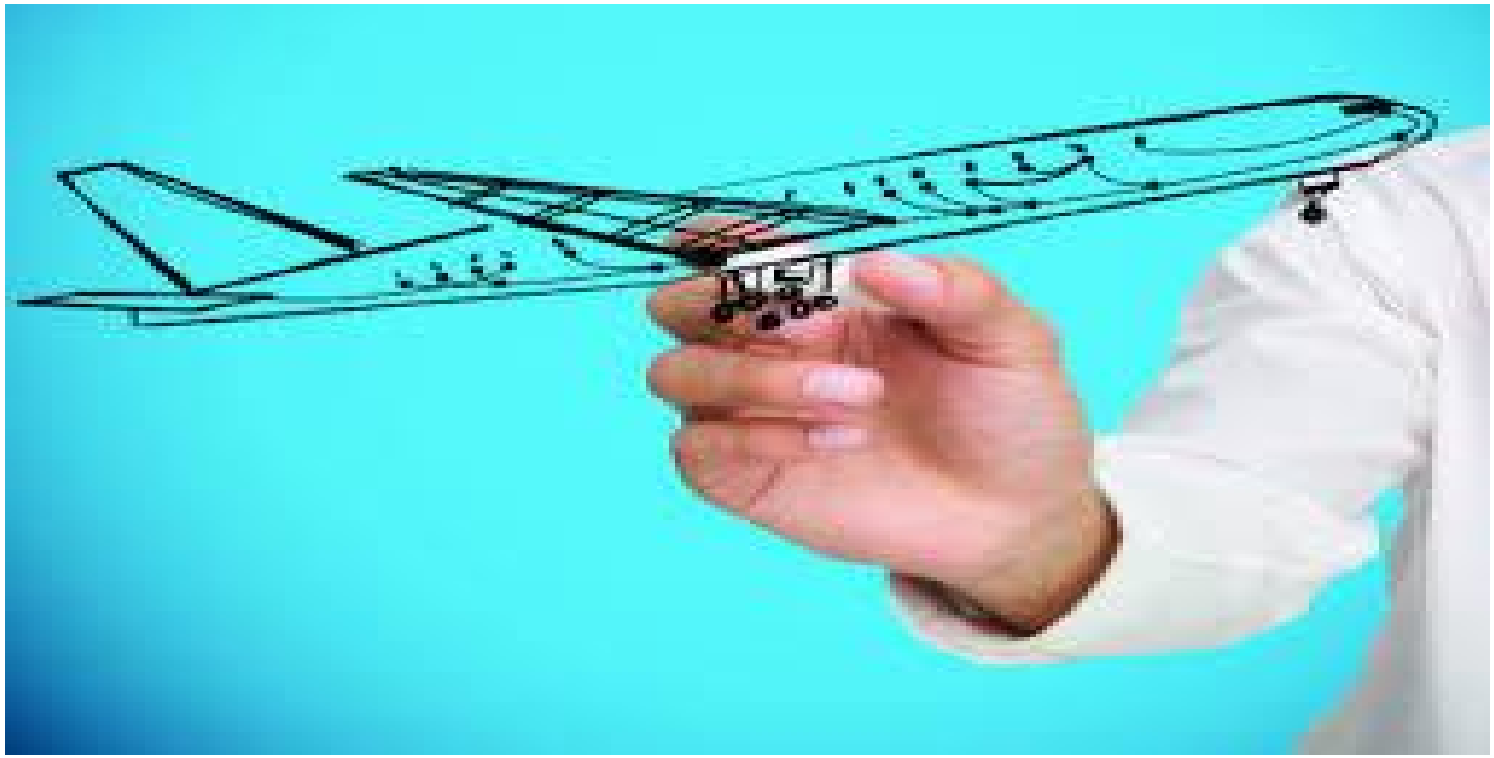


EWIS
Electrical Wiring Interconnection System

Goals of This Training…..

- Give you basic understanding of EWIS
- Show you some ways to protect EWIS from various factors.

- An **electrical wiring interconnection system** (EWIS) is the wiring system and components (such as bundle clamps, wire splices, etc.) for a complex system.
- originally designated as Electrical Interconnection Systems (EIS).
- The change from EIS to EWIS was done to emphasize the focus on the actual wires and wiring of the systems throughout aircraft

Content

EWIS Definition

Electrical Wiring Interconnection system (EWIS) means any wire, wiring device, or combination of these, including termination devices, installed in any area of the aeroplane for the purpose of transmitting electrical energy, including data and signals, between two or more intended termination points. This includes:

(1) Wires and cables.
(2) Bus bars.
(3) The termination point on electrical devices, including those on relays, interrupters, switches, contactors, terminal blocks, and circuit breakers and other circuit protection devices.
(4) Connectors, including feed-through connectors.
(5) Connector accessories.
(6) Electrical grounding and bonding devices and their associated connections.
(7) Electrical splices.
(8) Materials used to provide additional protection for wires, including wire insulation, wire sleeving, and conduits that have electrical termination for the purpose of bonding.
(9) Shields or braids.
(10) Clamps and other devices used to route and support the wire bundle.
(11) Cable tie devices.
(12) Labels or other means of identification.
(13) Pressure seals.

(14) EWIS components inside shelves, panels, racks, junction boxes, distribution panels and back-planes of equipment racks, including, but not limited to, circuit board back-planes, wire integration units and external wiring of equipment;

EWIS Definition

Excluded from the definition are EWIS components inside the following equipment and any associated external connectors:

(1) Electrical equipment or avionics qualified to environmental conditions and testing procedures when those conditions and procedures are appropriate for the intended function and operating environment.
(2) Portable electrical devices that are not part of the type design of the aeroplane. This includes personal entertainment devices and laptop computers
(3) Fiber optics.

Summary

In the year 2008, the main agencies responsible for air safety (EASA/FAA) amended the certification requirements applicable to commercial transport aircraft CS-25/FAR 25, for the interconnection electrical wiring systems (EWIS), with the goal to guarantee safe aircraft operations for the whole of their operational life period.

These requirements are applied in accordance to the conclusions and recommendations obtained during the program for the Airworthiness improvement regarding aircraft systems (EAPAS) established by the FAA after several accidents (TWA 800, SWISSAIR 111).

As a consequence of the introduction of these new requirements in the legal frame established by EASA/FAA, it is also required that Commercial Aircraft Operators, Airworthiness Management Organizations (CAMO) and Maintenance Organizations (Part 145) be familiar with EWIS applicable requirements that affect their inspection, maintenance and repair tasks.

Regulations applicable:

- EASA Regulation Applicable Sections (OPS-1, Part M, Part 145)
  Applicable Guide Material
- EASA AMC 20-21 - Programme to enhance aeroplane Electrical Wiring Interconnection System (EWIS)
- EASA AMC 20-22 - Aeroplane Electrical Wiring Interconnection System Training Programme
- EASA AMC 20-23 - Development of Electrical Standard Wiring Practices documentation
- FAA AC120-94 – Aircraft Wiring Interconnection Systems Training Programme

EASA Regulation Applicable Sections

AMC 20-21 - Programme to enhance aeroplane Electrical Wiring Interconnection System (EWIS) maintenance

AMC 20-22 Effective: 05/09/2008
Annex III to ED Decision 2008/007/R of 29/08/2008

This AMC was heavily based around maintenance providers and maintaining organisations with the emphasis being on enhancing maintenance procedures and inspection based on extensive research into aircraft wiring standards.
Objective was to promote new Enhanced Zonal Analysis Procedures (EZAP). To ensure appropriate attention was given to aircraft wiring and its related maintenance. New Guidance for General Visual Inspections (GVI) and it touches on the issue of staff and their awareness and training

AMC 20-22Aeroplane Electrical Wiring Interconnection System Training Programme

AMC 20-22 Effective: 05/09/2008
Annex III to ED Decision 2008/007/R of 29/08/2008

This AMC has been published in order to provide the approved organisations with acceptable means of compliance to comply with their training obligations as required in paragraphs 21.A.145 and 21.A.245 of Part-21, 145.A.30 and 145.A.35 of Part-145 and M.A.706 of Part-M with respect to EWIS.

EASA Regulation Applicable Sections

AMC 20-23 - Development of Electrical Standard Wiring Practices documentation

This AMC was heavily based around manufactures and TC holders and their terms for producing electrical wiring documentation

It was based on information from the FAA, which in turn came from a body called ASTRAC (The Aging Transport Systems Rulemaking Advisory Committee). EASA sits on the board of ASTRAC so in a round about EASA has been involved from conception.

Objective was to promote common standards, terms and content of any documents produced – ie Electrical Standard Wiring Practices Manual (ESWPM)

Contents:

- Cleaning
- Wire identification
- Standard practices – clamping, routing, repair/replacement, inspection methods

EASA Regulation Applicable Sections

Electrical Wiring Interconnection System Modules (AMC 20-22)

Module A – General electrical wiring interconnection system practices
Module B – Wiring practices documentation
Module C – Inspections
Module D – Housekeeping
Module E – Wire
Module F – Connective devices
Module G – Connective device repair

Target groups

Target Group 1: qualified staff performing EWIS maintenance
Target Group 2: qualified staff performing EWIS maintenance inspections
Target Group 3: qualified staff performing electrical/avionics engineering on in-service aircraft
Target Group 4: qualified staff performing general maintenance and/or inspections not involving wire maintenance (an LRU change is not considered wire maintenance)
Target Group 5: qualified staff performing other engineering or planning work on in-service aircraft
Target Group 6: other service staff with duties in proximity to electrical wiring interconnection systems
Target Group 7: flight deck crew
Target Group 8: cabin crew

EWIS Minimum Initial Training Program for Group

Target Group	Description as per ED/2008/007/R	Interpretation of who it applies to (UKCAA agreed)	Modules Required	Training Solution
1	Qualified staff performing EWIS maintenance. These staff members are personnel who perform wiring systems maintenance and their training is based on their job description and the work being done by them (e.g. avionics skilled workers or technicians cat B2).	Full B1.1 (no limitations) B2 and unlicensed avionic mechanics	Full Modules A, B, D, F, G Part Modules C, E	Theory and Practical, as appropriate to target group
2	Qualified staff performing maintenance inspections on wiring systems. These staff members are personnel who perform EWIS inspections (but not maintenance) and their training is based on their job description and the work being done by them (e.g. inspectors / technicians cat B2).	As per Target Group 1 when the local job description specifies inspection only	Full Modules B, C, E, F Part Modules A, D	Theory only, as appropriate to target group
3	Qualified staff performing electrical/avionic engineering on in-service aeroplanes. These staff members are personnel who are authorised to design EWIS installations, modifications and repairs (e.g. electrical / avionic engineers).	Part M and Part 21 personnel	Full Modules B, E, F Part Module D	
4	Qualified staff performing general maintenance/inspections not involving wire maintenance (LRU change is not considered wire maintenance). These staff members are personnel who perform maintenance on aeroplanes that may require removal/reconnection of electrical connective devices (e.g. inspectors/technicians cat A or B1).	Limited B1.1 (limitations 1 and 9), Cat A1 and unlicensed mechanics	Full Modules A, D Part Modules C, E	
5	Qualified staff performing other engineering or planning work on in-service aeroplanes. These staff members are personnel who are authorised to design mechanical/structure, systems installations, modifications and repairs, or personnel who are authorised to plan maintenance tasks.	Part M and Part 21 personnel	Full Module C Part Modules D, E	
6	Other service staff with duties in proximity to EWIS. These staff members are personnel whose duties would bring them into contact/view of aeroplane wiring systems. This would include, but not be limited to: aeroplane cleaners, cargo loaders, re-fuelling staff, lavatory servicing personnel, de-icing personnel, push back personnel.	As per ED description	Part Modules A, C, D, E (Low level only)	
7	Flight deck crew	As per ED description	Part Modules A, C, D, E (Low level only)	
8	Cabin crew	As per ED description		

MODULE A – GENERAL ELECTRICAL WIRING INTERCONNECTION SYSTEM PRACTICES:

Objective: Know or demonstrate safe handling of aeroplane electrical systems, line replaceable units (LRUs), tooling, troubleshooting procedures, and electrical measurement.

(1) Safety practices
(2) ESDS device handling and protection
(3) Tools, special tools and equipment
(4) Verify calibration/certification of instruments, tools, and equipment
(5) Required wiring checks using the Troubleshooting Procedures and charts
(6) Measurement and troubleshooting using meters
(7) LRU replacement general practices

A. (1) Safety practices

Objective: Know the safety procedures of normal and non-normal maintenance procedures so the person can protect him/herself and the aeroplane.

a. Current is lethal - First aid
b. Applying power to the aeroplane
c. Isolating the circuit
d. Aeroplane warnings
e. Human Factors

Safety practices

In the performance of your duties, you come across many potentially dangerous conditions and situations. You install, maintain, and repair electrical and electronic equipment in confined spaces where high voltages are present. Among the hazards of this work are injury caused by electric shock, electrical fires, and harmful gases. Also, you must include improper use of tools among these hazards. Common sense and carefully following established rules will produce an accident-free environment.

Some general safety precautions that you should follow are shown below:

. **Report any unsafe condition**, or any equipment or material that you consider to be unsafe, to the immediate supervisor.

. **Warn others** you believe to be endangered because of known hazards or who fail to follow safety precautions.

. **Wear or use approved protective clothing or equipment** for the safe performance of work or duty.

. **Report** to the supervisors **any injury** or evidence of impaired health occurring during work or duty.

. **Exercise reasonable caution** during any unforeseen hazardous occurrence, as is appropriate to the situation.

Before you work on an electrical or electronic apparatus, remove all rings, wristwatches, bracelets, and similar metal items. Make sure that your clothes do not contain exposed zippers, metal buttons, or any type of metal fastener.

Make sure warning signs and suitable guards are posted to prevent personnel from coming into accidental contact with high voltages.

Current is lethal - First aid

First Aid for Electric Shock

Electric shock produces a jarring, shaking sensation. The victim usually feels like he/she just received a sudden blow. If the voltage and resulting current is high enough, the victim may become unconscious. Severe burns may appear on the skin at the place of contact. Muscular spasm may occur, causing the victim to clasp the apparatus or wire causing the shock. If this happens the victim is unable to release it.

Use the following procedures for rescuing and caring for shock victims:

1. Remove the victim from electrical contact at once. DO NOT ENDANGER YOURSELF. Remove the victim by throwing the switch if it is nearby, or cut the cable or wires to the apparatus using an axe with a wooden handle. Protect your eyes from the flash when the wires are severed. Also, you can use a dry stick, rope, belt, coat, blanket, or any other nonconductor of electricity to drag or push the victim to safety.

2. Determine whether the victim is breathing. Keep the person lying down in a comfortable position and loosen the clothing about the neck, chest, and abdomen for easy breathing. Protect from exposure to cold, and watch closely.

3. Keep the victim from moving. In this condition, the heart is very weak. Any sudden muscular effort or activity of the patient may result in heart failure.

4. Do not give stimulants or opiates. Send for a medical doctor at once, and do not leave the patient until adequate medical care is available.

5. If the victim is not breathing, apply artificial ventilation without delay, even though the patient may be lifeless. Do not stop artificial respiration until the victim revives, or proper authority pronounces the victim is beyond help.

Aeroplane warnings

General

Assessment of existing conditions, good judgement and common sense must be exercised by airline personnel.

A. Before Maintenance Work Starts

To prevent injury to personnel and damage to equipment during maintenance operations on electrically operated equipment or while performing maintenance on any part of the electrical/electronic systems, use these safety practices:
(1) Identify the system that maintenance work is to be done on.
(2) Open circuit breakers and switches to make sure that power has been cut off from system components.
(3) Put this Warning Tag on the circuit breakers:

Warning: Do not close this circuit breaker. This circuit breaker must remain open until completion of maintenance work.

(4) To make sure that a circuit breaker will remain open, install a circuit breaker collar.
(5) Put this Warning Tag on the switches:
WARNING: DO NOT MOVE THIS SWITCH FROM THE OFF POSITION UNTIL MAINTENANCE WORK HAS BEEN COMPLETED.

Aeroplane warnings

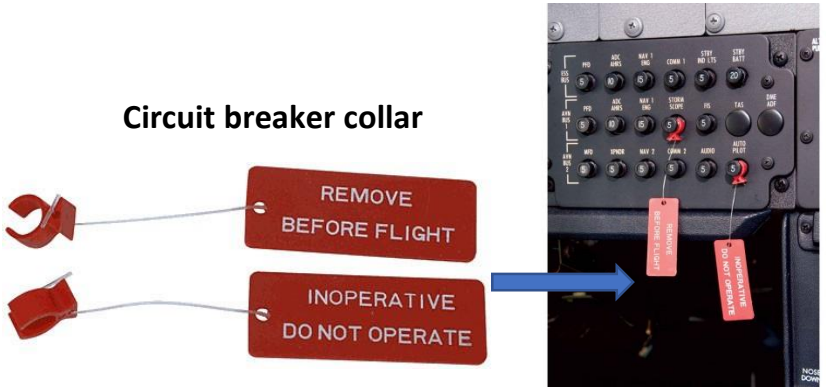
B. After Maintenance Work Ends

(1) Make sure that all switches and controls are in a position that prevents the accidental operation of any component.
(2) Remove the warning tags and close the circuit breakers and switches that were opened before the work started.
(3) Energize the system.
(4) Perform the required operational checks.
(5) When the checks have been satisfactorily completed, return the switches and controls to their normal shutdown positions.

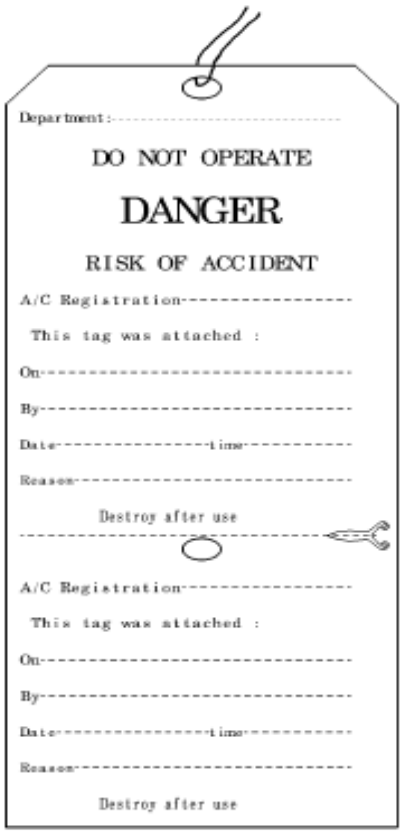
C. Circuit Breaker Reset

When a circuit breaker trips or opens, do not attempt to reset or close the breaker until the discrepancy or malfunction that caused the breaker to trip or open has been determined and corrected.

Circuit breaker collar



EWIS



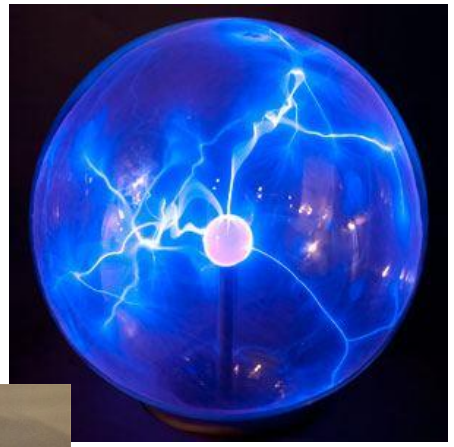
SIS 20 10 00 0 ACMO 00

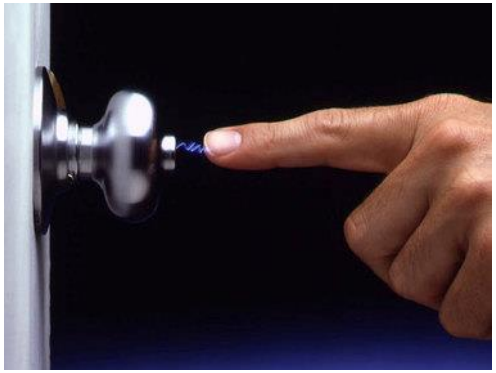
Safety Practices - Typical Tag
Figure 001

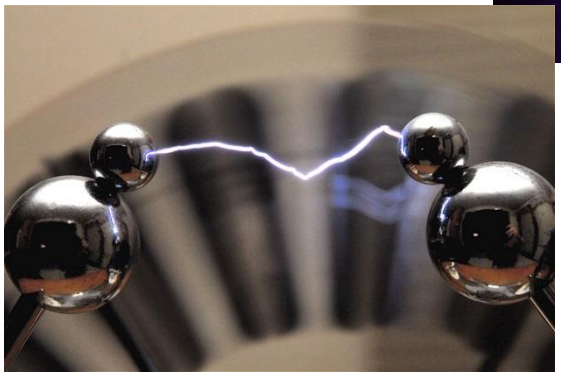
A. (2) ESDS device handling and protection

Objective: Recognize Electrostatic Discharge Sensitive (ESDS) equipment and demonstrate standard anti-static procedures so that no damage occurs to that equipment.

a. Sources of electrostatic discharge
b. Soft and hard failures
c. ESDS safety procedures
d. ESDS handling/packing procedures







Sources of electrostatic discharge

Static electricity is electrical energy at rest. Some substances readily give up electrons while others accumulate excessive electrons. When two substances are rubbed together, separated or flow relative to one another, such as a gas or liquid over a solid, one substance becomes negatively charged and the other positively charged. An electrostatic field or lines of force emanate between a charged object to an object at a different electrostatic potential, such as one with more or less electrons, or ground. Objects entering this field will receive a charge by induction. The capacitance of the charged object relative to another object or ground also has an effect on the field. If the capacitance is reduced, there is an inverse linear increase in voltage, since the charge must be conserved. As the capacitance decreases, the voltage increases until a discharge occurs via an arc.

Generation of static electricity on an object by rubbing is known as the triboelectric effect. The size of an electrostatic charge on two different materials is proportional to the separation of the two materials.
Electrostatic voltage levels generated by nonconductors can be extremely high. However, air will slowly dissipate the charge to a nearby conductor or ground. The more moisture in the air the faster a charge will dissipate.

POSITIVE (+)
ACETATE
GLASS
HUMAN HAIR
NYLON
WOOL
FUR
ALUMINUM
POLYESTER
PAPER (Small positive charge)
COTTON (No charge)
0
STEEL (No Charge)
WOOD (Small negative charge)
ACETATE FIBER
NICKEL, COPPER, & SILVER
BRASS & STAINLESS STEEL
RUBBER
ACRYLIC
POLYSTYRENE FOAM
POLYURETHANE FOAM
SARAN
POLYETHYLENE
POLYPROPYLENE
PVC (VINYL)
KEL-F
TEFLON
NEGATIVE (-)

Lists substances in the triboelectric series

Types of damage

Failures occur in two forms:
Catastrophic – Failures occur when a component is damaged to a point where it is Dead on Arrival and it will never function again.
Latent – This occurs when ESD weakens or damages the component to the point where it will still function properly during testing, but over time the damage components will cause intermittent system performance and eventually complete system failure.

EWIS

ESDS

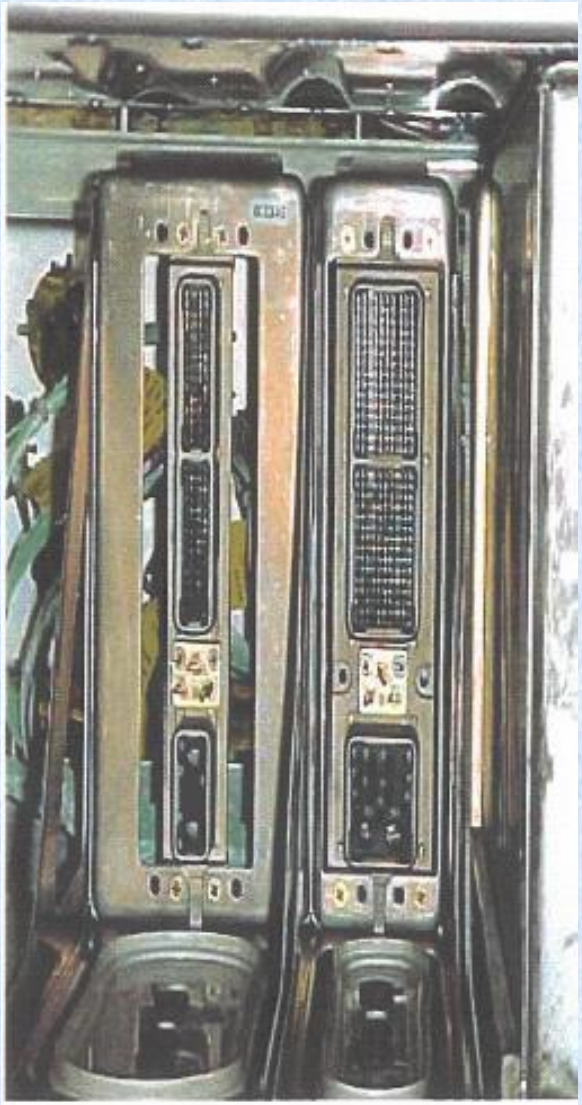
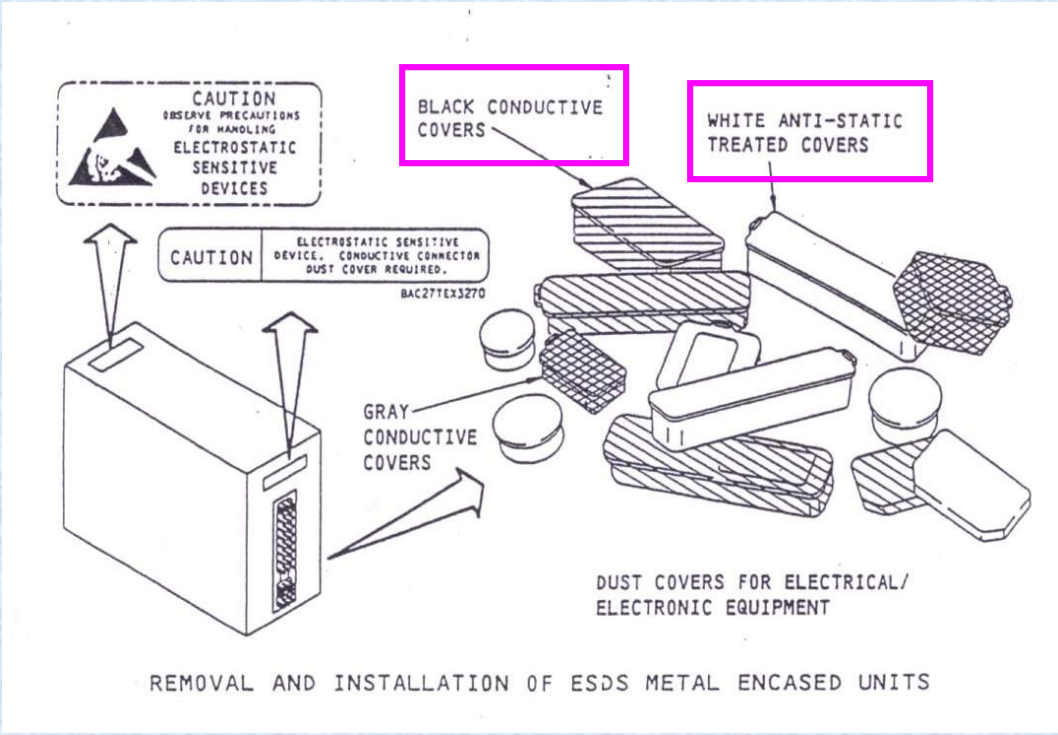


Figure 3.9 LRU Rack



REMOVAL AND INSTALLATION OF ESDS METAL ENCASED UNITS

ESDS device handling and protection

The following are general guidelines applicable to the handling of ESDS devices:

. Make sure that all containers, tools, test equipment, and fixtures used in ESD protective areas are grounded before and/or during use, either directly or by contact with a grounded surface.

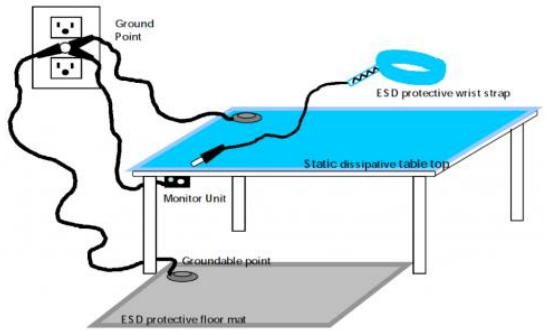
. Personnel handling ESDS items must avoid physical activities in the vicinity of ESDS items that are friction-producing, for example, removing or putting on smocks, wiping feet, sliding objects over surfaces, etc.

. Personnel handling ESDS items must wear cotton smocks and/or other anti-statically treated clothing.

. Avoid the use or presence of plastics, synthetic textiles, rubber, finished wood, vinyl, and other static-generating materials where ESDS items are handled out of their ESD protective packaging.

. Place the ESD protective material containing the ESD item on a grounded work bench surface to remove any charge before opening the packaging material.

ESDS markings



ESDS device handling and protection

. Personnel must attach personnel grounding straps to ground themselves before removing ESDS items from their protective packaging.
. Remove ESDS items from ESD protective packaging with fingers or metal grasping tool only after grounding and place on the ESD grounded work bench surface.
. Make periodic electrostatic measurements at all ESD protected areas. This assures the ESD protective properties of the work station and all equipment contained there have not degraded.
. Perform periodic continuity checks of personnel ground straps (between skin contact and ground connection), ESD grounded work station surfaces, conductive floor mats, and other connections to ground. Perform this check with a megohmmeter to make sure grounding resistivity requirements are met.

ESD Protective Materials

There are two basic types of ESD protective materials:

1. Conductive – Conductive materials protect ESD devices from static discharges and electromagnetic fields.
2. Anti-static – Anti-static material is a static inhibiting material. Other than not generating static, anti-static material offers no other protection to an ESD device.

A. (3) Tools, special tools and equipment

Objective: Demonstrate the correct use of hand tools including specialized and automated tools and equipment.

a. General hand tools
b. Specialized tools
c. Automated tools and equipment

Tools and equipment

Tools are such a common part of our lives that it is difficult to remember that they may pose hazards. Tragically, a serious incident can occur before steps are taken to identify and avoid or eliminate tool-related hazards. Employees who use hand and power tools and are exposed to the hazards of falling, flying, abrasive, and splashing objects, or to harmful dusts, fumes, mists, vapors, or gases must be provided with the appropriate personal protective equipment. All electrical connections for these tools must be suitable for the type of tool and the working conditions (wet, dusty, flammable vapors). When a temporary power source is used for construction a ground-fault circuit interrupter should be used.
Employees should be trained in the proper use of all tools. Workers should be able to recognize the hazards associated with the different types of tools and the safety precautions necessary.

Five basic safety rules can help prevent hazards associated with the use of hand and power tools:

- Keep all tools in good condition with regular maintenance.
- Use the right tool for the job.
- Examine each tool for damage before use and do not use damaged tools.
- Operate tools according to the manufacturers' instructions.
- Provide and use properly the right personal protective equipment.

Employees and employers should work together to establish safe working procedures. If a hazardous situation is encountered, it should be brought immediately to the attention of the proper individual for hazard abatement.

Tools and equipment

Hand tools are tools that are powered manually. The greatest hazards posed by hand tools result from misuse and improper maintenance. The employer is responsible for the safe condition of tools and equipment used by employees. Employers shall not issue or permit the use of unsafe hand tools. Employees should be trained in the proper use and handling of tools and equipment.

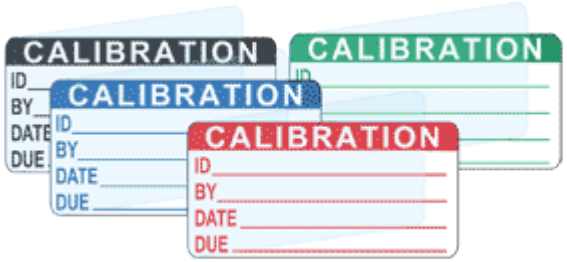
Special tools are normally maintained in a central tool room and signed out when needed. A tool falls into the *special* category for one of the following five main reasons.
- It is an item of special support equipment. These tools are designed, manufactured, and issued for supporting or maintaining one particular model of aircraft, engine, or support equipment.
- It is a seldom used tool. When needed, its use is essential in aircraft maintenance. Most of the time it is not required and would just take up room in the toolbox.
- It is a high-cost item. A central location is necessary to permit better use or for security.
- The large size or awkward shape of the tool makes it difficult, if not impossible, to put in a toolbox.
- It is an instrument type of tool that requires calibration.

Automated tools and equipment - precautions to follow when working with machinery are as follows:
1. Never operate a machine with a guard or cover removed.
2. Never operate mechanical or powered equipment unless you know how to operate them. When in doubt, consult the appropriate instruction or ask someone who knows.
3. Always make sure that everyone is clear before starting or operating mechanical equipment.
4. Cut off the source of power before trying to clear jammed machinery.
5. Always keep everyone clear when hoisting heavy machinery or equipment by a chain fall. Guide the hoist with lines attached to the equipment.
6. Never plug in electric machinery without knowing that the source voltage is the same as that called for on the nameplate of the machine.

A. (4) Verify calibration/certification of instruments, tools, and equipment

Objective: Verify the calibration of electrical measuring instruments, tools and equipment so that correct maintenance procedures may be carried out.

a. Tools requiring certification
b. Determining certification requirements
c. Typical problems




DMC
1.439
RAISE TO ROTATE
PUSH POSITIONER AND ROTATE 90° TO INSTALL
DMC-USA
CAGE 11851
SEL. NO.


Custom Stripmaster


PANDUIT GS4H


Custom Strippmaster

AIRBUS INDUSTRIE
ELECTRICAL STANDARD PRACTICES MANUAL

D. Position of Wire Insulation after Crimping (Barrel Closed) and (Open Barrel)
(Ref. Fig. 002, 003)

3. Procedure

A. Pre-crimping checks

(1) Wire shall be correctly stripped (Ref.Chapter. STRIPPING TOOL).

(2) Check correct combination of cable, tool, terminal end or connector

A. Pre-crimping checks

(1) Wire shall be correctly stripped (Ref.Chapter. STRIPPING TOOL).

(2) Check correct combination of cable, tool, terminal end or connector.

(a) Crimping tool and locator shall be correctly selected (Ref. CRIMPING TOOLS tables).

(b) Before use, every tool shall be checked for:
- Identification (tool serial No.) with its own particular history card.
  The tool used will not nave exceeded 1000 crimps on an interval of 12 months without being tested, unless otherwise stated,
- cleanliness of die faces,
- freedom from damage,
- freedom from corrosion,
- freedom from wear.
  Tools in regular use shall be cleaned daily to avoid build up of dirt and plating on die faces.
  Care shall be taken not to damage the die faces.

articular

s on an interval
wise stated,

avoid build up

isual checks:

that they cannot

female contact

- acceptable geometrical distortion, correct die mark,
- wire visible through inspection hole, if applicable,
- position of insulation after crimping,
  (Ref. Fig. 002)
- position of wire after crimping,
  (Ref. Fig. 003)

EFF : ALL

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Page 3
Apr 01/01

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- no strands outside the crimping barrel (and/or extending out the inspection hole),
- no cut strands,
- adequate insertion of conductor strands in barrel where it is possible to check without damaging conductor,
- absence of damage to the conductor.

NOTE : It is recommended that each crimp has a gentle manual pull applied in order to establish there is no movement of conductor within the crimp.
Due consideration must however be given to the size of cable under inspection.

4. Periodic Tests

A. Test Intervals
- Each new tool before use shall be submitted for gauging, where applicable, and specimen checks.
- Each tool shall be submitted for gauging at 1000 and 2000 crimps and only if successful, returned for use. The checking at 3000 crimps shall be by gauging and specimen checks. This procedure shall be followed at subsequent 1000 crimp checks.
- All tools not in regular use shall be similarly checked every 12 months to the gauging requirements.

- All tools not in regular use shall be similarly checked every 12 months to the gauging requirements.

B. Gauging of Tools :
(Ref. Fig. 004)
Each tool or die shall be tested by the insertion of GO/NO GO gauge.

(1) Example:
Gauge part number : M22520/3-1

(2) Procedure:
- A GO-NO GO gauge is used to check condition of crimping tool. When tool handles are squeezed, the GO element must pass through the dies, the NO-GO element must not pass.
- Only one gauge is necessary for periodic in-service inspection of crimping tool, examples:

Calibration/certification of instruments, tools, and equipment

Calibration is a set of operations, performed in accordance with a definite documented procedure that compares the measurement performed by a measurement device or working standard for the purpose of detecting and reporting or eliminating by adjustment errors in the measurement device, working standard, or aeronautical product tested.

Calibration label. A label affixed to a measurement device, precision tool and/or test equipment that shows its calibration status. The label typically indicates the measurement device, identification, who performed the last calibration and when.

Calibration facility or laboratory. A work space provided with calibrated measurement device(s), controlled environment and trained personnel established for the purpose of maintaining proper operation and accuracy of measurement devices.

Calibrator. A secondary standard that supplies outputs with a known uncertainty for use in checking the accuracy of measurement devices.

Measurement Device. A calibrated calibrator, standard, tool, equipment and test equipment that is intended to be used to test, measure, or calibrate working standards or other measurement devices. It is not to be used to test, measure, or calibrate an aircraft or aeronautical product.

Primary Standard. A standard defined and maintained by a State Authority and used to calibrate secondary standards.

Reference Standard. A standard that is used to maintain working standards.

Secondary Standard. A standard maintained by comparison with a primary standard.

For the purpose of clarification and standardization, tools, equipment and test equipment used by an AMO (Approved Maintenance Organisation) for product acceptance and/or for making a finding of airworthiness are otherwise known as working standards.

Calibration/certification of instruments, tools, and equipment

Sources of Error in Measuring Instruments

The main sources of error in a measuring system may be summarised as follows:

(a) The observation error, which is the error committed by the observer when reading the indication of an instrument. The main reasons for errors of this type are simple misreading, errors due to parallax , or faulty estimation of the fractional part of a scale interval.

(b) The scale error, due to the difference between the actual position of the scale mark and its theoretical position on a scale correctly graduated in accordance with the assumed law of operation of the instrument, i.e. the instrument scale may not be perfect.

(c) The indication error which is defined as the error obtained by subtracting the true value of the quantity measured from the indicated value, due regard being paid to the sign of each. When the instrument is in the specified conditions of use, and a physical quantity is presented to it for the purpose of verifying the setting, the indication error may be referred to as datum error.

(d) Zero-error which is the indication when the instrument is in the specified conditions of use and the magnitude of the physical quantity presented to it is zero. The limits of error for a measurement system are the positive and/or negative values of the errors which must not be exceeded under test. In the case of indication errors the limits may be expressed in the following ways:

1)Directly in units of the measured quantity.

2) As a percentage of the full-scale deflection (e.g. error 10% F.S.D.). c) Is a percentage plus or minus of the expected reading (e.g. ± 1% error at 30°C). Errors are often expressed in this form when the error varies over the working range.

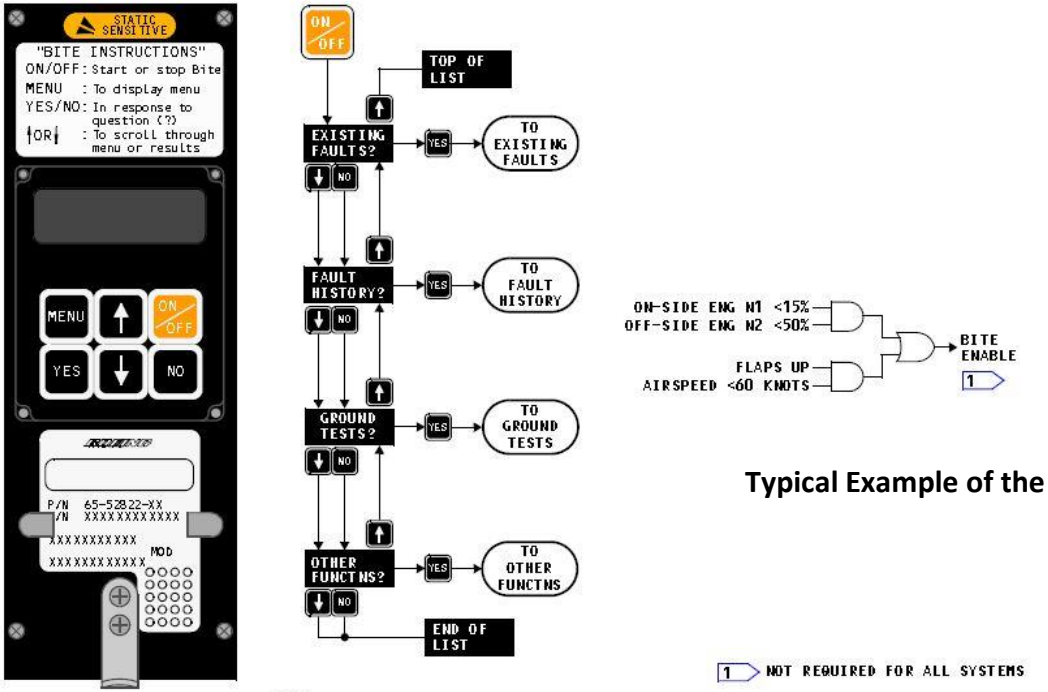
A. (5) Required wiring checks using the Troubleshooting Procedures and charts

Objective: Demonstrate the process and procedures to successfully use the Troubleshooting Procedures and charts of current aeroplane faults and know re-occurring problems causing "No Fault Found" on removed LRU's.

a. Troubleshooting procedures manual (all chapters)
b. Aeroplane Maintenance Manual / Illustrated Parts Catalogue
c. Wiring schematics / Troubleshooting graphics
d. Wiring diagrams
e. The process of troubleshooting
f. Testing of LRU connectors
g. Troubleshooting exercises
h. Company "No Fault Found" policy and data

LRU Troubleshooting

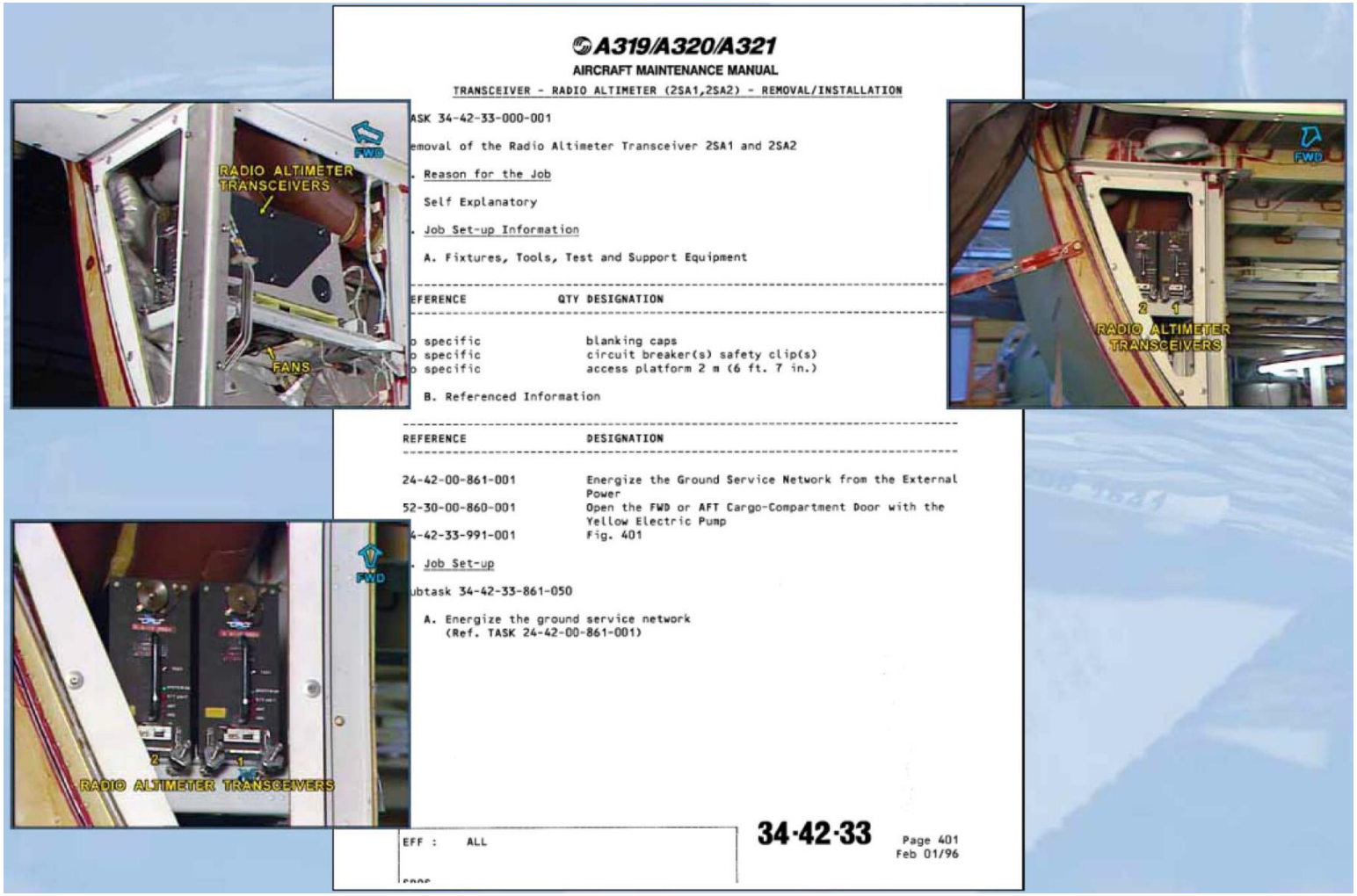
Line Replaceable unit troubleshooting is one of the few methods which are employed to locate and to quickly isolate and confirm a defect which is seen in the flight deck for several systems. Most major computers that are installed in the aircraft have “BITE” (Built in Test Equipment) which continuously monitors the unit for errors and faults and some my store those faults in a fault history memory.
Integrity of the component or computer in question can be checked by carrying out a bite test and test results or fault history will be displayed on the front of the unit or it may be shown as a bite display for an aircraft which is equipped with a “CMC” (Central Maintenance Computer)



737 GENERAL - BITE - BOEING BITE - MAIN MENU

Typical Example of the Boeing TYPE LRU which is BITE capable

LRU Troubleshooting



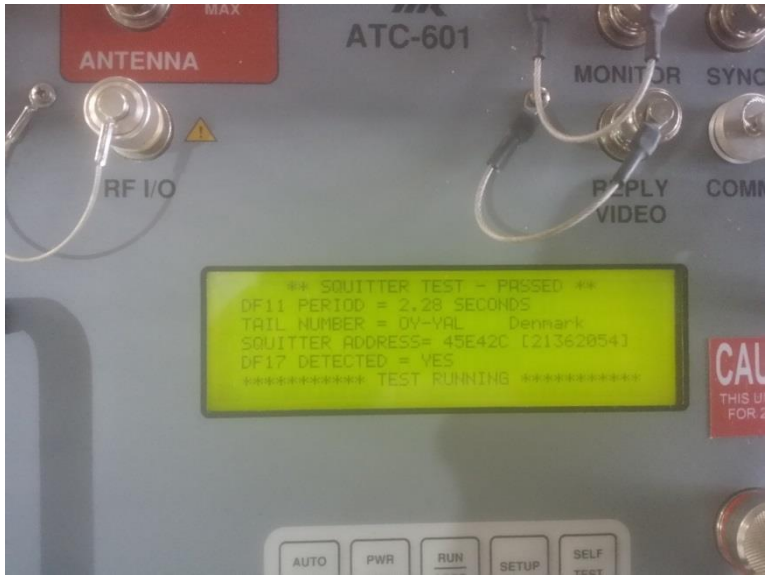
LRU Troubleshooting

Typical example of the ACSS T2CAS system computers which has a BITE capability on the front face of the box which shows its integrity of operation. Test capability is located in the front face of the component when there is no CMC/ CMS capability possible ACSS T2CAS is a combination of EGPWS and TCAS computers which are combined into a single unit.

Large connector located on the front face of the box allows the functional check to be carried out where the ACSS T2CAS computer can be linked to a laptop with appropriate software via a test cable to allow detailed functional checks to be carried out on the output and input data.

ACSS T2CAS computer with BITE capability on the front face of the box

LRU Troubleshooting

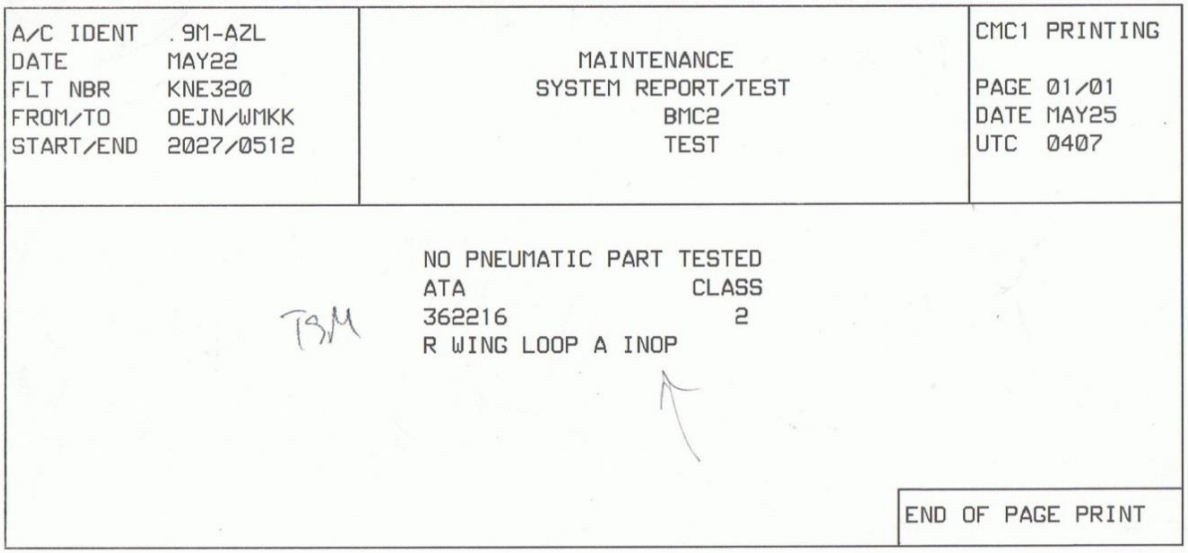


Typical ATC-601 transponder test equipment.

Transponder LRU functional test carried out by using an external test equipment. External test equipment required will be specified in the AMM. It may also specify the use of an alternate test equipment. In this case the ATC-601 is employed. A similar test equipment that can be used is a IFR-6000 by AEROFLEX.
The example shown here shows that external test equipment is required to carry out the functional check of the transmitted SQUITTER ADDRESS which is a MODE-S transponder code. There are multiple tests that are carried out and the results of the tests can be shown on the test equipment.
Note in the case of a typical transponder system. Tests are required to be carried out on system #1 and System #2. Tests results are then compared.

LRU Troubleshooting

On the AIRBUS type aircraft A320/A320/A380 CMC's are employed to control and monitor the vast numbers of individual computers and integrated software which are installed. CMC are used primarily to isolate and rectify defects.
The example shown is a typical message with a failure which is obtained from the CMC.
The fault message is shown as 362216. This message is then used together with the Troubleshooting Schematic manuals to rectify the defect.



Typical example of CMC defect and print-out from A330.
Similar information can be viewed from the MCDU

LRU Troubleshooting

In LRU troubleshooting, we have to consider equipment which do not have BITE capability.
What do we do then???

ATR in flight Altitude 3000ft / ASI 160 Knots. Note Engine ITT 530 and 595 and Right Fuel temperature in the Yellow BAND.

Example above shows an ATR type aircraft in flight with the RH engine ITT (Integrated Turbine Temperature) showing a significantly higher reading compared to the LH engine.

LH engine ITT 530
RH engine ITT 595
The engineer has to decide in this case if the defect is a genuine high ITT on the RH engine or is it an indicator defect. Typical digital/analogue indicators of these type may have a bite test button on the front of the display. These tests show the indicator integrity but cannot show if the source temperature is genuine. In troubleshooting this defect is then pertinent to swap the #1 and #2 ITT indicator to see if the defect transfers even if the BITE on the individual indicator has passed previously. If the defect transfers meaning the defect is probably caused by the indicator. If the defect does not transfer then there is a genuine overheat. With reference to the picture above, the defect was a genuine bleed leak within the RH engine. Also note there is also a temperature rise of the RH engine fuel temperature where the needle is in the YELLOW band due to increased temperatures within the nacelle area.

A. (6) Measurement and troubleshooting using meters

Objective: Demonstrate the correct use of electrical meters for measuring voltage, current, resistance, continuity, insulation and short to ground.

a. Voltage, current and resistance
b. Continuity
c. Insulation
d. Short to ground
e. Loop impedance.

Milliohm-Meter (MetraHit)

Analog Multimeter

Clip-on Ammeter

Digital Multimeter

Voltage, current and resistance

The avionics systems of an aircraft have been designed to be used as efficiently as possible. In spite of this, failures can always occur due to malfunctioning of indicators or parts of the transmission/receiving equipment. Other failures which occur very often are loose contacts in connectors or broken wires. Failures obstruct the functioning of systems and must be remedied quickly and correctly. To do this, it is important to locate the failure first and then determine the cause of a failure (troubleshooting). There are various techniques to locate failures: via BITE checks (Built in Test Equipment), by using troubleshooting trees or by electrical measuring. There are three basic for electrical measuring:

- Measuring electrical **current** with the help of an ammeter or clip-on ammeter.
- Measuring of **voltage** with the help of a voltmeter or a measuring probe.
- Measuring of **resistance** in a circuit with an ohmmeter or with a Wheatstone bridge. The insulation resistance meter is used for the measuring of very high resistances with high voltages. There are electro mechanical multi meters as well as electronic multi meters. The aircraft maintenance technician uses both. Each of these measuring instruments has its own Operator's Manual. This is a handbook supplied by the manufacturer. It describes how to use the instrument. The settings of the various electrical measuring instruments can differ.

Voltage, current and resistance

Safety Checklist

1. Use a meter that meets accepted safety standards.
2. Verify that the meter is calibrated and the time period therefore is not expired.
3. Only use test leads that have shrouded connectors and finger guards.
4. Use test leads with correct fitting pins, sockets and clips for taking measurements. Common test probes may slip off. Damage of electric circuits will result.
5. Inspect test leads for physical damage before making a measurement.
6. Use the meter to check continuity of the test leads.
7. Select the proper function and range for your measurement. At unknown volt-ages and currents start to read with the highest possible range.
8. Be aware of high current and high voltage situations and use the appropriate equipment, such as high voltage probes and high current clamps.
9. When measuring current without a clamp, turn the power off before connecting into the circuit.
10. Always disconnect the “hot” (red) test lead first.
11. Follow all equipment safety procedures.
12. Don't work alone.

urement display on **Measuring voltage** nock or dam

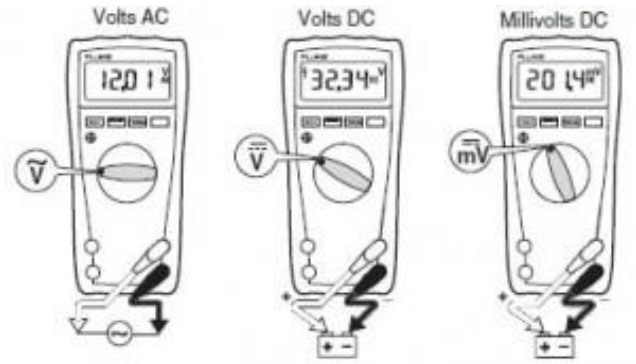
How to measure Ac & Dc voltages using a digital multimeter?

As all we know, an Ac voltage is generally flow in our houses and has a frequency of **50Hz** while Dc voltages flow in auto and household batteries and has a frequency of **0 Hz.**

Steps to measure voltage:

For the **measurement of voltage** following steps are described below:

1) Inside the COM jack insert the black lead.
2) Inside the VΩ jack insert the Red lead.
3) Turn the dial to voltage function either ac or dc.
4) Connect the black probe to the negative end of the battery.
5) Connect the Red probe to the positive end of the battery.
6) Connect firstly the black lead to the circuit and after that the Red lead.
7) Set AC or DC voltage as per your requirement.
8) Press specific button gave on the multimeter to measure dc mill volts & ac mill volts.
9) Note the measurement display on the LCD screen. When you have noted the readings, first remove the red lead from the circuit and then remove the black lead to avoid any electrical shock or damage to the device.



Measuring resistance

How to measure Resistance using a digital multimeter?

Resistance basically obstructs the path of flow of current. According to ohm's law, resistance is inversely proportional to current indicates that the more resistance will results in lesser current flow through the circuit.

Steps for measuring resistance:

1) Inside the com jack insert the black lead.
2) Inside the VΩ jack insert the Red lead.
3) Turn the dial to Ω.
4) Place the probes to the two end of the material.
5) Set resistance value as per your requirement.
6) For measurement, the meter sends small current through the circuit.
7) The resistance measured is the total resistance of all paths because the current flows through all possible paths between the probes.
8) Note the measurement display on the LCD screen. When you have noted the readings, first remove the red lead from the circuit and then remove the black lead to avoid any electrical shock or damage to the device.

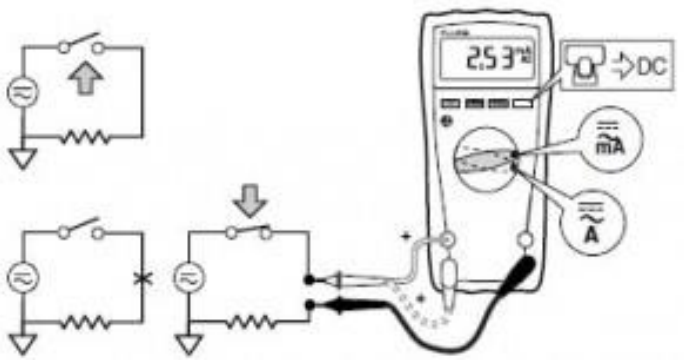
Measuring current

How to measure Ac & Dc current using a digital multimeter?

Steps to measure current:

For the **measurement of current** following steps are described below:

1) Inside the COM jack insert the black lead.
2) Inside the mA jack insert the Red lead.
3) Turn the dial to the current function.
4) Connect the black probe to the negative end of the battery.
5) Connect the Red probe to the positive end of the battery.
6) Set AC or DC current as per your requirement.
7) Connect firstly the black lead to the circuit and after that the Red lead.
8) Press specific button gave on the multimeter to measure dc mill ampere & ac mill ampere.
9) Note the measurement display on the screen. When you have noted the readings, first remove the red lead from the circuit and then remove the black lead to avoid any electrical shock or damage to the device.



Measuring continuity

How to test continuity with a digital multimeter?

Continuity is the physical property which indicates the ability of the material to conduct current through it. We perform continuity test to verify and check the soldering points and to debug the circuit for broken lines etc.

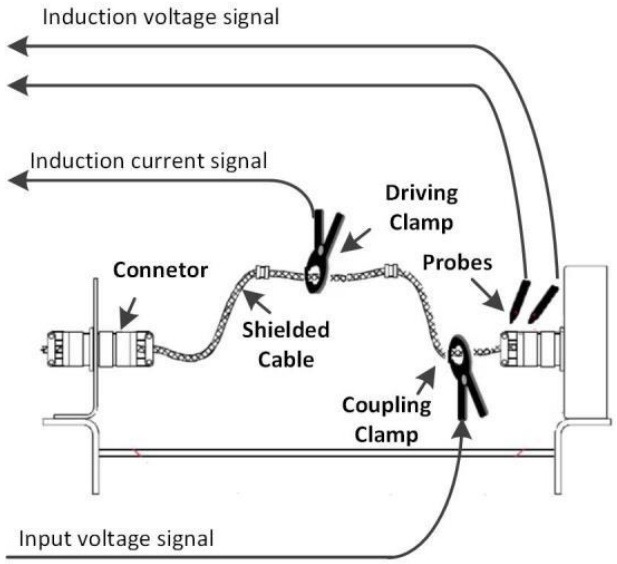
Steps for testing continuity :

For performing the **continuity test** following steps are described below:

1) Inside the COM jack insert the black lead.
2) Inside the mA jack insert the Red lead.
3) Turn the dial to the continuity function.
4) Place the probes at the two ends of the material that you want to check the continuity.
5) Connect firstly the black lead to the circuit and after that the Red lead.
6) Now if you hear the beep sound then the circuit connected is a closed circuit i.e. it is a conductor otherwise it is an open circuit.

Measuring loop impedance

1) The loop impedance measuring system is consist of driving clamp, coupling clamp, probes and processor.
2) To keep the coupler operating as close to ideal conditions as possible, loop impedance test system uses two magnetic couplers, one coupler is used to drive the voltage around the loop (drive coupler).
3) The second coupler is used to sense the current flowing in the loop (sense coupler).
4) Driver clamp can couple the driving voltage to the shield of the cable loop based on the principle of electromagnetic induction.
5) By connecting a coupler to the loop, the coupler forms the output winding and magnetic core of the transformer while the shield loop forms the input winding of the transformer.
6) The induction clamp can induction loop current. Then the loop current can be used to calculate to loop impedance. If the loop impedance beyond the threshold range, it shows that there is fault in the aircraft engine cable shield.
7) To troubleshoot a bad loop, the LRT has the joint mode where measuring the voltage across a joint (joint voltage) and loop current instead of measuring the loop voltage and the loop current.



A. (7) LRU replacement general practices

Objective: Know the removal and replacement techniques so that no damage will occur to the LRU or aeroplane connector.

a. Different retention devices
b. Certification considerations (e.g. CAT 2/CAT3 Landing)
c. LRU re-racking procedures
d. “No Fault Found” data (aeroplane specific)
e. Built in test equipment (BITE)

LRU replacement general practices

When replacing Line Replacement Units (LRUs), containing ESDs, on aircraft the following safety precautions must be observed.

a). All electrical power from the system should be removed by pulling the system circuit breaker(s).
b). If the power is not removed during LRU removal or installation, transient voltages may cause permanent damage.
c). After the removal of an LRU from its rack, a conductive shorting dust cap must be installed on each of its electrical connectors. Under no circumstances should the electrical pins in the connectors be touched by hand.
d). The conductive dust caps from the unit to be installed can be used on the unit being removed.
e). The removed unit is then transported with the conductive dust caps fitted.

MODULE B – WIRING PRACTICES DOCUMENTATION:

Objective: Know or demonstrate the construction and navigation of the applicable aeroplane wiring system overhaul or practices manual.

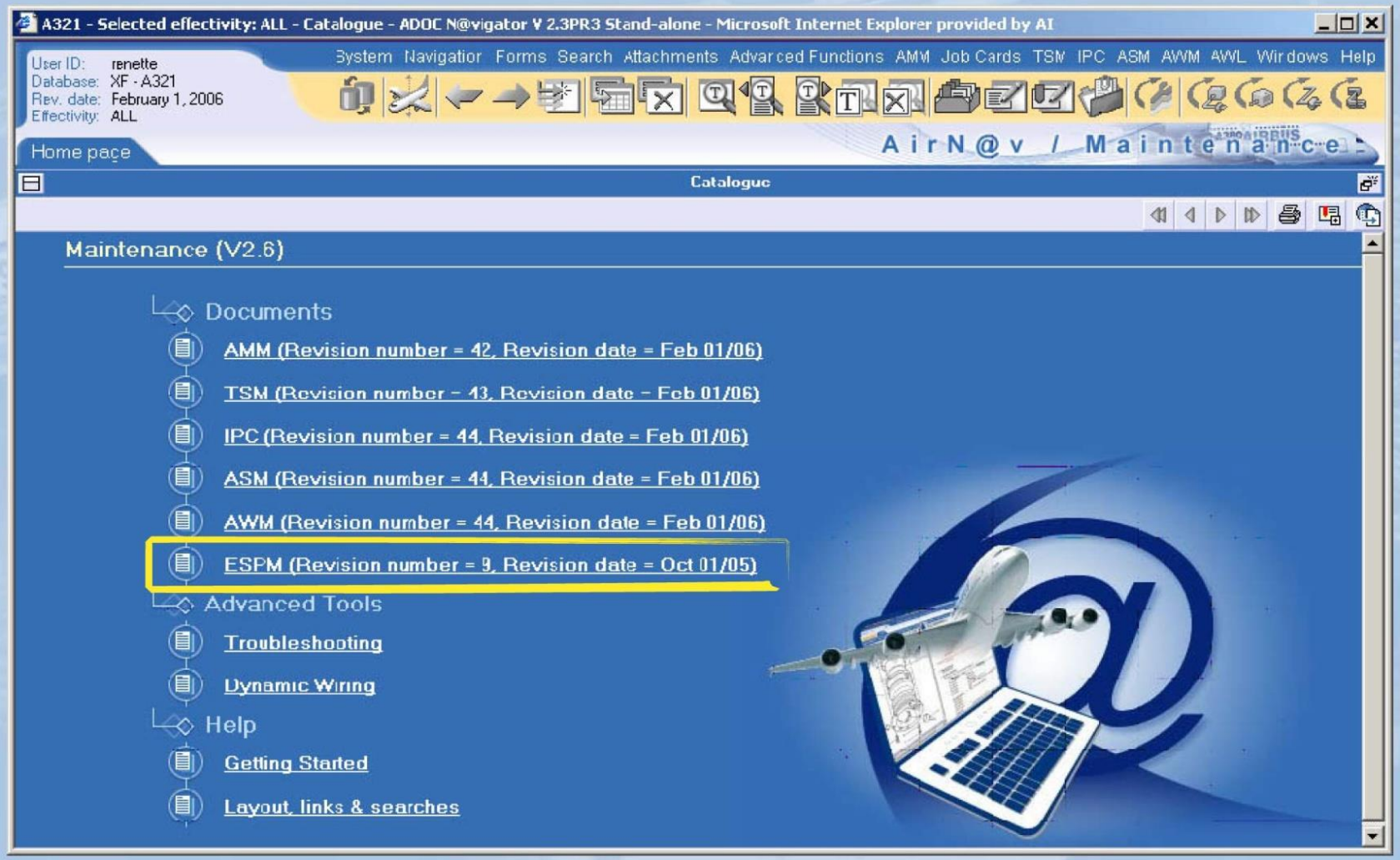
(1) Chapter 20 structure/overview
(2) Chapter 20 cross-reference index
(3) Chapter 20 important data and tables
(4) Wiring Diagram Manual
(5) Other documentation (as applicable)

The ESPM provides a quick and easy access to the information associated with connectors and connecting parts, such as contacts, terminals and splices.

This is the ESP (Electrical Standard Practices).
This document is only an extract of the ESPM. The HOW TO USE guide explains how to retrieve and search information with practical examples.

The INDEXES:
There are two different types of indexes. An alphabetical index, which allows you to find information with a keyword, and an alphanumerical index, which allows you to retrieve a Part Number in the document.

To easily understand the document, the data is classified and standard rules and recommendations are provided.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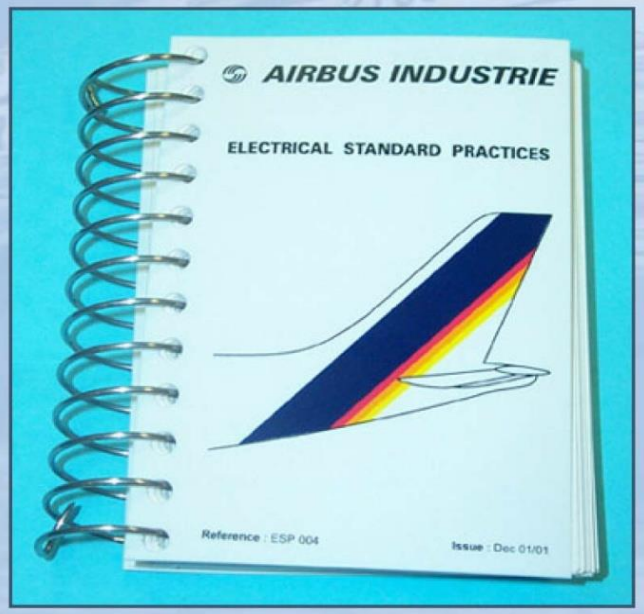
Rev. date: February 1, 2006
Effectivity: ALL
System Navigation Forms Search Attachments Advanced Functions AMM Job Cards TSM IPC ASM AWM AWL Windows Help
Home page
AirN@v / Maintenance
Catalogue
Maintenance (V2.6)
Documents
AMM (Revision number = 42, Revision date = Feb 01/06)
TSM (Revision number = 43, Revision date = Feb 01/06)
IPC (Revision number = 44, Revision date = Feb 01/06)
ASM (Revision number = 44, Revision date = Feb 01/06)
AWM (Revision number = 44, Revision date = Feb 01/06)
ESPM (Revision number = 9, Revision date = Oct 01/05)
Advanced Tools
Troubleshooting
Dynamic Wiring
Help
Getting Started
Layout, links & searches


AIRBUS INDUSTRIE
ELECTRICAL STANDARD PRACTICES
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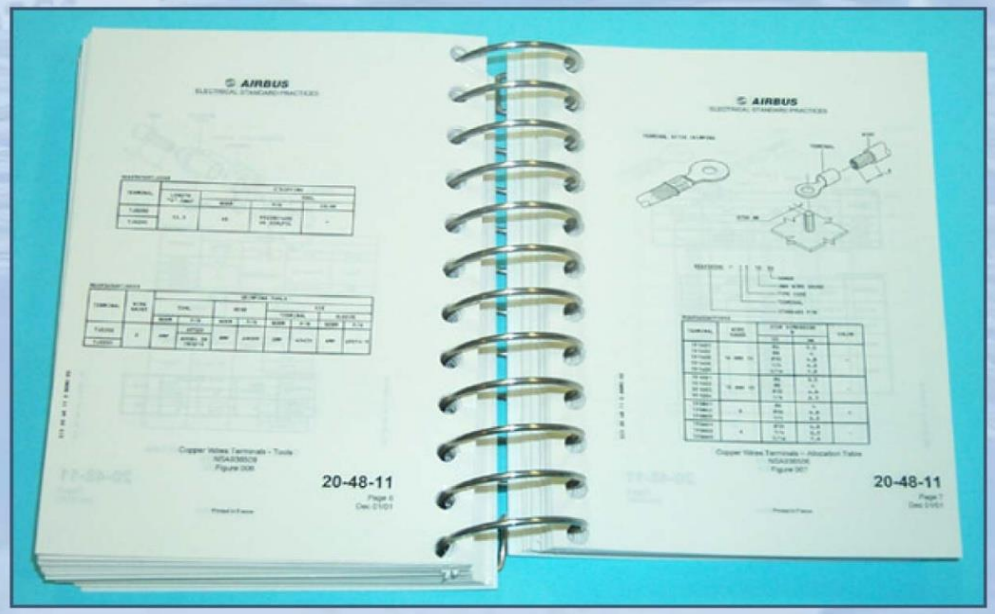
Issue : Dec 01/01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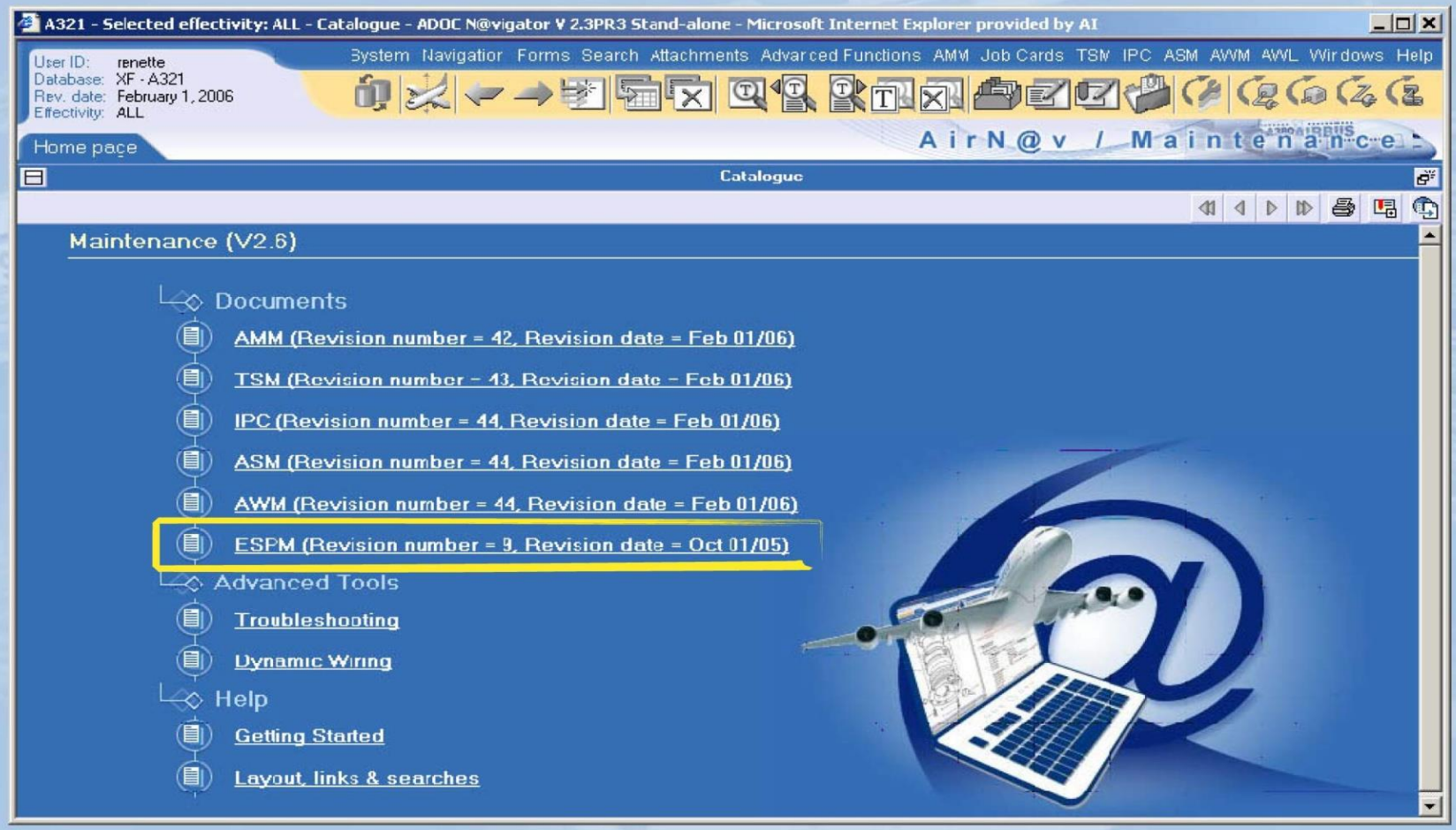
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AWM (Revision number = 44, Revision date = Feb 01/06)
ESPM (Revision number = 9, Revision date = Oct 01/05)
Advanced Tools
Troubleshooting
Dynamic Wiring
Help
Getting Started
Layout, links & searches

STRUCTURE OVERVIEW

LEP / TOC

INTRO (How to use, etc...)

INDEXES:
Alphabetical + ABS / ASN / DAN / EN / MIL / NSA

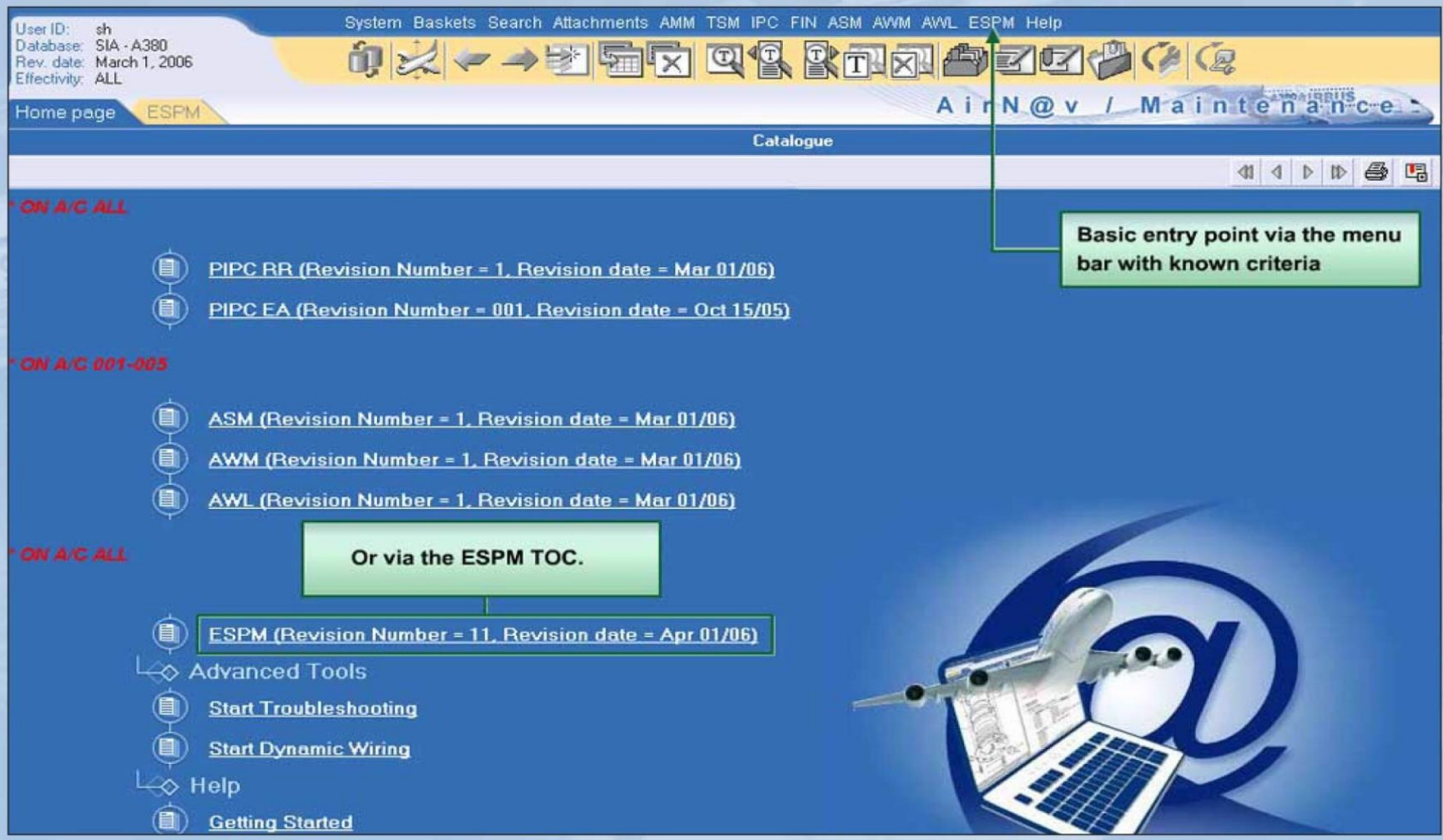
20-10-00 Safety Practices

20-25-00 Standard Tools

20-30-00 Standard Rules and Recommendations
(Specific areas, Identification / marking, Wires / Bundles)

20-40-00 Standard Electrical Items and Connecting Parts
(Splices, Connectors, Pressure seals, Contacts, Terminals, etc...)

20-50-00 Maintenance Processes
(Standard Processes, Inspection checks, Repair processes,
Protection during Maintenance checks, Cleaning)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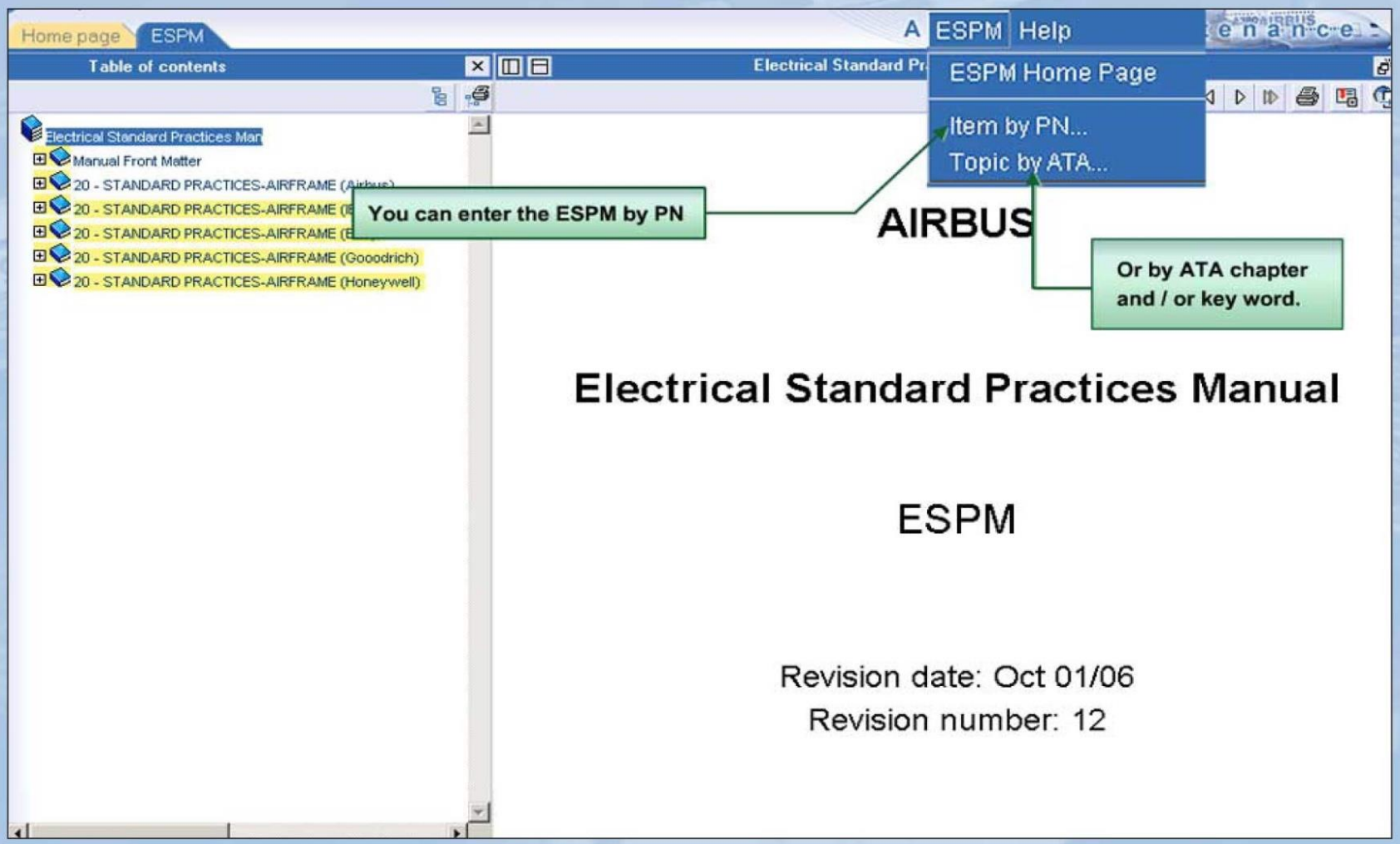
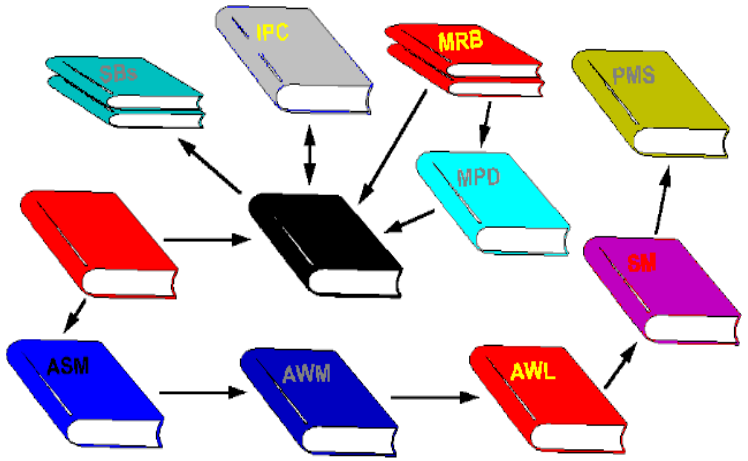
Rev. date: March 1, 2006
Effectivity: ALL
System Baskets Search Attachments AMM TSM IPC FIN ASM AWM AWL ESPM Help
Home page
ESPM
AirN@v / Maintenance
Catalogue
* ON A/C ALL
PIPC RR (Revision Number = 1, Revision date = Mar 01/06)
PIPC EA (Revision Number = 001, Revision date = Oct 15/05)
* ON A/C 001-005
ASM (Revision Number = 1, Revision date = Mar 01/06)
AWM (Revision Number = 1, Revision date = Mar 01/06)
AWL (Revision Number = 1, Revision date = Mar 01/06)
* ON A/C ALL
Or via the ESPM TOC.
ESPM (Revision Number = 11, Revision date = Apr 01/06)
Advanced Tools
Start Troubleshooting
Start Dynamic Wiring
Help
Getting Started
Basic entry point via the menu bar with known criteria


Home page
ESPM
Table of contents
Electrical Standard Practices Manual
Manual Front Matter
20 - STANDARD PRACTICES-AIRFRAME (Airbus)
20 - STANDARD PRACTICES-AIRFRAME (Goodrich)
20 - STANDARD PRACTICES-AIRFRAME (Honeywell)
ESPM
Help
ESPM Home Page
Item by PN...
Topic by ATA...
You can enter the ESPM by PN
AIRBUS
Or by ATA chapter and / or key word.
Electrical Standard Practices Manual
ESPM
Revision date: Oct 01/06
Revision number: 12

B. (2) Chapter 20 cross-reference index

Objective: Demonstrate the use of the Cross-Reference Index, Chapter Table of Contents, and Subject Tables of Contents so as to find specific material within each sub-chapter and section.

a. Cross-reference index – Alphanumeric
b. Cross-reference index – Standard Part number
c. Cross-reference index – Suppliers
e. Equivalence tables – Std Part Numbers EN-ASN-NSA



Cross-reference index – Alphanumeric

STANDARD WIRING PRACTICES MANUAL

CHAPTER CROSS-REFERENCE INDEX

A

STANDARD WIRING PRACTICES MANUAL

CHAPTER CROSS-REFERENCE INDEX

1

Example of finding specific material

STANDARD WIRING PRACTICES MANUAL

CHAPTER CROSS-REFERENCE INDEX

STANDARD WIRING PRACTICES MANUAL

ASSEMBLY OF INSULATED AND UNINSULATED TERMINAL LUGS

Boeing Standard	Part Number	Supplier
BACT12AC12	36161	AMP
	C-828-10	ETC
	R5109N	Hollingsworth
BACT12AC13	320576	AMP
	C-830-56	ETC
	R5111N	Hollingsworth
BACT12AC14	320577	AMP
	C-840-38	ETC
	R5112N	Hollingsworth
BACT12AC15	324043	AMP
	YAEV8C-L	Burndy
BACT12AC16	324082	AMP
	YAEV8C-L1	Burndy
BACT12AC17	324044	AMP
	YAEV8C-L2	Burndy
BACT12AC18	324045	AMP
	YAEV8C-L3	Burndy
BACT12AC19	324046	AMP
	YAEV6C-L1	Burndy
BACT12AC20	324047	AMP
	YAEV6C-L	Burndy
BACT12AC21	324048	AMP
	YAEV6C-L4	Burndy
BACT12AC22	324049	AMP
	YAEV6C-L2	Burndy
BACT12AC23	324050	AMP
	YAEV4C-L	Burndy
BACT12AC24	324051	AMP
	YAEVAC-L4	Burndy
BACT12AC25	324052	AMP
	YAEVAC-L2	Burndy
BACT12AC26	324053	AMP
	YAEV2C-L1	Burndy
BACT12AC27	324054	AMP
	YAEV2C-L	Burndy

B. (3) Chapter 20 important data and tables

Objective: Demonstrate the use of the associated tables for replacement of wire, connective devices and contacts, and associated components, including approved replacements.

a. Contact crimp tools, insertion/extraction tools
b. Wire Insulation removal tools
c. Electrical cable binding
d. Wire type codes and part numbers identification
e. Connective devices types and contacts
f. Terminal blocks and terminations
g. Terminal blocks modules, grounding modules and contacts
h. Cleaning procedures
i. Repair procedures

Example of contact crimp tool table

STANDARD WIRING PRACTICES MANUAL

CONTACT CRIMP TOOL CROSS REFERENCE

1. The Boeing ST2220-() Crimp Tool

A. General Description

The Boeing ST2220-() crimp tool is based on the MS3191-A crimp tool and has these features:

- The handle uses replacable contact locators
- The locators are also identified with an ST2220-() part number
- The tool must be operated through a full cycle
- Crimp depth is controlled by the locator.

ST2220-() CRIMP TOOL HANDLE AND LOCATOR
Figure 1

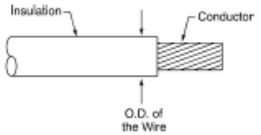
STANDARD WIRING PRACTICES MANUAL

CONTACT CRIMP TOOL CROSS REFERENCE

TABLE I
M22520/1-01 EQUIVALENT CRIMP TOOLS

Subject	Contact Size		Special	Equivalent Crimp Tool	
	Engaging End	Crimp Barrel		Basic Unit	Locator
Subject 20-61-11	20	20	-	M22520/1-01	M22520/1-02
				ST2220-1-Y	ST2220-1-1
				M22520/2-01	M22520/2-02
		18	-	M22520/1-01	M22520/1-02
				ST2220-1-Y	ST2220-1-1
				M22520/2-01	M22520/2-02
		16	-	M22520/1-01	M22520/1-02
				ST2220-1-Y	ST2220-1-45
				M22520/2-01	M22520/2-02
	16	16	-	M22520/1-01	M22520/1-02
				ST2220-1-Y	ST2220-1-2
				MS3191-1	MS3191-16
	12	12	-	M22520/1-01	M22520/1-02
				ST2220-1-Y	ST2220-1-3
				MS3191-1	MS3191-12
			Alumel	M22520/1-01	M22520/1-02
				ST2220-1-Y	ST2220-1-31
			Chromel	M22520/1-01	M22520/1-02
				ST2220-1-Y	ST2220-1-31
		10	-	M22520/1-01	M22520/1-02
				ST2220-1-Y	ST2220-1-3
				MS3191-1	MS3191-12
Subject 20-61-13	16S	16S	-	M22520/1-01	M22520/1-02
				ST2220-1-Y	ST2220-1-2
				MS3191-1	MS3191-16A
	16	16	-	M22520/1-01	M22520/1-02
				ST2220-1-Y	ST2220-1-2
				MS3191-1	MS3191-16A
	12	12	-	M22520/1-01	M22520/1-02
				ST2220-1-Y	ST2220-1-3
				MS3191-1	MS3191-12A

Example of wire insulation removal tool table



CONFIGURATION OF A WIRE
Figure 3

2.Cable Jacket and Wire Insulation Removal

A. Selection of a Removal Tool

(1) For the selection of a cable jacket removal tool:

(a) Find the Wire Type Code (WTC) of the cable. Refer to the Wiring Diagram Manual.

(b) Find the wire specification or the wire part number of the cable. Refer to Subject 20-00-13.

(c) Make a selection of a cable jacket removal tool. Refer to:

- Table I for a WTC with one wire specification or part number
- Table II for a WTC with more than one wire specification or part number.

(2) For the selection of an insulation removal tool:

(a) Find the Wire Type Code (WTC) of the cable. Refer to the Wiring Diagram Manual.

(b) Find the wire specification or the wire part number of the cable. Refer to Subject 20-00-13.

(c) Make a selection of an insulation removal tool. Refer to:

- Table III for a WTC with one wire specification or part number
- Table IV for a WTC with more than one wire specification or part number.

B. Cable Jacket Removal

This paragraph gives the procedure to remove a length of the outer jacket from a cable that has an O.D. that is less than or equal to 0.3 inch.

NOTE: It is recommended that a test of the cable jacket removal tool is done with a sample of the cable, before the operation is done on a cable that is installed or must be installed in the airplane.

(1) Put the end of the cable in the V-notch that is nearest the pivot and below the blade.

Make sure that the blade is on the side of the cable jacket removal tool that is opposite to the hand that holds the cable.

(2) Move the tool around the cable approximately three times.

(3) Remove the cable from the tool.

(4) Bend the cable on the line where the cable is cut to break the outer jacket loose.

(5) If the length of jacket is long, cut the jacket longitudinally with the front blade of the tool.

(6) Remove the length of jacket.

(7) Examine the cable for damage. Refer to Paragraph 1.A.

C. Wire Insulation Removal

NOTE: It is recommended that a test of the insulation removal tool is done with a sample of the wire, before the operation is done on a wire that is installed or must be installed in the airplane.

(1) Put the wire in the correct hole in the insulation removal tool.

(2) Close the handles of the tool until the tool makes a click.

Make sure the handles stay closed.

(3) Remove the wire from the tool.

(4) Release the handles of the tool.

(5) Examine the wire for damage. Refer to Paragraph 1.B.

3.Cable Jacket and Wire Insulation Removal Tools

A. Cable Jacket Removal Tools

Table I and Table II give the tools that are recommended for the removal of a length of the outer jacket from the end of a cable.

NOTE: Other tools are acceptable if the result of the removal operation agrees with the necessary conditions that are specified in Paragraph 1.A.

TABLE I
RECOMMENDED CABLE JACKET REMOVAL TOOLS

WTC	Wire Size (AWG)		Basic Unit	Replacement Blade
	Minimum	Maximum		
OA	-	-	45-402	K-6493
OB	-	-	45-402	K-6493
OC	-	-	45-402	K-6493
OD	-	-	45-402	K-6493
ON	-	-	45-403	K-6497
OQ	-	-	45-404	K-6500
OR	-	-	45-403	K-6495
OS	-	-	45-403	K-6497
OT	-	-	45-403	K-6499

Example of wire type replacement table

STANDARD WIRING PRACTICES MANUAL

STANDARD WIRE TYPE REPLACEMENT

This Subject gives:

- The general purpose BMS 13-48 and BMS 13-60 wire types that are equivalent
- The other general purpose wire types that can be replaced by BMS 13-48 and BMS 13-60 wire types
- The high temperature wire types that can be replaced by BMS 13-58 wire types.

1. Alternative Wires and Cables

A. Applicable Conditions for Wire Replacement

The Alternative Wire Data that is given in this Subject is also included in the Alternative Wire Data of Subject 20-00-13.

These conditions are applicable for the Alternative Wire Data and in Table III, Table IV, Table V, Table VI, and Table VII:

- An Alternative Wire is satisfactory when it is not possible to find or get the wire that is specified in the wire list of the Wiring Diagram Manual (WDM) that is applicable for the airplane model
- The replacement of a Specified Wire by a wire that is not given as an Alternative Wire is not recommended
- Each Alternative Wire is applicable for all models.

NOTE: Boeing Service Engineering can supply more data to answer questions about the Alternative Wires.

These conditions are also applicable when a Specified Wire is replaced with an Alternative Wire:

- The Alternative Wire must have the same number of conductors
- The Alternative Wire must have the same size of conductor
- The Alternative Wire must have the same color of the insulation or the outer jacket if a special color is specified.

For the replacement of standard wire types:

- Table I gives the equivalent BMS 13-60 wire types for the applicable BMS 13-48 wire types
- Table II gives the equivalent BMS 13-48 wire types for the applicable BMS 13-60 wire types
- Table III, Table IV, and Table V give the other general purpose wire types that can be replaced by the applicable BMS 13-48 and BMS 13-60 wire types
- Table VI and Table VII give the high temperature wire types that can be replaced by the applicable BMS 13-58 wire types.

B. BMS 13-48 Wire Types

TABLE I
BMS 13-60 WIRE TYPES THAT HAVE EQUIVALENT BMS 13-48 WIRE TYPES

BMS 13-48 Wire		Equivalent BMS 13-60 Wire	
Type	Description	Type	Description
Type 3	Insulation - 6 mil, Conductor - tin coated copper, Shield, Jacket	Type 13	Insulation - 6 mil, Conductor - tin coated copper, Shield, Jacket
Type 6	Insulation - 6 mil, Conductor - silver coated high strength copper alloy, Shield, Jacket	Type 15	Insulation - 6 mil, AWG 24 to AWG 16 conductors - nickel coated high strength copper alloy, AWG 14 to AWG 10 conductors - nickel coated copper, Shield, Jacket
Type 10	Insulation - 8 mil, Conductor - tin coated copper	Type 1	Insulation - 8 mil, Conductor - tin coated copper
Type 11	Insulation - 8 mil, Conductor - silver coated high strength copper alloy	Type 4	Insulation - 8 mil, Conductor - nickel coated high strength copper alloy
Type 12	Insulation - 8 mil, Conductor - tin coated copper, Shield, Jacket	Type 2	Insulation - 8 mil, Conductor - tin coated copper, Shield, Jacket
Type 13	Insulation - 8 mil, Conductor - silver coated high strength copper alloy, Shield, Jacket	Type 5	Insulation - 8 mil, Conductor - nickel coated high strength copper alloy, Shield, Jacket
Type 27	Insulation - 8 mil, Conductor - tin coated copper, Flat Conductor Shield, Jacket	Type 33	Insulation - 8 mil, Conductor - tin coated copper, Flat Conductor Shield, Jacket
Type 28	Insulation - 8 mil, Conductor - silver coated high strength copper alloy, Flat Conductor Shield, Jacket	Type 34	Insulation - 8 mil, Conductor - nickel coated high strength copper alloy, Flat Conductor Shield, Jacket
Type 32	Insulation - 8 mil, Conductor - nickel coated high strength copper alloy, Shield, Jacket	Type 5	Insulation - 8 mil, Conductor - nickel coated high strength copper alloy, Shield, Jacket

Example of wire gauge table

AWG gauge	Conductor Diameter Inches	Conductor Diameter mm	Ohms per 1000 ft.	Ohms per km	Maximum amps for chassis wiring	Maximum amps for power transmission	Maximum frequency for 100% skin depth for solid conductor copper	Breaking force Soft Annealed Cu 37000 PSI
0000	0.46	11.684	0.049	0.16072	380	302	125 Hz	6120 lbs
000	0.4096	10.40384	0.0618	0.202704	328	239	160 Hz	4860 lbs
00	0.3648	9.26592	0.0779	0.255512	283	190	200 Hz	3860 lbs
0	0.3249	8.25246	0.0983	0.322424	245	150	250 Hz	3060 lbs
1	0.2893	7.34822	0.1239	0.406392	211	119	325 Hz	2430 lbs
2	0.2576	6.54304	0.1563	0.512664	181	94	410 Hz	1930 lbs
3	0.2294	5.82676	0.197	0.64616	158	75	500 Hz	1530 lbs
4	0.2043	5.18922	0.2485	0.81508	135	60	650 Hz	1210 lbs
5	0.1819	4.62026	0.3133	1.027624	118	47	810 Hz	960 lbs
6	0.162	4.1148	0.3951	1.295928	101	37	1100 Hz	760 lbs
7	0.1443	3.66522	0.4982	1.634096	89	30	1300 Hz	605 lbs
8	0.1285	3.2639	0.6282	2.060496	73	24	1650 Hz	480 lbs
9	0.1144	2.90576	0.7921	2.598088	64	19	2050 Hz	380 lbs
10	0.1019	2.58826	0.9989	3.276392	55	15	2600 Hz	314 lbs
11	0.0907	2.30378	1.26	4.1328	47	12	3200 Hz	249 lbs
12	0.0808	2.05232	1.588	5.20864	41	9.3	4150 Hz	197 lbs
13	0.072	1.8288	2.003	6.56984	35	7.4	5300 Hz	150 lbs
14	0.0641	1.62814	2.525	8.282	32	5.9	6700 Hz	119 lbs
15	0.0571	1.45034	3.184	10.44352	28	4.7	8250 Hz	94 lbs
16	0.0508	1.29032	4.016	13.17248	22	3.7	11 k Hz	75 lbs
17	0.0453	1.15062	5.064	16.60992	19	2.9	13 k Hz	59 lbs
18	0.0403	1.02362	6.385	20.9428	16	2.3	17 kHz	47 lbs
19	0.0359	0.91186	8.051	26.40728	14	1.8	21 kHz	37 lbs
20	0.032	0.8128	10.15	33.292	11	1.5	27 kHz	29 lbs
21	0.0285	0.7239	12.8	41.984	9	1.2	33 kHz	23 lbs
22	0.0254	0.64516	16.14	52.9392	7	0.92	42 kHz	18 lbs
23	0.0226	0.57404	20.36	66.7808	4.7	0.729	53 kHz	14.5 lbs
24	0.0201	0.51054	25.67	84.1976	3.5	0.577	68 kHz	11.5 lbs

Example of connector contacts table

B. Contact Assembly with Filler Wire

TABLE II
APPLICABLE CONTACT CRIMP TOOLS AND FILLER WIRE

Wire Size (AWG)	Crimp Barrel Size	Filler Wire		Necessary Data for the Selection of a Crimp Tool	
		Quantity	Wire Size (AWG)	Adjusted Wire Size (AWG)	Crimp Barrel Size
24	16	1	18	16	16
22	16	1	18	16	16
20	12	2	16	12	12
	8	4	14	8	8
18	12	1	14	12	12
	8	4	14	8	8
16	8	4	14	8	8
14	8	2	12	8	8
12	8	2	12	8	8
10	8	3	16	8	8

(1) Find the quantity and size of filler wire that are applicable for the wire size and crimp barrel size in Table II.

(2) Find the insulation removal length for the specified contact. Refer to the Subject that is applicable for the assembly of the connector.

Make sure that the insulation removal length is the length that is specified for:

- The crimp barrel size of the contact
- A wire size that is the same size as the size of the crimp barrel.

NOTE: This length is the necessary length of insulation to remove.

(3) Remove the necessary length of insulation from the end of the wire and the end of each filler wire.

Refer to Figure 4 and Subject 20-00-15.

CAUTION: DO NOT CUT OR CAUSE DAMAGE TO THE STRANDS OF THE CONDUCTOR. THE MECHANICAL STRENGTH OF THE WIRE CAN BE DECREASED.

CAUTION: MAKE SURE THAT THE END OF THE INSULATION IS EQUAL AND SYMMETRICAL AROUND THE CIRCUMFERENCE OF THE CONDUCTOR. UNWANTED INSULATION IN THE CRIMP JOINT CAN INCREASE THE ELECTRICAL RESISTANCE.

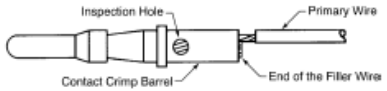
CAUTION: MAKE SURE THAT THE BASE METAL OF THE CONDUCTOR CANNOT BE SEEN. CORROSION OF THE CONDUCTOR CAN OCCUR.

Make sure that:

- All of the strands of each conductor are in the crimp barrel
- The conductor can be seen in the inspection hole
- The distance from the end of the insulation of the primary wire to the end of the crimp barrel is not more that 0.03 inch.

(8) Remove the unwanted length of the filler wires as close as possible to the end of the crimp barrel. Refer to Figure 6.

CAUTION: DO NOT CUT OR CAUSE DAMAGE TO THE STRANDS OF THE PRIMARY WIRE. THE MECHANICAL STRENGTH OF THE WIRE CAN BE DECREASED.



REMOVAL OF THE UNWANTED LENGTH OF THE FILLER WIRE
Figure 6

C. Contact Assembly with an Eyelet

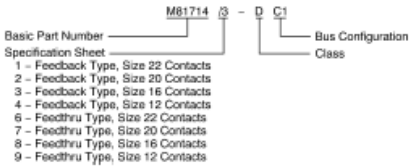
TABLE III
APPLICABLE CONTACT CRIMP TOOLS AND EYELETS

Wire Size (AWG)	Crimp Barrel Size	Eyelet	Necessary Data for the Selection of a Crimp Tool		
			Adjusted Wire Size (AWG)	Crimp Barrel Size	Special Instructions
24	16	CE46FC	20	16	–
		Y-6015-C	20	16	–
	12	CE66FC	14	12	Fold the conductor back
		Y-9015-C	14	12	Fold the conductor back
22	16	CE46FC	20	16	–
		Y-6015-C	20	16	–
	12	CE66FC	14	12	Fold the conductor back
		Y-9015-C	14	12	Fold the conductor back
20	12	CE66FC	14	12	–
		Y-9015-C	14	12	–
18	12	CE66FC	14	12	–
		Y-9015-C	14	12	–

Example of terminal junction table

TABLE II
OBSOLETE TERMINAL MODULE PART NUMBERS

Obsolete Module	Replacement Module
MRFB12E01-()	M81714/9-DH1
MRFB12E02-()	M81714/9-DD1
MRFB12E03-()	M81714/9-DB1
MRFB12E04-()	M81714/9-DA1
MRTB16E02-()	M81714/3-DD1
MRTB16E03-()	M81714/3-DB1
MRTB16E04-()	M81714/3-DA1
MRTB20E09-()	M81714/2-DE1
M81714/4-DA1	TJM112601
M81714/4-DB1	TJM112602
M81714/4-DB2	TJM112603
M81714/4-DC1	TJM112605
M81714/4-DC2	TJM112606
M81714/4-DD1	TJM112607



M81714 SERIES I TERMINAL MODULE PART NUMBER STRUCTURE
Figure 4

C. Contact Part Numbers

TABLE III
CONTACT PART NUMBERS

Contact Size		Part Number	Supplier
Engaging End	Crimp Barrel		
22	22	M39029/22-191	QPL
20	20	M39029/22-192	QPL
16	16	M39029/22-193	QPL
12	12	CT5-512/12	Deutsch

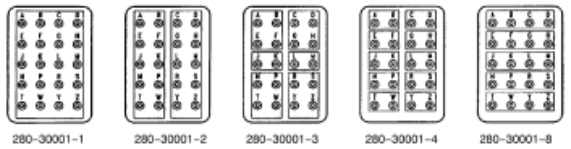
D. Seal Plug Part Numbers

TABLE IV
SEAL PLUG PART NUMBERS

Contact Size		Seal Plug	Supplier
Engaging End	Crimp Barrel		
22	22	1613-03-2205	QPL
20	20	81539-20	QPL
16	16	81539-16	QPL
12	12	81539-12	QPL

2. Insert Configurations

A. Boeing 280-30001-() Terminal Block Modules



280-30001-() INSERT CONFIGURATIONS WITH 20 SIZE 22 CONTACTS
Figure 1

Example of cleaning procedure table

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

PAGE 4
FEB 01/2003 20-10-04 MANUAL NO: D6-54446

CLEANING OF WIRE HARNESSES

TABLE III
SELECTION OF A CLEANING PROCEDURE FOR THE PRESSURIZED AREA

Location	Contamination			Cleaning Procedure
	Form	State	Example	
A wire, a cable, or a wire harness support clamp	Fluid, petroleum based or a hydraulic fluid	Wet or dry	BMS3-11, chemical, chemical cleaner, corrosion inhibiting compound, fuel, hydraulic fluid, oil, paint	Paragraph 3.A.
	Fluid, not petroleum based	Wet or dry	Chemical, chemical cleaner, de-icing fluid, food products, lavatory waste water, urine, salt water, soft drink, solvent	Paragraph 3.D.
	Solid, not petroleum based	Dry	Dirt, fecal matter, food, soot	Paragraph 3.C.
	Solid, not petroleum based	Loose particles, abrasive	Dirt, foreign object, metal particle, corrosion particle that falls from a part, sand	Paragraph 3.C.
	Solid, not petroleum based	Loose particles, not abrasive	Dust, lint, food, foreign object	Paragraph 4.A.
	Semi-solid	Wet or dry	Adhesive, grease, mud, sealant	Paragraph 3.A.
	Mixture of fluid and solid, petroleum based or hydraulic fluid	Wet or dry	Oil and dirt	Paragraph 3.A.
	Mixture of fluid and solid, not petroleum based	Wet or dry	Lavatory waste water and dirt	Paragraph 3.D.

PAGE 6
FEB 01/2003 20-10-04 MANUAL NO: D6-54446

Example of repair procedure table

TABLE IX
DAMAGE CONDITIONS AND REPAIR PROCEDURES

Fuel Quantity Indicator System	Damage Condition	Repair Condition	Reference
H1-Z	The conductor has damage	Assembly of a splice	Subject 20-14-12
	The conductor insulation has damage	Assembly of a splice	Subject 20-14-12
	The shield has damage	Assembly of a splice	Subject 20-14-12
	The damage goes through the outer jacket	Assembly of a splice	Subject 20-14-12
	The outer jacket has damage	Assembly of a splice	Subject 20-14-12
	The bond between the overlaps of the tape of the outer jacket is broken	Assembly of a splice	Subject 20-14-12
	The green outer braid has damage, the cable jacket has no damage	Repair of the green outer braid - Permanent Repair	Subject 20-14-12
	The green outer braid has damage less than one inch in length, the cable jacket has no damage	Repair of the green outer braid - Temporary Repair	Subject 20-14-12
Low-Z	The conductor has damage	Assembly of a splice	Subject 20-14-12
	The damage goes through the insulation	Assembly of a splice	Subject 20-14-12
	The insulation has damage	Assembly of a splice	Subject 20-14-12
	The bond between the overlaps of the insulation tape is broken	Assembly of a splice	Subject 20-14-12
	The green outer braid has damage, the cable jacket has no damage	Repair of the green outer braid - Permanent Repair	Subject 20-14-12
	The green outer braid has damage less than one inch in length, the cable jacket has no damage	Repair of the green outer braid - Temporary Repair	Subject 20-14-12

V. Fuel Quantity Indicator System Wire and Cable that are not Installed in a Fuel Tank

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

Repair not is 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.

Table X gives the damage conditions and repair procedures for the specified fuel quantity indicator system wire and cable that is external to the fuel tank.

NOTE: The replacement of the wire or cable is a satisfactory alternative to the repair of the wire or cable.

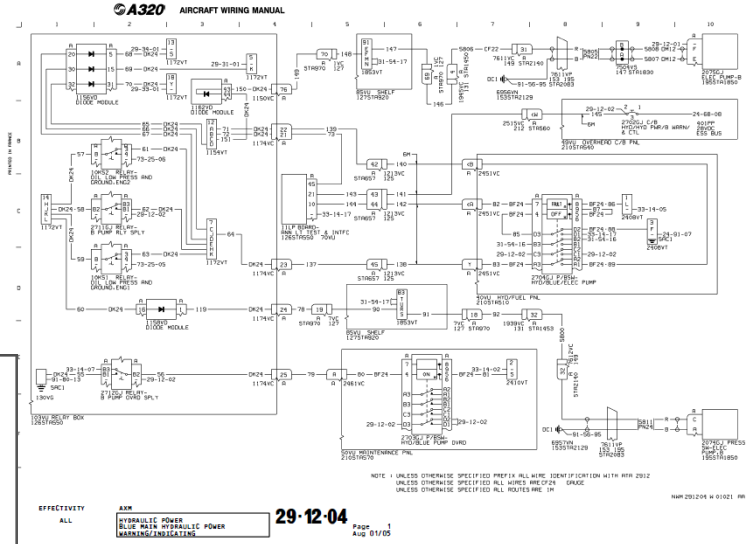
TABLE X
DAMAGE CONDITIONS AND REPAIR PROCEDURES

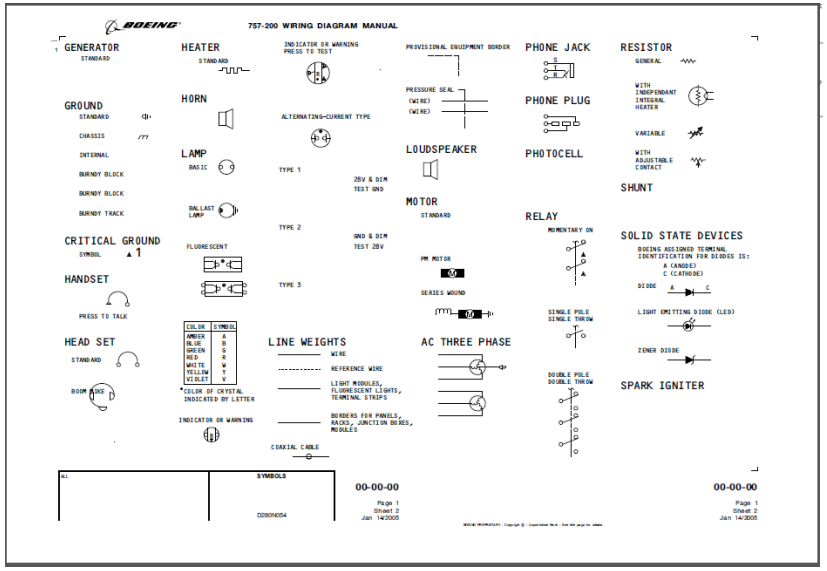
Wire or Cable	Damage Condition	Applicable Condition	Repair Procedure
BMS13-60T27	Damage to the inner jacket	Fuel Vapor	Paragraph 5.C.
		No Fuel Vapor	Paragraph 5.C.
			Paragraph 5.D.
	Damage to the outer shield is more than 1 inch in length, or more than 25 percent of the circumference of the shield	Fuel Vapor	Paragraph 5.C.
		No Fuel Vapor	Paragraph 5.C.
			Paragraph 5.D.
	Damage to the shield is less than 1 inch in length and less than 25 percent of the circumference of the shield	Fuel Vapor	Paragraph 6.C.
		No Fuel Vapor	Paragraph 6.C.
	Damage goes into or through the outer jacket, but the outer shield has no damage	Fuel Vapor	Paragraph 3.B.
		No Fuel Vapor	Paragraph 3.B.
10-60816-61	Damage to the inner jacket	Fuel Vapor	Paragraph 5.C.
		No Fuel Vapor	Paragraph 5.C.
			Paragraph 5.D.
	Damage to the outer shield is more than 1 inch in length, or more than 25 percent of the circumference of the shield	Fuel Vapor	Paragraph 5.C.
		No Fuel Vapor	Paragraph 5.C.
			Paragraph 5.D.
	Damage to the outer shield is less than 1 inch in length and less than 25 percent of the circumference of the shield	Fuel Vapor	Paragraph 6.C.
		No Fuel Vapor	Paragraph 6.C.
	Damage goes into or through the outer jacket, but the outer shield has no damage	Fuel Vapor	Paragraph 3.B.
		No Fuel Vapor	Paragraph 3.B.

B. (4) Wiring Diagram Manual

Objective: Demonstrate the use of the Wiring Diagram Manual.

a. Front matter
b. Diagrams
c. Charts
d. Lists





Example of manual usage in front matter

WIRING DIAGRAM MANUAL

INTRODUCTION

1. METHODS USED TO FIND INFORMATION

A. How To Locate A Diagram From A Wire Found In The Airplane

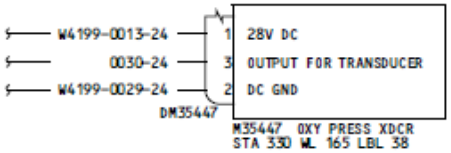
(a) As an example, take wire number W4199-0013-24.

(b) Knowing the wire bundle number W4199, refer to the Wire List in Chapter 91

(c) Using Self Indexing wire list shown, locate wire bundle W4199.

(d) Locate wire number 0013-24 and on the same line under the "Diagram" heading locate the diagram number 35-11-11.

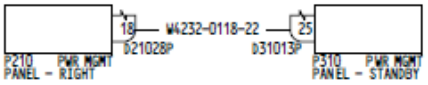
(e) Refer to Chapter 35 and locate the information needed on diagram 35-11-11.



B. How To Locate, In The Airplane, A Wire Found On A Wiring Diagram

(a) Wire number W4232-0118-22 appears on Wiring Diagram 28-21-11.

(b) Both ends of the wire are identified, disconnect D21028P at P210 panel and disconnect D31013P at P310 panel.



(c) Another method is to locate the bundle and wire number in the Wire List. The title of the bundle usually provides Station or Area for Airframe Bundles.

Attachment: Front Matter

Attachment: Chapter 28

WIRING DIAGRAM MANUAL

INTRODUCTION

1. APPLICABILITY

This Wiring Diagram Manual is applicable only to those Boeing airplanes listed on the Effective Aircraft page. The instructions and information contained herein apply solely to those airplanes and are not suitable for use with any other Boeing airplane(s).

2. GENERAL DESCRIPTION

The Boeing Wiring Diagram Manual (WDM) is a collection of diagrams, drawings, and Lists which define the wiring and hookup of associated equipment installed on the listed Boeing airplanes. These data are prepared essentially in accordance with the ATA Specification No. 2200, revision 2001.1.

This manual may also contain data and information provided by the customer. The Boeing Company assumes no responsibility for the accuracy and validity of data and information provided by a customer.

The WDM document number is unique to the customer whose name appears on the title page. Each chapter is preceded by its own Table of Contents (TOC), List of Effective Pages (LEP), and Alphabetical Index.

NOTE: System Schematics reside in a separate System Schematics Manual. Standard Wiring Practices–Chapter 20 reside in a separate Standard Wiring Practices manual (D6-54446).

All Wiring Diagrams are shown, unless otherwise specified, with the airplane on the ground, after normal flight, with the shutdown checklist complete (power off).

3. PROCESS CONTROLS

Control of the various manufacturing and installation processes used for wiring the airplane is covered in D6-36911 - Electrical Wiring Assembly and Installation Processes.

4. BOEING CHANGE DEFINITIONS

Changes used by Boeing to implement airplane changes that may affect this manual are listed below.

A. Customer Originated Changes (COC)

Customer Originated Changes are requests to incorporate airplane data, information, changes and modifications authorized by a customer into the WDM.

NOTE: Boeing will not undertake to test or evaluate, in any form, the validity or the technical accuracy of Customer Originated Changes. This will remain the sole responsibility of the customer submitting the Customer Originated Change request.

B. Service Bulletin (SB)

Service Bulletins provide information for accomplishing an engineering change on in-service airplanes. Service Bulletins are incorporated into this manual only upon customer request.

C. Service Letter (SL)

Service Letters notify customers of unique maintenance or operational items.

Example of diagrams, charts and list usage

WIRING DIAGRAM MANUAL

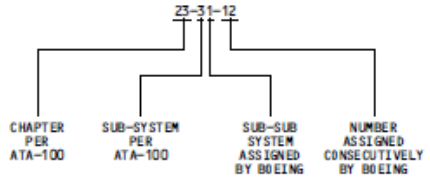
INTRODUCTION

1. BASIC INFORMATION ABOUT WIRING DIAGRAMS

A. Wiring Diagram And Page Numbering

(a) Wiring Diagram Numbering

The Diagram numbering is in accordance with ATA Specification 2200 Revision 2001.1



The first three digits will be identical on diagrams and schematics.

NOTE When a diagram is referenced to another, only the diagram number is used. Therefore, where there is more than one page of the same diagram, it is necessary to refer to the effectivity block to make certain the diagram applies to the airplane of interest.

(b) Diagram Page Numbering

Diagram page numbering begins at 1 then 2, 3 etc. Each page reflects different delivered configurations between aircraft. See the following example.

DIAGRAM	PAGE	EFFECTIVITY
21-31-12	1	001-004
21-31-12	2	005-999

The Page numbers (Page 101, 102, etc.) are used to represent different delivered configurations of a given schematic which may be applicable to different airplanes within the customer's fleet. When a schematic page number has a suffix (e.g., 101A, 102A for Customer Originated Changes or 101.1, 102.1, etc. for Service Bulletins) it reflects a post-delivery configuration for the same airplane(s). Both the configuration delivered by Boeing and the configuration after modification remain in the manual until the airline notifies Boeing that the post-delivery change has been incorporated in the customer's entire fleet of that model, and requests Boeing to delete the obsolete configurations.

WIRING DIAGRAM MANUAL

INTRODUCTION

1. CHARTS

The Chapter 91 Charts contain airplane station arrangements, wire zones, major wire bundle pathways, panel and equipment shelf locations, circuit breaker panel charts, disconnect bracket charts and Master Bundle information.

2. LISTS

The Chapter 91 Lists are numbered as follows:

91-02-00	--	Circuit Breaker List
91-04-00	--	Bracket List
91-21-11	--	Wire List
91-21-12	--	Spare Wire List
91-21-13	--	Master Bundle List
91-21-21	--	Ground List
91-21-31	--	Splice List
91-21-41	--	Terminal Strip List
91-21-51	--	Hookup List

Attachment: Chapter 91

The following paragraphs in this section define the contents of Chapter 91 Lists. The Wire List is the Primary source for Spare Wire through Hookup Lists.

A. Circuit Breaker List—Chapter 91-02-00

(a) The Circuit Breaker List reflects all the circuit breakers within an airplane and is derived from data contained in the Equipment List. It lists, in alphanumeric order, each Panel/Access Door, the Description and the Diagram of that panel.

(b) For each Panel/Access Door the grid location (Grid No), the circuit breaker number (Ckt Bkr), circuit breaker label (Description), Diagram and Effectivity are listed.

(c) Unused grid locations are not listed.

(d) The Circuit Breaker List is used as supplemental data for all Chapter 91-02-XX Panel Charts containing circuit breakers.

B. Bracket List—Chapter 91-04-00

(a) The Bracket List reflects all the disconnect brackets within an airplane and is derived from data contained in the Equipment List. It lists, in alphanumeric order, each disconnect bracket (BRACKET NO.), title (DESCRIPTION), EFFECTIVITY, and where the information is available: maximum number of positions (MAX POS), and location (STATION/WL/BL).

(b) Each POSITION within a bracket, that is being used, is listed, followed by the mounted receptacle number (RECEPTACLE) and its wire bundle number (BUNDLE), the mating plug (PLUG) and wire bundle number (BUNDLE) and the EFFECTIVITY.

B. (5) Other documentation (as applicable)

Objective: Demonstrate the use of other Documentation (as applicable).

Other Documentation (as applicable)

MODULE C – INSPECTION:

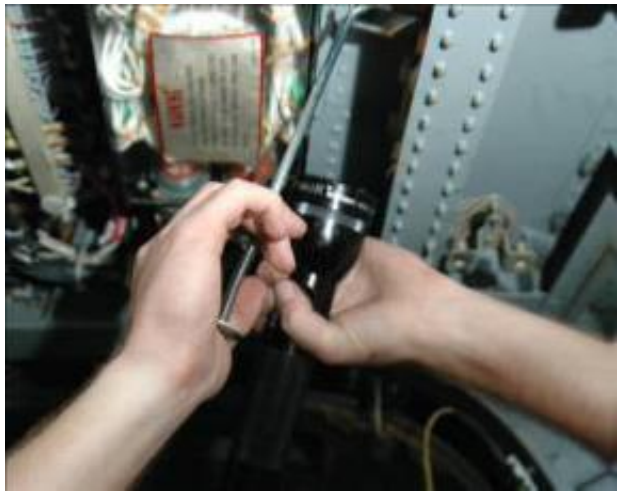
Objective: Know the different types of inspections, human factors in inspections, zonal areas and typical damages.

(1) Special inspections
(2) Criteria and standards
(3) Human factors in inspection
(4) Zonal areas of inspection
(5) Wiring system damage

C. (1) Special inspections

Objective: Know the different types of inspections: General Visual Inspection (GVI), Detailed Inspection (DET), Zonal Inspection and Enhanced Zonal Analysis Procedure (EZAP).

a. General Visual Inspection (GVI)
b. Detailed Inspection (DET)
c. Zonal Inspection
d. Enhanced Zonal Analysis Procedure (EZAP)



C. (2) Criteria and standards

Objective: Know the criteria and standards of inspection, so that the person knows which tools are used to ensure inspection procedures and standards are achieved which leads to all defects being found.

a. Tools
b. Criteria/standards
c. Procedures of inspection

EWIS Inspection Types

- General Visual Inspection (GVI)
- Stand-Alone GVI
- Detailed Inspection (DET)

General Visual Inspection (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.
For General Visual Inspection, 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.

Stand Alone GVI

A general visual inspection that is not performed as part of a zonal inspection. Even in cases where the interval coincides with the zonal inspection, the stand-alone GVI remains an independent step on the work card.

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. Surface cleaning and elaborate access procedures may be required.

Zonal Inspection

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

A zonal inspection is essentially a GVI of an area or zone to detect obvious unsatisfactory conditions and discrepancies. Unlike a stand-alone GVI, it is not directed to any specified component or assembly.

Enhanced Zonal Analysis Procedure (EZAP)

The EZAP identified in Appendix A of AMC 20_21 is designed to permit appropriate attention to be given to electrical wiring installations. This is achieved by providing a means to identify applicable and effective tasks to minimise accumulation of combustible materials and address wiring installation discrepancies that may not otherwise be reliably detected by inspections contained in existing maintenance programmes.

C. (3) Human factors in inspection

Objective: Know the effects of fatigue and complacency during inspection and how to combat their effects (Human Factors).

a. Fatigue
b. Complacency

Fatigue

Fatigue can be either physiological or subjective. **Physiological fatigue** reflects the body's need for replenishment and restoration. It is tied in with factors such as recent physical activity, current health, consumption of alcohol, and with circadian rhythms. It can only be satisfied by rest and eventually, a period of sleep. **Subjective fatigue** is an individual's perception of how sleepy they feel. This is not only affected by when they last slept and how good the sleep was but other factors, such as degree of motivation.
Fatigue is typically caused by delayed sleep, sleep loss, desynchronisation of normal circadian rhythms and concentrated periods of physical or mental stress or exertion. In the workplace, working long hours, working during normal sleep hours and working on rotating shift schedules all produce fatigue to some extent.

Symptoms of fatigue (in no particular order) may include:
• diminished perception (vision, hearing, etc.) and a general lack of awareness;
• diminished motor skills and slow reactions;
• problems with short-term memory;
• channelled concentration - fixation on a single possibly unimportant issue, to the neglect of others and failing to maintain an overview;
• being easily distracted by unimportant matters;
• poor judgement and decision making leading to increased mistakes;
• abnormal moods - erratic changes in mood, depressed, periodically elated and energetic;
• diminished standards of own work.

Fatigue is best tackled by ensuring adequate rest and good quality sleep are obtained. As fatigue is also influenced by illness, alcohol, etc., it is very important to get more sleep if feeling a little unwell and drink only in moderation between duties. Taking over-the-counter drugs to help sleep should only be used as a last resort.

Complacency

There is a tendency among human beings towards **complacency**. The belief that an accident will never happen to “me” or to “my Company” can be a major problem when attempting to convince individuals or organisations of the need to look at human factors issues, recognise risks and to implement improvements, rather than merely to pay ‘lip-service’ to human factors.

Repetitive tasks can be a danger when engineers become so **practised** at such tasks that they may cease to consult the maintenance manual, or to use job cards. Thus, if something about a task is changed, the engineer may not be aware of the change. **Complacency** is also a danger, whereby an engineer may skip steps or fail to give due attention to steps in a procedure, especially if it is to check something which is rarely found to be wrong, damaged or out of tolerance. This applies particularly to visual inspection, which is covered in greater detail in the next section.

At low levels of arousal, our attentional mechanisms will not be particularly active and our performance capability will be low (**complacency** and **boredom** can result). At the other end of the curve, performance deteriorates when arousal becomes too high. To a certain extent, this is because we are forced to shed tasks and focus on key information only (called **narrowing of attention**). Best task performance occurs somewhere in the middle.

C. (4) Zonal areas of inspection

Objective: Know the specific zonal inspection requirements related to system affiliation and environmental conditions.

a. Zonal areas of inspection
b. Zonal inspection procedures and standards

Zonal areas of Inspection

Guidance for zonal inspections

The following EWIS degradation items are typical of what should be detectable and subsequently addressed as a result of a zonal inspection (as well as a result of a stand-alone GVI). It is also recommended that these items be included in maintenance and training documentation. This list is not intended to be exhaustive and may be expanded as considered appropriate.

(1) Wire/Wire Harnesses

- Wire bundle/wire bundle or wire bundle/structure contact/chafing
- Wire bundle sagging or improperly secured
- Wires damaged (obvious damage due to mechanical impact, overheat, localised 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

(2) Connectors

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

(3) Switches

- Rear protection cap damaged

Zonal areas of Inspection (cont'd)

(4) Ground points
• Corrosion
(5) Bonding braid/bonding jumper
• Braid broken or disconnected
• Multiple strands corroded
• Multiple strands broken
(6) Wiring clamps or brackets
• Corroded
• Broken/missing
• Bent or twisted
• Faulty attachment (bad attachment or fastener missing)
• Unstuck/detached
• Protection/cushion damaged

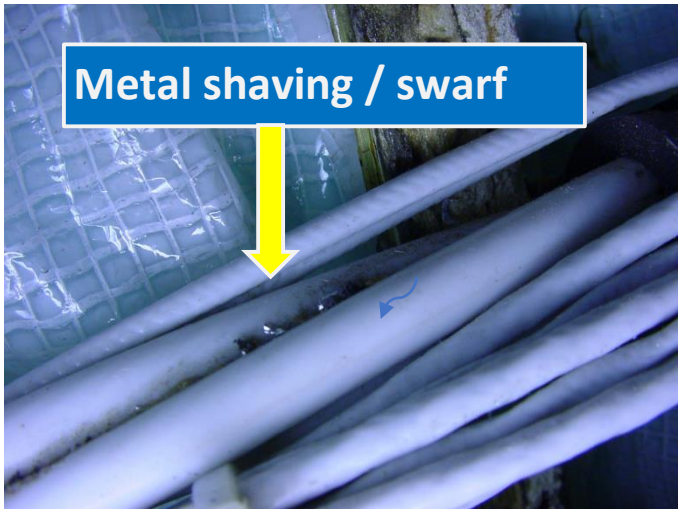
(7) Supports (rails or tubes/conduit)
• Broken
• Deformed
• Fastener missing
• Missing edge protection on rims of feed through holes
• Racetrack cushion damaged
• Obstructed drainage holes (in conduits)
(8) Circuit breakers, contactors or relays
• Signs of overheating
• Signs of arcing

C. (5) Wiring system damage

Objective: Recognize typical Wiring System damage, such as hot gas, fluid contamination, external mechanically induced damage, chafing, corrosion, signs of overheating of wire, wire bundles, connective and control device assemblies.

a. Swarf / FOD / metal shavings
b. External mechanically induced damage
c. Hot gas
d. Fluid contamination
e. Vibration/chafing
f. Corrosion
g. Signs of overheating

Examples of wiring system damage

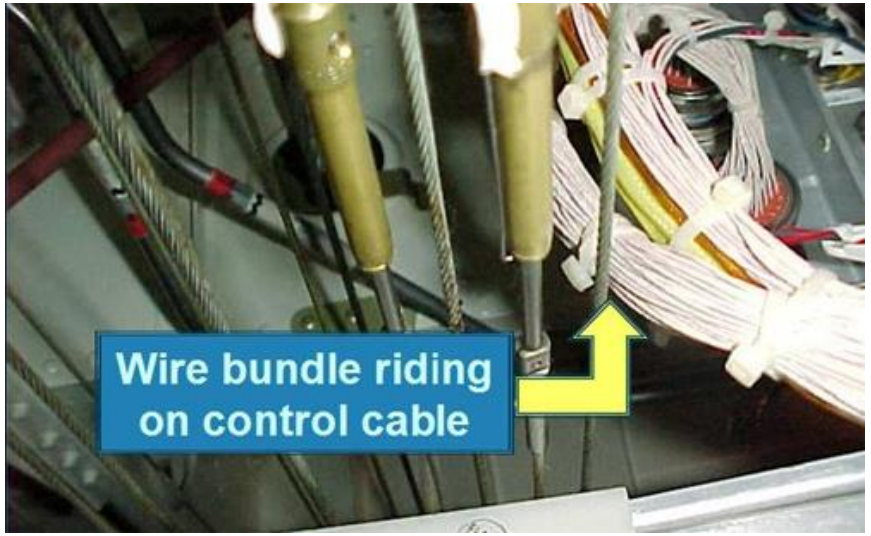


Swarf / FOD / metal shavings

Metal shavings and debris have been discovered on wire bundles after maintenance or repairs have been conducted. Care should be taken to protect wire bundles and connectors during modification work, and to ensure all shavings and debris are cleaned up after work is completed.

External mechanically induced damage

Chafing against a control cable leads to a 'sawing' effect that can expose conductor, creating conditions for arc tracking. The heat of electrical arcing is more than sufficient to burn through and sever the control cable.



Examples of wiring system damage

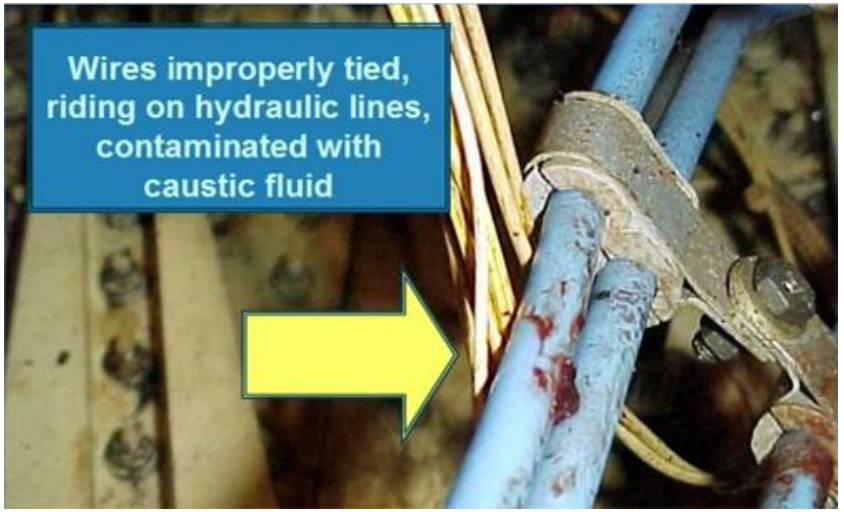
Hot gas

Separate wires from high-temperature equipment, such as resistors, exhaust stacks, heating ducts, etc., to prevent insulation breakdown.

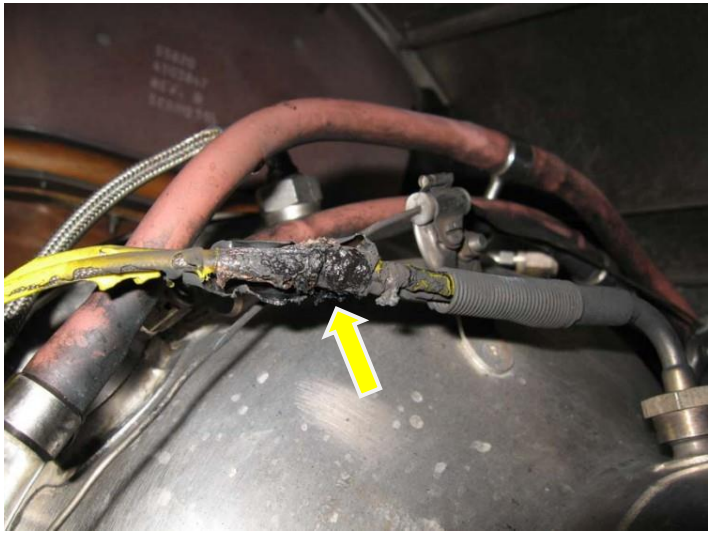
Insulate wires that must run through hot areas with a high-temperature insulation material such as fiberglass or PTFE.

Fluid contamination

A number of problems are shown: the wires in the bundle are not tied properly; the wire bundle is riding hard on the hydraulic lines; the wires appear to be contaminated with hydraulic fluid residue.



Examples of wiring system damage



Vibration/chafing

Wires and cables should be routed in such a manner that chafing will not occur against the airframe or other components.

Wire and cables should be supported and bound so that there is no interference with other wires, cables, and equipment.

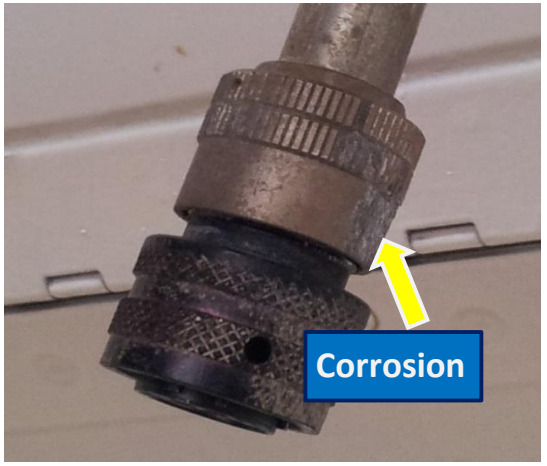
Wires and cables should be adequately supported to prevent excessive movement in areas of high vibration.

Corrosion

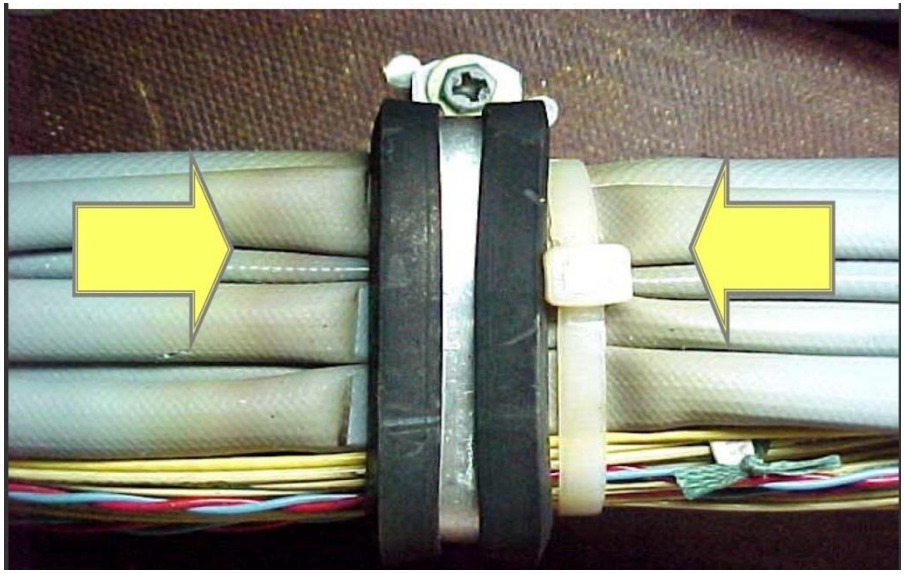
Arcing at connections within electrical connectors occurred due to bent pins or corrosion

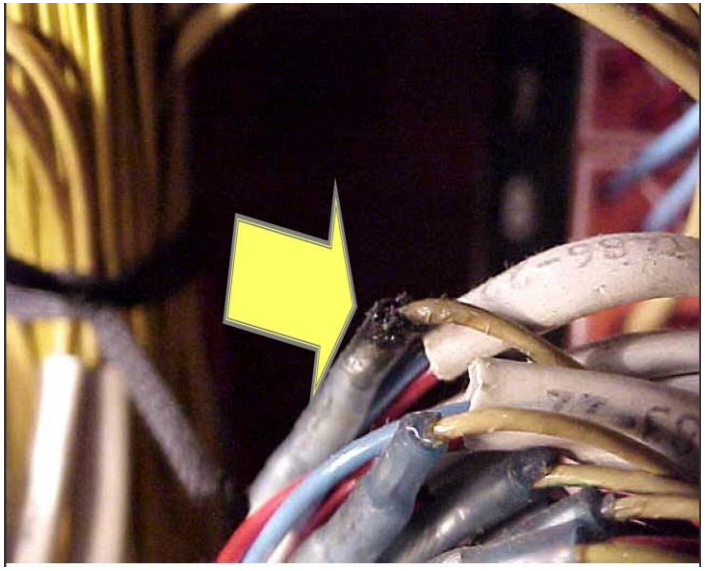
Moisture accelerates corrosion of terminals, pins, sockets, and conductors. Wiring installed in clean, dry areas with moderate temperatures appears to hold up well.

Dissimilar metals, when in contact, can produce electrolysis that can cause corrosion, thus degrading the terminal junction resistance and causing arcing or hot spots.



Examples of wiring system damage





Signs of overheating

Separate wires from high-temperature equipment, such as resistors, exhaust stacks, heating ducts, etc., to prevent insulation breakdown.

Insulate wires that must run through hot areas with a high-temperature insulation material such as fiberglass or PTFE.

MODULE D – HOUSEKEEPING:

Objective: Know the contamination sources, materials, cleaning and protection procedures.

(1) Aeroplane external contamination sources
(2) Aeroplane internal contamination sources
(3) Other contamination sources
(4) Contamination protection planning
(5) Protection during aeroplane maintenance and repair
(6) Cleaning processes

D. (1) Aeroplane external contamination sources

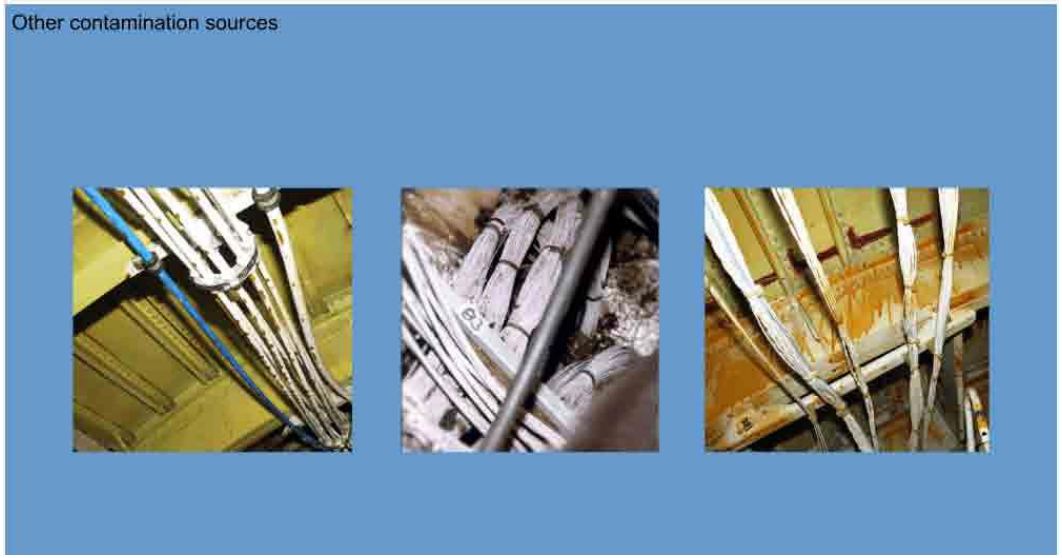
Objective: Recognize external contamination and other damage due to external environmental conditions.

a. De-ice fluids
b. Water and rain
c. Snow and ice
d. Miscellaneous (e.g. cargo / beverage spillage)
e. Air erosion

D. (2) Aeroplane internal contamination sources

Objective: Know the aeroplane internal contamination sources, so that inspection processes can be effectively carried out and contamination damage easily recognized.

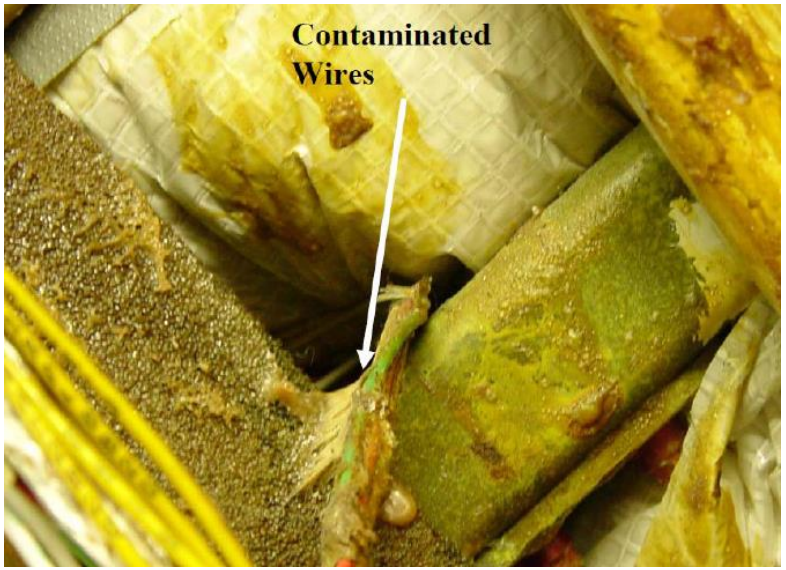
a. Hydraulic oils
b. Engine and APU oils
c. Fuel
d. Greases
e. Galleys and toilets
f. Lint/Dust
g. Bleed air and hot areas
h. Hazardous materials



D. (3) Other contamination sources

Objective: Recognize other possible contamination sources.

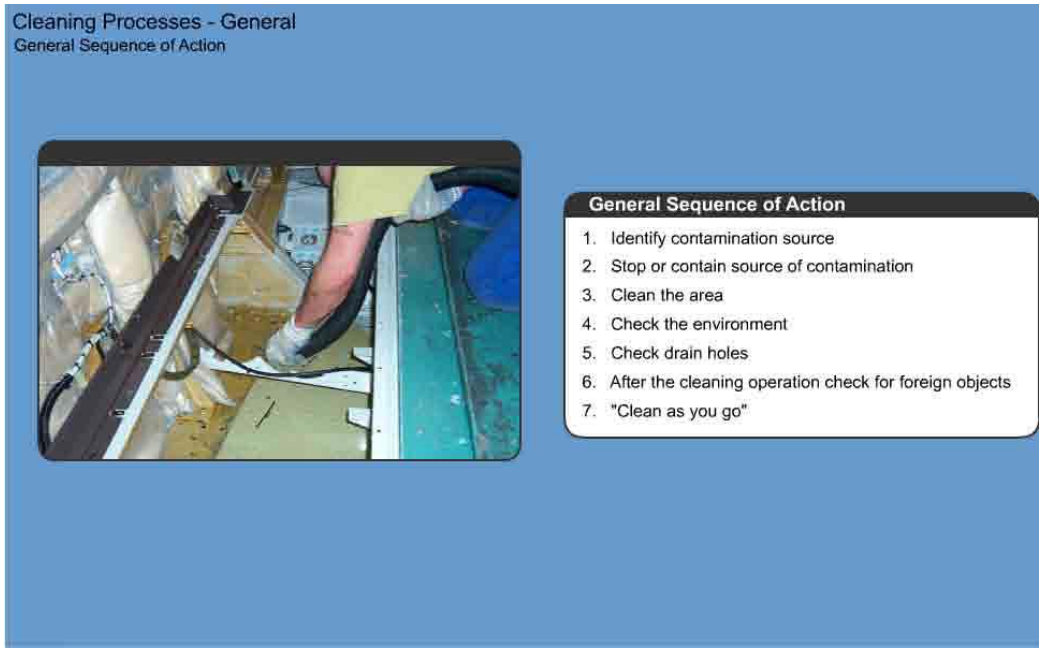
a. Paint
b. Corrosion inhibitor
c. Drill shavings / Swarf
d. Foreign objects (screws, washers, rivets, tools, etc.)
e. Animal waste



D. (4) Contamination protection planning

Objective: Know the planning procedures to be followed, on Electrical Wiring Interconnection System Areas in different parts of the aeroplane.

a. Have a plan / types of plan / area mapping
b. Protection and Caution Recommendations
c. Procedures
d. Keep cleaning



D. (5) Protection during aeroplane maintenance and repair

Objective: Know the protection procedures and processes to protect the Electrical Wiring Interconnection System during maintenance and repair.

a. Recommended general maintenance protection procedures
b. Recommended airframe repair protection procedures
c. Recommended powerplant repair protection procedures

Wiring Damage Prevention

Table 1: Wire Handling

	Damages caused by:	Damage prevention
Mechanical damages	• Tools: Paint scrappers, Knives, Drills, Screwdrivers etc. • Bad installations of cables: Chafing to structure & components. Too much stretched cables. Bending radius to small. Bad or defective cable clamps.	• Use correct tools. Work with correct application of the tool. • Usage of protection devices like Covers and Drillstops. Remove cables in working area by electricians.
Agents, Liquids	• Water, Acid or Lye, Solvents, Paint, Fuel, Oil, Grease. • Unspecified adhesive Covering Tape (remainders of glue)	• Use safe Liquid Containers for all Agents at work. • Covering of working area for Stripping, Cleaning and Painting. • Cleaning of contaminated Zones and Wire Bundles with dry Clothes and call for inspected by Specialists.
Heat Sources (Heat-Lamps)	• Overheating and drying out of Cable Insulation	• Arrange the removal of Wires located at heated places. • Monitor Ambient Temperature
Foreign Parts	• Sanding and grinding Dust, Drilling Swarfs • Lost remainders of Fasteners, Screws, Washers • Forgotten Tools	• Covering and protection of Wire-Bundles and open Connectors. • Cleaning of working area after completion of work. • Inspection and searching for lost parts and tools.
Working Employees	• Stepping on Cable Bundles • Using Cable Bundles as a Hand-Hold • Hanging Lights and other Items used at work on cables. • Unqualified Employees working on electrical cable installations.	• Watch Your Step ! Cover open Floor with Panels ! • Do not use Cable Bundle as Hand holds ! Use proper Steps. • Hang Lamps and necessary Items on Structural Points. • Call Electricians if work or inspection on Wiring is needed.

D. (6) Cleaning processes

Objective: Know the process of cleaning Wiring Systems during maintenance and repair.

- a. Fluid contamination
- (1) Snow and ice
- (2) De-ice fluid
- (3) Cargo spillage
- (4) Water and rain
- (5) Galleys
- (6) Toilets water waste
- (7) Oils and greases
- (8) Pressure washing
- b. Solid contamination
- (1) Drill shavings / Swarf
- (2) Foreign objects (screws, washers, rivets, tools, etc.)
- c. Environmental contamination
- (1) Lint and dust
- (2) Paint
- (3) Corrosion inhibitor
- (4) Animal waste

Cleaning processes

Cleaning of electrical Components

There are different contamination types: Surface Contamination, Deep Contamination, External contamination, Internal contamination and also:

• natural: the contamination agent is an identified material used in the aircraft systems (hydraulic fluid, fuel, etc.),
• accidental: the contamination agent comes from an external source (cleaning agent, etc.),
• the effect of ageing: the contamination agent is dust, lint or fluff. Procedure in relation to the type of contamination:
• stop the contamination source.
• keep the area that has contamination to a minimum.
• Estimate the damage in the contaminated area.
• Select the applicable cleaning procedure.

Cleaning Principle

You must clean only the areas and items that have contamination. Before you clean, make sure that the cleaning materials and methods will not cause more con-tamination.

Cleaning Method

Always start from the top to the bottom and from the periphery to the center of the area that has contamination.
Using cleaning agents:
• First, do a test with the cleaning agents and procedures 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 procedures and/or the materials as necessary.
Using a cloth:
• make sure that it is clean, dry and lint-free. Using 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.
For exact cleaning procedures, methods and cleaning products refer the ESPM or SWPM.

Cleaning processes

General Cleaning

Cleaning of electrical installation on aircraft.

Contamination can be internal or external.

Internal Contamination

This type of contamination is an identified material used in the aircraft systems (hydraulic fluid, fuel, etc...)

External Contamination

This type of contamination agent comes from an external source (coffee, miscellaneous liquids carried on aircraft, metal shaving, etc...) Following safety practices during cleaning operation is mandatory.

Sequence of actions:

- Stop the contamination source.
- Keep the contaminated area to a minimum.
- Apply the correct cleaning procedure

Liquid contamination example :

- Stop the contamination source.
- Make a sealed barrier.
- Remove liquid with vacuum cleaner for liquids.

For powder or granular or dust contamination, ensure there is no draught (wind) and remove the contamination with a vacuum cleaner and a soft brush. For external contamination, you have to make an estimate of the risk of deterioration of electrical item (some agents can cause damage to the polymers used in electrical items). In case of damage due to the contamination agent, refer to the SWPM/ESPM to know if:

- you can clean the item .
- you must replace the item.

Typical Cleaning Method

Precautions:

Always start cleaning from the periphery to the center or from the top to the bottom of the area. When using cleaning agents, do a test to ensure the product give satisfactory result. When you use a cloth, make sure it is clean, dry and lint-free. When you use a vacuum cleaner, make sure the filter is in position and its outlet is out of the aircraft. Always use a small capacity can in the aircraft and always put the cleaning agent on the cloth. This table gives you the type of cleaning agent you must use.

Example of Cleaning processes

STANDARD WIRING PRACTICES MANUAL

CLEANING OF WIRE HARNESSES

TABLE III
SELECTION OF A CLEANING PROCEDURE FOR THE PRESSURIZED AREA

Location	Contamination			Cleaning Procedure
	Form	State	Example	
A wire, a cable, or a wire harness support clamp	Fluid, petroleum based or a hydraulic fluid	Wet or dry	BMS3-11, chemical, chemical cleaner, corrosion inhibiting compound, fuel, hydraulic fluid, oil, paint	Paragraph 3.A.
	Fluid, not petroleum based	Wet or dry	Chemical, chemical cleaner, de-icing fluid, food products, lavatory waste water, urine, salt water, soft drink, solvent	Paragraph 3.D.
	Solid, not petroleum based	Dry	Dirt, fecal matter, food, soot	Paragraph 3.C.
	Solid, not petroleum based	Loose particles, abrasive	Dirt, foreign object, metal particle, corrosion particle that falls from a part, sand	Paragraph 3.C.
	Solid, not petroleum based	Loose particles, not abrasive	Dust, lint, food, foreign object	Paragraph 4.A.
	Semi-solid	Wet or dry	Adhesive, grease, mud, sealant	Paragraph 3.A.
	Mixture of fluid and solid, petroleum based or hydraulic fluid	Wet or dry	Oil and dirt	Paragraph 3.A.
	Mixture of fluid and solid, not petroleum based	Wet or dry	Lavatory waste water and dirt	Paragraph 3.D.

PAGE 6
FEB 01/2003

20-10-04

MANUAL NO: D6-54446

STANDARD WIRING PRACTICES MANUAL

CLEANING OF WIRE HARNESSES

Location	Contamination			Cleaning Procedure
	Form	State	Example	
The external surface of an unsealed connector, a backshell, a strain relief clamp	Fluid; solid; mixture of a fluid and a solid; semi-solid	Wet or dry	All types	Paragraph 4.C.
The external surface of an environmentally sealed connector, a backshell, a strain relief clamp	Fluid; solid; mixture of a fluid and a solid; semi-solid	Wet or dry	All types	Paragraph 4.B.
The internal surface of a connector	Fluid; solid; mixture of a fluid and a solid; semi-solid	Wet or dry	All types	Subject 20-60-01

MANUAL NO: D6-54446

20-10-04

PAGE 7
AUG 01/2001

MODULE E – WIRE:

Objective: Know or demonstrate the correct identification of different wire types, their inspection criteria and damage tolerance, repair and preventative maintenance procedures.

(1) Identification, type and construction
(2) Insulation qualities
(3) Inspection criteria and standards of wire and wire bundles
(4) Wire bundle installation practices
(5) Typical damage and areas found (aeroplane specific)
(6) Maintenance and repair procedures
(7) Sleeving
(8) Unused wires - termination and storage
(9) Electrical bonding and grounds

E. (1) Identification, type and construction

Objective: Demonstrate the procedure used to identify specific wire types using the aeroplane manuals.

a. Wire type codes – alphanumeric
b. Wire type codes – specification and standard part number
c. Wire type codes – specified wire and alternate
d. Manufacturer identification

Wire type codes – alphanumeric (Example)

This subject gives Wire Type Codes and Wire Specifications or Wire Part Numbers for the 727, 737, 747, 757, 767, and 777 model airplanes.

1.General Data

A. Applicable Conditions for Wire Type Code Data

These conditions are applicable for the Wire Type Code data and the Wire Part Number data in Table I and Table II:

- The primary purpose is to identify the Wire Part Number for the Wire Type Code that is specified in the Wire List of the Wiring Diagram Manual that is applicable for the airplane model
- The secondary purpose is to give a minimum description of the type of wire and its configuration
- An airplane model number for a Wire Type Code does not give approval to use that wire for electronic assembly wiring
- An airplane model number for a Wire Type Code does not give approval to use that wire for changes to airplane wiring that occur after the production of the airplane.

B. Wire Data

For the conditions that are applicable for Wire Type Code and Wire Part Number data, refer to Paragraph 1.A.

The primary data that is given in:

- Table I is the Wire Type Code (WTC) that is specified in the Wiring Diagram Manual (WDM)
- Table II is the Wire Specification or the Wire Part Number for the Wire Type Code (WTC) that is specified in the Wiring Diagram Manual (WDM)
- Table III is the alternative Wire Specification or Wire Part Number for the specified Wire Specification or the Wire Part Number and its alternative.

C. Wire Specification or Wire Part Number from the WTC

For the part number structure of Boeing Standard Wire Specifications, refer to Paragraph 4.A.

(1) Find the WTC in Table I.

(2) Look in the Model WDM columns for the model or the models that are applicable for the WTC.

(3) Find the Wire Specification or Wire Part Number for that WTC.

(4) If that wire is not available, find an Alternative Wire in Table III. Refer to Paragraph 3.B.

D. Wire Data from the Wire Specification or the Wire Part Number

This Paragraph gives the procedure to find the wire data if the Wire Type Code (WTC) is not known. The wire data is also specified in Table I by the Wire Type Code (WTC).

For the part number structure of Boeing Standard Wire Specifications, refer to Paragraph 4.A.

(1) Find the Wire Specification or the Wire Part Number in Table II.

(2) Look in the Model WDM columns for the model or the models that are applicable for the Wire Specification or Wire Part Number.

(3) Find the Wire Data for that Wire Specification or Wire Part Number.

(4) If that wire is not available, find an Alternative Wire in Table III. Refer to Paragraph 3.B.

2.Wire Type Codes and Wire Part Numbers

A. Wire Type Codes

TABLE I
WIRE TYPE CODES

WTC	7()7 Model WDM						Wire Specification or Part Number	Conductors	Notes
	2	3	4	5	6	7			
01	2	3	–	–	–	–	BMS 13-8 Type I Class A	01	High Temperature
02	2	3	–	–	–	–	BMS 13-8 Type II Class A	01	Shielded, High Temperature
03	2	3	–	5	–	–	1-70436-1, TWA, MIL-W-16878D	26	–

Wire type codes – specification and standard part number (Example)

Specified Wire	Alternative Wire	
	Specification or Part Number	Special Conditions
WC-101763, Al-Ch, Revere	853-4221172, Al-Ch, Pirelli	-
WC-62737, Al-Ch, Revere	852-4991972, Al-Ch, Specialty	-
WC101767, Al-Ch, Pirelli	853-4218376, Al-Ch, Pirelli	-
WW-63221, Cu-Cn, Revere	853-4125928, Cu-Cn, Pirelli	-
WW67587, Cu-Cn, Revere	853-4221073, Cu-Cn, Pirelli	-

4. Boeing Standard Wire Part Numbers

A. Boeing Standard Wire Part Number Data

BOEING STANDARD WIRE PART NUMBER STRUCTURE
Figure 1

TABLE IV
COLOR CODES FOR BOEING STANDARD WIRES

Boeing Standard Wire	Color Code	Color		
		Insulation or Jacket	First Stripe	Second Stripe
BMS13-48	000	Black	-	-
	001	Brown	-	-
	002	Red	-	-
	003	Orange	-	-
	004	Yellow	-	-
	005	Green	-	-
	006	Blue	-	-
	007	Violet	-	-
	008	Gray	-	-
	009	White	-	-
	00P	Pink	-	-
	063	Blue	Orange	-
	090	White	Black	-
	091	White	Brown	-
	092	White	Red	-
	093	White	Orange	-
	094	White	Yellow	-
	095	White	Green	-
	096	White	Blue	-
	097	White	Violet	-
	098	White	Gray	-
	09P	White	Pink	-
	921	White	Red	Brown
	924	White	Red	Yellow
	925	White	Red	Green
	926	White	Red	Blue
	927	White	Red	Violet

Wire type codes – specified wire and alternate (Example)

STANDARD WIRING PRACTICES MANUAL

STANDARD WIRE TYPE REPLACEMENT

This Subject gives:

- The general purpose BMS 13-48 and BMS 13-60 wire types that are equivalent
- The other general purpose wire types that can be replaced by BMS 13-48 and BMS 13-60 wire types
- The high temperature wire types that can be replaced by BMS 13-58 wire types.

1. Alternative Wires and Cables

A. Applicable Conditions for Wire Replacement

The Alternative Wire Data that is given in this Subject is also included in the Alternative Wire Data of Subject 20-00-13.

These conditions are applicable for the Alternative Wire Data and in Table III, Table IV, Table V, Table VI, and Table VII:

- An Alternative Wire is satisfactory when it is not possible to find or get the wire that is specified in the wire list of the Wiring Diagram Manual (WDM) that is applicable for the airplane model
- The replacement of a Specified Wire by a wire that is not given as an Alternative Wire is not recommended
- Each Alternative Wire is applicable for all models.

NOTE: Boeing Service Engineering can supply more data to answer questions about the Alternative Wires.

These conditions are also applicable when a Specified Wire is replaced with an Alternative Wire:

- The Alternative Wire must have the same number of conductors
- The Alternative Wire must have the same size of conductor
- The Alternative Wire must have the same color of the insulation or the outer jacket if a special color is specified.

For the replacement of standard wire types:

- Table I gives the equivalent BMS 13-60 wire types for the applicable BMS 13-48 wire types
- Table II gives the equivalent BMS 13-48 wire types for the applicable BMS 13-60 wire types
- Table III, Table IV, and Table V give the other general purpose wire types that can be replaced by the applicable BMS 13-48 and BMS 13-60 wire types
- Table VI and Table VII give the high temperature wire types that can be replaced by the applicable BMS 13-58 wire types.

B. BMS 13-48 Wire Types

TABLE I
BMS 13-60 WIRE TYPES THAT HAVE EQUIVALENT BMS 13-48 WIRE TYPES

BMS 13-48 Wire		Equivalent BMS 13-60 Wire	
Type	Description	Type	Description
Type 3	Insulation – 6 mil, Conductor – tin coated copper, Shield, Jacket	Type 13	Insulation – 6 mil, Conductor – tin coated copper, Shield, Jacket
Type 6	Insulation – 6 mil, Conductor – silver coated high strength copper alloy, Shield, Jacket	Type 15	Insulation – 6 mil, AWG 24 to AWG 16 conductors – nickel coated high strength copper alloy, AWG 14 to AWG 10 conductors – nickel coated copper, Shield, Jacket
Type 10	Insulation – 8 mil, Conductor – tin coated copper	Type 1	Insulation – 8 mil, Conductor – tin coated copper
Type 11	Insulation – 8 mil, Conductor – silver coated high strength copper alloy	Type 4	Insulation – 8 mil, Conductor – nickel coated high strength copper alloy
Type 12	Insulation – 8 mil, Conductor – tin coated copper, Shield, Jacket	Type 2	Insulation – 8 mil, Conductor – tin coated copper, Shield, Jacket
Type 13	Insulation – 8 mil, Conductor – silver coated high strength copper alloy, Shield, Jacket	Type 5	Insulation – 8 mil, Conductor – nickel coated high strength copper alloy, Shield, Jacket
Type 27	Insulation – 8 mil, Conductor – tin coated copper, Flat Conductor Shield, Jacket	Type 33	Insulation – 8 mil, Conductor – tin coated copper, Flat Conductor Shield, Jacket
Type 28	Insulation – 8 mil, Conductor – silver coated high strength copper alloy, Flat Conductor Shield, Jacket	Type 34	Insulation – 8 mil, Conductor – nickel coated high strength copper alloy, Flat Conductor Shield, Jacket
Type 32	Insulation – 8 mil, Conductor – nickel coated high strength copper alloy, Shield, Jacket	Type 5	Insulation – 8 mil, Conductor – nickel coated high strength copper alloy, Shield, Jacket

Manufacturer identification (Example)

BOEING

STANDARD WIRING PRACTICES MANUAL

STANDARD WIRE TYPE REPLACEMENT

C. BMS 13-60 Wire Types

TABLE II
BMS 13-48 WIRE TYPES THAT HAVE EQUIVALENT BMS 13-60 WIRE TYPES

BMS 13-60 Wire		Equivalent BMS 13-48 Wire	
Type	Description	Type	Description
Type 1	Insulation - 8 mil, Conductor - tin coated copper	Type 10	Insulation - 8 mil, Conductor - tin coated copper
Type 2	Insulation - 8 mil, Conductor - tin coated copper, Shield, Jacket	Type 12	Insulation - 8 mil, Conductor - tin coated copper, Shield, Jacket
Type 4	Insulation - 8 mil, Conductor - nickel coated high strength copper alloy	Type 11	Insulation - 8 mil, Conductor - silver coated high strength copper alloy
Type 5	Insulation - 8 mil, Conductor - nickel coated high strength copper alloy, Shield, Jacket	Type 13	Insulation - 8 mil, Conductor - silver coated high strength copper alloy, Shield, Jacket
		Type 32	Insulation - 8 mil, Conductor - nickel coated high strength copper alloy, Shield, Jacket
Type 13	Insulation - 6 mil, Conductor - tin coated copper, Shield, Jacket	Type 3	Insulation - 6 mil, Conductor - tin coated copper, Shield, Jacket
Type 15	Insulation - 6 mil, AWG 24 to AWG 16 conductors - nickel coated high strength copper alloy, AWG 14 to AWG 10 conductors - nickel coated copper, Shield, Jacket	Type 6	Insulation - 6 mil, Conductor - silver coated high strength copper alloy, Shield, Jacket
Type 33	Insulation - 8 mil, Conductor - tin coated copper, Flat Conductor Shield, Jacket	Type 27	Insulation - 8 mil, Conductor - tin coated copper, Flat Conductor Shield, Jacket
Type 34	Insulation - 8 mil, Conductor - nickel coated high strength copper alloy, Flat Conductor Shield, Jacket	Type 28	Insulation - 8 mil, Conductor - silver coated high strength copper alloy, Flat Conductor Shield, Jacket

2. Replacement of Standard Wire Types

A. General Purpose Wire Types

CAUTION: THE REPLACEMENT OF A SPECIFIED WIRE BY A WIRE THAT IS NOT GIVEN IN TABLE III AS AN ALTERNATIVE WIRE IS NOT RECOMMENDED.

MANUAL NO: D6-54446 20-00-14 PAGE 3 AUG 01/2004

BOEING

STANDARD WIRING PRACTICES MANUAL

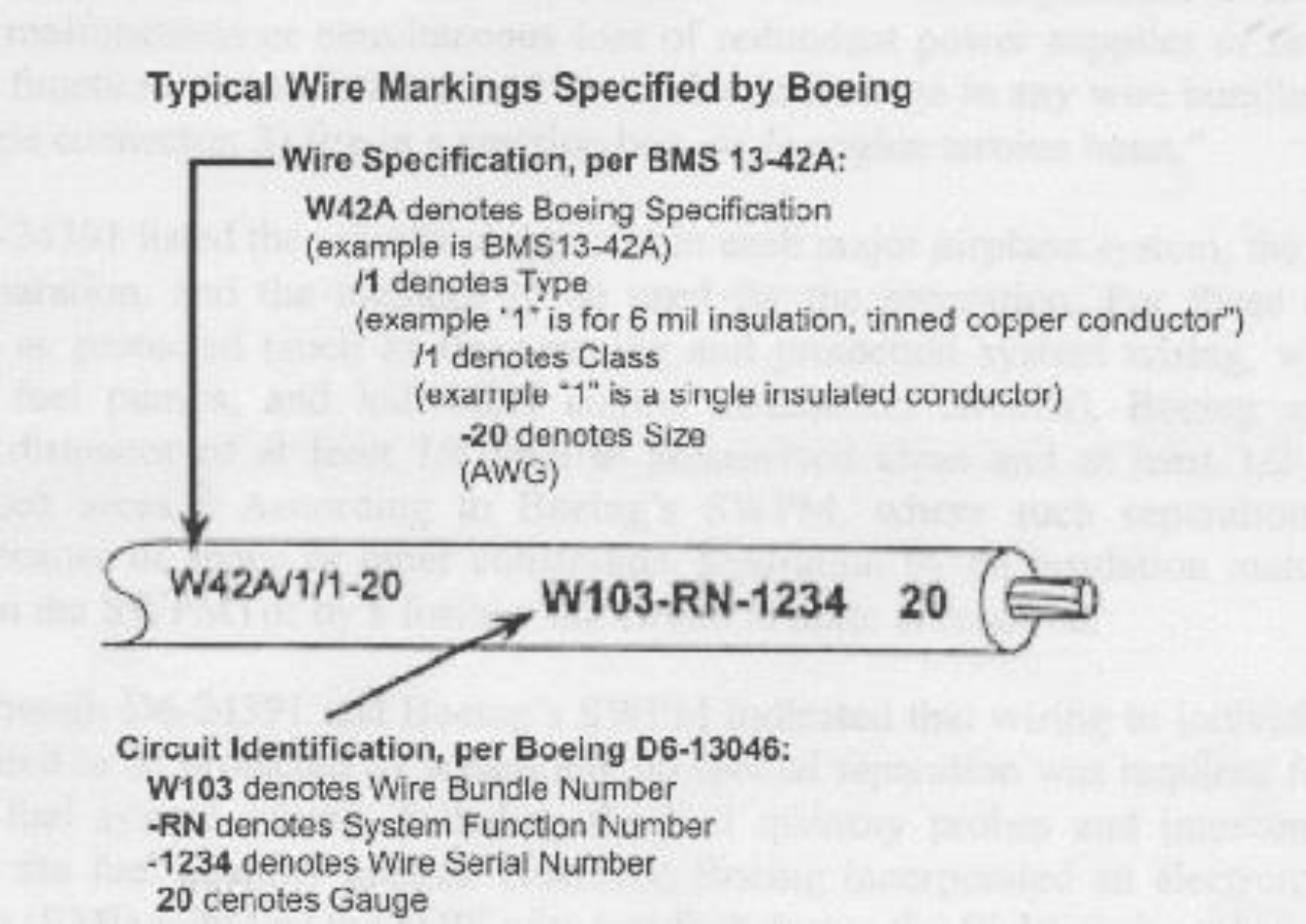
STANDARD WIRE TYPE REPLACEMENT

TABLE III
ALTERNATIVE BMS 13-48 AND BMS 13-60 WIRE TYPES FOR SPECIFIED STANDARD WIRE TYPES

Specified Wire Type	Alternative Wire Type	
	BMS 13-48	BMS 13-60
BMS 13-10 Type I	BMS 13-48 Type 10	BMS 13-60 Type 1
BMS 13-10 Type III	BMS 13-48 Type 12	BMS 13-60 Type 2
BMS 13-10 Type IV	BMS 13-48 Type 12	BMS 13-60 Type 2
BMS 13-11 Type I	BMS 13-48 Type 10	BMS 13-60 Type 1
BMS 13-11 Type II	BMS 13-48 Type 10	BMS 13-60 Type 1
BMS 13-11 Type V	BMS 13-48 Type 12	BMS 13-60 Type 2
BMS 13-13 Type I	BMS 13-48 Type 10	BMS 13-60 Type 1
BMS 13-13 Type III	BMS 13-48 Type 12	BMS 13-60 Type 2
BMS 13-16 Type I	BMS 13-48 Type 10	BMS 13-60 Type 1
BMS 13-16 Type III	BMS 13-48 Type 12	BMS 13-60 Type 2
BMS 13-30 Type I	BMS 13-48 Type 11	BMS 13-60 Type 4
BMS 13-30 Type III	BMS 13-48 Type 13	BMS 13-60 Type 5
BMS 13-30 Type III	BMS 13-48 Type 32	BMS 13-60 Type 5
BMS 13-39 Type I	BMS 13-48 Type 10	BMS 13-60 Type 1
BMS 13-39 Type III	BMS 13-48 Type 12	BMS 13-60 Type 2
BMS 13-39 Type VI	BMS 13-48 Type 32	BMS 13-60 Type 5
BMS 13-42 Type I	BMS 13-48 Type 10	BMS 13-60 Type 1
BMS 13-42 Type XII	BMS 13-48 Type 12	BMS 13-60 Type 2
BMS 13-42 Type XIII	BMS 13-48 Type 13	BMS 13-60 Type 5
BMS 13-42 Type XIII	BMS 13-48 Type 32	BMS 13-60 Type 5
BMS 13-48 Type 1	BMS 13-48 Type 10	BMS 13-60 Type 1
BMS 13-48 Type 13	BMS 13-48 Type 32	BMS 13-60 Type 5
BMS 13-48 Type 3	BMS 13-48 Type 12	BMS 13-60 Type 2
BMS 13-48 Type 6	BMS 13-48 Type 13	BMS 13-60 Type 5
BMS 13-48 Type 8	BMS 13-48 Type 10	BMS 13-60 Type 1
BMS 13-48 Type 9	BMS 13-48 Type 11	BMS 13-60 Type 4
BMS 13-48 Type 24	BMS 13-48 Type 32	BMS 13-60 Type 5
BMS 13-48 Type 25	BMS 13-48 Type 12	BMS 13-60 Type 2
BMS 13-48 Type 26	BMS 13-48 Type 13	BMS 13-60 Type 5
BMS 13-48 Type 26	BMS 13-48 Type 32	BMS 13-60 Type 5
BMS 13-48 Type 27	BMS 13-48 Type 12	BMS 13-60 Type 2
BMS 13-48 Type 28	BMS 13-48 Type 13	BMS 13-60 Type 5
BMS 13-48 Type 28	BMS 13-48 Type 32	BMS 13-60 Type 5

PAGE 4 AUG 01/2004 20-00-14 MANUAL NO: D6-54446

Wire markings (Example)



E. (2) Insulation qualities

Objective: Know from approved data different insulation types and their relative qualities.

a. Types of insulation
b. Typical insulation damage and limitations
c. Carbon Arcing

Comparative Properties of Wire Insulation Systems

Relative Ranking	Most desirable → Least 1	2	3	4
Weight	PI	ETFE	COMP	PTFE
Temperature	PTFE	COMP	PI	ETFE
Abrasion resistance	PI	ETFE	COMP	PTFE
Cut-through resistance	PI	COMP	ETFE	PTFE
Chemical resistance	PTFE	ETFE	COMP	PI
Flammability	PTFE	COMP	PI	ETFE
Smoke generation	PI	COMP	PTFE	ETFE
Flexibility	PTFE	ETFE	COMP	PI
Creep (at temperature)	PI	COMP	PTFE	ETFE
Arc propagation resistance	PTFE	ETFE	COMP	PI

Insulation types

INSULATION TYPE

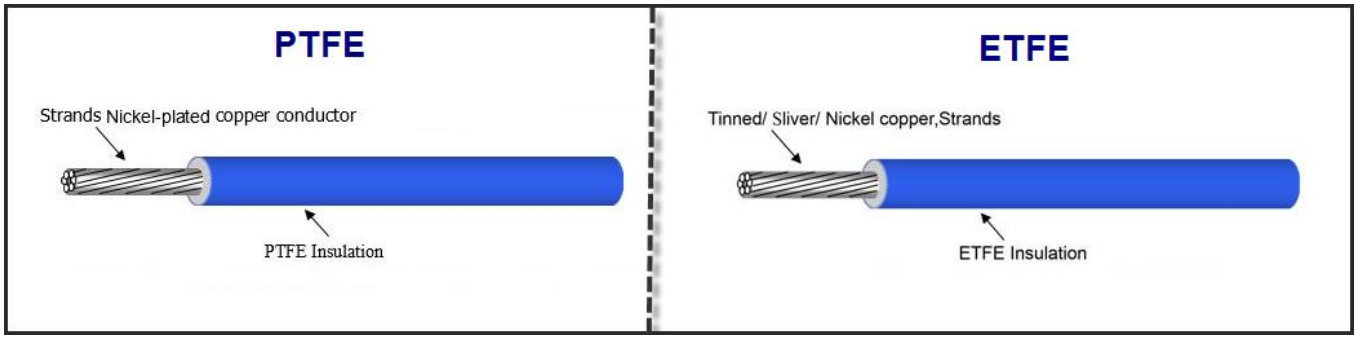
Without getting too complicated, there are generally four types of insulation material commonly found in aircraft: (1) Aromatic Polyimide, (2) ETFE, (3) PTFE, and (4) TKT.

Aromatic Polyimide – Sometimes polyimide is abbreviated PI; it is also called Kapton. The 'aromatic' refers to its molecular structure that offers great thermostability, hence its usage in insulating wiring. This material possesses great abrasion and cut-through resistance. It is also low smoke and non-flammable while lighter in weight compared to others. Its disadvantages: low arc-track resistance and limited flexibility.

ETFE – Short form of ethylene tetrafluoroethylene; aka Tefzel. Its ease of use makes it desirable. It also excels in chemical and abrasion resistance. Beware: ETFE tends to soften at higher temperatures and does not offer much in cut-through resistance. Because of its softness, it is well to avoid when bundling with other wire types.

PTFE – Stands for polytetrafluoroethylene but is often referred to as Teflon. PTFE offers a slew of advantages: superb high temperature properties, non-flammability, great flexibility and chemical resistance. Unfortunately, PTFE has poor cut-through resistance and is the heaviest form of insulation.

TKT – A composite of plastics; it stands for Teflon-Kapton-Teflon. It possesses a high temperature rating (260°C) and contains a solid level of cut-through and arc-track resistance. However, TKT is prone to outer layer scuffing.



Insulation properties

Ten characteristics are often used when comparing one insulating material over another.

Weight – This is a major issue. Heavy wire multiplied by the amount of wire can add several hundred pounds of weight to your plane, especially if there are miles of wire required in your EWIS. The lighter the plane the less fuel is needed to overcome the weight burden. This translates to savings on costs associated with fuel consumption.

Temperature – Flight exposes wire to wide temperature variances. You want to ideally aim for insulation that offers the widest range or the highest temperature resistance.

Creep (at temperature) – This refers to the insulating material's susceptibility to deformation, in this case how temperature warps the integrity of the material.

Flammability – When you deal with electrical wire there's always the possibility of fire. Safety concerns have you aim for insulation that offers added protection against flames.

Smoke Generation – With flames comes smoke. Once a fire exists and the insulation starts to burn will it generate a great deal of toxic fumes

Flexibility – Try to wire an airplane and you will quickly find configurations that use only straight lines are impossible. Wires have to bend during installations where point A to point B are not direct.

Resistance to:

Abrasion – Friction wears down materials. Wires are sometimes bundled but can still run up against adjacent surfaces. This leads to chafing and deterioration of insulation. No question, you don't want insulation to wear down. If a wire is exposed, there's the potential for electrocution, arc and spark creation, and possible fires.

Cut-through – This refers to the pressure exuded by a mechanical force, like the sharp edge of a wire cutter. You want the insulation material to be durable and be able to resist heavy loads or forces acted on it without disrupting the wires functionality.

Chemical – Planes, amongst other things, operate on the interaction of various chemicals. Fuel and even cleaning supplies will over time corrode insulation.

Arc Propagation – The causes of arc propagation are numerous; chafing, faulty installation, exposure to nearby water and fluids. Electric arcs can cause fires and pose a serious safety threat.

Insulation qualities

There are many insulation materials and combinations used on aircraft electrical wire. Characteristics should be chosen based on environment; such as abrasion resistance, arc resistance, corrosion resistance, cut-through strength, dielectric strength, flame resistant, mechanical strength, smoke emission, fluid resistance, and heat distortion.

Wire Insulation Selection Guidelines

Insulation Types	Advantages	Disadvantages
FEP and PTFE (Dupont ™ Teflon)	• Excellent high temperature properties. PTFE Teflon is preferred for solder applications. FEP is preferred for jacket material. • Non-flammable • Good outgassing characteristics • Most flexible of all insulations • Good weatherability, resists moisture absorption and atomic oxygen erosion	• Susceptible to cold flow when stressed (bent) over tight radius or when laced too tightly. • Degraded by solar radiation above 5 x 10^5 RADS. • FEP has poor cut through resistance • Heaviest insulation
ETFE (Dupont ™ Tefzel)	• Withstands physical abuse during and after installation • Good high and low temperature properties • High flex life • Good outgassing characteristics • Fair cold flow properties	• Some ETFE insulations fail flammability in a 30% oxygen environment • Insulation tends to soften at high temperature • Degraded by gamma radiation above 10^6 RADS

Crosslinked ETFE (Dupont ™ Tefzel)	• Higher strength than normal ETFE
	• Resistant to cold flow and abrasion
	• More resistant to radiation effects (to 5 x 10^7 RADS)
	• Higher maximum temperature than normal ETFE
	  ○ Tin Coating = 150°C Max.
	  ○ Silver Coating = 200°C Max.
	• Good outgassing characteristics
		• Some ETFE insulations fail flammability in a 30% oxygen environment
		• Less flexible than extruded ETFE
		• More difficult to work with than PTFE Teflon

Polyimide (Dupont ™ Kapton)	• Lightest weight wire insulation material. Commonly used with FEP or PTFE Teflon to form layered insulation tapes • Excellent physical thermal and electric properties. Excellent cut-through resistance and cold flow resistance • Excellent radiation resistance (to 5 x 10^9 RADS) • Good outgassing characteristics	• Inflexibility - difficult to strip. • Absorbs moisture. Degraded by atomic oxygen. Poor weatherability • Prone to wet-arc and dry-arc tracking from abrasions and cuts • More difficult to flex • Not stable to ultraviolet radiation

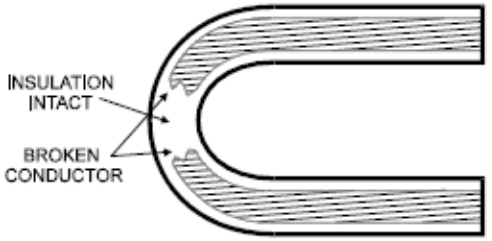
Crosslinked Polyalkene	• Dual extrusion which is fused by sintering. Combines excellent abrasion and cut through resistance of Polyvinylidene Fluoride (PVDF, PVF_2- Penwalt Corp. ™ Kynar) with Polyolefin for greater flexibility and improved heat resistance. Polyalkene is used mainly as a primary insulation under an outer jacket such as crosslinked ETFE or
	
	crosslinked PVDF/PVF_2
	• High dielectric constant, used in high voltage applications
	• PVDF has good radiation resistance
	
	(to 10^8 RADS)
	• More resistant to cold flow
	• Good outgassing characteristics
		• Lower maximum conductor temperature rating
		  ◦ (135°C for GSFC S-311-P-13)
		  ◦ (150°C for MIL-W-81044)
		• Reduced flexibility

Silicon Rubber	• Excellent flexibility at low temperatures • Excellent high voltage corona resistance • Good radiation resistance (to 10^8 RADS) • Good cold flow resistance	• Poor cut through resistance, mechanical toughness, and fluid resistance • Must be processed for outgassing control • Flammable • No standard silicon rubber insulated wire or cable

E. 3) Inspection criteria and standards of wire and wire bundles

Objective: Know the inspection criteria for wire and wire bundles.

a. Inspection of individual wiring
b. Inspection of wire bundles



Hidden Broken Conductors

Common faults that may encounter in electrical looms, cables and connectors:

- Broken Conductors,
- Overheated Conductors and Insulation,
- Chafed Insulation,
- Contamination,
- Cracking, Hardening and Contaminated Insulation, and
- Connector Damage.

Visible Broken Conductors

Contamination

Overheated

Chafed Insulation

Arcing

Inspection of individual wiring

- Non-environmental splices that exhibit signs of discolouration or other degradation should be replaced with environmentally sealed splices.
- Abrasion of wire insulation can also occur because of differences in 'hardness' between adjacent wires. Therefore, new wires, added during modification, which have significantly different insulation 'hardness' or abrasion characteristics to current aircraft wiring, should be routed in separate bundles. This is particularly important in areas of high vibration.
- When repairing wire, use serviceable tooling and methods that are appropriate for the wire type being repaired.
- The practice of 'pulling through' wires during replacement or modification should be avoided wherever possible. If cables are 'laid in' then damage to insulation surface by snagging or abrasion will be avoided. Additionally, the strain placed on the wire being 'pulled' can cause damage to the insulation or conductor.
- Piercing of wiring insulation for test purposes is not an acceptable practice.
- Wiring should be replaced under the following circumstances:
    - Wiring that has been subjected to chafing or fraying, that has been damaged, or where the primary insulation is suspected of being penetrated.
    - Wiring on which the outer insulation is brittle when slight flexing causes it to crack.
    - Wiring that has weather-cracked outer insulation. NOTE: some wire insulation types appear to be wrinkled when the wire is bent and may not be damaged.
    - Wiring that is known to have been exposed to electrolyte or on which the insulation appears to be, or is suspected of being, in an initial stage of deterioration due to the effects of electrolyte.
    - Wiring where there is visible evidence of insulation damage due to overheating.
    - Wiring that bears evidence of having been crushed or severely kinked.
    - Shielded wiring on which the metallic shield is frayed and/or corroded.
    - Wiring showing evidence of breaks, cracks, dirt, or moisture in the plastic sleeves placed over wire splices or terminal lugs.
- Replacement wires should have the same physical, electrical and shielding characteristics as the original wires.

Inspection of wire bundles

- Wiring located below or adjacent to maintenance activity, including painting, should be appropriately covered to protect it from damage or contamination.
- Individual wires and looms should be handled and moved the minimum amount necessary during maintenance activity. Ensure minimum bend radii of looms and individual wires and cables are never exceeded. This is particularly relevant when wiring is moved for access.
- Wires and wiring components should be kept clean using appropriate cleaning materials. While all wiring insulations used in aircraft are resistant to fuels and lubricants, continuous contact with these chemicals will cause deterioration over time. Additionally, fluids can migrate along looms to connectors and other wiring components that can suffer degradation.
- Any accumulations of combustible materials such as lint, fluff and dust should be removed using appropriate cleaning methods. These materials can be readily ignited from an electrical arc and then, in turn, ignite less flammable materials.
- Ensure swarf from structural repairs is completely removed and does not become trapped in wiring looms. Metal shavings left in looms can eventually cut through insulation and cause short circuits.
- Wires and looms resting against the aircraft structure should be adequately restrained to achieve appropriate clearance. Where this is impractical, looms should be wrapped with abrasion resistant material such as teflon sheet to provide additional protection.
- Abrasion of either the insulation or the insulation-facing material of clamps, conduits, or other devices used to secure or support wires or bundles can also be hazardous. Therefore, during maintenance activity, any rework or replacement of wires or looms should ensure that the original integrity of the design is maintained. The insulation-facing material should have ‘hardness’ compatible with that of the insulation.
- Wiring looms should be appropriately clamped to avoid relative movement that can cause fatigue and chafing.
- Ensure there is adequate strain relief for looms particularly where they are located across hinged, movable panels etc.

E. (4) Wire bundle installation practices

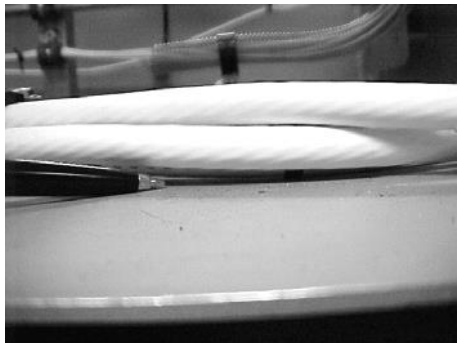
Objective: Know the standard installation practices for wire and wire bundles (aeroplane specific).

a. Routing
b. Segregation rules
c. Clearance
d. Clamp inspection
e. Clamp removal and fitting
f. Conduit types and fitting
g. Raceways
h. Heat shields and drip shields

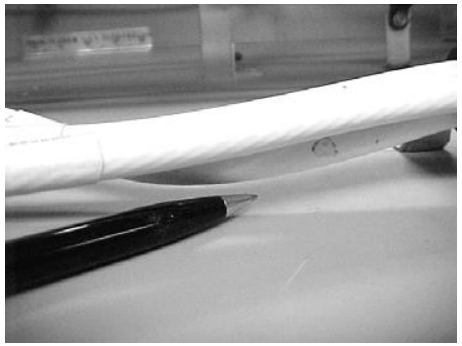
Routing

- Eliminate potential for chafing against structure or other components
- Position to eliminate/minimize use as handhold or support
- Minimize exposure to damage by maintenance crews or shifting cargo
- Avoid battery electrolytes or other corrosive fluids
- Protect EWIS in wheel wells and other exposed areas
- Route EWIS above fluid lines, if practicable
- Use drip loops to control fluids or condensed moisture
- Keep slack to allow maintenance and prevent mechanical strain

Examples of wire chafing



Improper



Proper

EWIS Riding on Structure

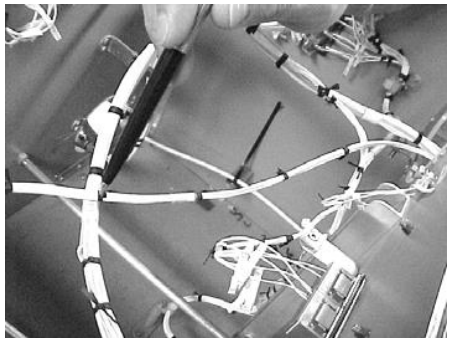
Power cables riding on structure can cause damage to the power cables

EWIS as a Handhold

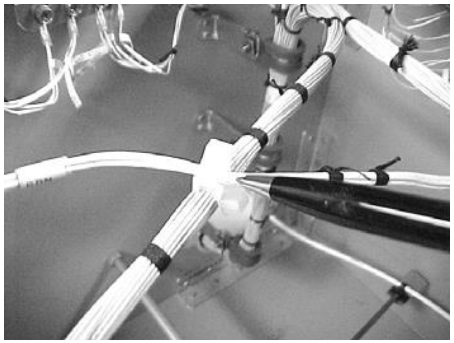
Route EWIS so that it is not used as a handhold or as a support for maintenance personnel.

Routing

Examples of wire chafing

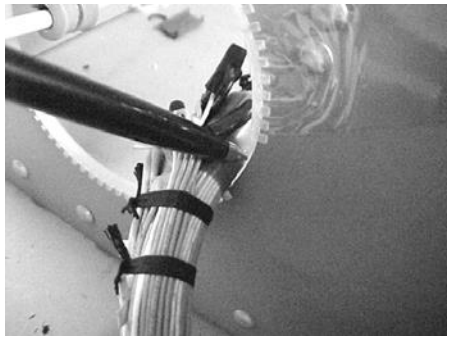


Improper

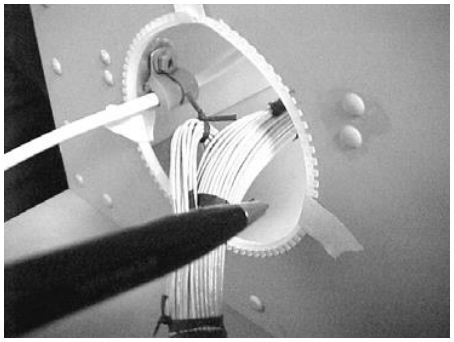


Proper

EWIS Riding on Other EWIS
Wire bundles that cross should be secured together to avoid chafing



Improper



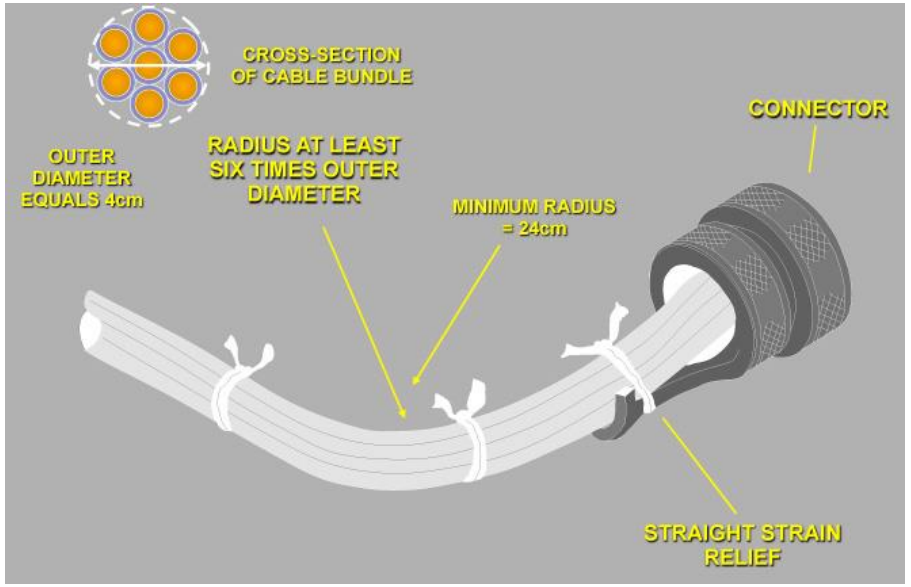
Proper

EWIS Riding on Lightening Hole Edge
If the grommet is too short, then there is wire bundle chafing

Bend radius

The proper bend radius for wire on aircraft should be 10 times the outside diameter of the largest diameter wire in the bundle for one side supported (3 times for two sides supported.)

Example of improper bend radius



EWIS Separation / Segregation

EWIS separation/segregation is a fundamental design technique used to isolate failure effects such that certain single failures that can compromise redundancy are minimized. EWIS separation is also used to control the effects of EMI (Electromagnetic interference) in aircraft EWIS.

• From a regulatory standpoint, we have regulations in place that may influence EWIS design with respect to separation/segregation.

• In addition, manufacturers may have company design standards which establish EWIS separation requirements with respect to power and signal routing which are usually driven from a EMI standpoint.

System Separation: EWIS § 25.1707

• Applies to each EWIS on airplane

• Requires adequate physical separation between EWIS and certain airplane systems known to have potential for creating a hazardous condition, for example:

– Fuel systems
– Hydraulic systems
– Oxygen systems
– Water/waste systems

Adequate physical separation must be achieved by separation distance or by a barrier that provides protection equivalent to that separation distance

• "Hazardous" -- must perform a qualitative design assessment of installed EWIS

– Use engineering & manufacturing judgment
– Evaluate relevant service history to decide whether an EWIS, any other type of system, or any structural component could fail so that a condition affecting the airplane's ability to continue safe operation could result

Reference AMC 25.1707

Clearance

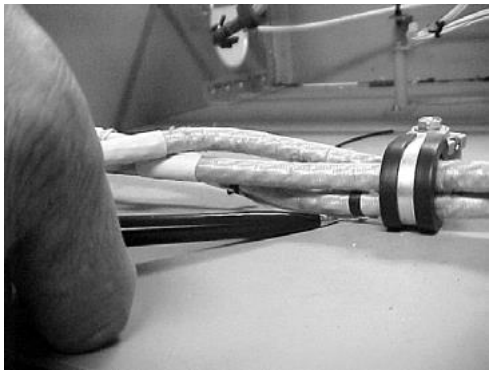
EWIS routing should be reviewed to ensure proper clearance from aircraft structure, fluid lines, and other equipment.

Stand-offs

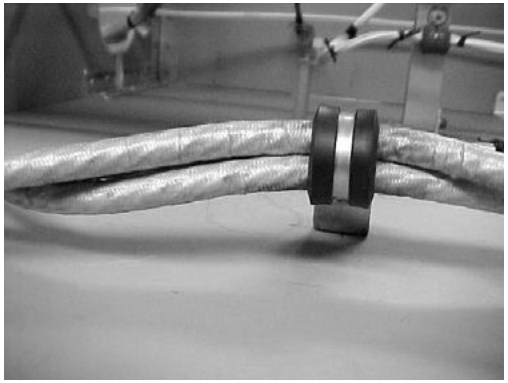
- **Use stand-offs to maintain clearance between EWIS and structure**

– Employing tape or tubing is generally *not* acceptable as an alternative

- **Exception: Where impossible to install off-angle clamps to maintain EWIS separation in holes, bulkheads, floors, etc.**



Improper



Proper

When using standoffs for additional clearance, clamps should not be installed in a manner that defeats the standoff's purpose of providing additional clearance between EWIS and structure.

Clamp inspection / Clamp removal and fitting

Clamping

• Support wires by suitable clamps, grommets, or other devices at intervals of not more that 24 inches

• Supporting devices should be of suitable size and type with wire and/or cables held securely in place without damage to wire or wire insulation

Clamps

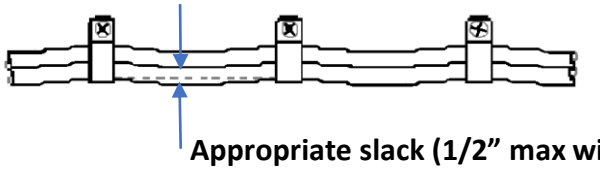
• Wire bundles should be snug in clamp (no movement) – Cable not able to move axially

• RF cables: do not crush

• Mount clamps with attachment hardware on top

• Tying *not* used as alternative to clamping

Correct Cable Slack



Appropriate slack (1/2" max with normal hand pressure)

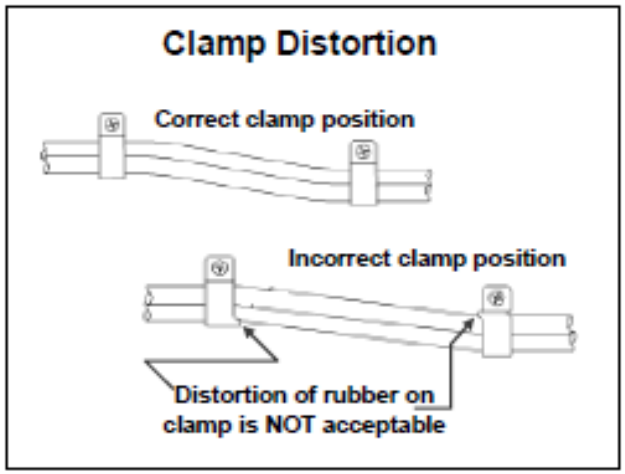
This is an example of an appropriate amount of cable slack between clamps. Appropriate slack protects the wires from stress and from contact with inappropriate surfaces.

• **Too much cable slack** can allow the cable to contact structure or other equipment which could damage the wire bundle.

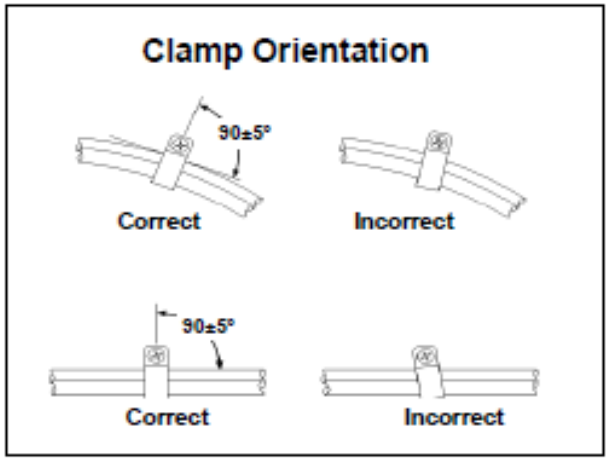
• **Too little slack** can cause a pre-load condition on the cable which could cause damage to the wire bundle and/or clamps as well.

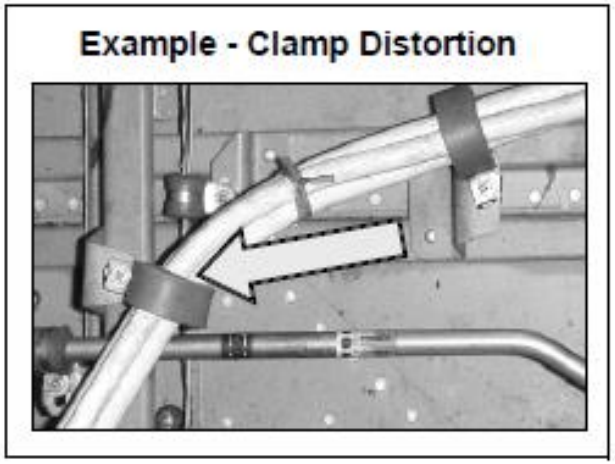
• **Also, sufficient slack should be left between the last clamp and the termination** or electrical equipment to prevent strain at the terminal and to minimize adverse effects of shock-mounted equipment.

Clamp inspection / Clamp removal and fitting



If wire bundles are not routed perpendicular to the clamp (bottom graphic), stress can be created against the clamp and clamp grommet which can distort the clamp and/or clamp grommet. Distorted lamps/clamp grommets can cause wire bundle damage over time.





Incorrect clamp orientation can lead to wire bundle damage.

Clamp inspection / Clamp removal and fitting

Proper

Improper

Wires can be pinched and damaged due to improper clamp installation.

Conduits type and fitting

Purpose. Primarily the purpose of conduits is for mechanical protection of cables or wires. Secondarily, conduits are used for environmental protection and grouping of wires by signal type.
Standards. Conduit should be inspected for: proper end fittings; absence of abrasion at the end fittings; proper clamping; distortion; adequate drain holes that are free of dirt, grease, or other obstructions; and freedom from abrasion or damage due to moving objects, such as aircraft control cables or shifting cargo.
Size of conduit. Conduit size should be selected for a specific wire bundle application to allow for ease in maintenance, and possible future circuit expansion, by specifying the conduit inner diameter (I.D.) about 25 percent larger than the maximum diameter of the wire bundle.
Conduit fittings. Wire is vulnerable to abrasion at conduit ends. Suitable fittings should be affixed to conduit ends in such a manner that a smooth surface comes in contact with the wire. When fittings are not used, the end of the conduit should be flared to prevent wire insulation damage. Conduit should be supported by use of clamps along the conduit run.

Conduit installation. Conduit problems can be avoided by following these guidelines:
Do not locate conduit where service or maintenance personnel might use it as a handhold or footstep.
Provide inspectable drain holes at the lowest point in a conduit run. Drilling burrs should be carefully removed.
Support conduit to prevent chafing against structure and to avoid stressing its end fittings.

Raceways

A raceway (sometimes referred to as a raceway system) is an enclosed conduit that forms a physical pathway for electrical wiring. Raceways protect wires and cables from heat, humidity, corrosion, water intrusion and general physical threats.

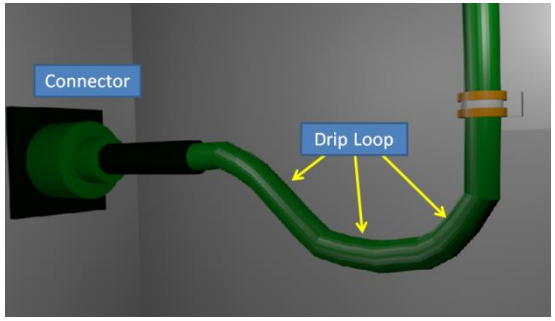
Addition of wires to existing wire raceways may cause undue wear and chafing of the wire installation and inability to maintain the wire in the raceway. Addition of wires to existing bundles may cause wire to sag against the structure, which can cause chafing.

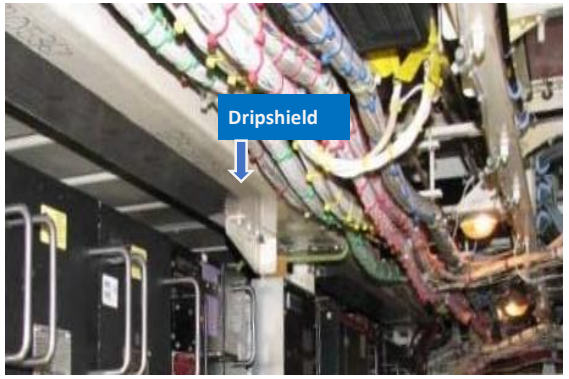
Shielding requirements

Electricity and fluids do not mix. Potential problems from exposure to fluids include:

- Degradation of insulation
- Shorting/arcing between damaged wires or wire to ground
- Shorting/arcing at connectors
- Contamination of connectors

It is important that the EWIS is protected along its length from exposure to fluids. These sources of fluids may come from leaking fuel or hydraulic lines, plumbing, or spillage from passengers/crew. If routed above these sources, the potential for exposure is limited. Where it is necessary to be routed below a potential fluid leak location, drip shields or umbrellas can be used to protect the wiring. Molded harnesses should be considered in areas that are regularly exposed to fluid and cannot be protected through other means. Additionally, addressing problems caused by fluids should include harness drip loops before connectors. Make sure that drain holes are present in drip loops or in the lowest portion of tubing placed over the wiring.





Replacement wires should have the same shielding characteristics as the original wires, such as shield optical coverage and resistance per unit length. If any wires are going to be replaced inside a shielded wire bundle, the replacement wires should not be installed outside the bundle shield.

E. (5) Typical damage and areas found (aeroplane specific)

Objective: Know typical damage that can be found (aeroplane specific).

a. Vibration
b. Heat
c. Corrosion
d. Contamination
e. Personnel traffic passage

Examples of the causes damages

EWIS Degradation

Vibration – High vibration areas tend to accelerate degradation over time, resulting in "chattering" contacts and intermittent symptoms. High vibration can also cause tie-wraps, or string-ties to damage insulation. In addition, high vibration will exacerbate any existing problem with wire insulation cracking.

Heat – EWIS components exposed to high heat can accelerate degradation, insulation dryness, and cracking. Direct contact with a high heat source can quickly damage insulation. Even low levels of heat can degrade EWIS over long periods of time. This type of degradation is sometimes seen on engines, in galleys, and behind lights.

Moisture – High moisture areas generally accelerate corrosion of terminals, pins, sockets, and conductors. It should be noted that EWIS installed in clean, dry areas with moderate temperatures appears to hold up well.

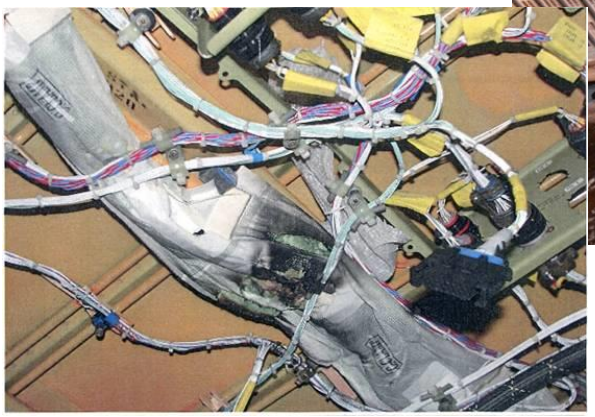
Chemical contamination – Chemicals such as hydraulic fluid, battery electrolytes, fuel, corrosion inhibiting compounds, waste system chemicals, cleaning agents, deicing fluids, paint, and soft drinks can contribute to degradation of EWIS. EWIS in the vicinity of these chemicals should be inspected for damage or degradation. Recommended original equipment manufacturer cleaning instructions should be followed. Hydraulic fluids, for example, require special consideration. Hydraulic fluid is very damaging to connector grommet and wire bundle clamps, leading to indirect damage, such as arcing and chafing. EWIS components that may have been exposed to hydraulic fluid should be given special attention during EWIS inspections.

Personnel traffic passage – Protect EWIS area from potential damage. Surrounding EWIS should be carefully inspected to ensure no damage is evident.

E. (6) Maintenance and repair procedures

Objective: Demonstrate the repair procedures for typical damage found on the student's type of aeroplane.

a. Wire damage assessment and classification
b. Approved repairs - Improper repairs
c. Shielded wire repair
d. Repair techniques
e. Terminals and splices
f. Preventative maintenance procedures



General Conditions for the Repair of Wire and Cable

These conditions are applicable all repairs:
- The condition that is the cause of the damage must be removed to prevent subsequent damage
- A repair must be done with clean hands and clean tools to prevent contamination that can cause a bad seal of the insulation materials
- The repair is permanent, unless it is specified differently in the applicable repair conditions or in the applicable repair procedure
- A repair done in a fuel vapor area must be applicable for a fuel vapor area.

Note: A fuel vapor area is an area where fuel vapors are present.
Warning: Heat Sources or other ignition sources must not be used when fuel vapors are present. Injury personnel from fire or explosion can occur.
Caution: Heat sources or other ignition sources must not be used when fuel vapors are present. Damage to equipment from fire or explosion can occur.

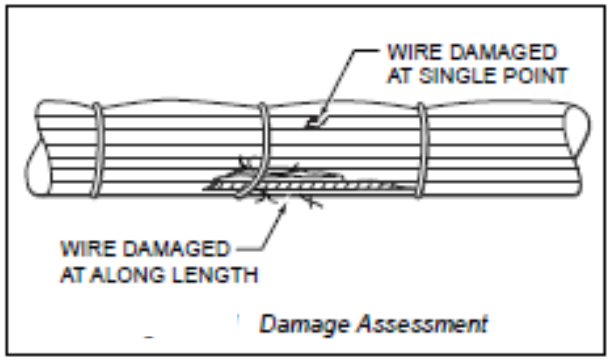
These conditions are applicable for the selection of the parts and materials for a repair:
The Temperature Grade of the insulation materials for the repair the insulation of a wire or the jacket of a cable must be the same as or higher than the Temperature Grade of the wire or the cable
- The Temperature Grade of the metal components for the repair of a wire or a cable must be the same as the Temperature Grade of the wire or the cable
- The Temperature Grade of the materials used for the repair of a wire or a cable in a high temperature area must be Temperature Grade
- If it is necessary to repair damage of a wire or a cable with a segment of wire or cable, the segment must have the same part number as the damaged wire or cable.

These conditions are applicable for the location of the repair:
- A repair must not be put in a conduit
- A repair must not be put in a connector backshell or a backshell adapter
- A repair must not be put on a bend of a wire or a cable
- A repair must not be put on a wire harness where the wire harness is frequently bent; for example, an instrument panel or a hinged door.

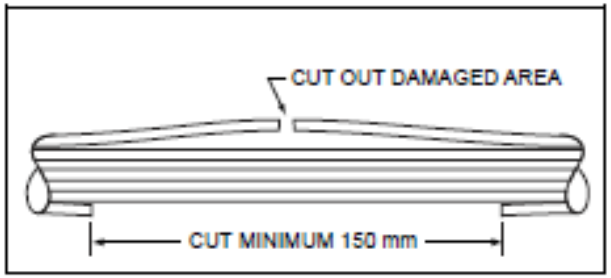
Repair techniques - Single Wire Repair

Single Wire Repair

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



Damage Assessment



Removing Damaged Area

Carry out repairs as follows:

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

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

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

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

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

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

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

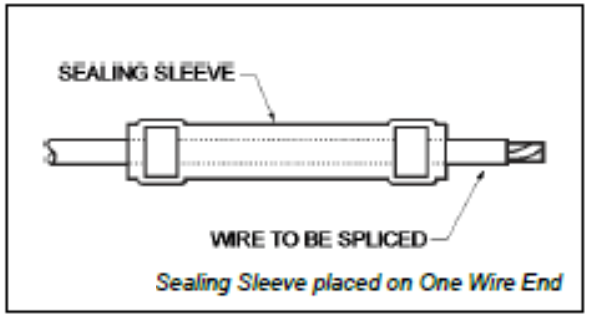
h. Select appropriate splice for wire replacement.

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

j. Strip wire insulation appropriate length for selected splice.

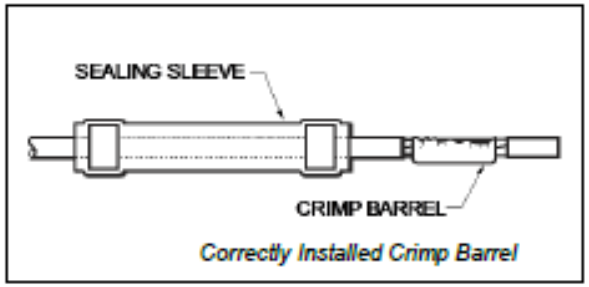
k. Slide splice sealing sleeve over one end of stripped wire

Repair techniques - Single Wire Repair - cont'd



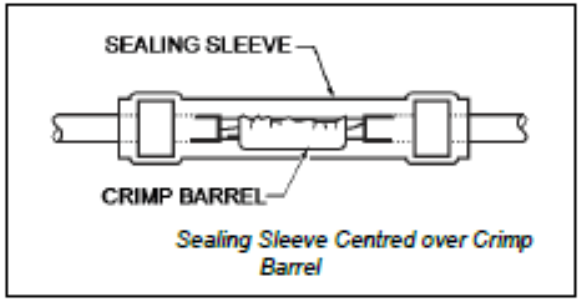
Sealing Sleeve placed on One Wire End

l. Using appropriate crimping tool and die. Crimp splice to wire ends.



Correctly Installed Crimp Barrel

m. Centre sealing sleeve over crimp barrel.



Sealing Sleeve Centred over Crimp Barrel

n. Shrink sealing sleeve using hot air gun with small termination reflector. Shrink middle first and move heat towards one end until sealant melts and begins to flow out of sleeve

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

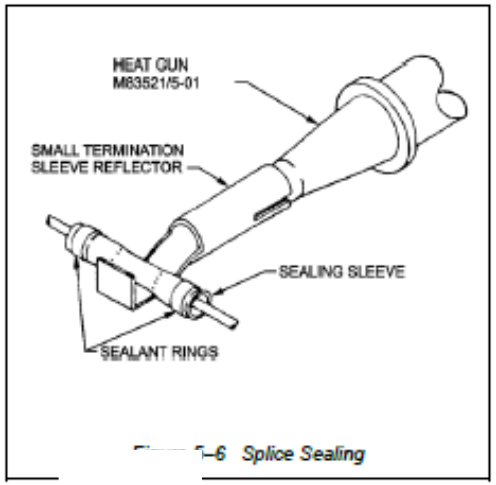


Figure 5–6 Splice Sealing

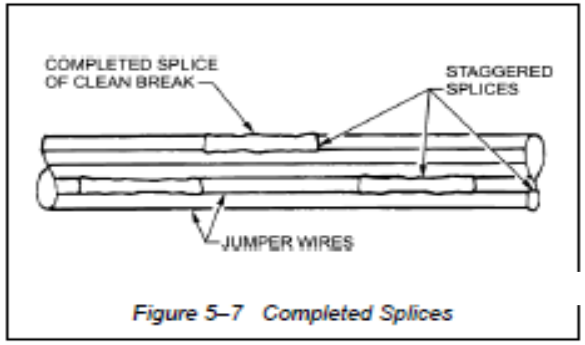


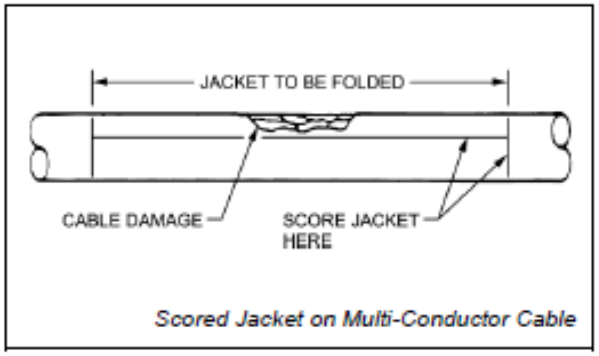
Figure 5–7 Completed Splices

p. Work repaired wires into the bundle ensuring splices remain staggered

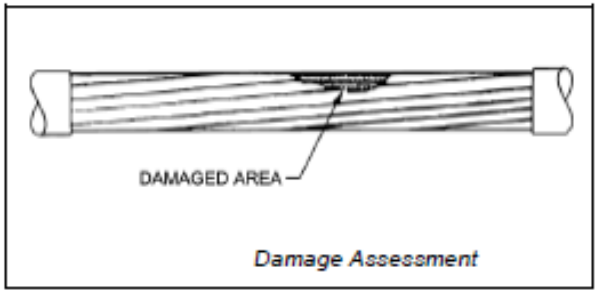
q. Replace cable clamps and cable ties removed for access.

Repair techniques - Unshielded Cable Repair (Multi conductor)

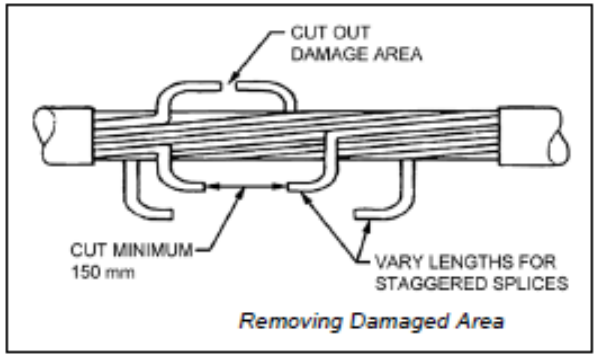
a. Cut cable ties and remove cable clamps as required to access cable damage.
b. Using a sharp blade or knife, score cable jacket around the cable and along the length of the damaged area.
c. Flex cable at score marks until jacket separates.
d. Remove jacket to gain access to damaged wires.
e. If more than one wire is to be spliced and wires are not colour coded or otherwise identified, tag wires before proceeding.
f. Cut out the segment of wire with conductor or insulation damage. If a jumper wire is required, cut out at least 15cm of the damaged wire to allow room for splicing.
g. If more than one jumper wire is to be installed, stagger splice positions by varying lengths of sections that are cut out of the damaged wires.
h. Determine type and gauge of wire to be replaced from wire identification code or wiring diagram.
i. Cut replacement wire 12.7 mm longer than removed segment.
j. Select appropriate splice for wire being replaced.



Scored Jacket on Multi-Conductor Cable



Damage Assessment

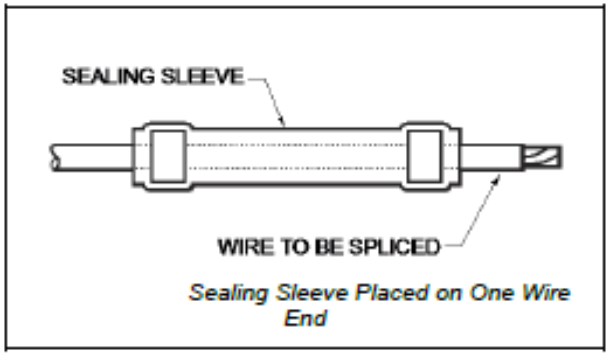


Removing Damaged Area

Repair techniques - Unshielded Cable Repair (Multi conductor) – cont'd

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

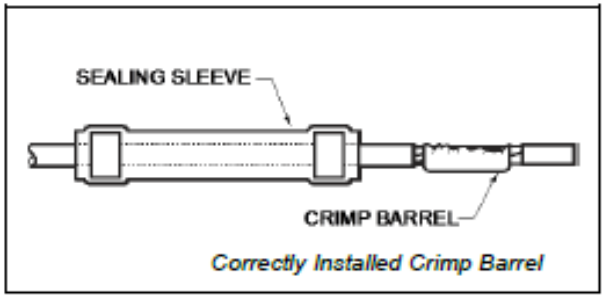
l. Strip wire insulation appropriate length for selected splice.



Sealing Sleeve Placed on One Wire End

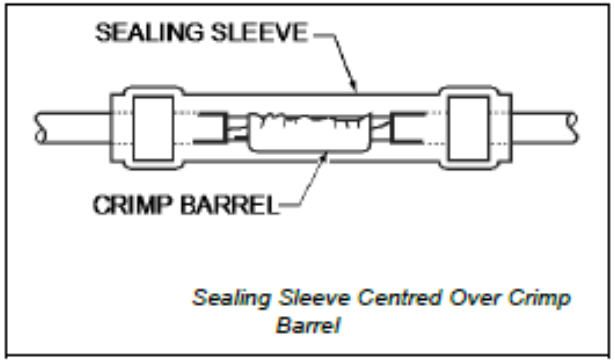
m. Slide splice sealing sleeve over one end of stripped wire.

n. Using appropriate crimping tool and crimp splice to wire ends.



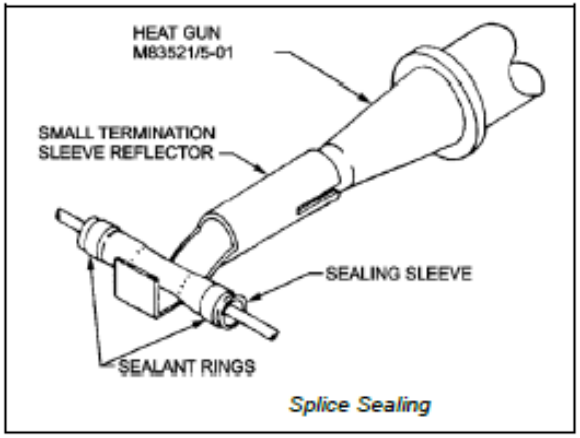
Correctly Installed Crimp Barrel

o. Centre sealing sleeve over crimp barrel



Sealing Sleeve Centred Over Crimp Barrel

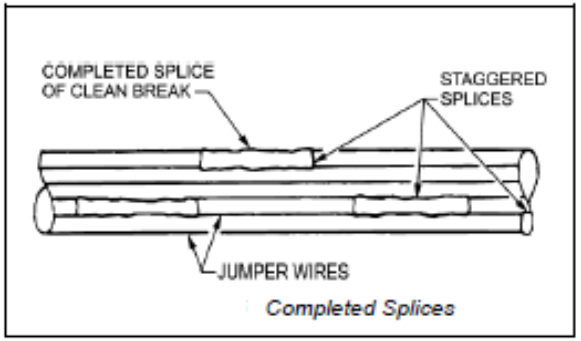
p. Shrink sealing sleeve using hot air gun with small termination reflector. Shrink the middle first and heat towards one end until sealant melts and begins to flow out of sleeve.



Splice Sealing

Repair techniques - Unshielded Cable Repair (Multi conductor) – cont'd

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



Completed Splices

s. Apply insulating tape starting 12.7 mm before repaired area. Wrap tape one complete turn around cable parallel to jacket cut line.

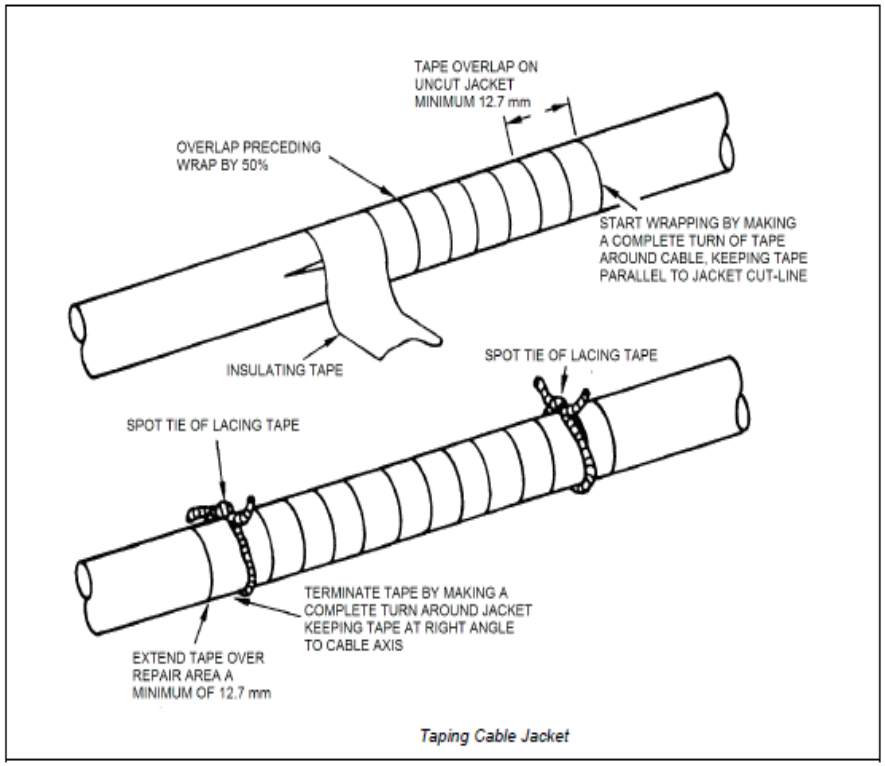
t. Keeping tape stretched firmly, begin wrapping around cable in a single layer, spiral wrap, using a 50% overlap.

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

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

w. Spot tie both ends of insulating.

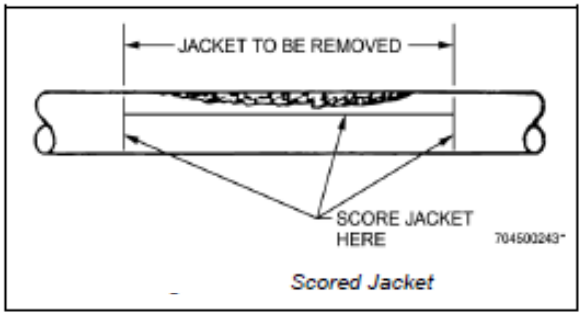
x. Replace cable clamps and cable ties removed for access.



Taping Cable Jacket

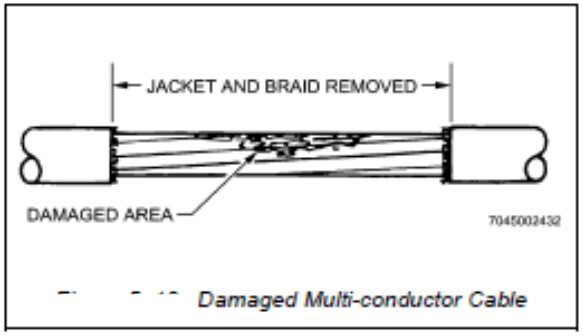
Repair techniques - Shielded Cable Repair

a. Cut cable ties and remove cable clamps as required to access cable damage.
b. Select shield repair kit according to the outside diameter of the damaged cable jacket.
c. Using a sharp blade, score cable jacket around the cable and along the length of the damaged area.



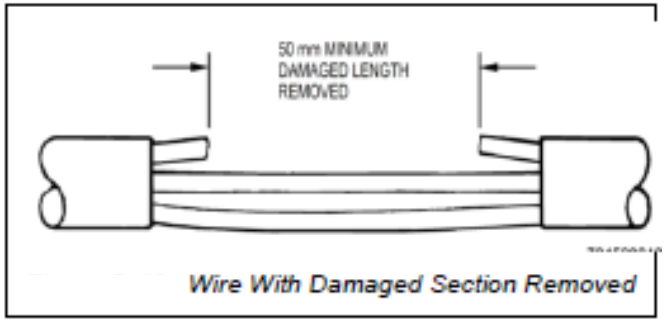
Scored Jacket

d. Flex cable at score marks until jacket separates.
e. Remove jacket.
f. Using small scissors or diagonal cutter, remove shield, taking care not to damage underlying wire insulation.



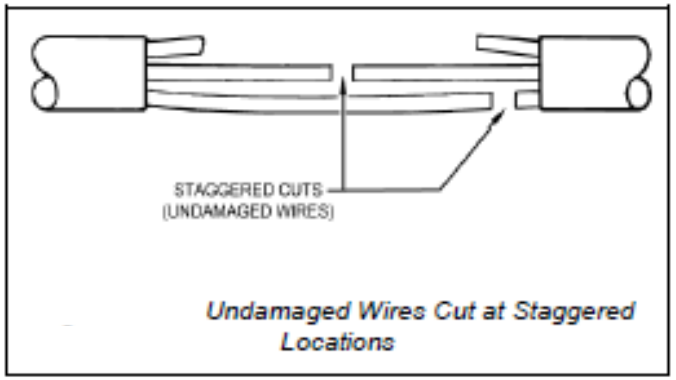
Damaged Multi-conductor Cable

g. If wires are not colour coded or otherwise identified, tag all wires before proceeding.
h. Cut wires to remove damage. If a segment of damaged wire must be cut out, remove at least 50 mm total length. If damage is at a single point, damaged wire can be cut at the point of damage.



Wire With Damaged Section Removed

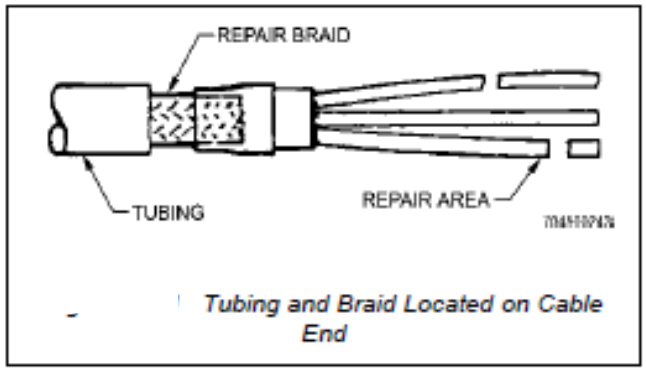
i. Cut undamaged wires at staggered locations



Undamaged Wires Cut at Staggered Locations

Repair techniques - Shielded Cable Repair – cont'd

j. Slide tubing and braid from shield repair kit, over one cable end. Tape tubing and braid away from repair area.



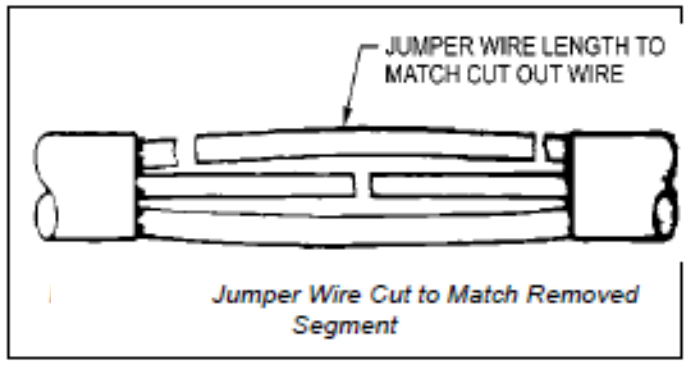
Tubing and Braid Located on Cable End

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

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

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

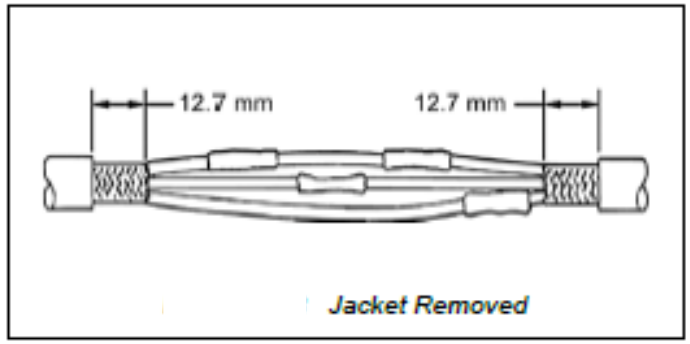
n. Cut replacement wire appropriate length to match removed segment.



Jumper Wire Cut to Match Removed Segment

o. Carry out the appropriate wire splicing procedure - steps i to n.

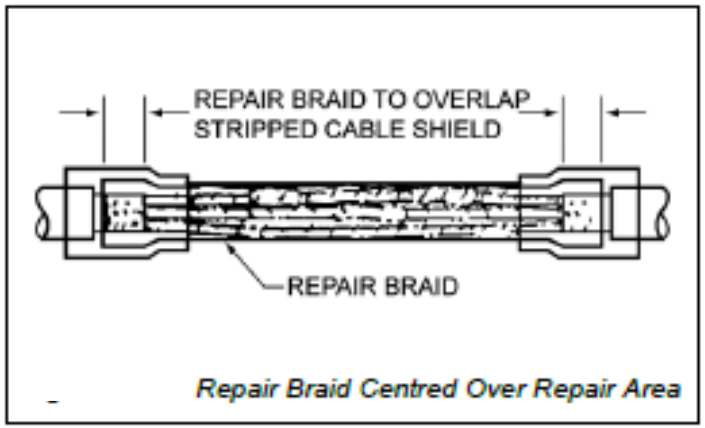
p. When all wires have been reconnected, remove 12.7 mm of cable jacket at each end by carefully scoring around cable and along length to be stripped.



Jacket Removed

Repair techniques - Shielded Cable Repair – cont'd

q. Slide repair braid along cable and center over repaired area



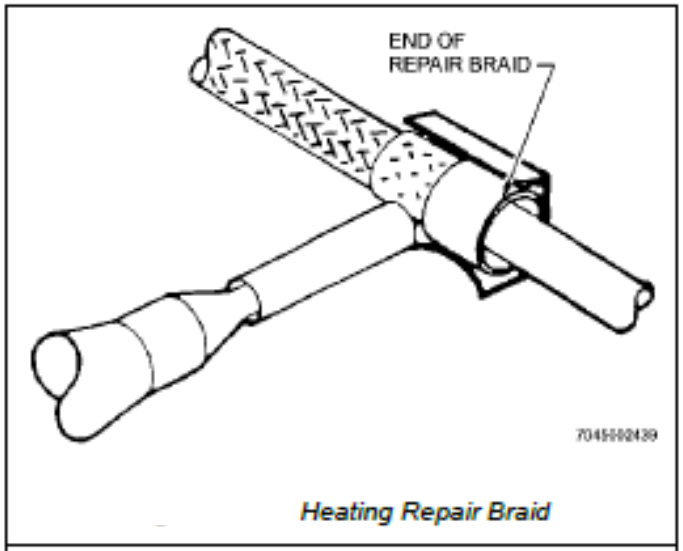
Repair Braid Centred Over Repair Area

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

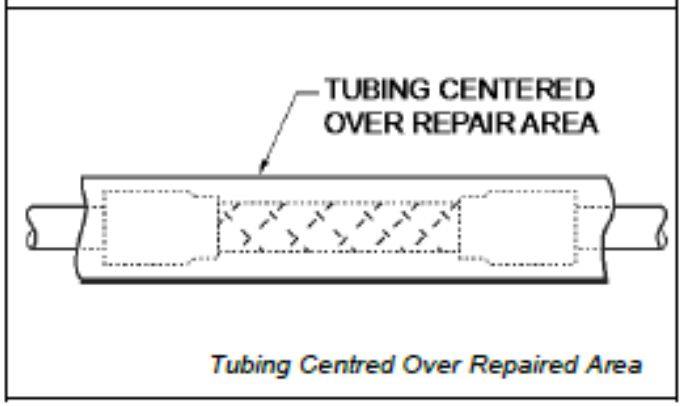
s. Repeat step r. for opposite end.

t. Slide heat shrink tubing over repaired area and centre.

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



Heating Repair Braid



Tubing Centred Over Repaired Area

E. (7) Sleeving

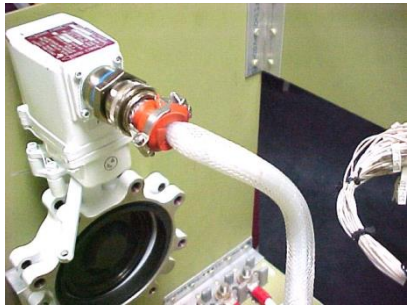
Objective: Demonstrate the procedures to fitting differing types of sleeving (aeroplane specific).

a. Identification sleeves
b. Shrink sleeves
c. Screen braid grounding crimp sleeves
d. Screen braid grounding solder sleeves

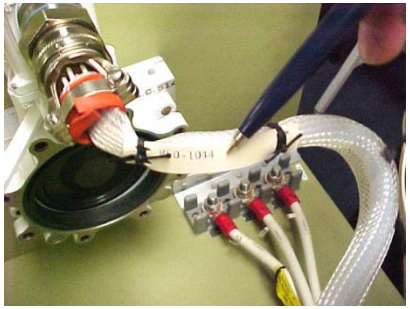
EWIS Identification

Purpose. The proper identification of EWIS components with their circuits and voltages is necessary to provide safety of operation, safety to maintenance personnel, and ease of maintenance.

- **The method of identification** should not impair the characteristics of the EWIS.
- **Original wire identification.** To facilitate installation and maintenance, retain the original wire-marking identification. The wire identification marks should consist of a combination of letters and numbers that identify the wire, the circuit it belongs to, its gauge size, and any other information to relate the wire to a EWIS diagram. All markings should be legible in size, type, and color.
- **Identification and information related to the EWIS diagrams.** The wire identification marking should consist of similar information to relate the wire to a EWIS diagram.



No marking



Proper indirect marking

There can be serious repercussions when there is a situation in which a number of unmarked cables are disconnected. When the cables reconnected, the chances are high that they will be connected incorrectly, thus causing numerous problems.

Marking EWIS in aircraft.

Identification markings generally are placed at each end of the wire and at 15-inch maximum intervals along the length of the wire.

• Wires less than 3 inches long need not be identified.

• Wires 3 to 7 inches in length should be identified approximately at the center.

• Added identification marker sleeves should be located so that ties, clamps, or supporting devices need not be re-moved in order to read the identification.

• The wire identification code must be printed to read horizontally (from left to right) or vertically (from top to bottom). The two methods of marking wire or cable are as follows:

- **(1) Direct marking** is accomplished by printing the cable's outer covering.
- **(2) Indirect marking** is accomplished by printing a heat-shrinkable sleeve and installing the printed sleeve on the wire or cables outer covering. Indirect marked wire or cable should be identified with printed sleeves at each end and at intervals not longer than 6 feet. The individual wires inside a cable should be identified within 3 inches of their termination.

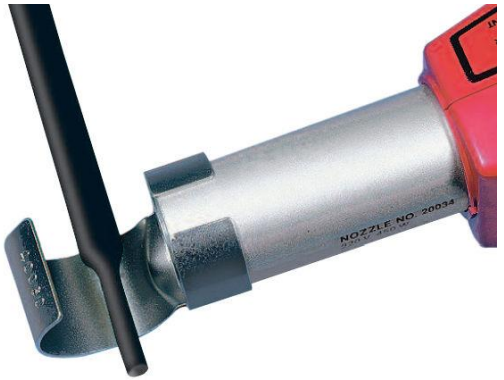
• The marking should be permanent such that environmental stresses during operation and maintenance do not adversely affect legibility.

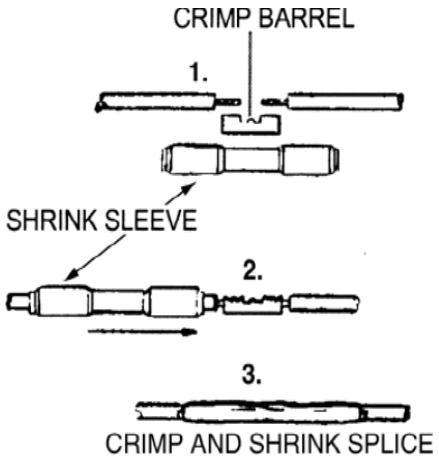
Direct marking

Indirect marking

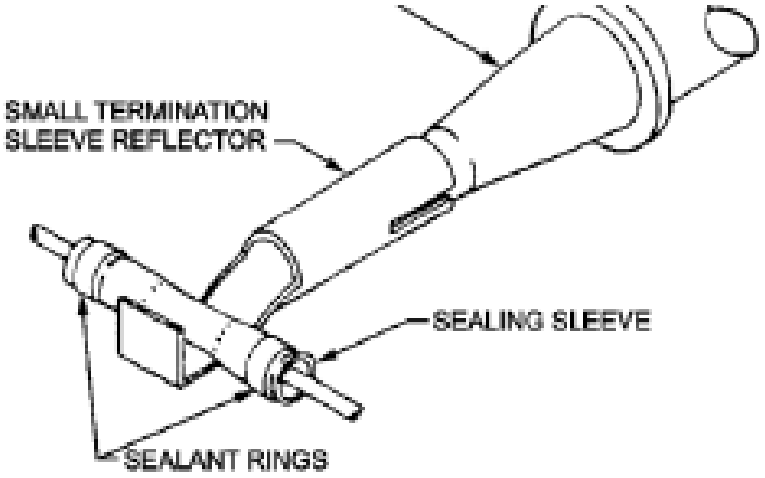
Types of sleeving

Heat-shrinkable tubing is a plastic-like tubing (similar to insulation sleeving) that will shrink to a smaller diameter with proper heating. Place the tubing over the joint, terminal, or part needing insulation. Now apply heat with a heat gun, oven, or other appropriate heat source. When the tubing reaches a specific temperature (shrink temperature depends upon the type of tubing), it quickly shrinks around the object, forming a snug jacket. In addition to being an insulator, the shrinkable tubing helps relieve strain and adds waterproofing.





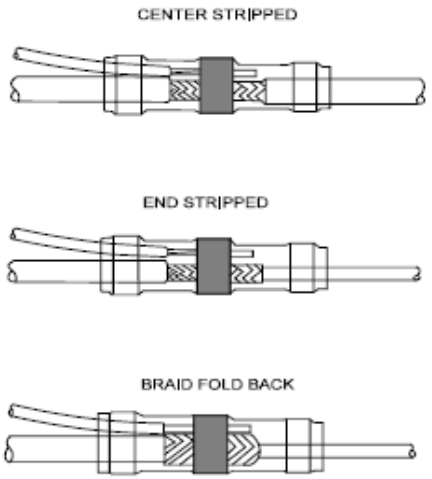
Crimp and shrink splice repair



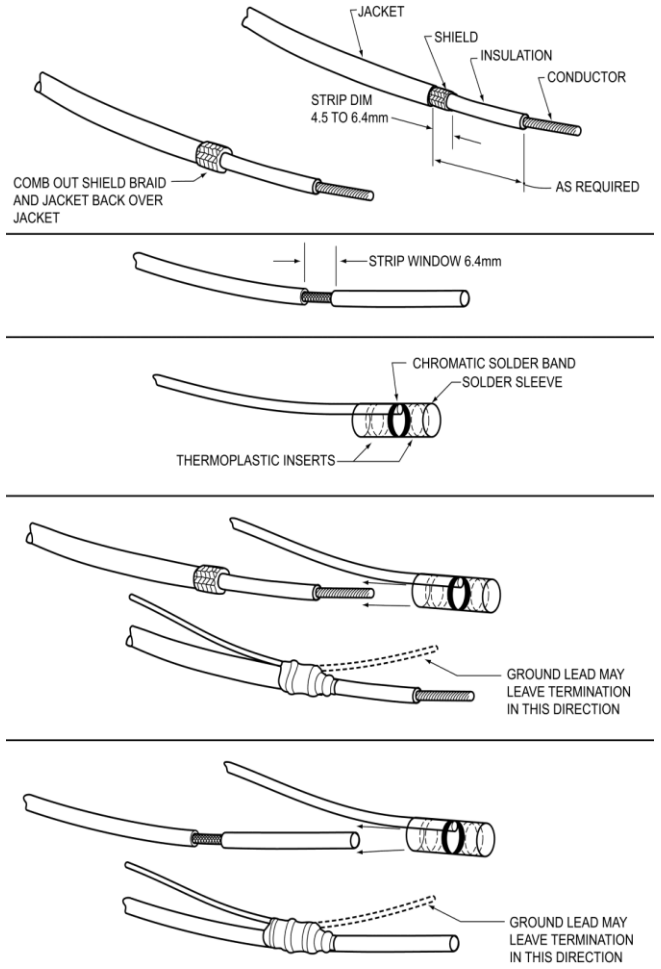
Types of sleeving

Screen braid grounding solder sleeves

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



Examples of solder sleeve assemble

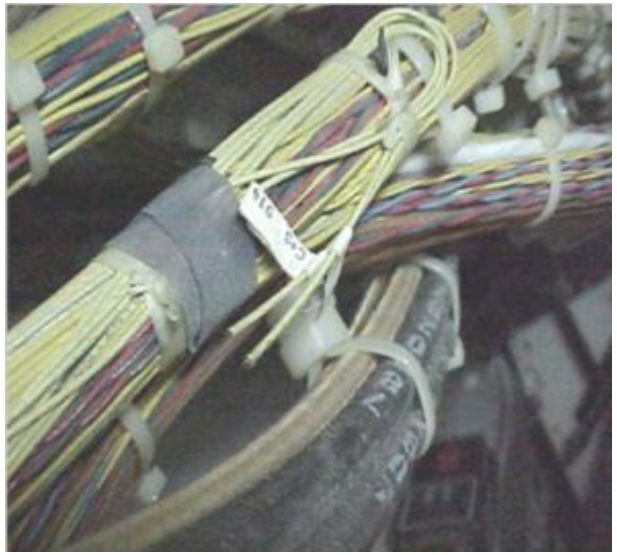


Solder sleeve shield termination

E. (8) Unused wires - termination and storage

Objective: Know the procedures for termination and storage of unused wires.

a. Termination – End caps
b. Storage and attachment

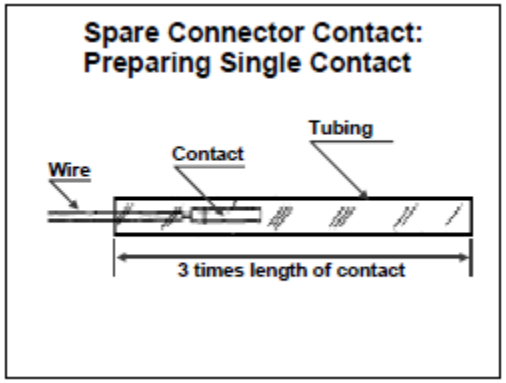


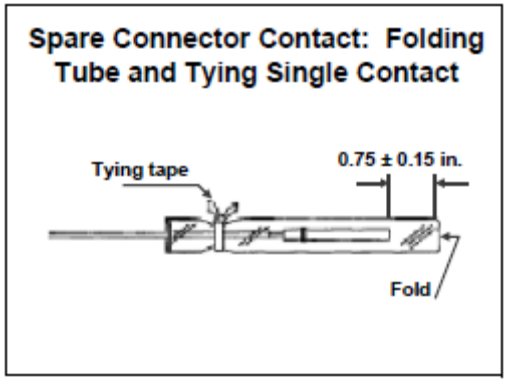
Improper termination of unused wires can cause damage

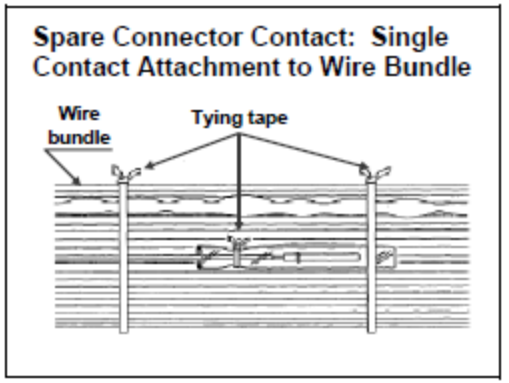
Unused Wires

Unused wires should be:
- Secured
- Tied into a bundle or secured to a permanent structure
- Individually cut with strands even with insulation
- Pre-insulated, closed-end connector or 1-inch piece of insulating tubing folded and tied back

Acceptable method of insulating and physically securing a spare connector contact within a wire bundle.

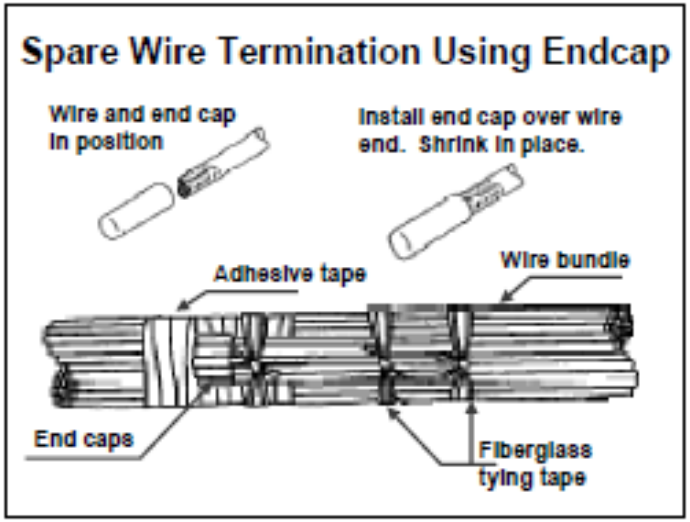


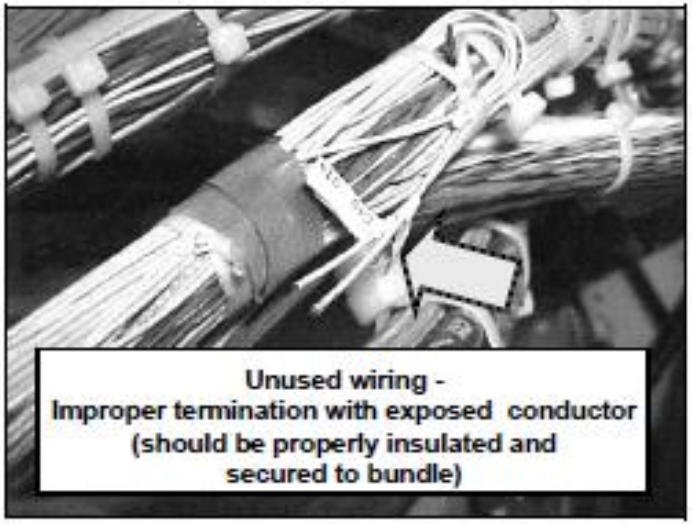




Unused Wires

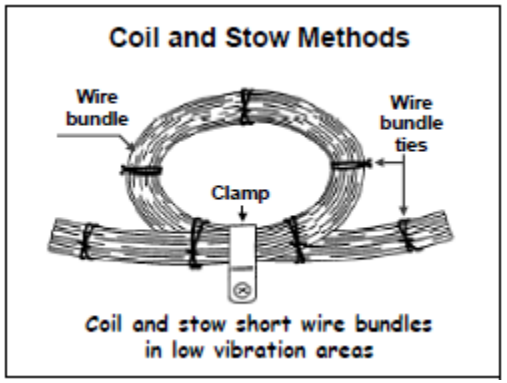
Spare wire termination using an endcap. This is another way to protect unused wiring.

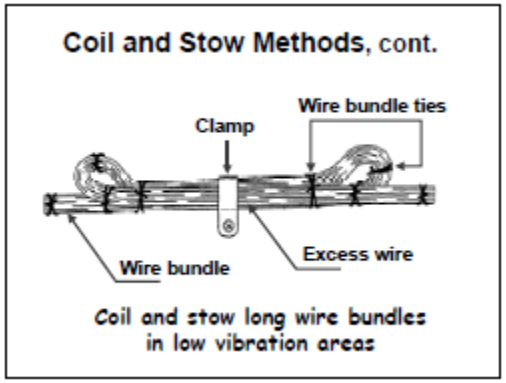


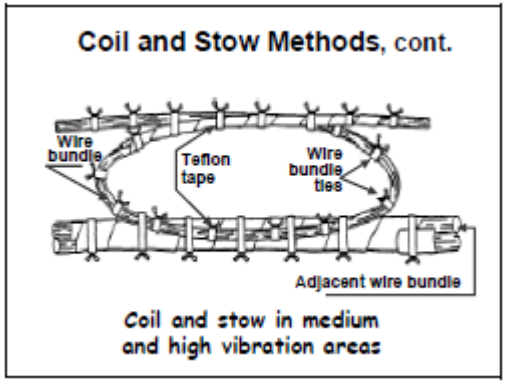


Unused Wires

Coil and stow methods





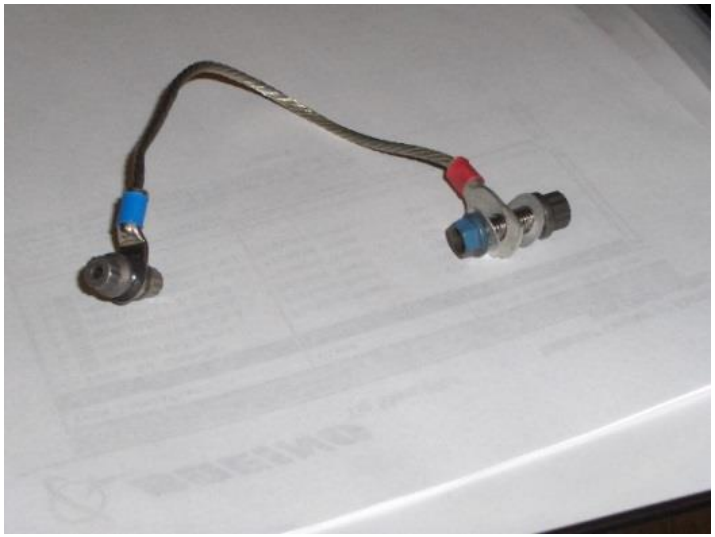


- Coil and stow methods are often used to secure excess length of a wire bundle or to secure wire bundles that are not connected to any equipment, such as wiring provisioning for a future installation.
- The key objective to coiling and stowing wiring is to safely secure the wire bundle to prevent excessive movement or contact with other equipment that could damage the wiring.
- Coil and stow in medium and high vibration areas requires additional tie straps, sleeving, and support.

E. (9) Electrical bonding and grounds

Objective: Know the correct installation practices for electrical bonds and grounds (aeroplane specific).

a. Inspection standards
b. Primary Bonding (HIRF protection)
c. Secondary Bonding (System grounding)
d. Lightning strikes



Bonding and grounding

Bonding and grounding connections are made for the following purposes:

- To protect aircraft and personnel against hazards from lightning discharge.
- To provide current return paths.
- To prevent development of RF potentials.
- To protect personnel from shock hazard.
- To provide stability and homogeneity of radio transmission and reception.
- To prevent accumulation of static charge.
- To provide fault current return paths.

Definitions

Bonding
The electrical connecting of two or more conducting objects not otherwise adequately connected.

Grounding
The electrical connecting of conducting object to primary structure or earth electrode, for return of current.

Primary Bonding
Primary bonding is supplied by all the conductive structural parts (fuselage, wings, control surfaces, nacelles, landing gears, etc.) of the aircraft to:

- Collect high energy (as caused by lightning).

Secondary Bonding
The secondary bondings which include the other cases of conductibility related to electrical potentials circulating in the aircraft and especially the following:

- Current return through aircraft ground return.
- Electrostatic potential circulation.
- Grounding of various shieldings.
- Electrostatic potential discharging.
- Grounding of the aircraft.
- Protective grounding against electric shock in case of defective insulation.

Bonding and grounding

Equipment bonding

- Low impedance paths to aircraft structure required for electronic equipment to provide radio frequency return circuits
- Facilitates reduction in EMI for most electrical equipment
- Cases of components that produce EMI should be grounded to structure

Metallic surface bonding

- Electrically connecting conductive exterior airframe components through mechanical joints, conductive hinges, or bond straps
- Protects against static charges and lightning strikes

Static bonds

- Required for all isolated conducting parts with area greater than 3 in 2 and a linear dimension over 3" subjected to appreciable electrostatic charging due to precipitation, fluid, or air in motion
- Resistance of less than 1 ohm when clean and dry usually ensures static dissipation on larger objects

Bonding and grounding

General precautions and procedures

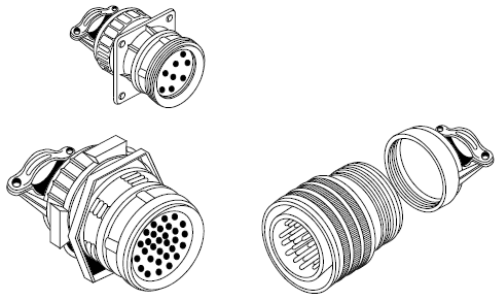
When making bonding or grounding connections in aircraft, observe the following general precautions and procedures:

- Bond or ground parts to the primary aircraft structure where practicable.
- Make bonding or grounding connections in such a way as not to weaken any part of the aircraft structure.
- Bond parts individually wherever possible.
- Make bonding or grounding connections against smooth, clean surfaces.
- Install bonding or grounding connections so that vibration, expansion or contraction, or relative movement incident to normal service use will not break or loosen the connection.
- Locate bonding and grounding connections in protected areas whenever possible. Locate connections, whenever possible, near hand holes, inspection doors, or other accessible areas to permit easy inspection and replacement.
- Do not compression-fasten bonding or grounding connections through any non-metallic material.
- Inspect the grounding and bonding straps to ensure that they are free of corrosion which will adversely affect performance, and are not frayed or cut more than 25% of the original strap.
- No more than four ground wires should be connected to a common ground stud. No more than 16 ground wires should be connected in a ground module. Each ground for electric power sources (primary, secondary, emergency) should be connected to separate ground points. Grounds for utilisation equipment may be connected to a common ground point only when supplied from the same power source, provided this equipment does not

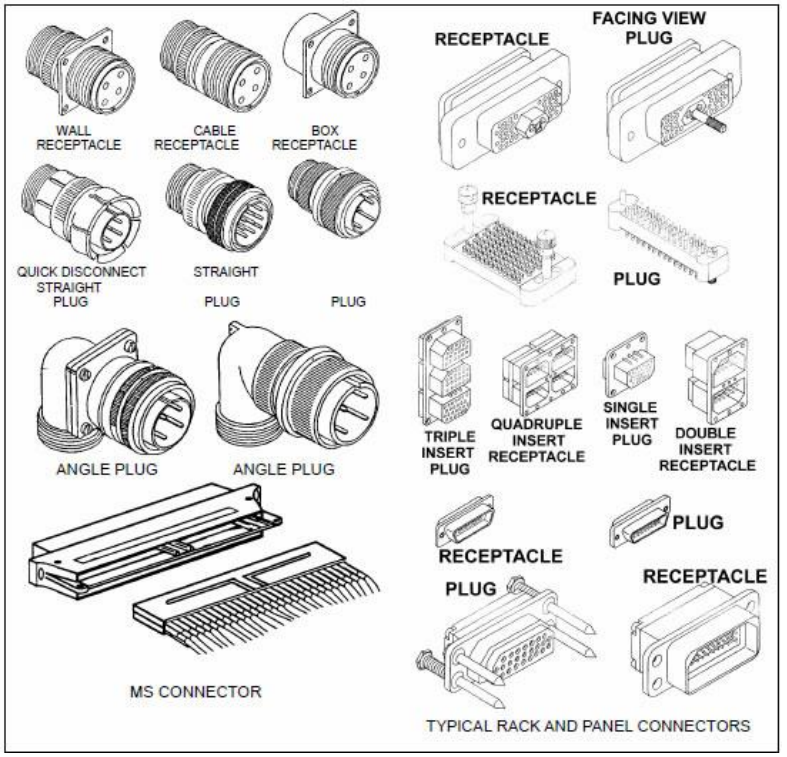
MODULE F – CONNECTIVE DEVICES:

Objective: Know or demonstrate the procedures to identify, inspect, and find the correct repair for typical types of connective devices found on the applicable aeroplane.

(1) General types and identification
(2) Cautions and protections
(3) Visual inspection procedures
(4) Typical damage found
(5) Repair procedures



Different types of connectors



F. (1) General types and identification

Objective: Know the general types and positive identification of connective devices. (aeroplane specific).

a. Part number identification
b. Reference tables
c. Specific connective devices chapters

Connectors

The number and complexity of EWIS have resulted in an increased use of electrical connectors. The proper choice and application of connectors is a significant part of the aircraft EWIS system. Connectors should be kept to a minimum, selected, and installed to provide the maximum degree of safety and reliability to the aircraft. For the installation of any particular connector assembly, the specification of the manufacturer should be followed.

There are many types, however crimped contacts generally used
– Circular type
– Rectangular
– Module blocks

A wide variety of circular environment-resistant connectors are used in applications where they will probably be subjected to fluids, vibration, thermal, mechanical shock, corrosive elements, etc. In addition, firewall class connectors incorporating these same features should be able to prevent the penetration of the fire through the aircraft firewall connector opening and continue to function without failure for a specified period of time when exposed to fire. Hermetic connectors provide a pressure seal for maintaining pressurized areas.

When EMI/RFI protection is required, special attention should be given to the termination of individual and overall shields. Backshell adapters designed for shield termination, connectors with conductive finishes, and EMI grounding fingers are available for this purpose.

Types of connectors

Circular Connectors

•Consideration should be given to the design of the pin arrangement to avoid situations where pin-to-pin shorts could result in multiple loss of functions and/or power supplies.

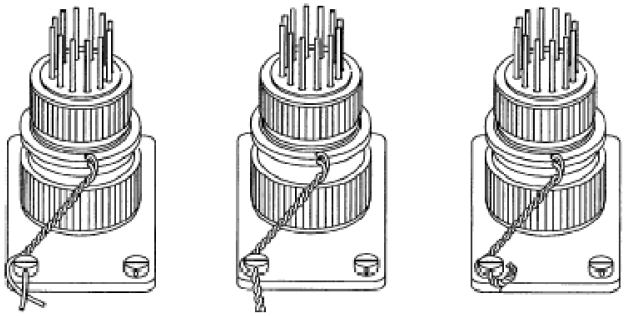
•A wide variety of circular environment-resistant connectors are used in applications where they will probably be subjected to fluids, vibration, thermal, mechanical shock, corrosive elements, etc.

•In addition, firewall class connectors incorporating these same features should be able to prevent the penetration of the fire through the aircraft firewall connector opening and continue to function without failure for a specified period of time when exposed to fire.

•Hermetic connectors provide a pressure seal for maintaining pressurized areas.

•When EMI/RFI protection is required, special attention should be given to the termination of individual and overall shields.

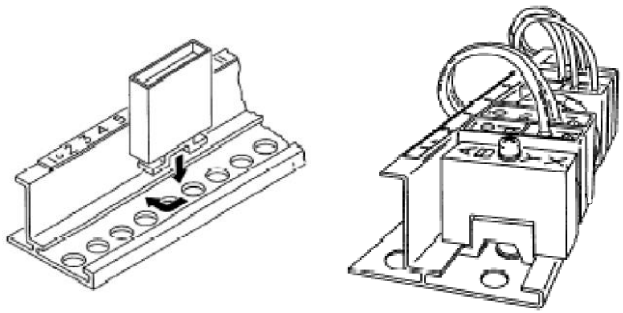
•Backshell adapters designed for shield termination, connectors with conductive finishes, and EMI grounding fingers are available for this purpose.

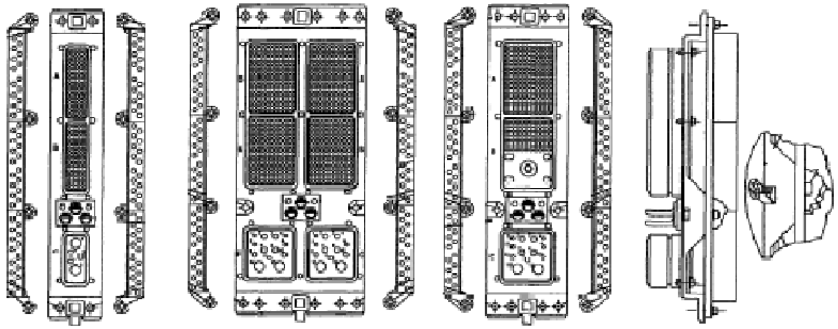


Circular Connectors

In medium or high vibration areas it may be necessary to provide a locking device to keep the connectors from loosening.

Types of connectors





Module blocks accept crimped contacts similar to those on connectors. Some use internal busing to provide a variety of circuit arrangements.

• Module blocks (or terminal blocks) are useful where a number of wires are connected for power or signal distribution. When used as grounding modules, they save and reduce hardware installation on the aircraft.

• Standardized modules are available with wire-end grommet seals for environmental applications and are track-mounted.

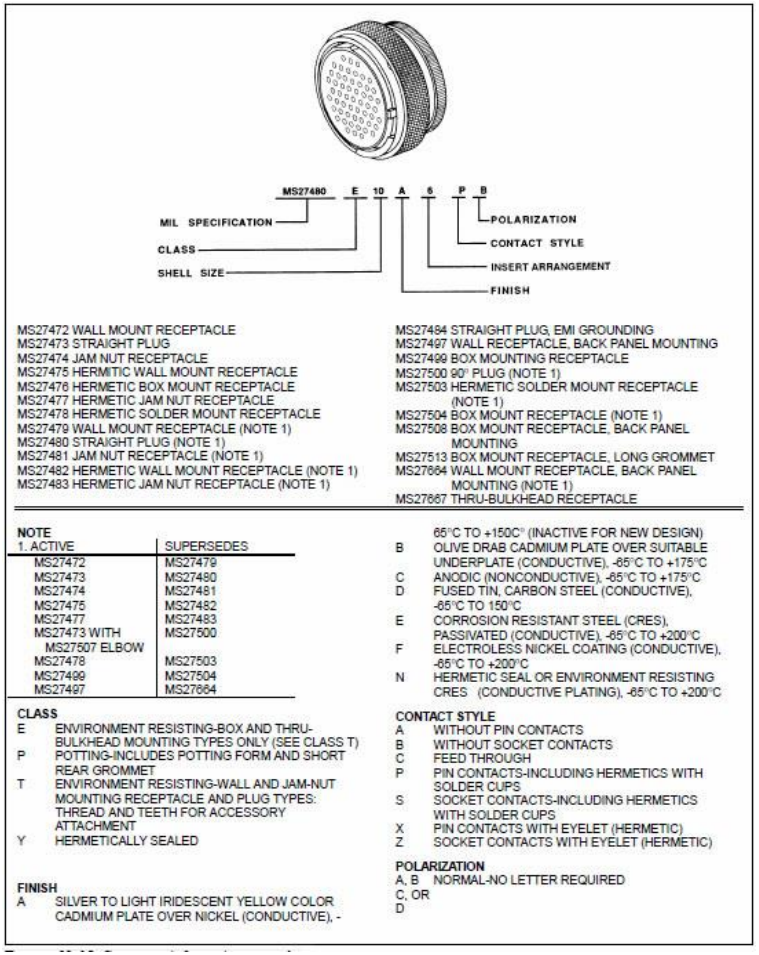
Rectangular connectors are typically used in applications where a very large number of circuits are accommodated in a single mated pair. They are available with a great variety of contacts, which can include a mix of standard, coaxial, and large power types. Coupling is accomplished by various means.

• Smaller types are secured with screws that hold their flange together.

• Larger ones have integral guide pins that ensure correct alignment, or jackscrews that both align and lock the connectors.

• Rack and panel connectors use integral or rack-mounted pins for alignment and box mounting hardware for couplings.

Connector Identification



MS27480 E 10 A 6 P B

- MIL SPECIFICATION
- CLASS
- SHELL SIZE
- FINISH
- INSERT ARRANGEMENT
- CONTACT STYLE
- POLARIZATION

MS27472 WALL MOUNT RECEPTACLE
MS27473 STRAIGHT PLUG
MS27474 JAM NUT RECEPTACLE
MS27475 HERMITIC WALL MOUNT RECEPTACLE
MS27476 HERMETIC BOX MOUNT RECEPTACLE
MS27477 HERMETIC JAM NUT RECEPTACLE
MS27478 HERMETIC SOLDER MOUNT RECEPTACLE
MS27479 WALL MOUNT RECEPTACLE (NOTE 1)
MS27480 STRAIGHT PLUG (NOTE 1)
MS27481 JAM NUT RECEPTACLE (NOTE 1)
MS27482 HERMETIC WALL MOUNT RECEPTACLE (NOTE 1)
MS27483 HERMETIC JAM NUT RECEPTACLE (NOTE 1)

MS27484 STRAIGHT PLUG, EMI GROUNDING
MS27497 WALL RECEPTACLE, BACK PANEL MOUNTING
MS27499 BOX MOUNTING RECEPTACLE
MS27500 90° PLUG (NOTE 1)
MS27503 HERMETIC SOLDER MOUNT RECEPTACLE (NOTE 1)
MS27504 BOX MOUNT RECEPTACLE (NOTE 1)
MS27508 BOX MOUNT RECEPTACLE, BACK PANEL MOUNTING
MS27513 BOX MOUNT RECEPTACLE, LONG GROMMET
MS27664 WALL MOUNT RECEPTACLE, BACK PANEL MOUNTING (NOTE 1)
MS27667 THRU-BULKHEAD RECEPTACLE

NOTE
1. ACTIVE

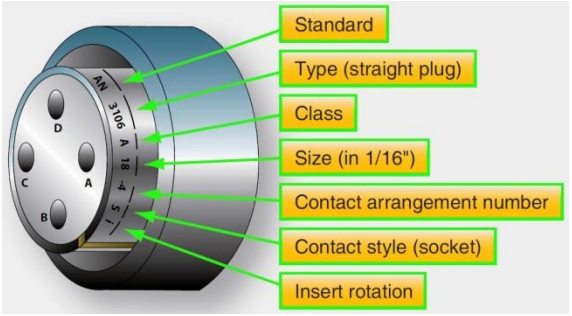
	SUPERSEDES
MS27472	MS27479
MS27473	MS27480
MS27474	MS27481
MS27475	MS27482
MS27477	MS27483
MS27473 WITH MS27507 ELBOW	MS27500
MS27478	MS27503
MS27499	MS27504
MS27497	MS27664

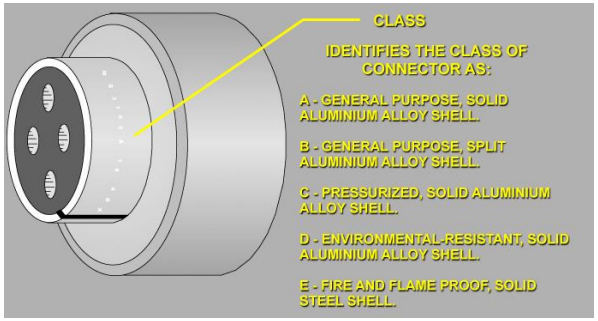
CLASS
- E ENVIRONMENT RESISTING-BOX AND THRU-BULKHEAD MOUNTING TYPES ONLY (SEE CLASS T)
- P POTTING-INCLUDES POTTING FORM AND SHORT REAR GROMMET
- T ENVIRONMENT RESISTING-WALL AND JAM-NUT MOUNTING RECEPTACLE AND PLUG TYPES: THREAD AND TEETH FOR ACCESSORY ATTACHMENT
- Y HERMETICALLY SEALED

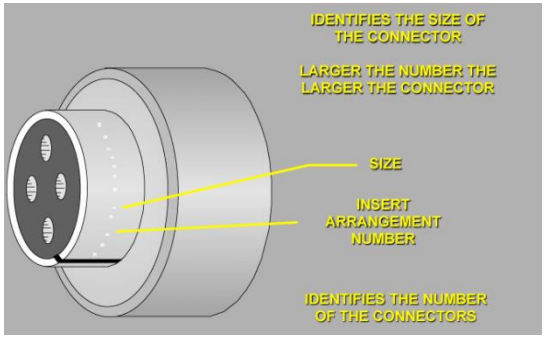
FINISH
- A SILVER TO LIGHT IRIDESCENT YELLOW COLOR CADMIUM PLATE OVER NICKEL (CONDUCTIVE), -65°C TO +150C° (INACTIVE FOR NEW DESIGN)
- B OLIVE DRAB CADMIUM PLATE OVER SUITABLE UNDERPLATE (CONDUCTIVE), -65°C TO +175°C
- C ANODIC (NONCONDUCTIVE), -65°C TO +175°C
- D FUSED TIN, CARBON STEEL (CONDUCTIVE), -65°C TO 150°C
- E CORROSION RESISTANT STEEL (CRES), PASSIVATED (CONDUCTIVE), -65°C TO +200°C
- F ELECTROLESS NICKEL COATING (CONDUCTIVE), -65°C TO +200°C
- N HERMETIC SEAL OR ENVIRONMENT RESISTING CRES (CONDUCTIVE PLATING), -65°C TO +200°C

CONTACT STYLE
- A WITHOUT PIN CONTACTS
- B WITHOUT SOCKET CONTACTS
- C FEED THROUGH
- P PIN CONTACTS-INCLUDING HERMETICS WITH SOLDER CUPS
- S SOCKET CONTACTS-INCLUDING HERMETICS WITH SOLDER CUPS
- X PIN CONTACTS WITH EYELET (HERMETIC)
- Z SOCKET CONTACTS WITH EYELET (HERMETIC)

POLARIZATION
- A, B, C, OR D NORMAL-NO LETTER REQUIRED



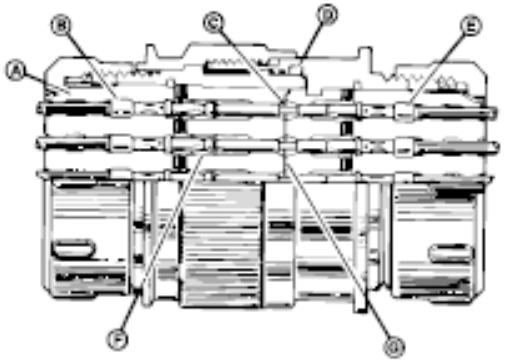




Examples of connector identification

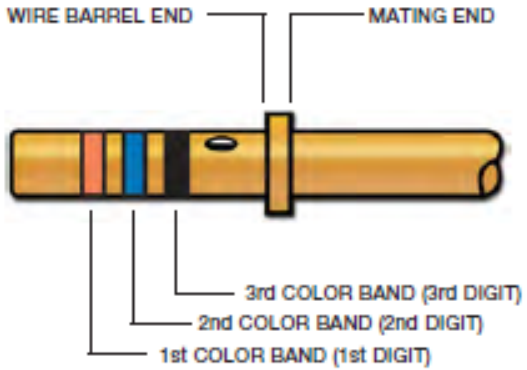
Connector Identification

TYPICAL COMPLEX CABLE CONNECTOR



A. Wire Seal
B. Socket Contact
C. Chamfered Socket Lead-In
D. Peripheral O-Ring Seal
E. Pin Contact
F. Contact Retention Clip
G. Interfacial Seal

CONTACT COLOR CODE AND BIN*



0 – Black (BLK)	5 – Green (GRE)
1 – Brown (BRN)	6 – Blue (BLU)
2 – Red (RED)	7 – Violet (VIO)
3 – Orange (ORN)	8 – Gray (GRA)
4 – Yellow (YEL)	9 – White (WHI)

*BASIC IDENTIFICATION NUMBER

- Example shown: 360 (Orange, Blue, Black)
- Manufacturers have the option of identifying contacts by stamping the BIN code on the shoulder or the wire barrel (size 16 and larger).

Example of Specific connective devices chapters

STANDARD WIRING PRACTICES MANUAL

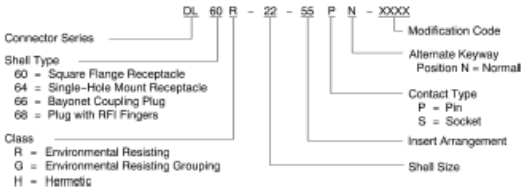
ASSEMBLY OF DEUTSCH DL TYPE CONNECTORS

1.Part Numbers and Description

A. Connector Part Numbers

TABLE I
CONNECTOR PART NUMBERS

Part Number	Supplier
DL60()	Deutsch
DL64()	Deutsch
DL66()	Deutsch
DL68()	Deutsch



DEUTSCH DL CONNECTOR PART NUMBER STRUCTURE
Figure 1

STANDARD WIRING PRACTICES MANUAL

ASSEMBLY OF AVIBANK AV667 AND AV697 CONNECTORS

1.Part Numbers and Description

A. Connector Part Numbers

TABLE I
CONNECTOR PART NUMBERS

Part Number	Supplier
AV667	Avibank
AV697	Avibank

B. Connector Adapter Part Numbers

TABLE II
ADAPTER PART NUMBERS

Part Number	Supplier
3651-1604-0603	Avibank
3651-1804-0603	Avibank

2.Connector Assembly

A. Wire Harness Preparation

(1) Put a 30 inch ±1/4 inch length of 3/4 inch diameter RT-876 heat shrinkable sleeve on the wire harness.

(2) Put a 2 inch ±1/8 inch length of 1 inch diameter PD 70 heat shrinkable sleeve on the wire harness.

(3) Put a 2 inch ±1/8 inch length of 1/2 inch diameter PD 70 heat shrinkable sleeve on the wire harness.

(4) Put the specified adapter on the wire harness. Refer to Table II.

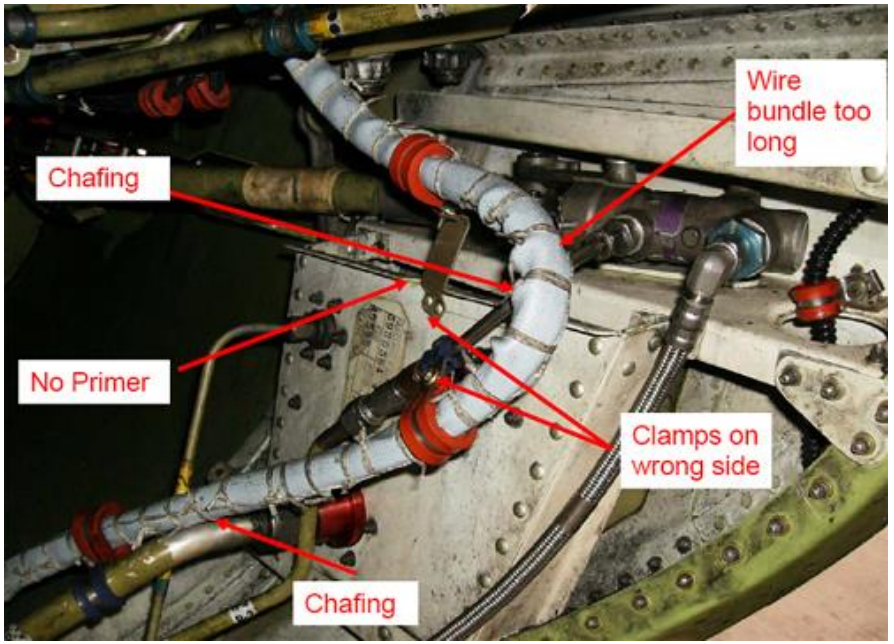
B. Contact Assembly

Refer to Subject 20-61-11.

F. (2) Cautions and protections

Objective: Know the various safety procedures, cautions and warnings prior to inspection.

a. Safety precautions
b. Maintenance precautions



Connector maintenance and Inspections

PRECAUTIONS SHOULD BE OBSERVED WHEN HANDLING ELECTRICAL CONNECTORS:

Disconnecting electrical connectors. Prior to disconnecting any electrical connector the following precautions are to be observed:

- Ensure system power has been removed (turned off) before disconnecting any of the systems electrical connectors;
- Always use the correct tool to disconnect an electrical connection (soft jawed multigrips called plug pliers);
- Never use the loom to pull a connector from its receptacle;
- When disconnecting a component with multiple plugs, ensure that they are clearly identified to ensure their correct reconnection; and
- Annotate disconnection of electrical connector in appropriate aircraft documentation.

Connecting electrical connectors. Prior to connecting any electrical connector, the following precautions are to be observed:

- Ensure system power has been removed (turned off) before connecting any of the system's electrical connectors;
- Never force a connector together; always ensure keyways align before attempting connection;
- After connection, ensure that the connector is securely mated (locked in the indent); and
- Ensure that if the connection was previously lock wired the lock wiring is replaced.

Connector maintenance and Inspections

Conditions for Repair or Replacement

The cable assembly must be replaced or repaired when one or more of these conditions occur:

- The connector has a crack
- The connector has damage that causes a short circuit between two or more contact cavities
- A contact has damage
- A contact retention mechanism does not lock a contact in a contact cavity
- The jackscrew hardware does not tightly hold the receptacle and the plug together
- A wire has damage

Guidance for Zonal Inspections for connectors

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

Wiring installations and areas of concern for connectors.

Worn environmental seals, loose connectors, missing seal plugs, missing dummy contacts, or lack of strain relief on connector grommets can compromise connector integrity and allow contamination to enter the connector, leading to corrosion or grommet degradation. Connector pin corrosion can cause overheating, arcing and pin to pin shorting.

F. (3) Visual inspection procedures

Objective: Know the relevant visual inspection procedures for each type of connector so that any internal or external damage can be found.

a. Installed inspection criteria
b. Removed inspection criteria

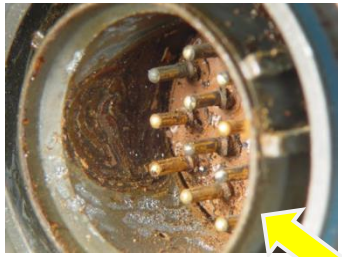
Whenever disconnecting or reconnecting an electrical connector it must be examined for the following possible damage:

- Pins or sockets pushed back into the insulator;
- Pins bent over or shorting other pins;
- Moisture, corrosion or contamination (this can cause shorts when power is applied);
- The insulator has no cracks or tears and is not perished;
- Wire/s loose in the back of the plug (possible causes are: contact not seated; or wire no longer connected to contact);
- Overall physical condition of the connector; and
- Burn marks caused by poor connections or shorting.

F. (4) Typical damage found

Objective: Recognize typical external and internal damage to the connector.

a. Exterior damage
b. Internal damage



Incorrect – No wrap on Back shell of connector and no tie tape

Correct – Wrap on connector and tie tape

F. (5) Repair procedures

Objective: Demonstrate where to find the relevant repair schemes from Ch. 20 for connector repair.

a. Finding the correct section
b. Finding the correct part
c. Finding the correct tooling
d. Confirming the correct repair

Connector damage inspection example

STANDARD WIRING PRACTICES MANUAL

INSPECTION OF WIRING

C. Damage Conditions and Repair Conditions – Corrosion

TABLE I
CORROSION DAMAGE AND REPAIR CONDITIONS – CONNECTOR EXTERNAL SURFACES

Type of Damage	Damage Condition	Repair Condition	Reference
Layer of corrosion material	A heavy layer of white corrosion materials in most areas	Replacement of the connector	The applicable subject for the connector
	A medium layer of white corrosion materials in some areas	Replacement of the connector recommended	The applicable subject for the connector
	A light layer of white corrosion materials in some areas	Examine at regular intervals	Paragraph 2.B.
Damage to the plated finish	The color of the finish is completely gone in the areas with corrosion	Replacement of the connector	The applicable subject for the connector
	The color of the finish is faded in some areas	Replacement of the connector recommended	The applicable subject for the connector
Damage to the base metal	Many pits or holes in the connector shell	Replacement of the connector	The applicable subject for the connector
	Some pits in the connector shell	Replacement of the connector recommended	The applicable subject for the connector
Damage to the coupling mechanism	The coupling mechanism is impossible to operate because of the corrosion	Replacement of the connector	The applicable subject for the connector
	The coupling mechanism does not operate easily because of the corrosion	Replacement of the connector recommended	The applicable subject for the connector
	The coupling mechanism operates easily	Examine at regular intervals	Paragraph 2.B.

External Inspection

STANDARD WIRING PRACTICES MANUAL

INSPECTION OF WIRING

Type of Damage	Damage Condition	Repair Condition	Reference
Damage to the threads	The threads are impossible to engage or disengage because of the corrosion	Replacement of the connector	The applicable subject for the connector
	The threads do not engage or disengage easily because of the corrosion	Replacement of the connector recommended	The applicable subject for the connector
	The threads engage and disengage easily	Examine at regular intervals	Paragraph 2.B.

TABLE II
CORROSION DAMAGE AND REPAIR CONDITIONS – CONNECTOR INTERNAL SURFACES

Type of Damage	Damage Condition	Repair Condition	Reference
Damage to the connector shell	Corrosion materials on the surface of the shell	Replacement of the connector	The applicable subject for the connector
	Damage to the plated finish	Replacement of the connector	The applicable subject for the connector
	Pits in the base metal	Replacement of the connector	The applicable subject for the connector
Damage to a contact	The plating is completely gone in some areas	Replacement of the contact	The applicable subject for the connector
	Pits in the base metal	Replacement of the contact	The applicable subject for the connector
	Blue-green contamination	Replacement of the contact	The applicable subject for the connector
	Black stains or red stains	Replacement of the contact	The applicable subject for the connector
Contamination from moisture	Moisture in the connector	Clean the internal surfaces with isopropyl alcohol	Subject 20-60-01
		Examine at regular intervals	Paragraph 2.B.

Internal Inspection

MODULE G – CONNECTIVE DEVICE REPAIR:

Objective: Demonstrate the procedures for replacement of all parts of typical types of connectors found on the applicable aeroplane.

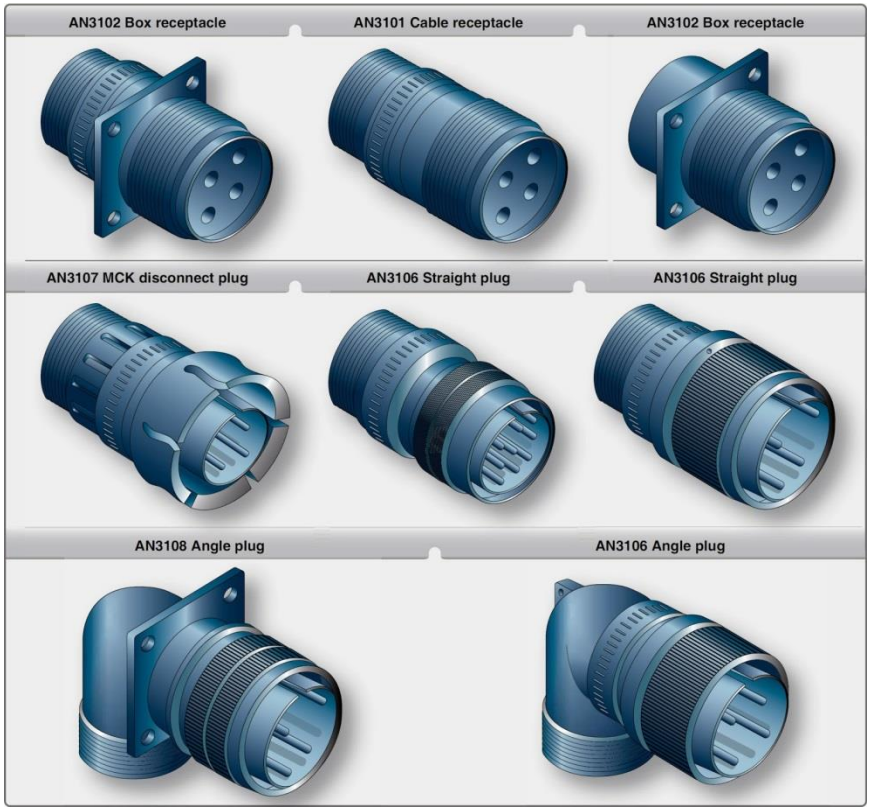
(1) Circular connectors
(2) Rectangular connectors
(3) Terminal blocks - modular
(4) Terminal blocks - non-modular
(5) Grounding modules
(6) Pressure seals

G. (1) Circular connectors

Objective: Demonstrate the replacement of components for circular connectors.

a. Disassembly
b. Back-shell maintenance
c. Contact extraction and insertion
d. Contact Crimping
e. Assembly and strain relief

Typical Mated Pair Connectors



Connector Removal and Installation

Assembly of Connectors to Receptacles

Assemble connectors to receptacles as follows:

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

Caution: Do not use excessive force to mate connectors to receptacles.

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

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

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

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

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

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

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

Disassembly of Connectors from Receptacles

Disassemble connectors as follows:

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

a. Use a strap wrench or padded pliers to loosen coupling rings which are too tight to be loosened by hand.

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

Caution: Do not pull on attached wires.

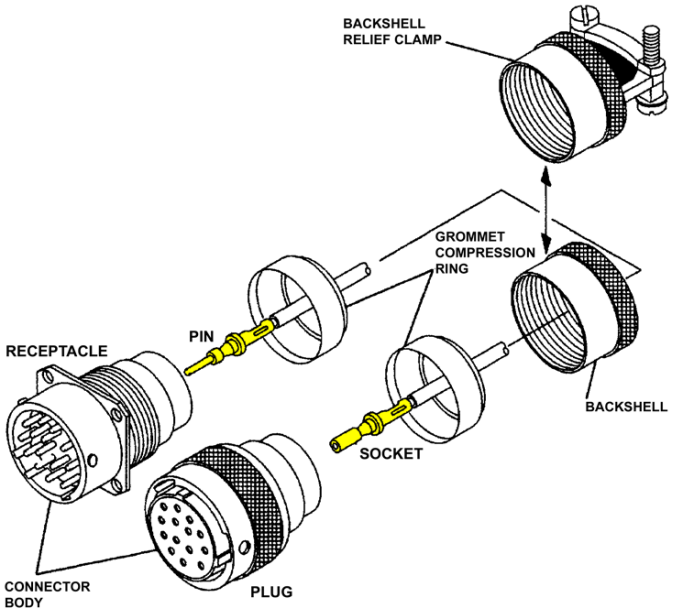
c. Protect disconnected plugs and receptacles with caps to keep debris from entering and causing faults.

Removal and Insertion of Wired Contacts

There are two basic types of contact (pin or socket) retention used in plug and receptacles connectors in aircraft, one which the contacts being released for removal from the rear and one where release is from the front using the insertion/ extraction tools. Therefore, it is essential that the correct procedures and tools are used for a particular type of plug or socket.

- Front Release - The contact is removed by pushing from the front of the connector and removing from the rear.
- Rear Release - The extraction tool enters the connector from the rear of the connector and the contact is also removed from the rear.

Multiway connectors, terminal junctions, inline single wire connectors, switches, motors, indicators, instruments and other electrical components; all may now be terminated by a rear release system which requires the use of a few tools and the minimum of operator training. Contacts crimped with a standard crimping tool are inserted and removed using a single fail-safe plastic tool for each size of contact.



Connector with Contacts

Contact Insertion and Extraction

To facilitate maintenance of connectors, their contacts, in most cases can be extended individually, manually inspected and then replaced or re-inserted. Accompanying most manufactures connectors is the recommended contact insertion / extraction tool. Care should be taken before contact removal to see if the contact is of the:

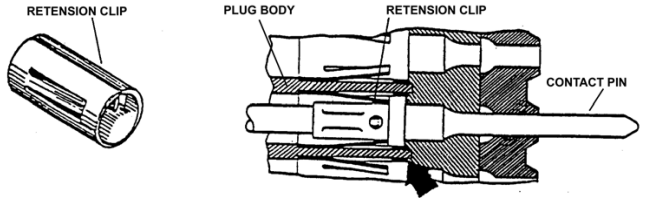
- Front release type.
- Rear release type.

The correct procedure for the removal and installation of contacts must always be follow otherwise the following could result:

- Contact may be damaged.
- Wires may be broken.
- Contact insert holding spring could be damaged.

Rear Release Contacts

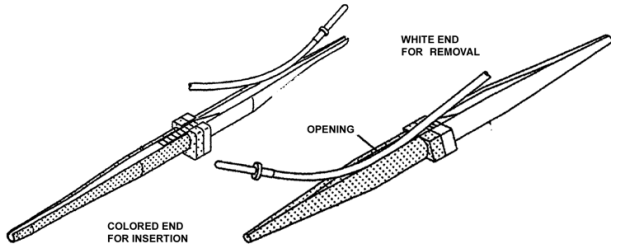
Pins or sockets are inserted and removed by a single expendable plastic tool which is fail-safe in that mishandling will result in damage to the tool rather than to the connector or termination modules. The tines of the clip snap in behind the shoulder of the contact. The removal tool displaces the tines of the clip sufficiently to allow the contact to be withdrawn rear-wards



Contact retention for rear release

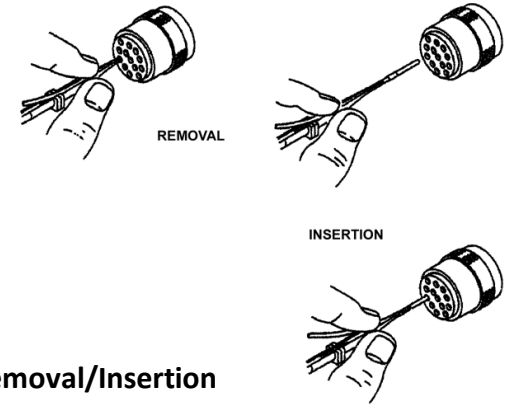
Contact Removal

1. Slip the removal tool (with white tip) around the wire of the contact to be extracted.
2. Slide the tool along the wire into the insulator until it buts against he shoulder of contact.
3. Remove wire and tool together.



Contact Insertion

1. Press the conductor into the conical end of the slot with the thumb and press the wire into the slot by moving it along the tool.
2. Under this pressure, the slot will open to accept the wire.
3. Hold the connector in one hand and insert the contact into its cavity, pushing with the tool perpendicular to the insulator face. When contact is in place a metallic click is audible.
4. Remove tool to the rear. Check that contact is firmly in position by pulling gently.



Removal/Insertion

Front Release Contacts

Two separate tools are used. Make sure, that the plug is a front release type, otherwise the retention mechanism inside the plug could be damaged.

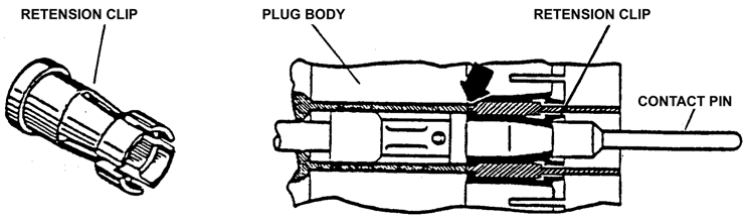
Contact Removal Note:

Use the correct tool and make sure that it is in a good shape.

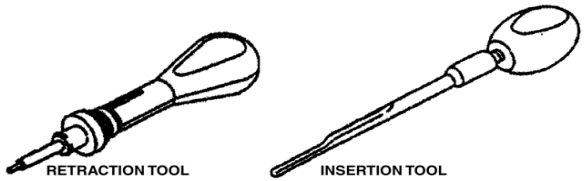
1. Align tool squarely insert face,
2. Push tool squarely into insert hole until it butts against insert face.
3. Holding the tool firmly, advance the slider knob so that the contact is ejected from its seated position.
4. The contact may then be pulled free of the grommet with the hand.

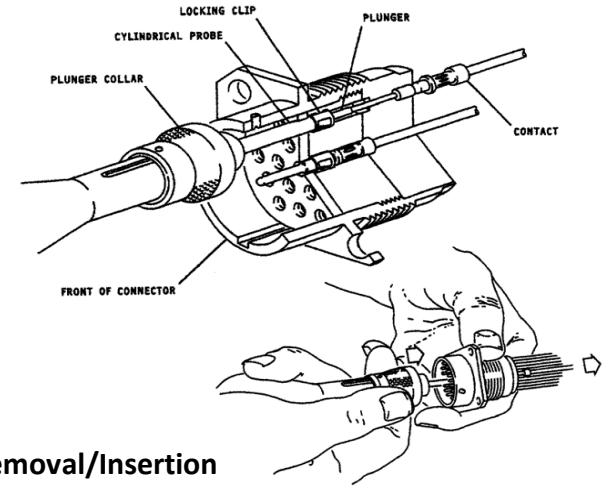
Contact Insertion

1. Slip insertion tool over the wire and put it against the contact shoulder.
2. Align tool and contact axially with the grommet.
3. Guide contact carefully through grommet hole, pushing tool axially to grommet all times.
4. Remove tool and check that contact is firmly in position by pulling gently.



Contact retention for front release





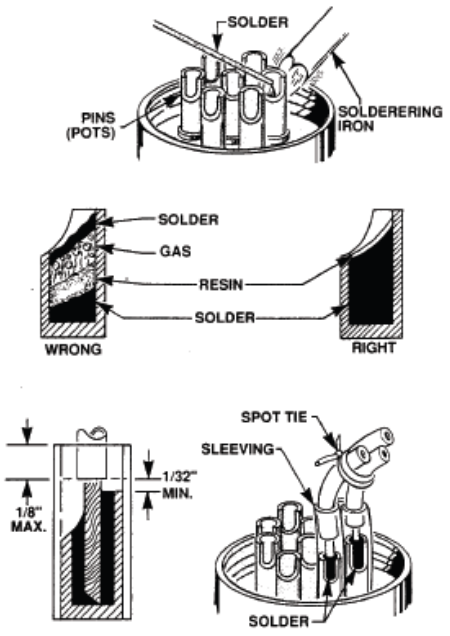
Removal/Insertion

Soldering Type Connectors

Many of older type connectors have the wires soldered into solder pots in the end of the pin or socket. When soldering a wire into a connector, leave about 0.8 mm of stranded wire between the top of the solder pot and the end of the wire insulation. When the solder in the connection has cooled, slip a piece of close-fitting in-sulation tubing over the end of the connector to insulate it. In commercial aircrafts only connectors of passenger related items like ovens are soldered. All others are crimped.

Recommendations for soldering connector contacts.

- Arrange the contact in such a position that the solder bucket always points up-wards.
- Use a bench vice with insulated clamp teeth to hold the connector.
- Clean the individual contacts with spirits and let them dry.
- Heat the contact bucket and fill a small amount of solder into the contact bucket.
- Bring the blade of the iron below the contact and place the stripped wire into the bucket.
- Apply solder to the wire in the bucket, as soon as the solder becomes liquid push the stripped wire in further.
- When the soldered is melted and freely flowing through the wire strands in the contact bucket, remove the soldering iron.
- Hold the cable in position until the solder has set, make sure that the solder does not extend outside of the bucket up toward the insulation.
- Ensure that the solder is between all the strands.
- No wire strands will be outside of the contact bucket.



Soldering of Connector

After each soldering task (contact), the soldered connection should be checked, for the following:

- The conductor strands are each covered in solder.
- No solder drop or bulge appears outside of the contact bucket.
- The soldered connection looks smooth and shiny.
- Wire insulation does not touch the contact bucket.

Contact crimping

1. Place contact on die of crimp tool. Close handles just enough to hold contact in place
2. Insert center conductor into contact until dielectric touch against contact
3. Close handles until ratchet releases
4. Remove terminated wire assembly

Checking tool calibration with the "GO/NO-GO" gauge

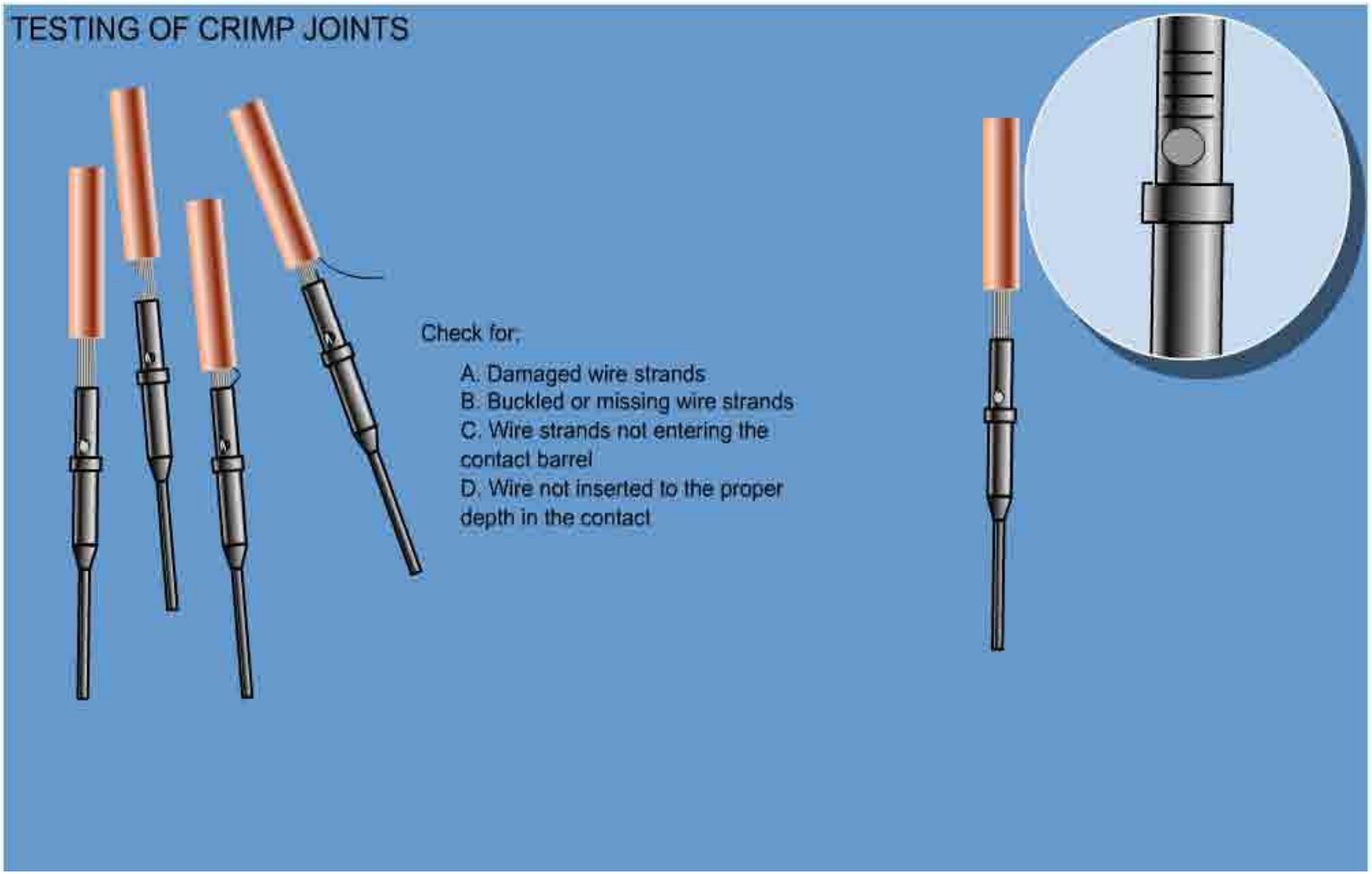
INSERT CONTACT

INSERT PRE-STRIPPED WIRE

CLOSE / OPEN HANDLE

REMOVE TERMINATED WIRE ASSEMBLY

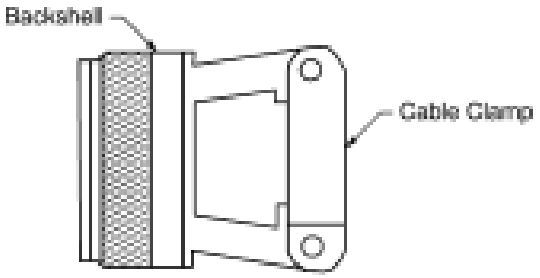
Contact crimping



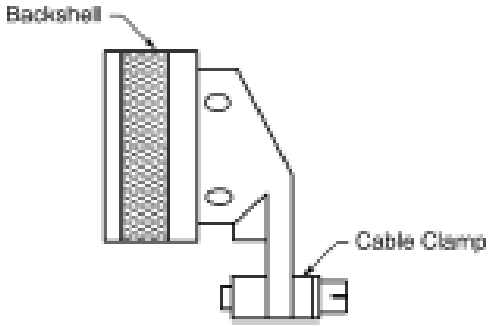
Backshell Disassembly and Assembly

Backshell Disassembly

(1) If the backshell has safety wire, remove the safety wire from the cable clamp screws and the backshell coupling ring.
(2) Remove the strain relief clamp screws.
(3) Put the saddle bars, the screws, and the washers in a safe place.
(4) Make a selection of an appropriate strap wrench.
(5) Disengage the threads of the backshell and the connector.



STRAIGHT STRAIN RELIEF BACKSHELL



90 DEGREE STRAIN RELIEF BACKSHELL

Backshell Disassembly and Assembly (cont'd)

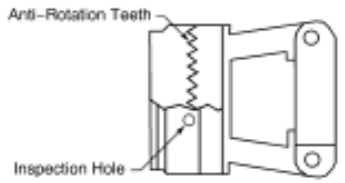
Backshell Assembly

(1) Make a selection of a strap wrench.
(2) Put the necessary backshell components on the wire harness.
Make sure that the cable clamp of the backshell is pointed away from the end of the wire harness.
(3) Install the contacts in the connector. Refer to the Subject that is applicable for the assembly of the connector.
(4) Put the wires into their positions.
Make sure that:
- The wires do not go across each other
- The wires do not have tension that pulls the seal web out of its shape
- Strain is not put on the wires.

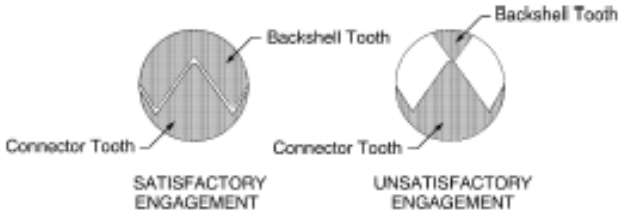
(5) If the backshell has anti-rotation teeth, examine the teeth of the backshell through the inspection hole. Make sure that the backshell teeth are engaged with the connector teeth.
(6) Tighten the backshell on the connector with the strap wrench.
Make sure that:
- The backshell does not make more than 1/8 turn with the strap wrench
- The backshell is in the correct clock position.

Caution: Do not tighten the backshell more than necessary.
Damage to the backshell can cause unsatisfactory performance of the connector or the backshell.

(7) If the backshell has set screws, tighten one of the set screws.
(8) Try to loosen the backshell manually.
Note: The backshell is installed correctly when the backshell does not move in relation to the connector.
(9) If the backshell is loose, do Step (6) through Step (8) again.
(10) Assemble the strain relief.



BACKSHELL WITH ANTI-ROTATION TEETH

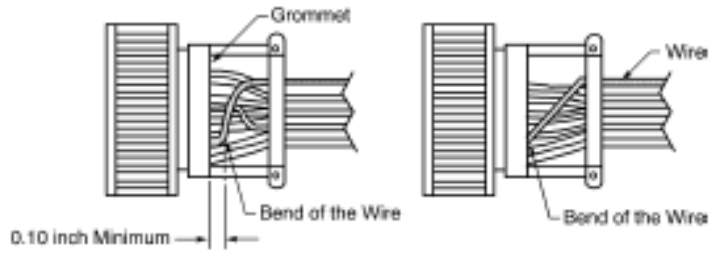


ENGAGEMENT OF THE CONNECTOR TEETH AND THE BACKSHELL TEETH

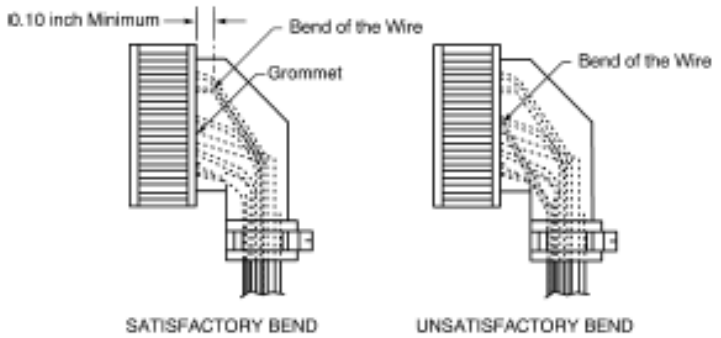
Applicable Conditions for Backshell Assembly

These conditions are applicable for a wire harness in a backshell with a cable clamp:
- Strain must not be put on the wires
- The wires must not have tension that pulls the seal webs of the grommet out of their shape
- The crimp barrel of a contact cannot be seen in the rear grommet of an environmental connector
- When a wire makes an exit from the rear of the connector grommet at an angle that is less than 60 degrees, the distance from the rear of the grommet to the bend must be 0.10 inch minimum
- Safety wire must be installed on the coupling ring of the backshell if the applicable conditions occur
  - A shield is attached to the cable clamp
  - The cable clamp is on the APU
  - The cable clamp is on the engine side of the firewall
  - The connector and cable clamp are attached to the landing gear
  - The backshell had safety wire before any maintenance.

Caution: If it is not known whether safety wire is necessary or not, install the safety wire.



BEND OF THE WIRE IN A STRAIGHT BACKSHELL



BEND OF THE WIRE IN A 90 DEGREE BACKSHELL

Applicable Conditions for Strain Relief Assembly

These conditions are applicable for the assembly of the strain relief:
- The wires must not go across each other in the cable clamp
- The wire harness must have a minimum of two layers of tape for protection
- The tape must not be between the saddle bar and the backshell leg
- The wire harness must be held tightly in the cable clamp
- The cable clamp must not crush the wire harness
- The cable clamp screws must be tight.

The diameter of a wire harness must be increased when these conditions occur:
- The cable clamp does not hold the wire harness tightly
- The wire harness has a small number of wires
- The contact assemblies are installed only near the outer edge of the connector grommet

These conditions are applicable for the layers of tape:
- The forward and rear edges of the tape must extend a minimum of 0.06 inch farther than the edges of the saddle bar
- The edge of one layer is a maximum of 0.05 inch from the edge of a different layer
- For U shaped tape, each layer makes a 100 percent overlap.

Spacers must be installed between the saddle bar and the backshell leg when these conditions occur:
- The diameter of the wire harness is much larger than the diameter of the clamp
- The clamp crushes the wire harness before the screws are fully tightened.

G. (2) Rectangular connectors

Objective: Demonstrate the replacement of components for rectangular connectors.

a. Disassembly
b. Back-shell maintenance
c. Contact extraction and insertion
d. Contact Crimping
e. Assembly and strain relief

Rectangular connectors are typically used in applications where a very large number of circuits are accommodated in a single mated pair. They are available with a great variety of contacts, which can include a mix of standard, coaxial, and large power types. Coupling is accomplished by various means.

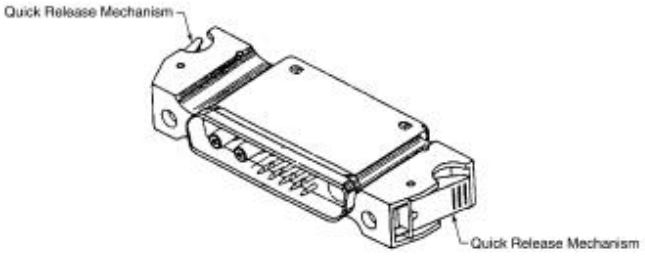
- Smaller types are secured with screws that hold their flange together.
- Larger ones have integral guide pins that ensure correct alignment, or jackscrews that both align and lock the connectors.
- Rack and panel connectors use integral or rack-mounted pins for alignment and box mounting hardware for couplings.

Example of rectangular connector assembly / disassembly

4. Connector Disassembly

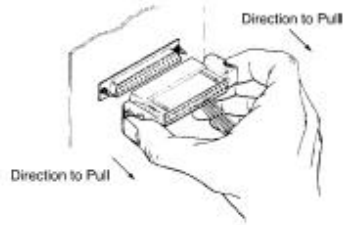
A. Separation of the Plug and the Receptacle

(1) Push and hold the quick release mechanism on each side of the plug at the same time. Refer to Figure 27.



LOCATION OF THE QUICK RELEASE MECHANISM ON THE PLUG
Figure 27

(2) Pull the plug from the receptacle. Refer to Figure 28.



SEPARATION OF THE PLUG FROM THE RECEPTACLE
Figure 28

B. Removal of the Receptacle from a Panel

TABLE XVI
NECESSARY TOOLS

Tool	Size (inch)
Nut Driver	3/16
Wrench	3/16

(1) Make a selection of a tool from Table XVI.

(2) Remove the 4-40 self locking nuts at the rear of the receptacle.

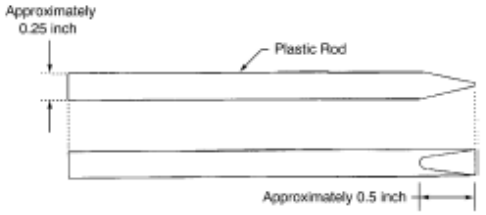
NOTE: Make sure to keep the nuts in a safe location; they are necessary to install the receptacle in the panel again.

(3) Remove the receptacle from the panel.

C. Backshell Removal

TABLE XVII
NECESSARY TOOLS

Tool	Diameter (inch)	Reference
Awl, Plastic	0.25	Figure 29



DIMENSIONS OF THE PLASTIC AWL
Figure 29

(1) Make a selection of an awl from Table XVII.

(2) Put the tip of the awl between the backshell and the connector at one of the four backshell latches.

Example of rectangular connector assembly / disassembly (cont'd)

Refer to Figure 5 for the location of the backshell latches on the connector.

For the location of the backshell latch retainers on a connector that has:

- An equatorial backshell, refer to Figure 11
- A polar backshell, refer to Figure 12
- A straight backshell, refer to Figure 13.

(3) Lift the latch retainer of the backshell away from the plug shell.

(4) Do Step (2) and Step (3) again for each remaining latch.

(5) Remove the backshell from the connector.

D. Contact Removal

This paragraph gives the procedure to remove standard contacts.

For the procedure to remove:

- Special purpose contacts, refer to Paragraph 4.E.
- Coax contacts, refer to Paragraph 4.F.

TABLE XVIII
CONTACT REMOVAL TOOLS

Crimp Barrel Size	Removal Tool
20HD	91066-4
	M81969/1-02
	MS3156-20

NOTE: The backshell must be removed from the connector before the contacts can be removed. Refer to Paragraph 4.C.

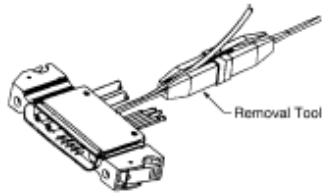
(1) Make a selection of a contact removal tool from Table XVIII.

(2) Put the tip of the tool on the wire.

(3) At the rear of the connector, axially align the tool and the contact cavity.

(4) Carefully push the tool into the contact cavity until it stops. Refer to Figure 30.

Make sure that the tool stays aligned with the contact cavity.



POSITION OF THE REMOVAL TOOL IN THE CONTACT CAVITY
Figure 30

CAUTION: DO NOT USE MORE THAN THE NECESSARY AMOUNT OF FORCE TO PUSH THE TOOL INTO THE CONTACT CAVITY. DAMAGE TO THE CONTACT RETENTION CLIPS CAN OCCUR.

CAUTION: DO NOT TURN THE TOOL CLOCKWISE OR COUNTERCLOCKWISE WHEN IT IS IN THE CONTACT CAVITY. DAMAGE TO THE CONTACT RETENTION CLIPS CAN OCCUR.

(5) Hold the wire against the tool.

(6) Pull the tool and the wire out of the contact cavity at the same time.

Make sure that the tool stays aligned with the contact cavity.

(7) If the contact is not released:

(a) Carefully pull the tool out of the contact cavity.

(b) Turn the tool approximately 90 degrees.

(c) Do Step (2) through Step (6) again.

E. Special Purpose Contact Removal

NOTE: Size 2018 special purpose contacts cannot be removed from the connector.

TABLE XIX
CONTACT REMOVAL TOOLS

Contact Cavity Size	Removal Tool
08	DRK38

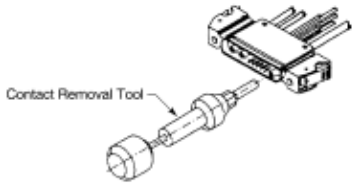
NOTE: The backshell must be removed from the connector before the contacts can be removed. Refer to Paragraph 4.C.

(1) For a pin contact, remove the alignment ring from the contact at the front of the connector.

(2) Make a selection of a contact removal tool from Table XIX.

(3) At the front of the connector, axially align the tool with the engaging end of the contact. Refer to Figure 31.

Example of rectangular connector assembly / disassembly (cont'd)



ALIGNMENT OF THE REMOVAL TOOL AND THE CONTACT
Figure 31

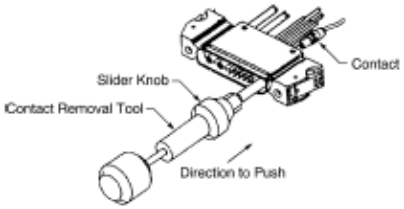
(4) Put the tip of the tool on the contact.

(5) Push the tool forward until the first mark on the tool is aligned with the front face of the connector.

CAUTION: IF THE REMOVAL TOOL IS PUSHED FARTHER THAN THE SPECIFIED MARK, DAMAGE TO THE RETENTION CLIPS OF THE CONTACT CAN OCCUR.

(6) Hold the tool and the connector tightly in position.

(7) Push the slider knob forward to release the contact. Refer to Figure 32.



OPERATION OF THE REMOVAL TOOL SLIDER KNOB
Figure 32

(8) From the rear of the connector, carefully pull the cable or the contact crimp barrel.

F. Coax Contact Removal

The procedure to remove coax contacts is the same as the procedure to remove special purpose contacts. Refer to Paragraph 4.E.

5. Connector Assembly

A. Contact Assembly

This paragraph gives the procedure to assemble standard and special purpose contacts.

For the procedure to assemble:

- The CQME()-316, CQME()-501, and CQME()-502 coax contacts, refer to Paragraph 5.B.
- The CQME()-503 coax contacts, refer to Paragraph 5.C.

TABLE XX
INSULATION REMOVAL LENGTH

Wire Size (AWG)	Crimp Barrel Size	Removal Length L (inch)	
		Target	Tolerance
24	20HD	0.17	±0.01
22	20HD	0.17	±0.01
20	20HD	0.17	±0.01
	16	0.28	±0.02
18	18	0.17	±0.01
	16	0.28	±0.02
16	16	0.28	±0.02
14	12	0.28	±0.02
12	12	0.28	±0.02
10	08	0.28	±0.02
8	08	0.28	±0.02

Example of rectangular connector contact insertion

D. Contact Insertion

This paragraph gives the procedure to install:

- Standard contacts
- Size 2018 special purpose contacts.

For the procedure to install:

- Other special purpose contacts, refer to Paragraph 5.E.
- Coax contacts, refer to Paragraph 5.E.

TABLE XXIX
CONTACT INSERTION TOOLS

Crimp Barrel Size	Insertion Tool
20HD	282-881
	91066-4
	DAK145J
	M81969/1-02
	MS3156-22
18	282-881
	91066-4
	DAK145J
	M81969/1-02
	MS3156-22

NOTE: A size 2018 special purpose contact cannot be removed after it is inserted.

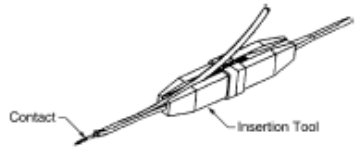
(1) If a backshell is specified, put the backshell on the wire harness. Make sure that the end of the backshell with the latch retainers is pointed forward to the end of the wire harness.

(2) Make a selection of the contact insertion tool from Table XXIX.

(3) If it is necessary to install an unwired contact in an empty contact cavity, install each unwired contact. Refer to Paragraph 5.F.

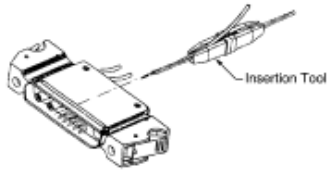
(4) Put the contact assembly in the insertion tool. Refer to Figure 49.

TRI-STAR CQ() AND CORY CQ() RECTANGULAR CONNECTORS



POSITION OF THE CONTACT ASSEMBLY IN THE INSERTION TOOL
Figure 49

(5) At the rear of the connector, axially align the contact assembly, the insertion tool, and the contact cavity. Refer to Figure 50.



ALIGNMENT OF THE CONTACT ASSEMBLY, THE INSERTION TOOL, AND THE CONTACT CAVITY
Figure 50

(6) Push the tool into the contact cavity until it stops. Make sure that the tool stays aligned with the contact cavity.

CAUTION: DO NOT USE MORE THAN THE NECESSARY AMOUNT OF FORCE TO PUSH THE TOOL INTO THE CONTACT CAVITY. DAMAGE TO THE CONTACT RETENTION CLIPS CAN OCCUR.

CAUTION: DO NOT TURN THE TOOL CLOCKWISE OR COUNTERCLOCKWISE WHEN IT IS IN THE CONTACT CAVITY. DAMAGE TO THE CONTACT RETENTION CLIPS CAN OCCUR.

(7) Carefully pull the tool from the contact cavity.

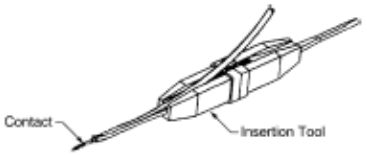
(8) Lightly pull the wire to make sure that the contact is locked in the contact cavity.

CAUTION: DO NOT PULL THE WIRE WITH A STRONG OR A SUDDEN FORCE. DAMAGE TO THE CONNECTOR OR THE CONTACT CAN OCCUR.

CAUTION: DO NOT MAKE A DENT IN THE WIRE INSULATION WITH THE FINGERNAILS. DAMAGE TO THE WIRE INSULATION CAN CAUSE UNSATISFACTORY PERFORMANCE OF THE WIRE.

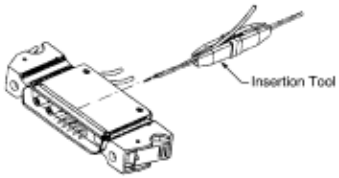
(9) If the contact is not locked in the contact cavity:
(a) Pull the contact assembly out of the cavity.
(b) Do Step (4) through Step (8) again.

Example of rectangular connector contact insertion (cont'd)



POSITION OF THE CONTACT ASSEMBLY IN THE INSERTION TOOL
Figure 51

(4) At the rear of the connector, axially align the contact assembly, the insertion tool, and the contact cavity. Refer to Figure 52.



ALIGNMENT OF THE CONTACT ASSEMBLY, THE INSERTION TOOL, AND THE CONTACT CAVITY
Figure 52

(5) Push the tool into the contact cavity until it stops.
Make sure that the tool stays aligned with the contact cavity.

CAUTION: DO NOT USE MORE THAN THE NECESSARY AMOUNT OF FORCE TO PUSH THE TOOL INTO THE CONTACT CAVITY. DAMAGE TO THE CONTACT RETENTION CLIPS CAN OCCUR.

CAUTION: DO NOT TURN THE TOOL CLOCKWISE OR COUNTERCLOCKWISE WHEN IT IS IN THE CONTACT CAVITY. DAMAGE TO THE CONTACT RETENTION CLIPS CAN OCCUR.

(6) Carefully pull the tool from the contact cavity.

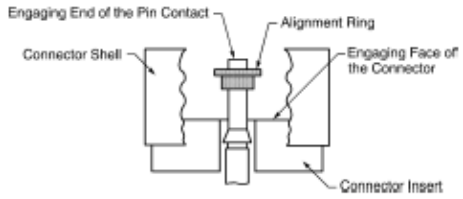
(7) Lightly pull the wire to make sure that the contact is locked in the contact cavity.

CAUTION: DO NOT PULL THE WIRE WITH A STRONG OR A SUDDEN FORCE. DAMAGE TO THE CONNECTOR OR THE CONTACT CAN OCCUR.

CAUTION: DO NOT MAKE A DENT IN THE WIRE INSULATION WITH THE FINGERNAILS. DAMAGE TO THE WIRE INSULATION CAN CAUSE UNSATISFACTORY PERFORMANCE OF THE WIRE.

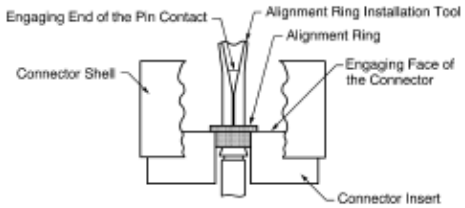
(8) If the contact is not locked in the contact cavity:
  (a) Pull the contact assembly out of the cavity.
  (b) Do Step (3) through Step (7) again.

(9) For a pin contact:
  (a) Make a selection of a contact alignment ring from Table XIII.
  (b) Make a selection of an alignment ring installation tool from Table XXXII.
  (c) Put the alignment ring on the engaging end of the contact. Refer to Figure 53.



INITIAL POSITION OF THE ALIGNMENT RING
Figure 53

  (d) Put the end of the tool on the engaging end of the contact.
  (e) Push the alignment ring forward to the engaging face of the connector. Refer to Figure 54.



POSITION OF THE ALIGNMENT RING AGAINST THE FACE OF THE CONNECTOR
Figure 54

  (f) Remove the tool from the engaging end of the contact.

Example of rectangular connector backshell installation

F. Seal of an Empty Contact Cavity

For environmental connectors, an empty contact cavity must be sealed with a seal rod or a seal plug.

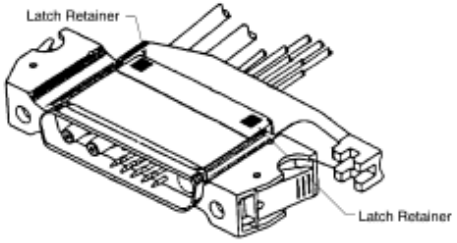
Refer to Figure 4 and Subject 20-60-08.

G. Backshell Installation

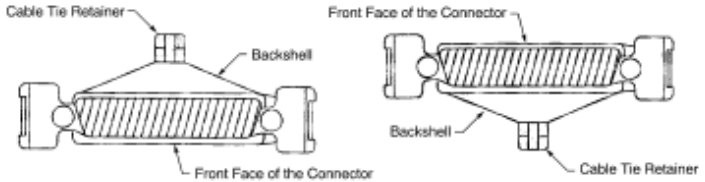
(1) Align the forward end of the backshell with the rear end of the connector.

(2) Engage the four latches on the connector with the latch retainers on the backshell. Refer to Figure 55.

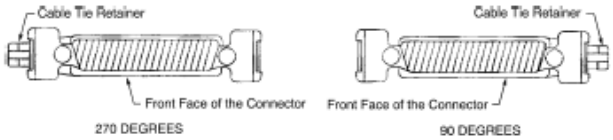
If the backshell is an equatorial backshell or a polar backshell, make sure that the backshell is in the correct clock position. Refer to Figure 56 and Figure 57.



POSITION OF THE LATCH RETAINERS AND THE LATCHES
Figure 55



CLOCK POSITIONS OF THE EQUATORIAL BACKSHELLS
Figure 56



CLOCK POSITIONS OF THE POLAR BACKSHELLS
Figure 57

Example of rectangular connector backshell installation

(3) Assemble the strain relief.

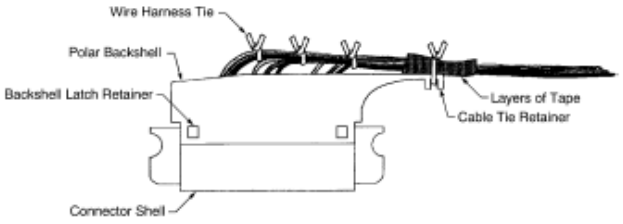
For the assembly of the strain relief of a wire harness that:

- Does not have a coax cable, refer to Paragraph 5.H.
- Has a coax cable, refer to Paragraph 5.I.

H. Strain Relief Assembly

This paragraph gives the procedure to assemble the strain relief for a wire harness that does not have a coax cable.

For the procedure to assemble the strain relief for a wire harness that has a coax cable, refer to Paragraph 5.I.



CONFIGURATION OF THE WIRE HARNESS TIES OF THE STRAIN RELIEF
Figure 58

Refer to Figure 58.

(1) Make a selection of a silicone tape. Refer to Subject 20-10-11.

(2) Put a minimum of two layers of the tape around the wire harness at the location that is adjacent to the cable tie retainer of the backshell.

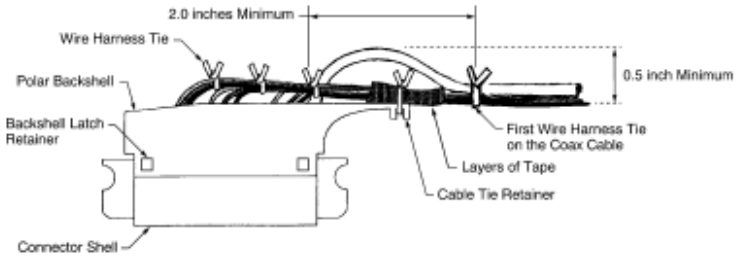
(3) Assemble the wire harness ties around:

- The wires and cables of the wire harness
- The wire harness and the cable tie retainer.

Refer to Subject 20-10-11.

NOTE: A plastic tie strap is an acceptable alternative to a wire harness tie. Refer to Subject 20-10-11.

I. Strain Relief Assembly for a Wire Harness with a Coax Cable



CONFIGURATION OF THE WIRE HARNESS TIES OF THE STRAIN RELIEF
Figure 59

Refer to Figure 59.

(1) Make a selection of a silicone tape. Refer to Subject 20-10-11.

(2) At the location that is adjacent to the cable tie retainer of the backshell, put a minimum of two layers of the tape around:

- The wires of the harness
- The cables of the wire harness that are not coax cables.

(3) If the connector has a straight backshell, assemble a wire harness tie around:

- The wires and cables of the wire harness
- The cable tie retainer.

Refer to Subject 20-10-11.

NOTE: A plastic tie strap is an acceptable alternative to a wire harness tie. Refer to Subject 20-10-11.

(4) If the connector has a polar or an equatorial backshell and the distance from the rear end of the coax contact to the cable tie retainer is equal to or more than 2.0 inches, assemble a wire harness tie around:

- The wires and cables of the wire harness
- The cable tie retainer.

Refer to Subject 20-10-11.

Make sure that the radius of the curve of the coax cable is not less than the minimum bend radius for coax cable. Refer to Subject 20-10-11.

Example of rectangular connector backshell installation (cont')

TRI-STAR CQ() AND CORY CQ() RECTANGULAR CONNECTORS

CAUTION: IF THE COAX CABLE IS ATTACHED TO THE CABLE TIE RETAINER WHEN THE DISTANCE FROM THE COAX CONTACT TO THE CABLE TIE RETAINER IS LESS THAN 2.0 INCHES, DAMAGE TO THE COAX CONTACT OR THE COAX CABLE CAN OCCUR.

NOTE: A plastic tie strap is an acceptable alternative to a wire harness tie. Refer to Subject 20-10-11.

(5) If the connector has a polar or an equatorial backshell and the distance from the rear end of the coax contact to the cable tie retainer is less than 2.0 inches:

(a) Assemble a wire harness tie around:
- The wires of the harness
- The cables of the wire harness that are not coax cables
- The cable tie retainer.

Refer to Subject 20-10-11.

NOTE: A plastic tie strap is an acceptable alternative to a wire harness tie. Refer to Subject 20-10-11.

(b) At a location that is equal to or more than 2.0 inches from the the rear end of the coax contact, assemble a wire harness tie around:
- The coax cable
- The wire harness.

Refer to Subject 20-10-11.

Make sure that the radius of the curve of the coax cable is not less than the minimum bend radius for coax cable. Refer to Subject 20-10-11.

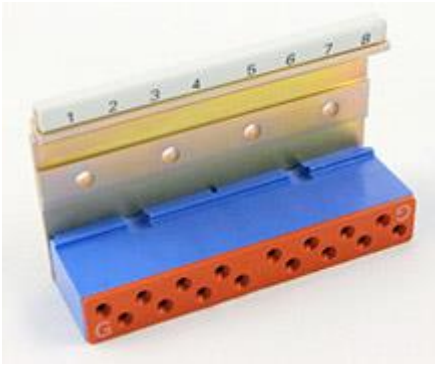
CAUTION: IF THE COAX CABLE IS ATTACHED TO THE WIRE HARNESS AT A LOCATION THAT IS LESS THAN 2.0 INCHES, DAMAGE TO THE COAX CONTACT OR THE COAX CABLE CAN OCCUR.

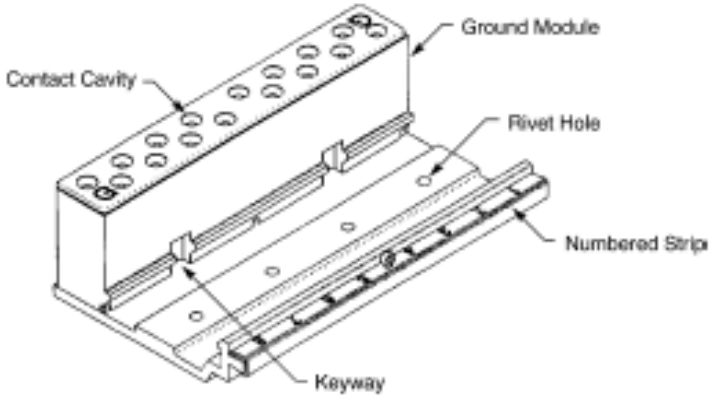
NOTE: A plastic tie strap is an acceptable alternative to a wire harness tie. Refer to Subject 20-10-11.

G. (3) Terminal blocks – modular

Objective: Demonstrate the replacement of components for terminal blocks-modular.

a. Disassembly
b. Contact extraction and insertion
c. Contact Crimping
d. Assembly and strain relief





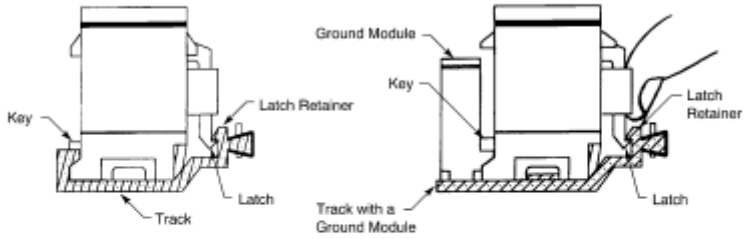
S280W555-5() TRACK WITH A GROUND MODULE

Example of terminal module connector assembly / disassembly

3. Disassembly of the Terminal Junction System

A. Removal of a Terminal Module from a Track

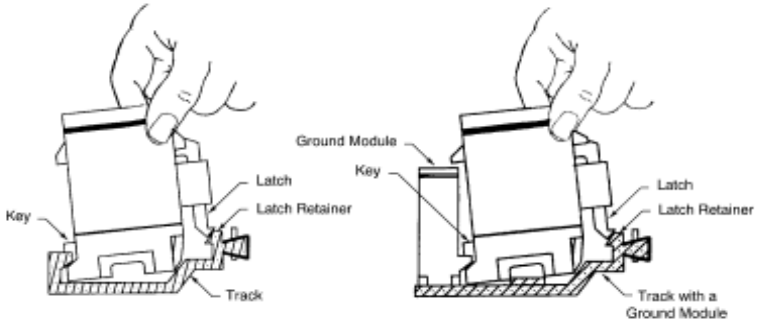
(1) Push the latch of the terminal module to release the latch from the latch retainer on the track. Refer to Figure 14.



LOCATION OF THE LATCH ON THE TERMINAL MODULE
Figure 14

(2) Pull the front of the module from the front of the track. Refer to Figure 15.

S280W555-() TERMINAL JUNCTION SYSTEM



REMOVAL OF THE TERMINAL MODULE FROM THE TRACK
Figure 15

(3) Carefully pull the module to the front of the track until the key is disengaged from the keyway.

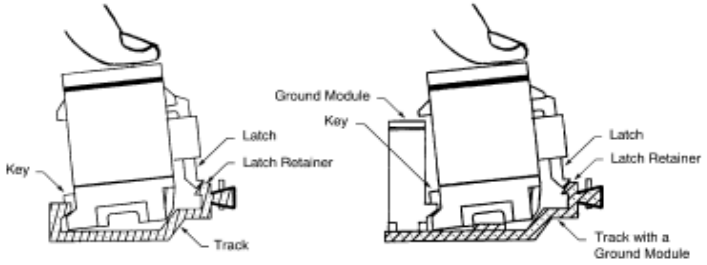
(4) Pull the module from the track.

S280W555-() TERMINAL JUNCTION SYSTEM

5. Installation of the Terminal Junction System

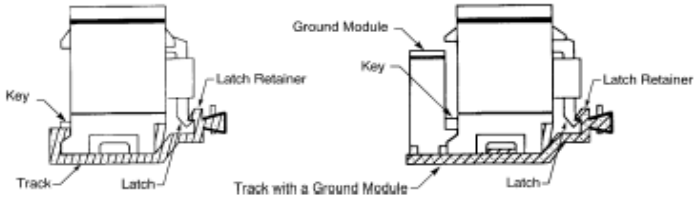
A. Installation of a Terminal Module on a Track

(1) Align the key of the module with the applicable keyway on the track. Refe to Figure 24.



POSITION OF THE TERMINAL MODULE ON THE TRACK
Figure 24

(2) Push the top of the module until it makes a click and the latch is locked in the latch retainer. Refer to Figure 25.



TERMINAL MODULE INSTALLED ON THE TRACK
Figure 25

Example of terminal module connector assembly / disassembly (cont'd)

C. Contact Removal

For the procedure to remove an unwired contact, refer to Paragraph 3.D.

TABLE XVI
CONTACT REMOVAL TOOLS

Crimp Barrel Size	Removal Tool	
	Part Number	Color
20	ATR 2080 BAC	–
	ATR 2079 BAC	–
	DRK83-20	Red
	M81969/14-11	White
	RRX20B	–
18	ATR 2080 BAC	–
	ATR 2079 BAC	–
	M81969/14-11	White
16	ATR 2112 BAC	–
	ATR 2106 BAC	–
	M81969/14-03	White
	RRX16B	–

(1) Make a selection of a contact removal tool from Table XVI.
(2) Put the end of the tool on the wire near the rear grommet.
(3) Carefully push the tool straight into the contact cavity until it stops.
CAUTION: DO NOT TURN THE TOOL WHILE IT IS IN THE CONTACT CAVITY. DAMAGE TO THE CONTACT RETENTION CLIPS CAN OCCUR.
(4) Carefully pull the wire and the tool out of the contact cavity at the same time.
(5) If the contact does not come out of the contact cavity:
(a) Pull the tool out of the contact cavity.
(b) Turn the tool 90 degrees.
(c) Do Step (2) through Step (4) again.

D. Unwired Contact Removal

TABLE XVII
UNWIRED CONTACT REMOVAL TOOLS

Contact Size		Removal Tool		
Engaging End	Crimp Barrel	Handle	Bit	
			Part Number	Color
16	20	DRK-110-1SA	DRK-20-2	Red
	18	DRK-110-1SA	DRK-20-2	Red
	16	DRK-110-1SA	DRK-16-2	Blue

(1) Make a selection of a contact removal tool from Table XVII.
(2) Align the tool axially with the contact.
(3) Pull the plunger back until it stops.
(4) Hold the plunger in position.
(5) Carefully push the end of the tool straight into the contact cavity until it stops.
(6) Carefully pull the tool straight out of the contact cavity.
(7) Push the plunger forward to release the contact from the tool.

E. Seal Plug or Seal Rod Removal

(1) Make a selection of a pair of needle nose pliers that has:
- Jaws with smooth surfaces
- No sharp edges.

CAUTION: ROUGH SURFACES OR SHARP EDGES CAN CAUSE DAMAGE TO THE REAR GROMMET.
(2) Hold the end of the seal plug or seal rod tightly in the jaws of the pliers.
(3) Pull the plug or rod straight out of the rear grommet.

Example of terminal module connector assembly / disassembly (cont'd)

S280W555-() TERMINAL JUNCTION SYSTEM

4.Assembly of the Terminal Module

A. Contact Assembly

TABLE XVIII
INSULATION REMOVAL LENGTH

Wire Size (AWG)	Crimp Barrel Size	Removal Length L (inch)		Special Instructions
		Target	Tolerance	
24	20	0.15	±0.02	–
	16	0.54	±0.04	Fold the conductor back
22	20	0.15	±0.02	–
	16	0.54	±0.04	Fold the conductor back
20	20	0.15	±0.02	–
	16	0.27	±0.02	–
18	18	0.15	±0.02	–
	16	0.27	±0.02	–
16	16	0.27	±0.02	–

TABLE XIX
CONTACT CRIMP TOOLS

Wire Size (AWG)	Crimp Barrel Size	Crimp Tool			
		Basic Unit		Locator	
		Part Number	Setting	Part Number	Color
24	20	M22520/1-01	2	M22520/1-02	Red
		M22520/2-01	5	M22520/2-11	–
		WA22	5	M22520/2-11	–
		WA22LC	5	M22520/2-11	–
		WA27	2	M22520/1-02	Red
	16	M22520/1-01	5	M22520/1-02	Blue
		ST2220-1-Y	–	ST2220-1-2	–
		WA27F	5	M22520/1-02	Blue

S280W555-() TERMINAL JUNCTION SYSTEM

Wire Size (AWG)	Crimp Barrel Size	Crimp Tool			
		Basic Unit		Locator	
		Part Number	Setting	Part Number	Color
22	20	M22520/1-01	3	M22520/1-02	Red
		M22520/2-01	6	M22520/2-11	–
		WA22	6	M22520/2-11	–
		WA22LC	6	M22520/2-11	–
		WA27	3	M22520/1-02	Red
	16	M22520/1-01	6	M22520/1-02	Blue
		ST2220-1-Y	–	ST2220-1-2	–
		WA27F	6	M22520/1-02	Blue
20	20	M22520/1-01	4	M22520/1-02	Red
		M22520/2-01	7	M22520/2-11	–
		WA22	7	M22520/2-11	–
		WA22LC	7	M22520/2-11	–
		WA27	4	M22520/1-02	Red
	16	M22520/1-01	4	M22520/1-02	Blue
		ST2220-1-Y	–	ST2220-1-2	–
		WA27F	4	M22520/1-02	Blue
18	18	M22520/1-01	5	M22520/1-02	Red
		WA27	5	M22520/1-02	Red
	16	M22520/1-01	5	M22520/1-02	Blue
		WA27	5	M22520/1-02	Blue
16	16	M22520/1-01	6	M22520/1-02	Blue
		WA27	6	M22520/1-02	Blue

(1) Remove the necessary length of insulation from the end of the wire.
Refer to:
- Figure 17
- Table XVIII
- Subject 20-00-15 for the insulation removal procedures.

WIRE PREPARATION
Figure 17

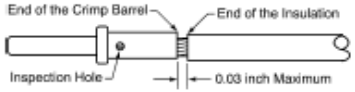
Example of terminal module contact insertion

(2) If it is specified, fold the conductor back. Refer to Figure 18.

CONDUCTOR FOLDED BACK
Figure 18

(3) Make a selection of a crimp tool from Table XIX.

(4) Put the end of the wire into the crimp barrel of the contact. Refer to Figure 19.
Make sure that:
- All of the strands of the conductor are in the crimp barrel
- The strands of the conductor can be seen in the inspection hole
- The distance from the end of the insulation to the end of the crimp barrel is a maximum of 0.03 inch.



POSITION OF THE WIRE IN THE CRIMP BARREL
Figure 19

(5) Crimp the contact.

(6) Examine the contact assembly for these types of damage:
- Broken strands of the conductor
- Strands of the conductor on which the base metal can be seen
- Cracks in the crimp barrel of the contact.

(7) If the contact or the wire has damage, replace the contact.

B. Contact Insertion

TABLE XX
CONTACT INSERTION TOOLS

Crimp Barrel Size	Insertion Tool	
	Part Number	Color
20	DAK83-20	-
	M81969/14-11	Red
	ST2220-2-28	-

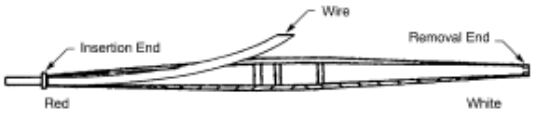
Crimp Barrel Size	Insertion Tool	
	Part Number	Color
18	91039-1	-
	DAK83-20	-
	M81969/14-11	Red
16	DAK83-16	-
	M81969/14-03	Blue
	ST2220-2-4	-
	ST2220-2-11A	-

(1) Make a selection of a contact insertion tool from Table XX.
CAUTION: DO NOT USE A TOOL WITH A TIP THAT:
- IS BENT
- IS FLARED
- IS BROKEN
- HAS A CRACK.

WARNING: A DEFECTIVE TOOL CAN CAUSE INJURY TO THE OPERATOR.

CAUTION: A DEFECTIVE TOOL CAN CAUSE DAMAGE TO THE GROMMET OF THE CONNECTOR OR THE CONTACT RETENTION CLIPS.

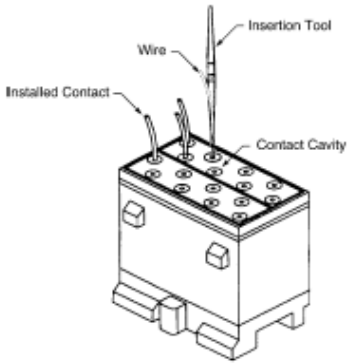
(2) Put the contact in the insertion end of the insertion tool. Refer to Figure 20.



POSITION OF THE CONTACT IN THE INSERTION TOOL
Figure 20

(3) Axially align the contact and the tool with the contact cavity. Refer to Figure 21.

Example of terminal module contact insertion (cont'd)



POSITION OF THE CONTACT INSERTION TOOL AND THE CONTACT CAVITY
Figure 21

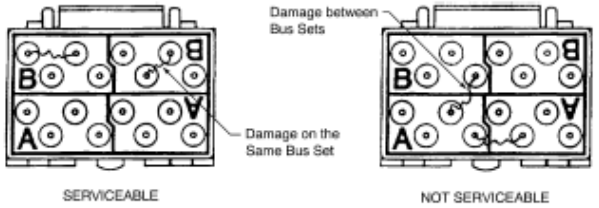
(4) Carefully push the tool straight into the contact cavity until it stops.
CAUTION: DO NOT TURN THE TOOL WHEN IT IS IN THE CONTACT CAVITY. DAMAGE TO THE CONTACT RETENTION CLIPS CAN OCCUR.

(5) Carefully pull the tool straight out of the contact cavity.

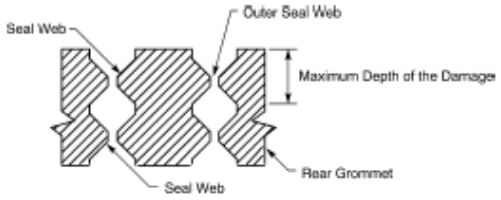
(6) Lightly pull the wire to make sure that the contact is locked in position.
CAUTION: DO NOT PULL THE WIRE WITH A STRONG OR A SUDDEN FORCE. THE FORCE CAN CAUSE DAMAGE TO THE TERMINAL MODULE OR THE CONTACT.
CAUTION: DO NOT MAKE A DENT IN THE WIRE INSULATION WITH THE FINGERNAILS. DAMAGE TO THE WIRE INSULATION CAN CAUSE UNSATISFACTORY PERFORMANCE AND RELIABILITY OF THE WIRE.

(7) If the contact is not locked in the contact cavity:
(a) Pull the contact out of the cavity.
(b) Do Step (2) through Step (6) again.

(8) Examine the grommet for these types of damage:
- Damage between the bus sets; refer to Figure 22
- Damage of the contact cavity that has a depth that is more than the outer seal web in the grommet; refer to Figure 23.



TYPES OF DAMAGE OF THE MODULE GROMMET
Figure 22



DAMAGE OF THE GROMMET IN RELATION TO THE OUTER SEAL WEB
Figure 23

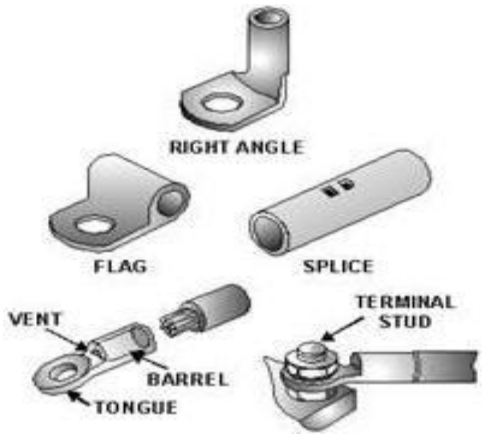
C. Seal of an Empty Contact Cavity
These conditions are applicable:
- For a ground module, an empty contact cavity cannot be sealed
- For a terminal module in the pressurized area, the seal of an empty contact cavity is not necessary
- For a terminal module in the unpressurized area, an empty contact cavity must be sealed with a seal plug or a seal rod.

(1) If it is applicable, install a seal plug or a seal rod in each empty contact cavity of the terminal module. Refer to Subject 20-60-08.
If a seal rod is installed, make sure that the length of the seal rod is 0.5 inch ±0.1 inch.

G. (4) Terminal blocks - non-modular

Objective: Demonstrate the replacement of components for terminal blocks-non-modular.

a. Disassembly
b. Terminal Lug Crimping
c. Terminal Lug Stacking
d. Assembly, torque and strain relief



Terminal lugs

Terminal lugs

- Connect wiring to terminal block studs no more than 4 lugs, or 3 lugs and a bus bar, per stud
- Lug hole size should match stud diameter
- Greatest diameter on bottom, smallest on top
- Tightening terminal connections should not deform lugs

a) Wire terminal lugs should be used to connect wiring to terminal block studs or equipment terminal studs.

b) When the terminal lugs attached to a stud vary in diameter, the greatest diameter should be placed on the bottom and the smallest diameter on top.

c) Terminal lugs should be so positioned that bending of the terminal lug is not required to remove the fastening screw or nut, and movement of the terminal lugs will tend to tighten the connection.

Aluminum lugs

- Crimped to aluminum wire only

Special attention needed to guard against excessive voltage drop at terminal junction

- Inadequate terminal contact area
- Stacking errors
- Improper torquing

Use calibrated crimp tools

d) The tongue of the aluminum terminal lugs or the total number of tongues of aluminum terminal lugs when stacked, should be sandwiched between two flat washers (cadmium plated) when terminated on terminal studs. Spacers or washers should not be used between the tongues of like material terminal lugs.

- Examples of such conditions are improper installation of terminals and washers, improper torsion (“torquing” of nuts), and inadequate terminal contact areas.

e) Aluminum wire is normally used in sizes of 10 gauge and larger to carry electrical power in large transport category aircraft in order to save weight. Although not as good a conductor as copper, aluminum is lighter when compared to copper and the weight savings can be significant for a large aircraft that may have several hundred feet of power feeder cable.

f) Because aluminum is used primarily for high current power applications, the terminal junctions are more sensitive to conditions leading to increased junction resistance which can cause arcing and localized heat distress.

Terminal lugs (cont')

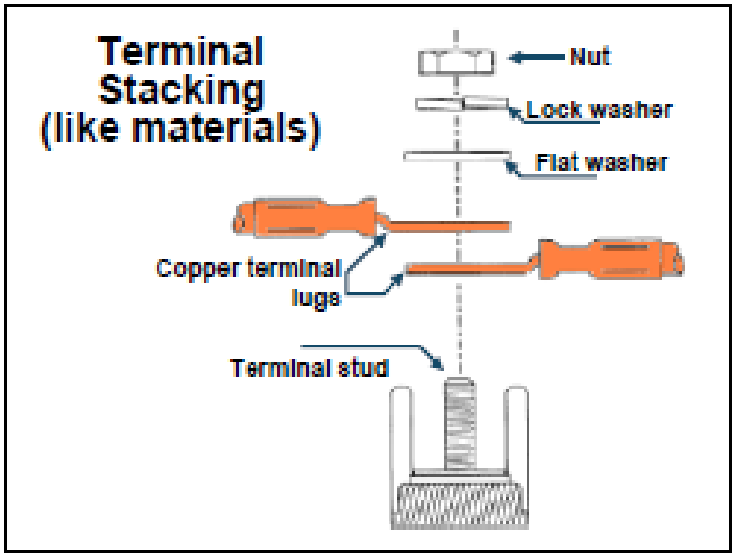
Terminal stacking materials and methods

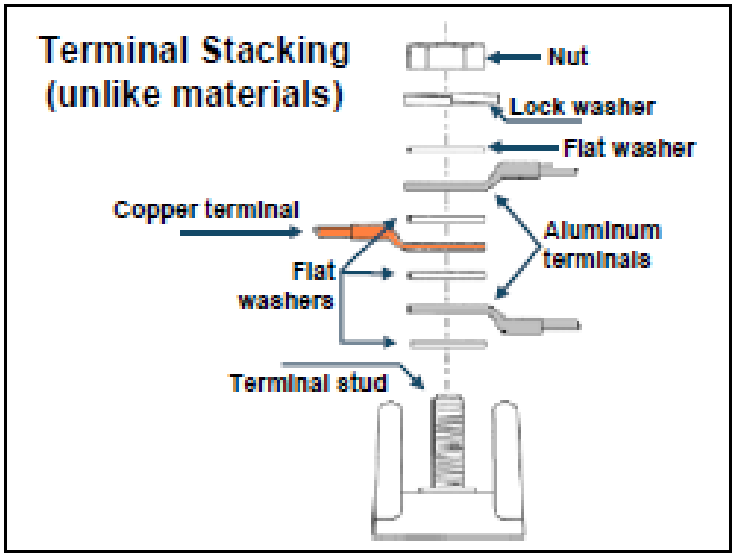
a) Multiple wires often terminate onto a single terminal stud.

Care should be taken to install the terminal properly. The materials that the terminals are constructed of will impact the type of stacking methods used. Dissimilar metals, when in contact, can produce electrolysis that can cause corrosion, thus degrading the terminal junction resistance and causing arcing or hot spots.

b) For stacking **terminals that are made of like materials**, the terminals can be stacked directly on top of each other.

c) When **stacking unlike materials together**, use a cadmium plated flat washer to isolate the dissimilar metals.

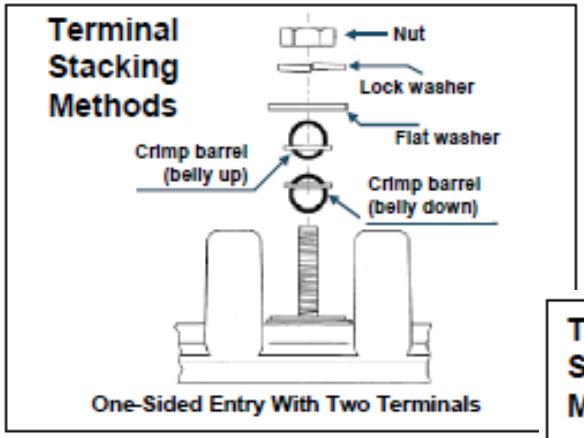


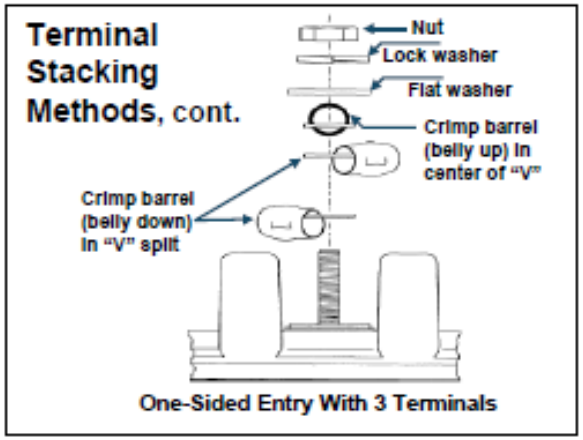


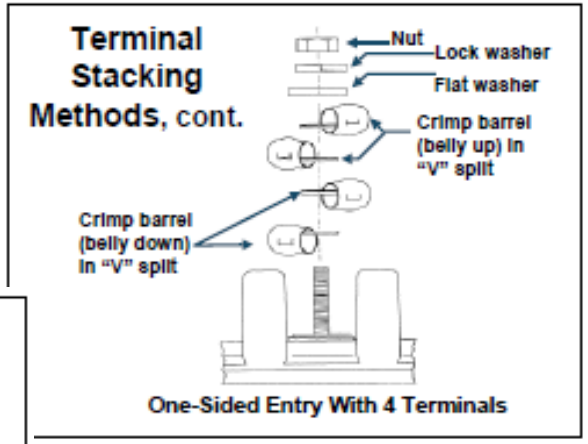
Terminal lugs (cont')

d) When **two terminals are installed on one side** of the terminal strip, ensure that the terminal crimp barrels do not interfere with one another. One method to avoid this problem is to install the terminals with the barrels "back to back."

e) The stacking method used to connect terminals to terminal strips should cause no interference between terminals that could compromise the integrity of the terminal junction.







Terminal lugs (cont')

Terminal tightening hardware

a) Service history has shown that hardware stack up at terminals is prone to human error.

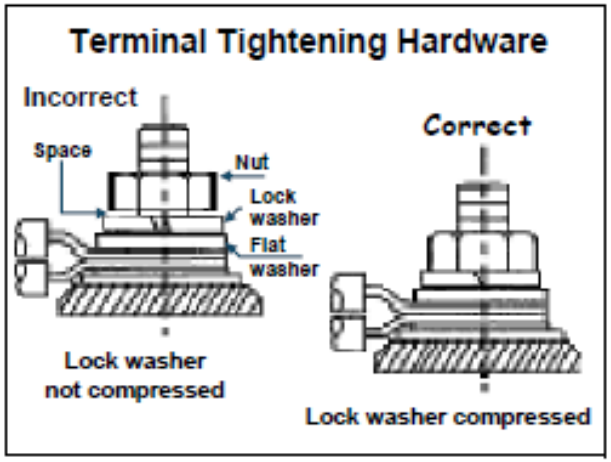
b) It is important to use the correct tightening hardware and install it correctly for a given installation. It is important to ensure the locking washer is fully compressed and is adjacent to the nut.

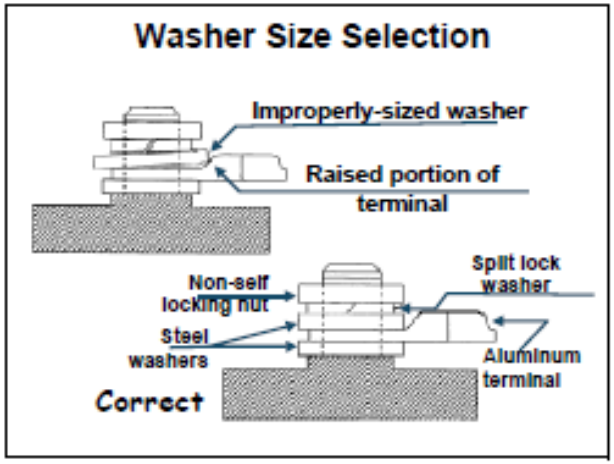
c) There should be a minimum of two to three threads showing on the stud when the nut is properly torqued.

Washer size selection

a) Select and use the correct size washers in any termination. Undersized or oversized washers can lead to increased junction resistance and localized heat or arcing.

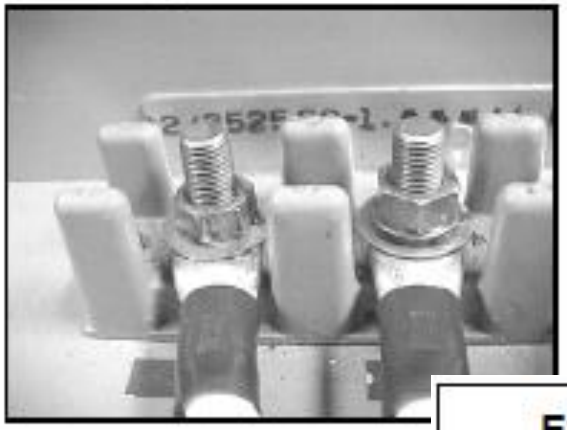
b) An improperly sized washer can lead to insufficient contact between the terminal and terminal lug.



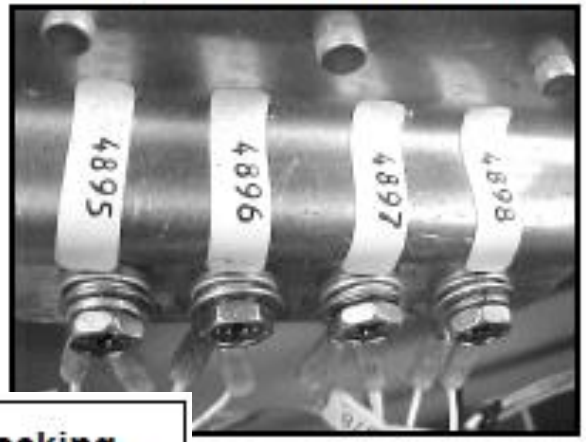


Terminal lugs (cont')

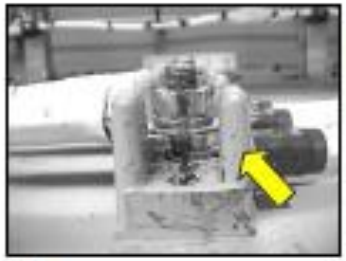
Example: Lock Washers



Example: Lock Washers, cont.



Example: Terminal Stacking



A

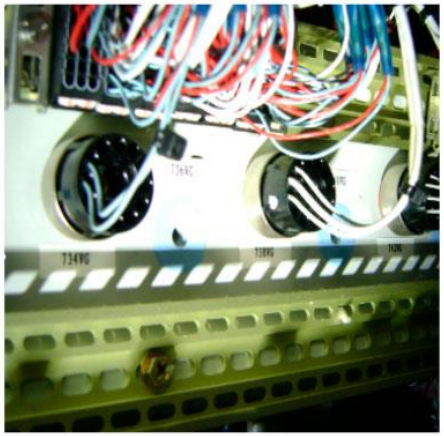
To prevent corrosion from dissimilar metals, put a cadmium washer between aluminum and copper terminals.

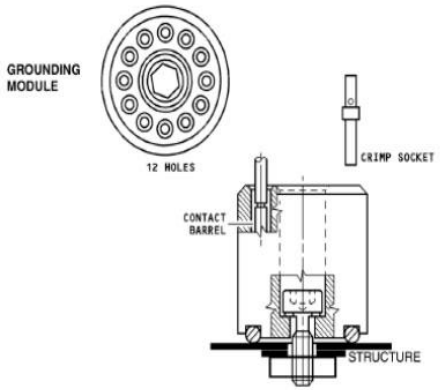
B

G. (5) Grounding modules

Objective: Demonstrate the replacement of components for grounding modules.

a. Disassembly
b. Contact extraction and insertion
c. Contact Crimping
d. Assembly and strain relief





EXAMPLE OF AIRBUS TYPE GROUNDING MODULE

THE MODULE BODY IS IN CONTACT WITH THE AIRCRAFT STRUCTURE TO CREATE A RETURN PATH FOR ELECTRICAL CIRCUTS AND TO GROUND THE SHIELDED OR SENSITIVE WIRES PREVENTING ELECTRICAL NOISE OR INTERFERENCE

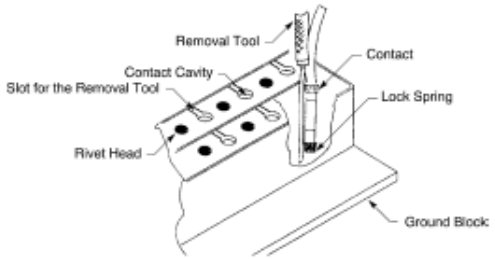
Example of grounding module assembly / disassembly

2.Ground Block Module Disassembly

A. Contact Removal

TABLE III
CONTACT REMOVAL TOOLS

Removal Tool		Supplier
Handle	Tip	
ATB3062-2	-	Astro
DHK21	-	Daniels
J-1276-1	-	Burndy
ST2220-3-34A-1	ST2220-3-34A-3	Boeing
ST2220-3-34A-2	ST2220-3-34A-8	Boeing



CONTACT REMOVAL
Figure 3

(1) Make a selection of a contact removal tool from Table III.
CAUTION: ONLY THE REMOVAL TOOLS THAT ARE GIVEN IN TABLE III PERMITTED. OTHER REMOVAL TOOLS CAN CAUSE DAMAGE TO THE MODULE.

(2) Put the tip of the removal tool in the slot that is adjacent to the contact cavity. Refer to Figure 3.

(3) Push the tool into the slot and into the module until it stops.
This releases the lock spring that holds the contact in position. Refer to Figure 3.

CAUTION: IF REMOVAL OF THE CONTACT IS TRIED BEFORE THE LOCK SPRING IS RELEASED, DAMAGE TO THE CONTACT, THE MODULE, OR THE WIRE CAN OCCUR.

(4) Carefully pull the wired contact from the contact cavity.

(5) Pull the removal tool out of the slot.

3.Ground Block Module Assembly

A. Contact Selection

NOTE: The BACC47DE()A contacts are replacements for the BACC47DE() contacts.

TABLE IV
CONTACT SELECTION

Wire Size (AWG)	Insulation Diameter (inch)		Contact		
	Minimum	Maximum	Boeing Standard	Finish	Color Band
24	0.032	0.045	BACC47DE8A	Gold	Violet
			BACC47DE8	Silver	Green
	0.041	0.065	BACC47DE4A	Gold	Green
			BACC47DE4	Gold	Green
	0.070	0.080	BACC47DE3A	Gold	None
			BACC47DE3	Gold	None
22	0.047	0.065	BACC47DE7A	Gold	Red
			BACC47DE7	Gold	Red
	0.041	0.065	BACC47DE4A	Gold	Green
			BACC47DE4	Gold	Green
	0.070	0.080	BACC47DE3A	Gold	None
			BACC47DE3	Gold	None
20	0.047	0.065	BACC47DE7A	Gold	Red
			BACC47DE7	Gold	Red
	0.056	0.069	BACC47DE6A	Gold	Black
			BACC47DE6	Silver	Black
	0.063	0.083	BACC47DE5A	Gold	Blue
			BACC47DE5	Silver	Red
	0.080	0.110	BACC47DE1A	Gold	Brown
			BACC47DE1	Silver	None

Example of grounding module assembly / disassembly (cont'd)

ASSEMBLY OF BURNDY YHLZG GROUND BLOCK MODULES

Wire Size (AWG)	Insulation Diameter (inch)		Contact		
	Minimum	Maximum	Boeing Standard	Finish	Color Band
18	0.056	0.069	BACC47DE6A	Gold	Black
			BACC47DE6	Silver	Black
	0.063	0.083	BACC47DE5A	Gold	Blue
			BACC47DE5	Silver	Red
	0.080	0.110	BACC47DE1A	Gold	Brown
			BACC47DE1	Silver	None
16	0.063	0.083	BACC47DE5A	Gold	Blue
			BACC47DE5	Silver	Red
	0.080	0.110	BACC47DE1A	Gold	Brown
			BACC47DE1	Silver	None

(1) Use BACC47DE4 or BACC47DE4A contacts for these wires:
- BMS 13-51 Type XXVI AWG 22
- BMS 13-48 Type IX AWG 20
- Haveg 51-04570
- Haveg 51-04569.

(2) For BMS 13-48 Type VIII AWG 20 wire, use BACC47DE7 or BACC47DE7A contacts.

(3) For all other wires:
(a) Find the wire size.
(b) Measure the outer diameter of the insulation of the wire.
(c) Make a selection of the contact from Table IV.

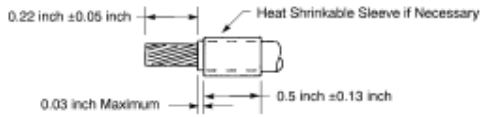
B. Contact Assembly

TABLE V
CONTACT CRIMP TOOLS

Basic Unit	Die	Locator	Supplier
M10S-1	S-1	SL-53	Burndy

(1) Remove 0.22 inch ±0.05 inch of insulation from the end of the wire. Refer to Figure 4.

ASSEMBLY OF BURNDY YHLZG GROUND BLOCK MODULES



WIRE PREPARATION
Figure 4

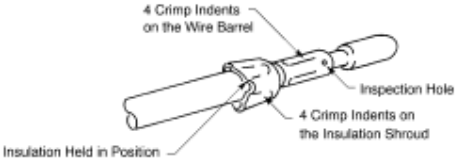
(2) If the diameter of the wire insulation is not within the minimum and maximum diameter for the contact:
(a) Put a 0.5 inch ±0.13 inch length of RT-876 heat shrinkable sleeve on the wire. Refer to Figure 4.
Make sure that:
- The sleeve has the smallest diameter that will fit over the wire
- The forward end of the sleeve is aligned with or is within 0.03 inch of the end of the insulation of the wire.

(b) Shrink the sleeve in position. Refer to Subject 20-10-14.

(3) Put the conductor into the wire barrel of the contact.
Make sure that:
- The conductor can be seen in the inspection hole
- The wire insulation is against the bottom of the insulation shroud of the contact.

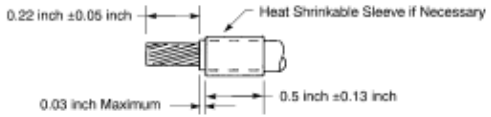
(4) Make a selection of a crimp tool from Table V.

(5) Crimp the contact. Refer to Figure 5.
Make sure that there are 4 crimp indents on:
- The insulation shroud of the contact to hold the insulation
- The wire barrel of the contact to hold the wire.



POSITION OF THE CRIMP INDENTS ON THE CONTACT
Figure 5

Example of grounding module assembly / disassembly (cont'd)



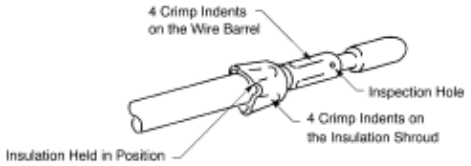
WIRE PREPARATION
Figure 4

(2) If the diameter of the wire insulation is not within the minimum and maximum diameter for the contact:
   (a) Put a 0.5 inch ±0.13 inch length of RT-876 heat shrinkable sleeve on the wire. Refer to Figure 4.
   Make sure that:
   - The sleeve has the smallest diameter that will fit over the wire
   - The forward end of the sleeve is aligned with or is within 0.03 inch of the end of the insulation of the wire.
   (b) Shrink the sleeve in position. Refer to Subject 20-10-14.

(3) Put the conductor into the wire barrel of the contact.
Make sure that:
- The conductor can be seen in the inspection hole
- The wire insulation is against the bottom of the insulation shroud of the contact.

(4) Make a selection of a crimp tool from Table V.

(5) Crimp the contact. Refer to Figure 5.
Make sure that there are 4 crimp indents on:
- The insulation shroud of the contact to hold the insulation
- The wire barrel of the contact to hold the wire.

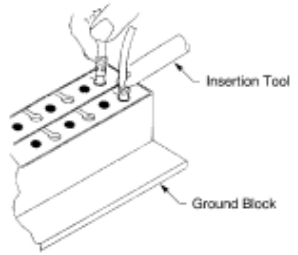


POSITION OF THE CRIMP INDENTS ON THE CONTACT
Figure 5

C. Contact Insertion

TABLE VI
CONTACT INSERTION TOOLS

Insertion Tool	Supplier
ATB3062-2	Astro
DHK21	Daniels
J-1276-1	Burndy
ST2220-3-34A-1	Boeing
ST2220-3-34A-2	Boeing



CONTACT INSERTION
Figure 6

Refer to Figure 6.
(1) Make a selection of a contact insertion tool from Table VI.
(2) Put the wired contact into the contact cavity of the module.
(3) Push the tip of the insertion tool onto the end of the contact.
(4) Push the tool and the contact into the contact cavity until it is fully inserted.
(5) Make sure the contact is locked in the contact cavity of the module:
   (a) Lightly hold the wire between the thumb and the forefinger.
   (b) Pull slowly until the thumb and the forefinger move on the wire.
   CAUTION: DO NOT CAUSE DAMAGE TO THE WIRE INSULATION WITH THE FINGERNAILS.

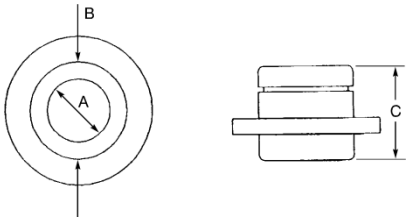
G. (6) Pressure seals

Objective: Demonstrate the replacement of pressure seals.

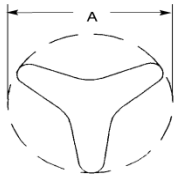
a. Disassembly
b. Maintenance
c. Assembly and strain relief

Reference: SWPM 20-10-20

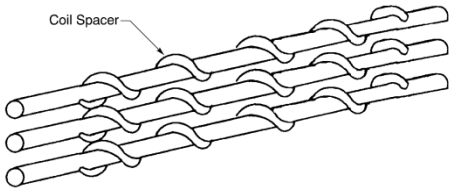
Types of pressure seals and spacers



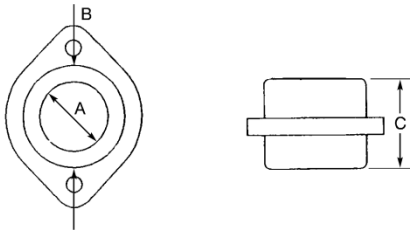
WIRE HARNESS SEAL WITH A CIRCULAR FLANGE



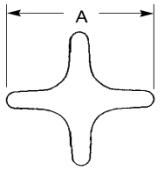
STAR SPACER WITH THREE SEPARATIONS



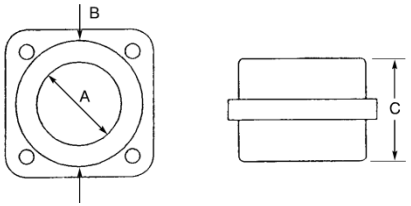
COIL SPACERS



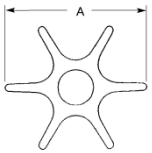
WIRE HARNESS SEAL WITH AN OVAL FLANGE



STAR SPACER WITH FOUR SEPARATIONS



WIRE HARNESS SEAL WITH A SQUARE FLANGE



STAR SPACER WITH FIVE SEPARATIONS

Pressure Bulkhead Seal – Removal/Installation and Maintenance

Removal of the Pressure Bulkhead Seal

Seal Removal

Caution: Do not cause damage to:

- The structure.
- The wire harness, if the wire harness must be use again.

(1) Make a selection of a scraper made of wood or plastic.

Caution: Do not use a scraper that is made of a material that is harder than2024-T3 aluminum. A harder material can cause damage to the structure.

(2) Make a selection of an appropriate solvent.

(3) Remove the sealant on and around the installation hardware of the seal fitting.

(4) Remove the installation hardware.

(5) Remove the seal fitting from the structure:

(a) Carefully put the scraper between the seal fitting and the structure.

(b) Move the two halves of the seal apart.

(6) If the fitting must be replaced, discard the seal fitting.

(7) If the wire harness must be installed again:

(a) Carefully remove the sealant from each wire or cable.

(b) Clean the wire or cable with solvent.

(8) Remove the sealant from each side of the structure with the scraper.

Caution: Do not use a scraper that is made of a material that is harder than2024-T3 aluminum. A harder material can cause damage to the structure.

(9) Clean each side of the structure with solvent.

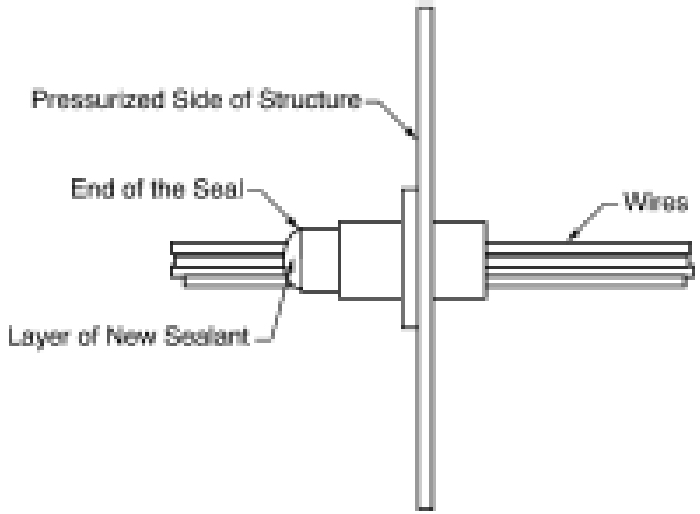
(10) Remove the remaining solvent with a clean, dry cloth.

Pressure Bulkhead Seal – Removal/Installation and Maintenance

Assembly of a Pressure Bulkhead Seal

Wire Preparation

(1) Make a selection of an appropriate wire harness seal.
(2) Make a selection of an appropriate solvent.
(3) Put the wires, the cables, or the wire harness through the cutout.
(4) Install the wires, or the cables, or the wire harness. Make sure that the wire harness has 2 inches of slack on the pressurized side of the cutout so that the assembly of the seal is easier.
(5) Clean all of the surfaces where the sealant must be applied.
(6) Remove the remaining solvent with a clean, dry cloth.



THANK YOU!