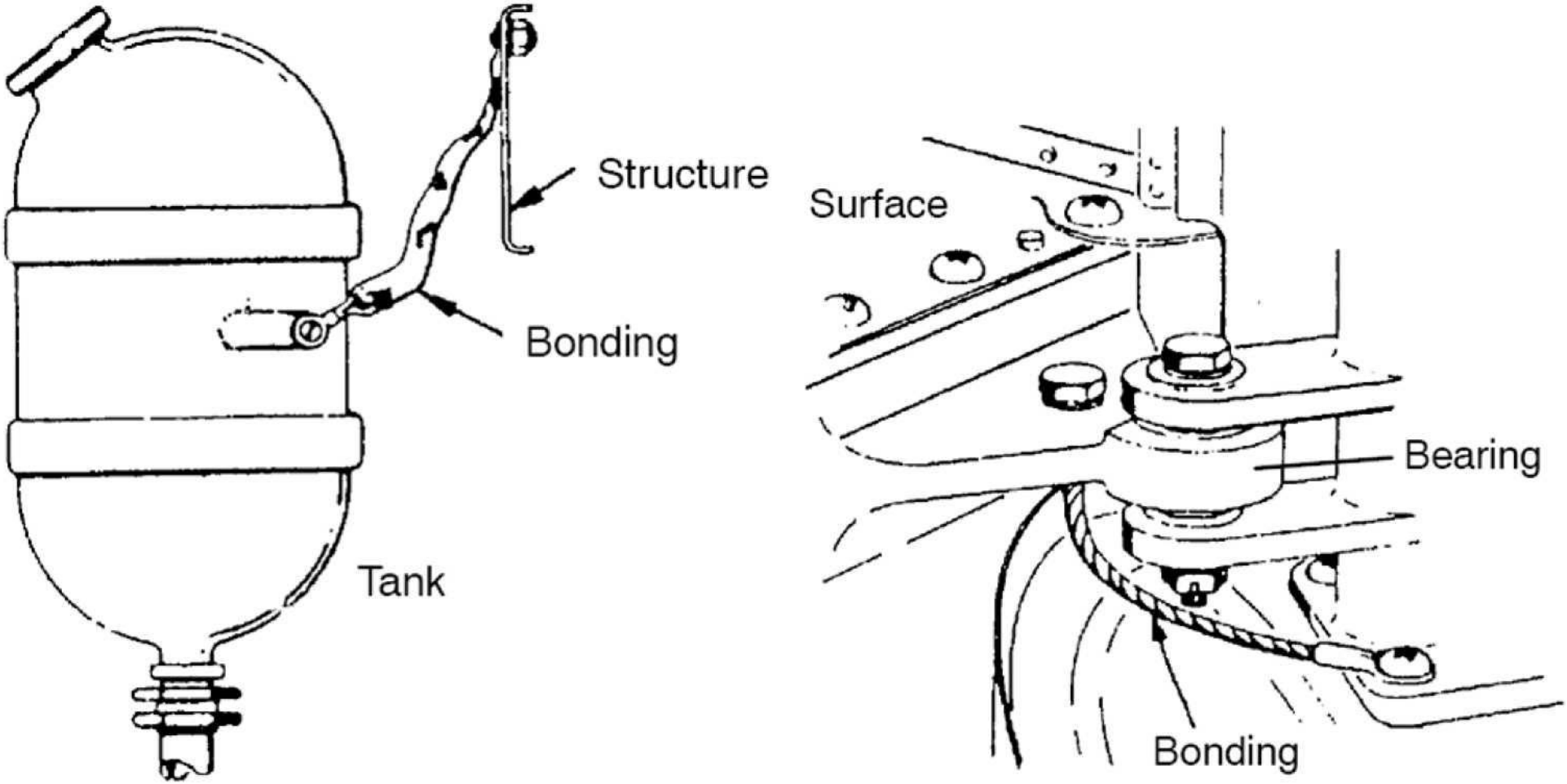


Figure 145 Various Bondings

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Groundings

Contrary to bondings, groundings have the purpose to lead the feedback current into the structure.

It is extremely important to check for any signs of electrochemical corrosion for currents are permanently flowing through this connection.

A corrosion–preventing installation is crucial.

The risk of penetration of moisture and humidity into groundings must be prevented by means of appropriate sealing.

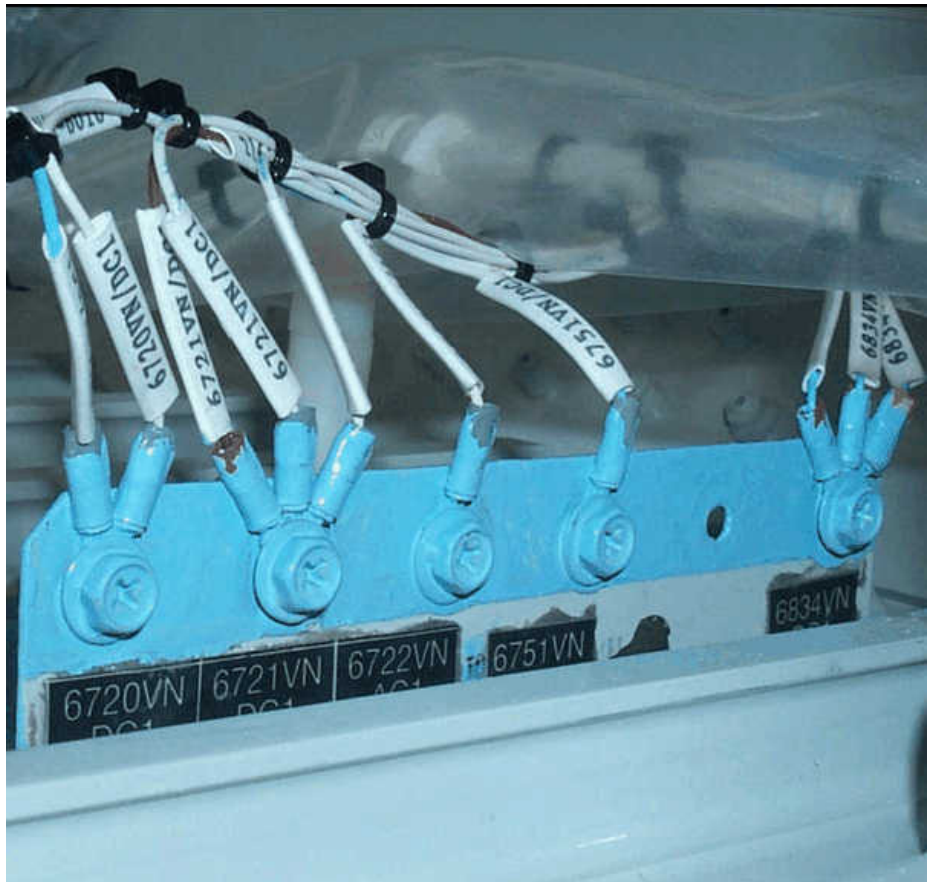


Figure 146 Groundings 1

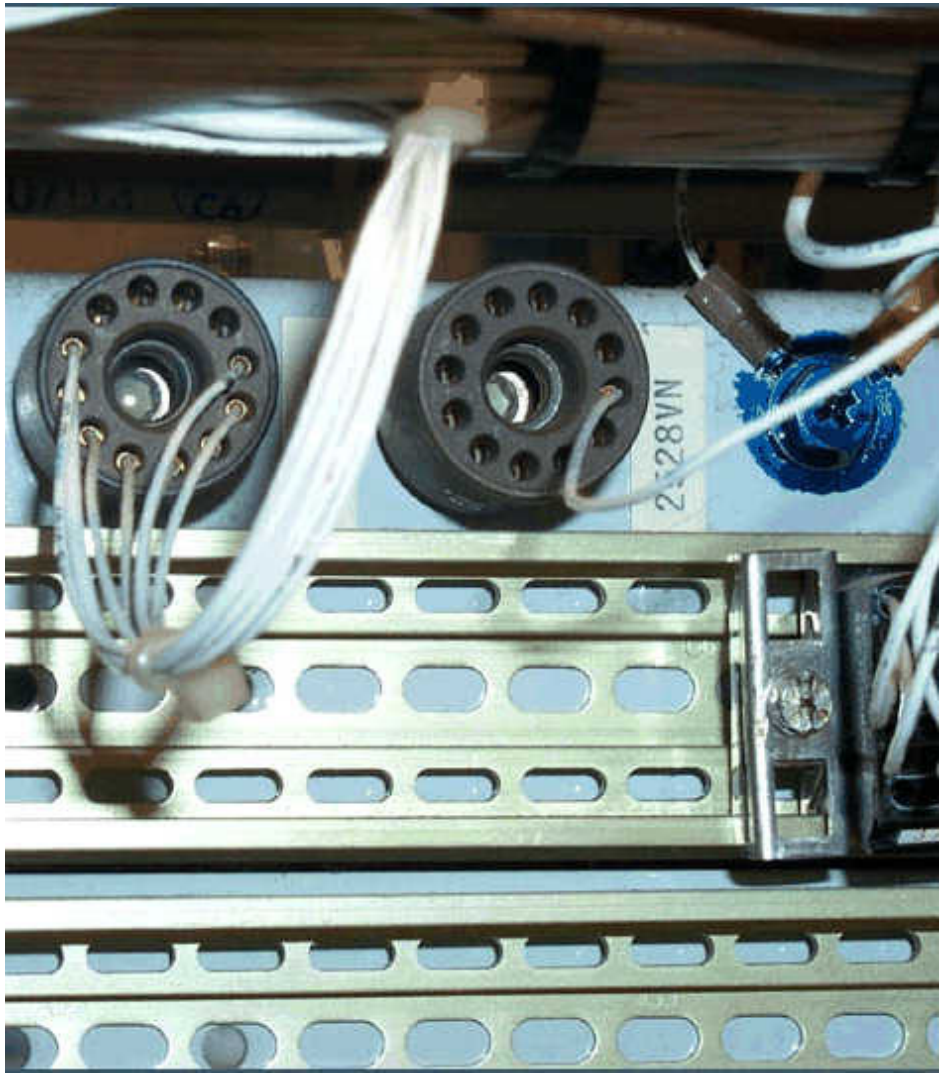


Figure 147 Groundings 2

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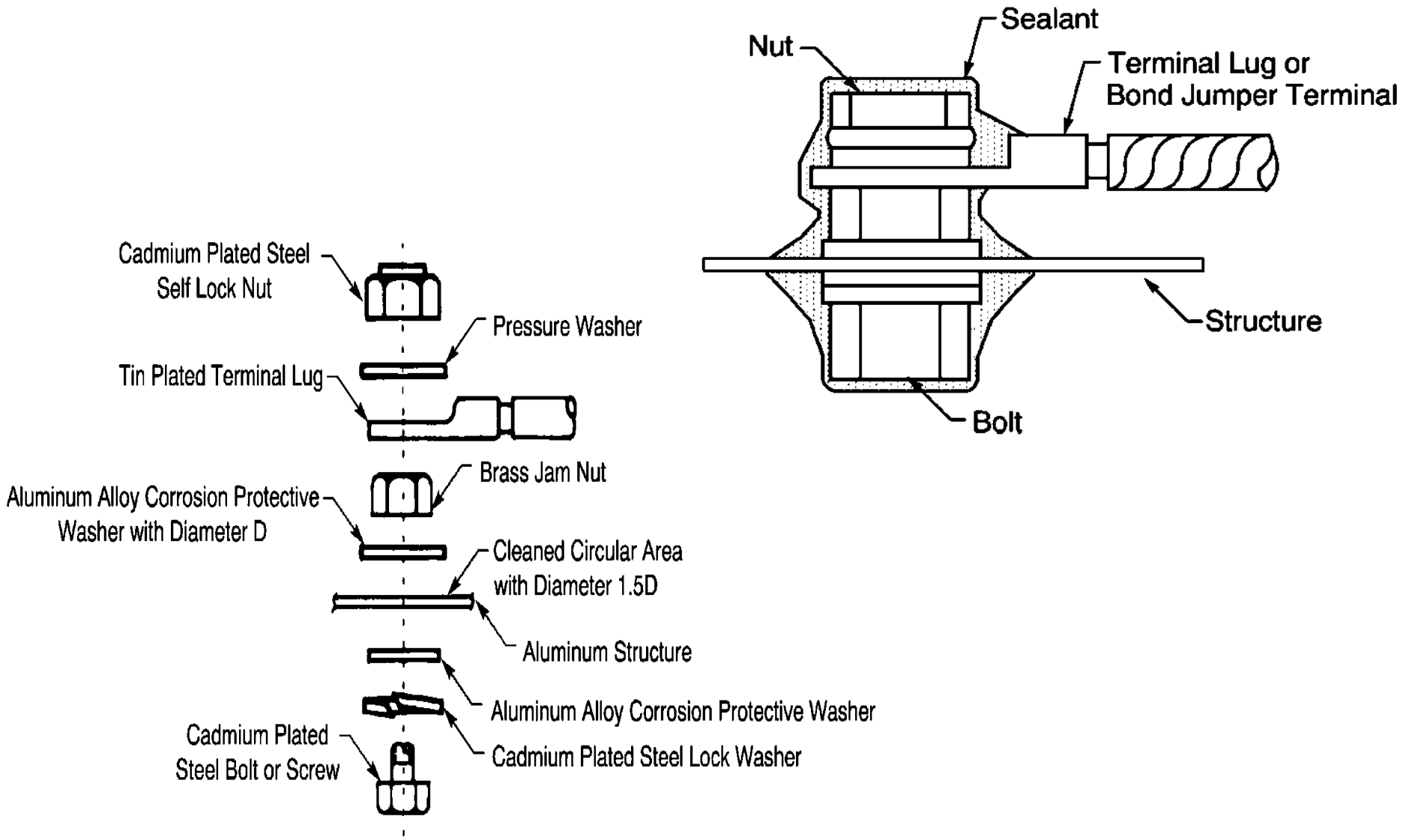


Figure 148 Structure of Groundings

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A double grounding wire is mandatory outside of the pressurized cabin; it reduces the total resistance of the grounding and increases reliability.

Basic rules for groundings:

- generally separated according to terminal points for direct current (DC), alternating current (AC) and shieldings (SH)
- no groundings on magnesium structure (risk of corrosion)
- no more than four terminals per terminal bolt
- eliminate the corrosion risk!
- always keep power supply groundings separated from all other systems.

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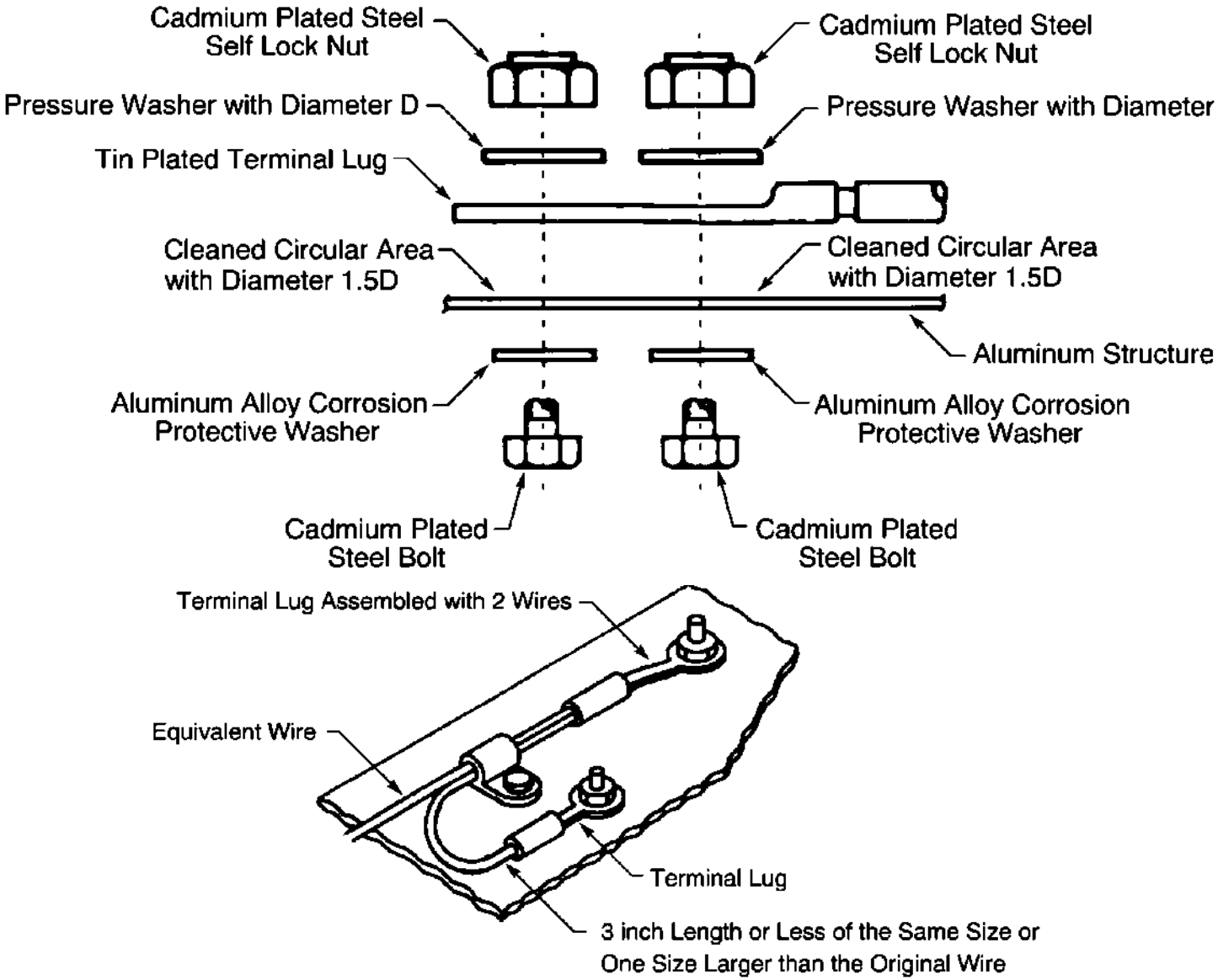


Figure 149 Double Grounding Wire Connections

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CONTINUITY, INSULATION AND BONDING TECHNIQUES

Measurement of wiring and components

There are different measuring methods for the control of wiring and components with suitable measuring devices.

Continuity Measurement

Continuity measurement is a method to measure the conductivity of a wire. A multimeter or ohmmeter is used for this purpose.

A distinction is made between two different techniques:

- measuring while the wire is connected to ground

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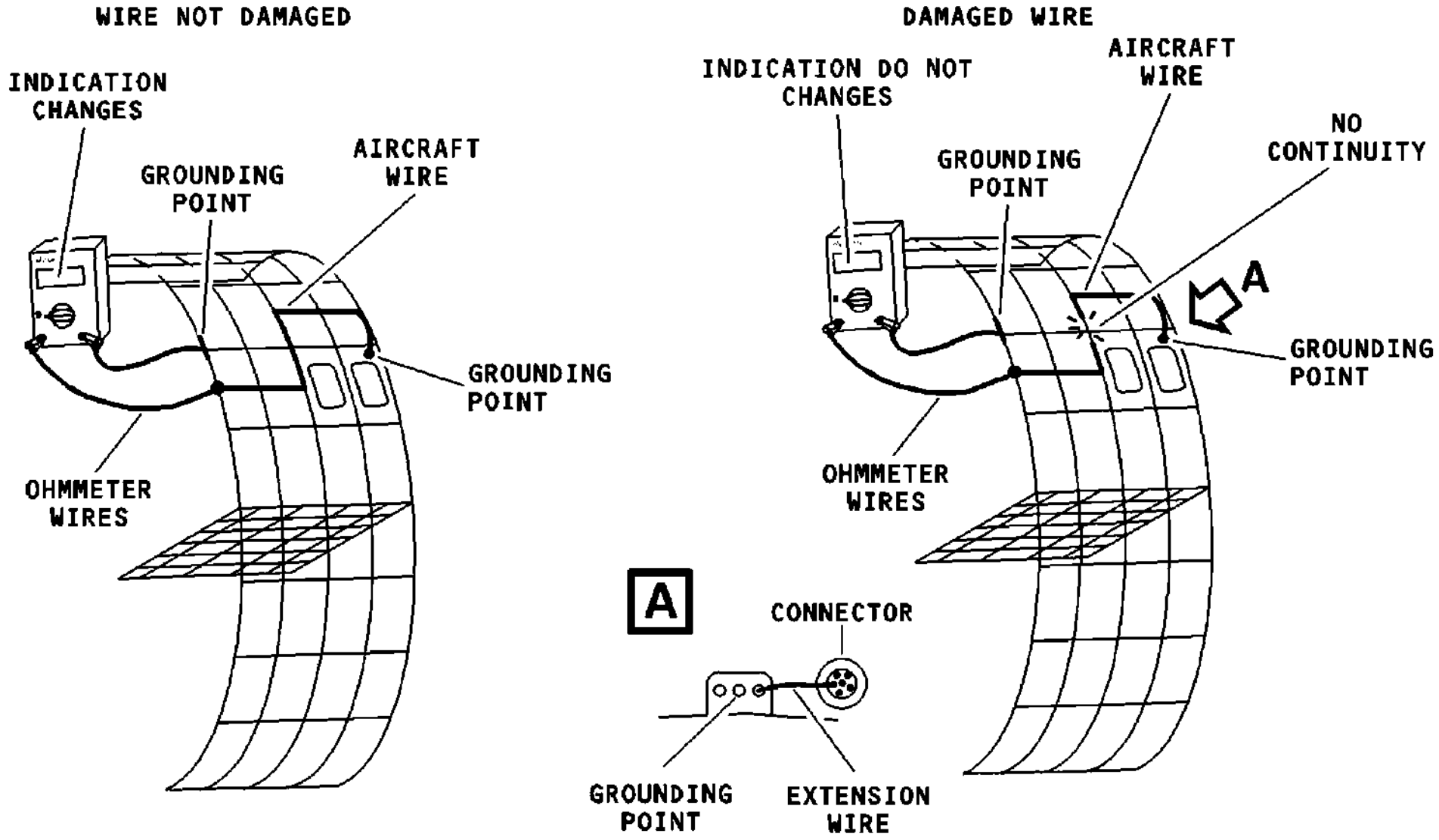


Figure 150 Continuity Measurement

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- measuring with an extension wire

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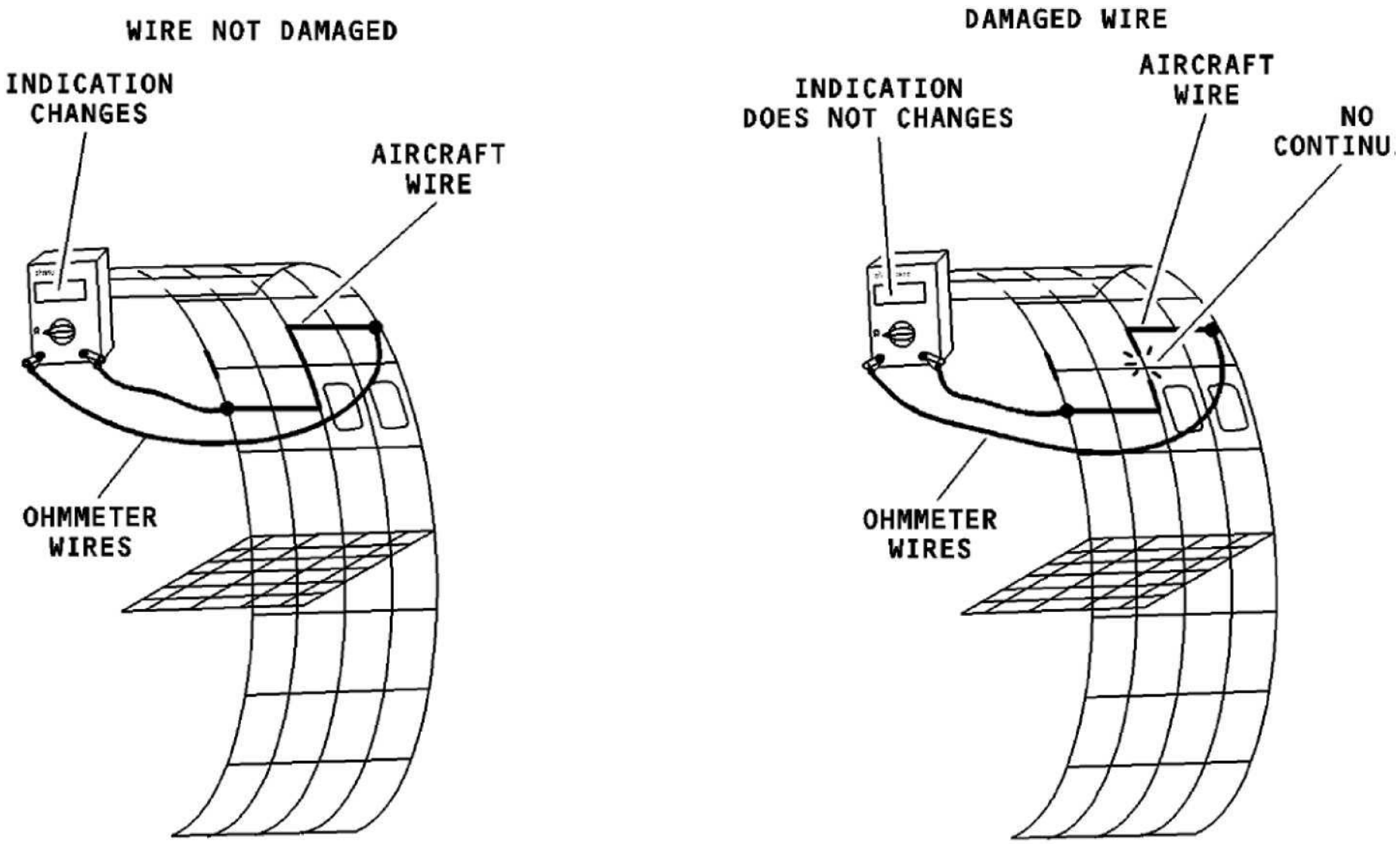


Figure 151 Measuring with an Extension

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Contact Resistance Measurement

The contact resistance measurement is a special case in continuity measurement for bondings and groundings.

Because of the low resistance to be measured, a special measuring device with corresponding measurement technique is used for this purpose.

The bonding–meter works with two current– and two voltage power lines – the so–called ”four wire technology”. A defined current goes through the power lines and via the connection to be measured; the resistance leads to a voltage drop which is then measured due to the voltage peaks.

This minimizes measuring errors caused by this measuring arrangement.

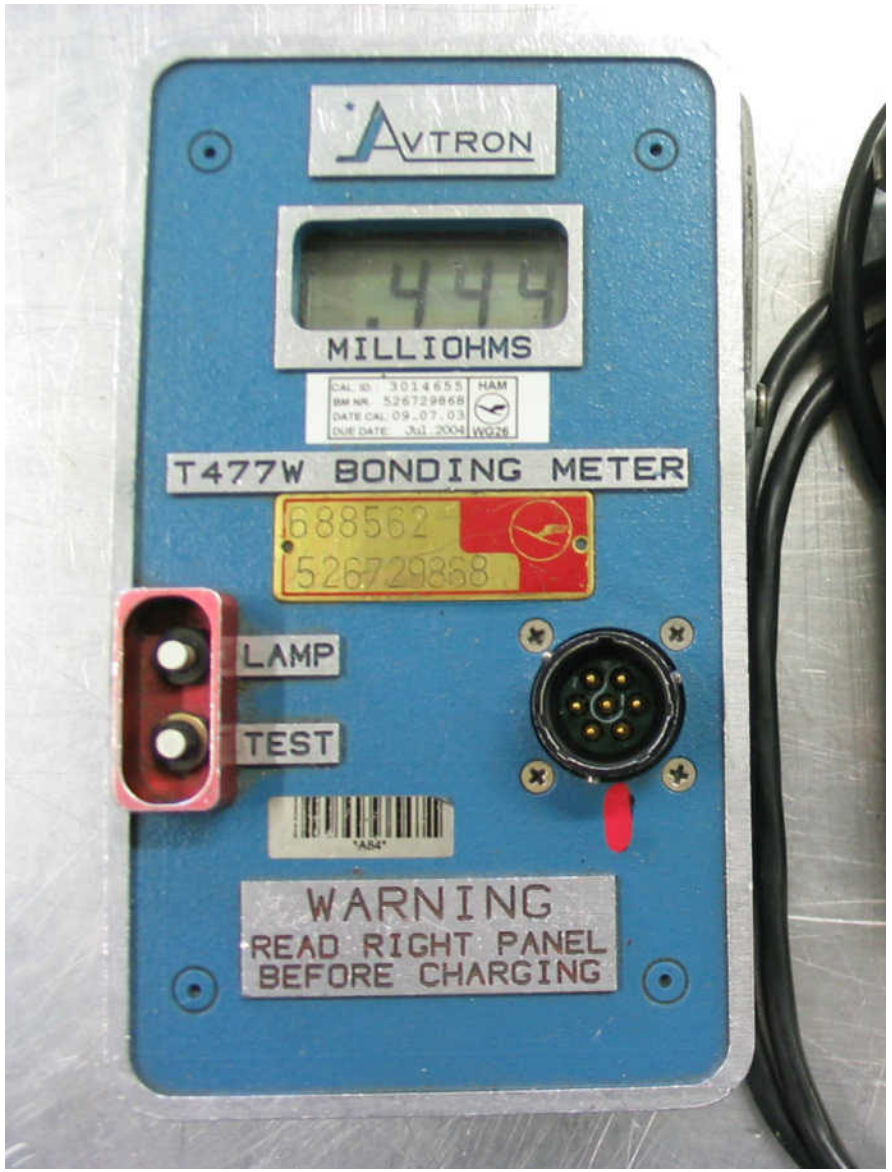


Figure 152 Bonding Meter

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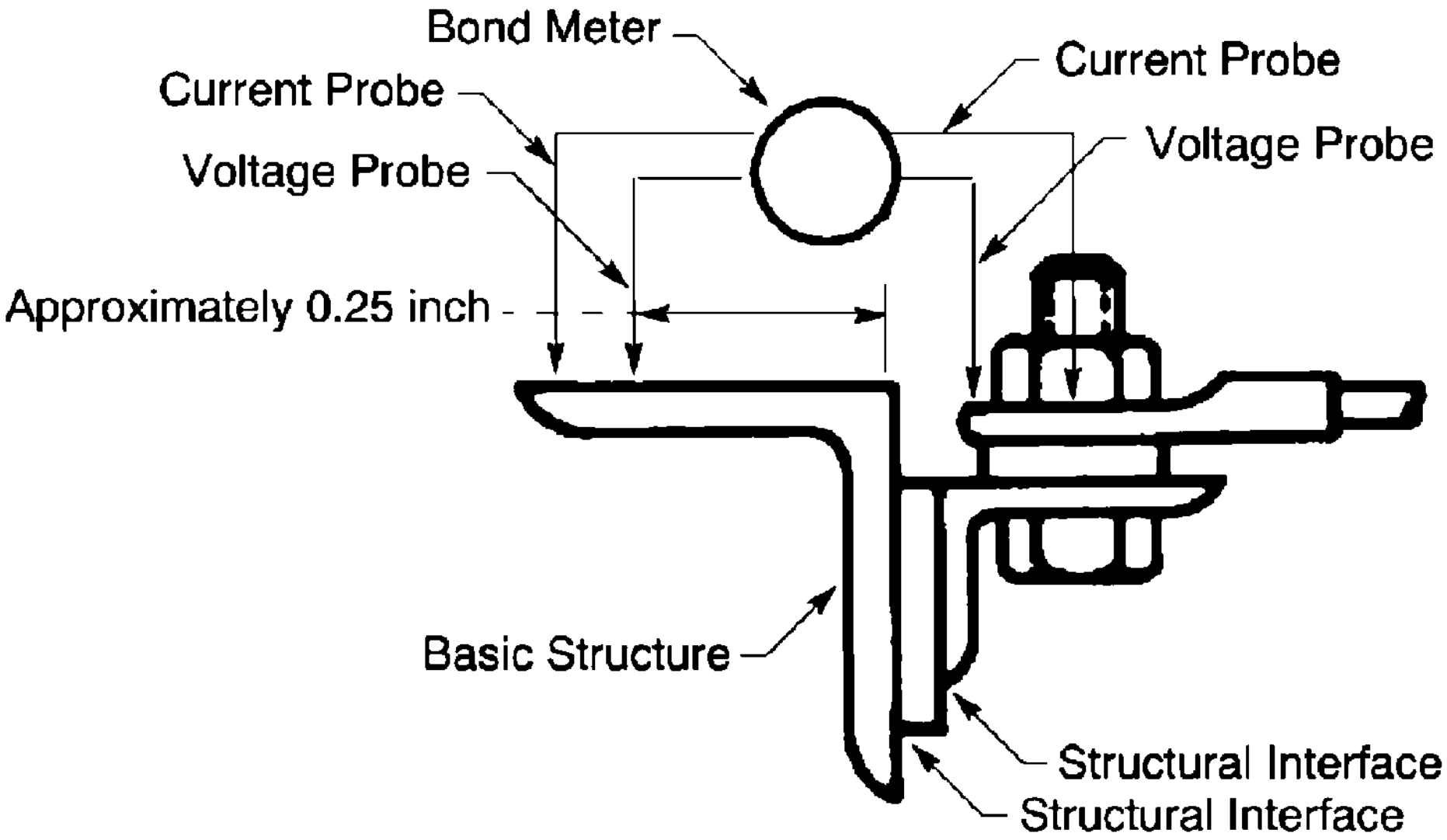


Figure 153 Contact Resistance Measurement

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Insulation Resistance Measurement

Insulation measurements are used to check the quality of insulation.

Similar to a pipe pressure test, an increased pressure, i.e. a voltage that is higher than the nominal voltage is used. Therefore all devices, motors, sensors etc. must be disconnected before starting the measurement.

The test can be performed either between two adjacent wires or between the wire and the structure.



Figure 154 Insulation Tester

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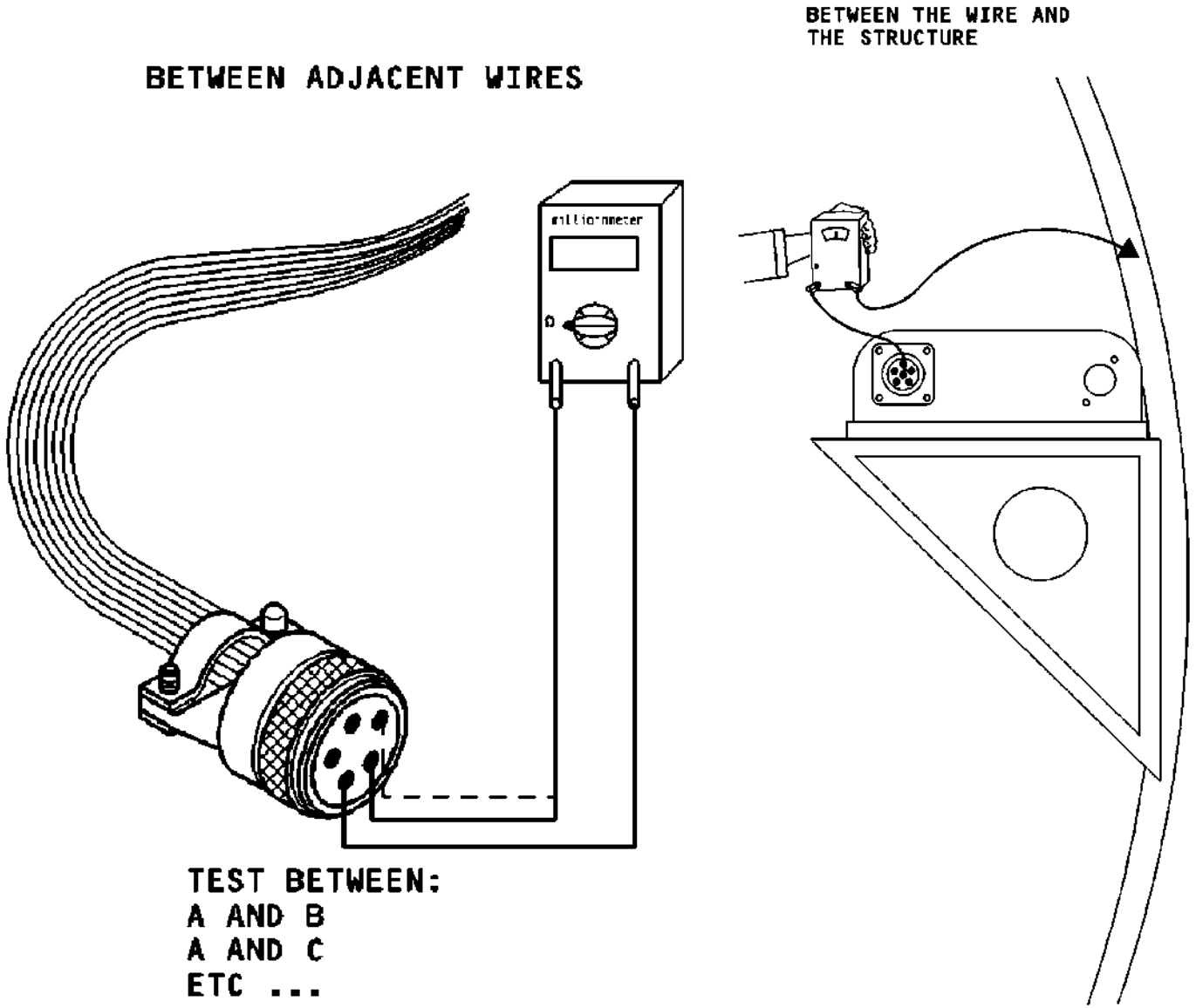


Figure 155 Insulation Measurement

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CO-AXIAL CABLES:TESTING AND INSTALLATION

Reflectometer Measurement

Coaxial Cable Measurement via Reflectometer

For detecting and locating defects in coaxial cables or twisted wire pair cables, an impulse reflectometry tester (time domain reflectometry TDR) can be used.

This tester sends an impulse into the cable to be measured. Any defect in this cable will cause the impulse energy to be partially reflected back to the tester. This reflected impulse is then compared to the output impulse regarding the phasing, time shift and amplitude. This comparison then determines the distance to the defect and provides indicators for the type of defect.

To obtain an accurate distance measurement, it has to be considered that waves move at different speeds depending on the material they are in.

The relation of the propagation speed to the speed of light is indicated as “velocity factor“ (e.g. air = 0.99; Teflon = 0.7; polyethylene = 0.66). The velocity factor is usually stated by the cable manufacturer.

The tester primarily consists of an impulse generator which is connected to an oscilloscope.



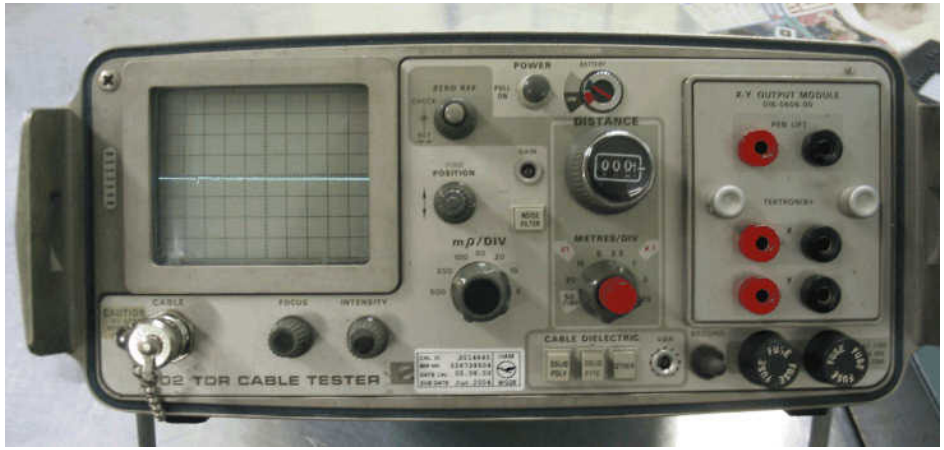


Figure 156 Reflectometry Tester

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TIME DOMAIN REFLECTOMETER

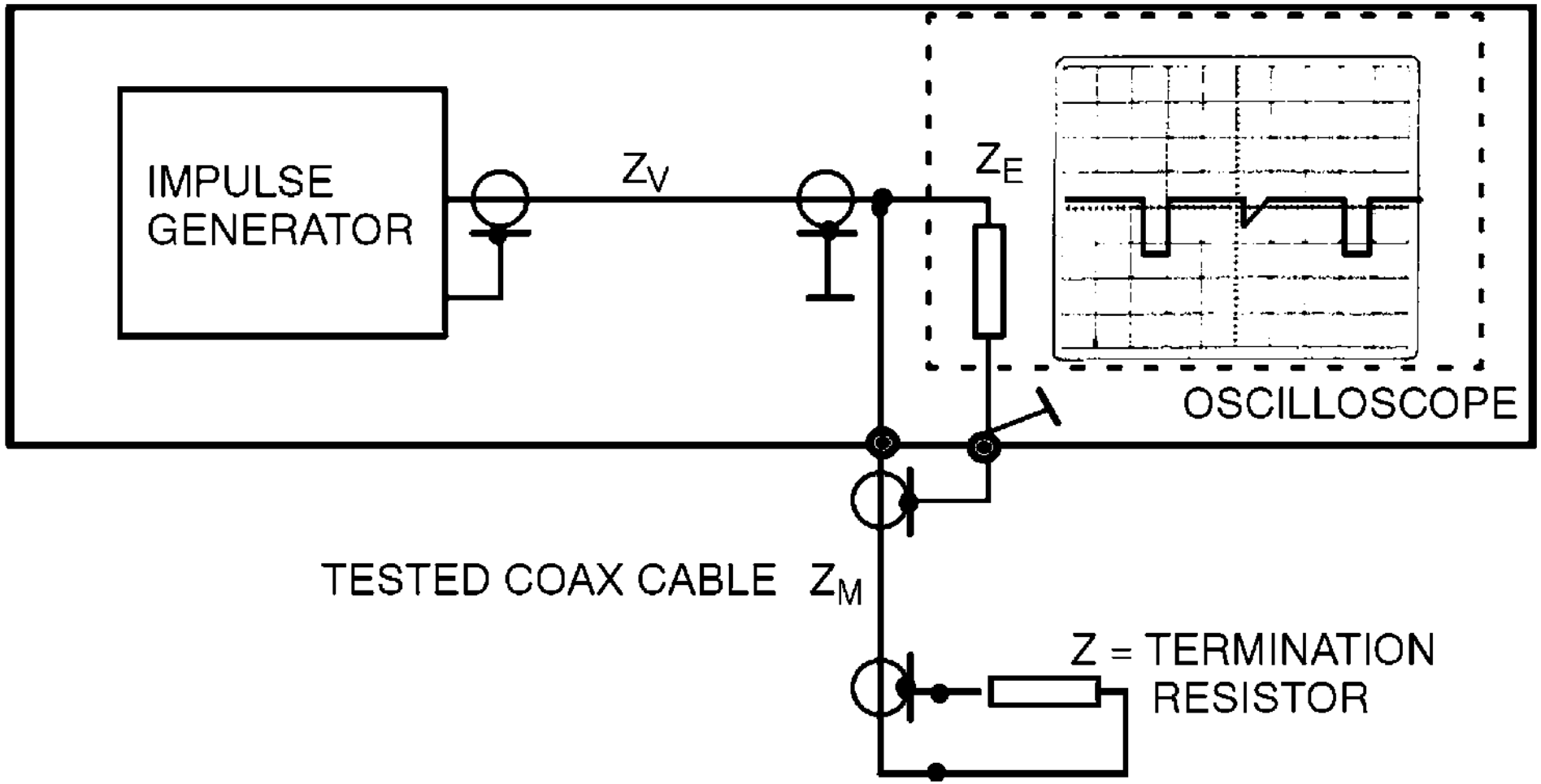


Figure 157 Reflectometry Circuit

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Error Pattern

Different errors in the measured lines cause different characteristic patterns.

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The type of reflected impulse provides information on the respective defect. A faultless line with correct terminating resistance will not cause any reflections.

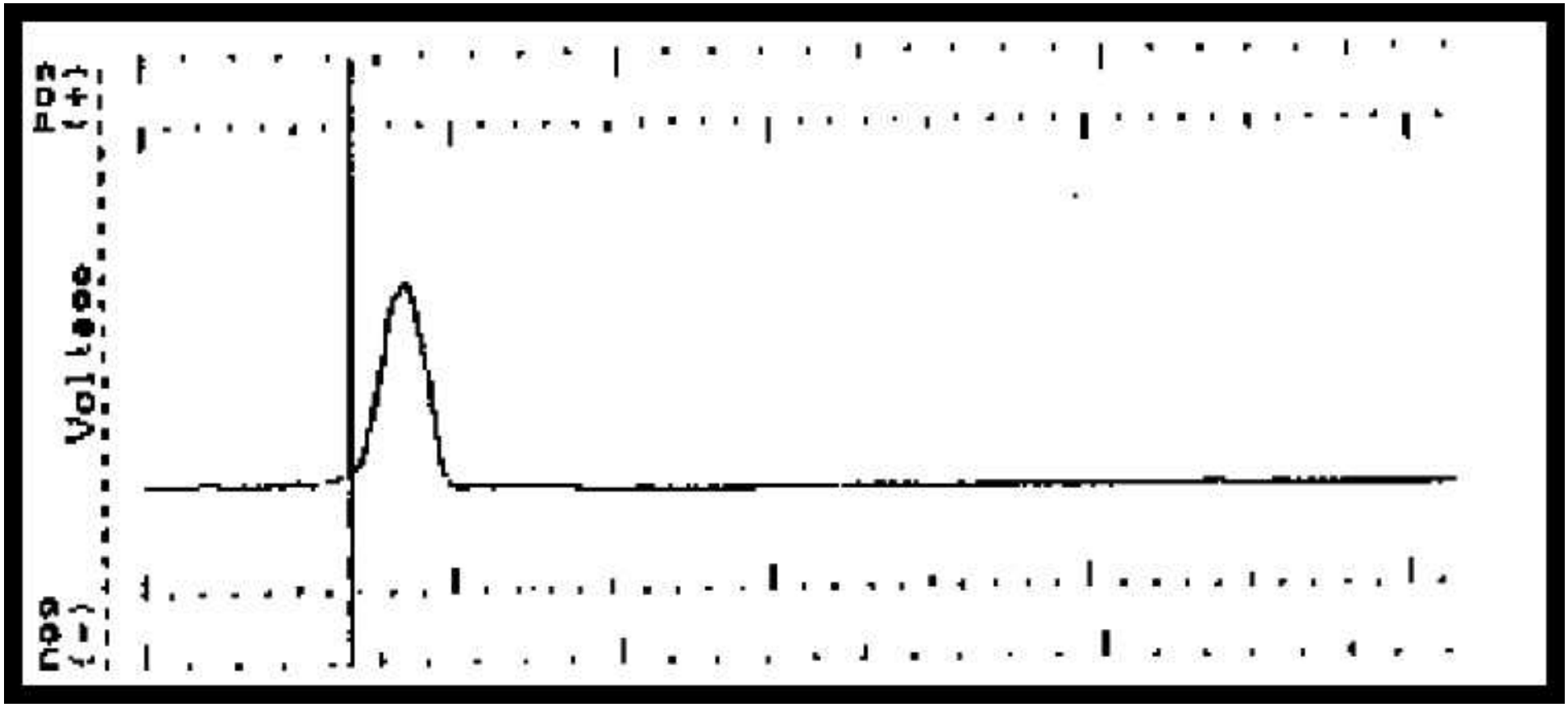


Figure 158 Faultless Wire

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A reflection with the same polarity as the input impulse indicates an open line,
i.e. a completely open line.

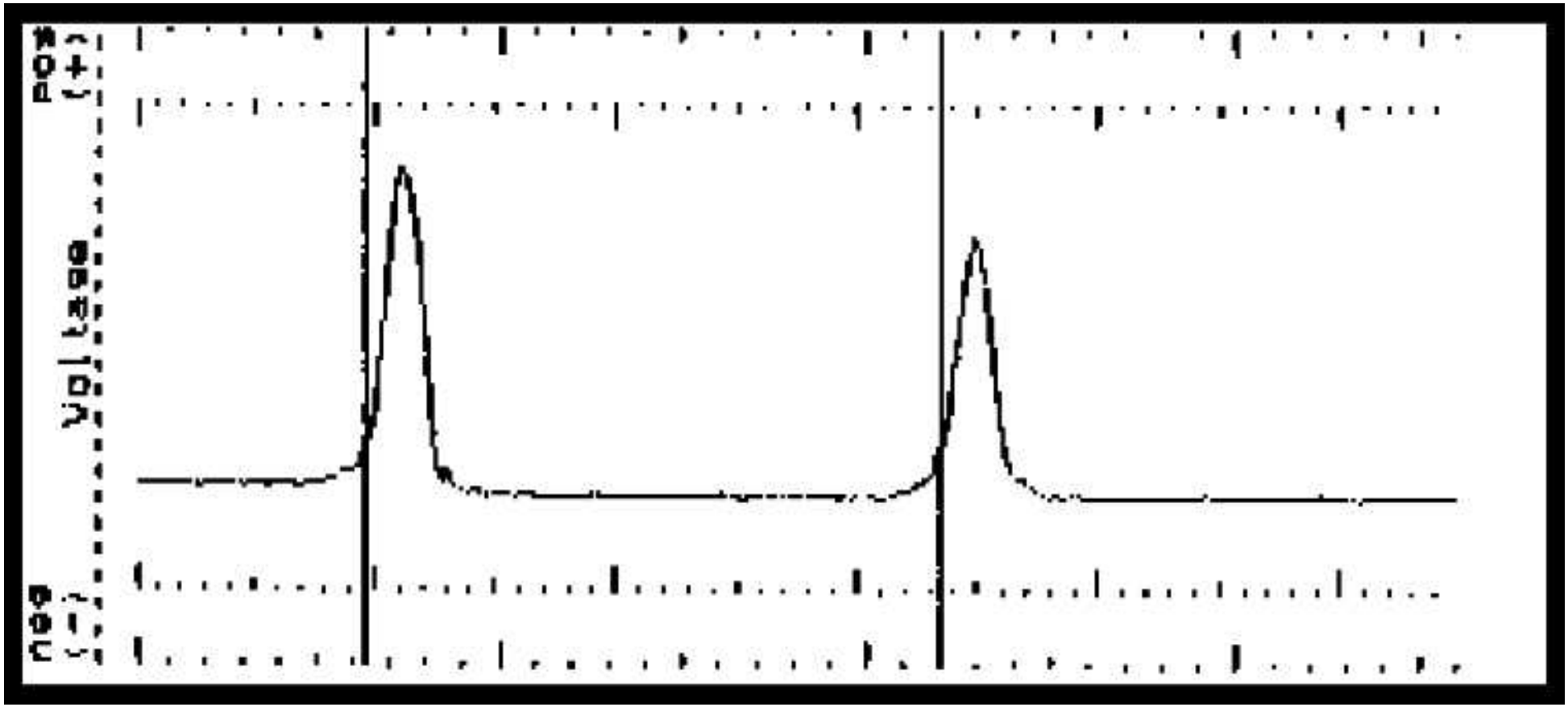


Figure 159 Open Wire

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With a short circuit in the line, a negative impulse is reflected.



Figure 160 Shortened Wire

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Installation Instructions for Co-Axial Cables

High-frequency signals are very susceptible due to damaged co-axial cables. The damages reduces the signal quality and power.

Because of this, it is very important to pay attention in correct installation of co-axial cables. Especially not to damage the cable during installation work.

the isolation, the shielding, the dielectric and the conductore must be in a proper condition. Especially the dialectric is very sensitive, a buckling of the cable is enough to damage the cable irreparably.

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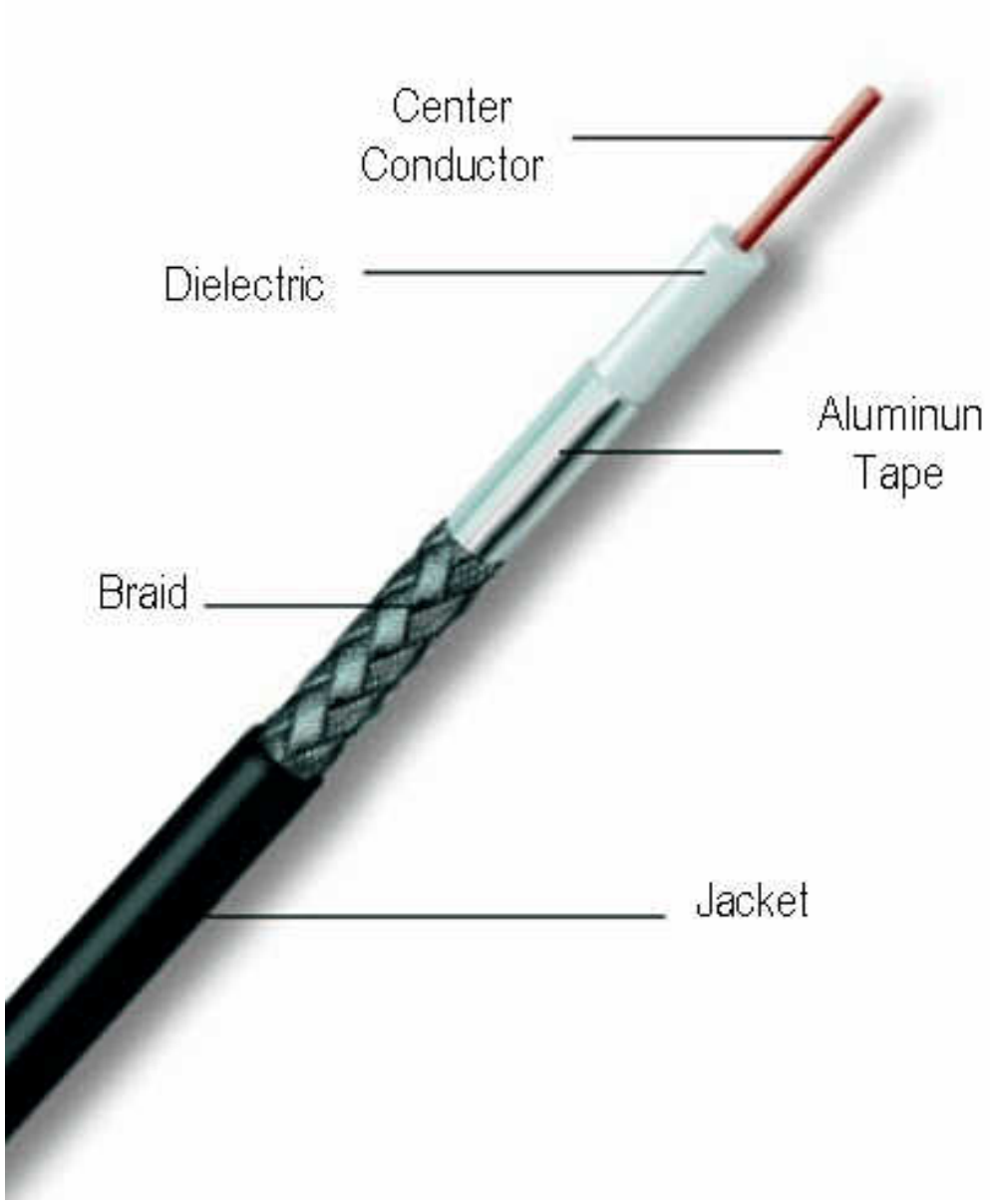


Figure 161 co-axial cable

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