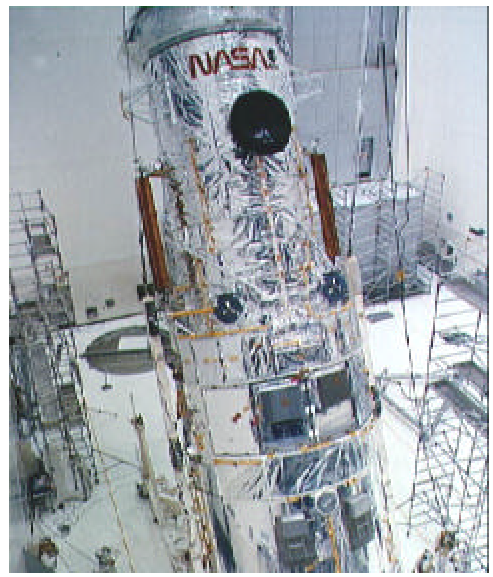
In Accordance with
NASA-STD-8739.4
February 1998

NASA Training Program



Student Workbook for Crimp, Cable and Harnessing

December 1998

NASA

National Aeronautics and
Space Administration

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NASA Training Program
Student Workbook for
Crimping, Interconnecting Cables Harness, and Wiring

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Student Workbook for NASA-STD-8739.4
Crimping, Cabling and Harnessing

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This document was prepared by the Goddard Space Flight Center, and the Jet Propulsion Laboratory, California Institute of Technology under a contract with the National Aeronautics and Space Administration.

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INTRODUCTION

NASA has designated Goddard Space Flight Center/ Unisys Corporation and the Jet Propulsion Laboratory as the Manufacturing Technology Transfer Centers for the Eastern Region and Western Region, respectively, of the United States. The NASA Manufacturing Technology Transfer Centers specialize in the development and implementation of technical training courses for space flight and ground support equipment.

The courses conform to released NASA Handbook and are recognized by NASA.

The intent of this Crimping, Cabling and Harnessing course is to train personnel who instruct, fabricate, or inspect space flight hardware to NASA-STD-8739.4, Crimping, Interconnecting Cables, Harness, and Wiring. This is a hands-on course. Instructions are accomplished through slide presentation, written documentation, demonstrations, and actual construction of a variety of crimped connections, cabling and harnessing. This document specifies the methods and techniques required in the production of reliable crimped connections, cabling, harnessing, and wiring.

The purpose of this course is to assure that each individual who trains, fabricates or inspects is appropriately skilled in the types of connections involved in his/her work. This course provides students with the theory and hands-on experience to produce or inspect quality crimped connections and harnesses. Hands-on training programs with qualified instructors are essential in training personnel to perform these tasks consistently.

POLICY MATTERS ON TRAINING

Questions regarding policy matters on training should be directed to the attention of the Manager of the Jet Propulsion Laboratory Manufacturing Technology Transfer Center or the Goddard Space Flight Manufacturing Technology Transfer Center, whichever is appropriate.

ENTRANCE REQUIREMENTS

A vision and color test is required as a prerequisite to the Crimping, Cabling and Harnessing (CCH) course. All personnel who train, fabricate or inspect must meet the vision and color test requirements as described in NASA-STD-8739.4, paragraph 5.2. A copy of the eye test results must be available the first day of class.

COMPLETION OF TRAINING

Upon completion of the course, students will be issued a diploma and a wallet- size card showing completion of training. All documents contain information as to the type of course, classification (operator, inspector, or instructor), date of expiration, and authorizing signatures.

Certification of trained personnel shall be provided by the supplier based upon successful completion of training. See NASA-STD-8739.4, paragraph 5.4 for details.

RETRAINING

Retraining is based on performance and application of theory, with passing grades of classroom work in accordance with course requirements. Retraining shall be accomplished prior to training expiration date shown on the wallet- size identification card. Failure to successfully complete retraining requires the student to attend a full training course.

GUIDELINES TO FOLLOW FOR CRIMPING, CABLING AND HARNESSING

Crimped connections and harnesses must perform reliably under conditions such as vibration, vacuum, radiation, and shock. General principles of assuring and controlling reliable connections are: proper design; control of tools, materials, and work environments; and good workmanship by trained personnel. Some general factors and rules controlling reliability can be found in NASA-STD-8739.4, paragraph 4.3.

COURSE REQUIREMENTS

Students will be required to fabricate and inspect crimped connections and harnesses. A written examination covering materials from NASA-STD-8739.4 and from class lectures will also be given. Each attendee will be graded for performance on work accomplished during the class. The minimum requirements to pass are:

Field of Employment	Testing Activity	Grades
Operators	Fabrication	85%
	Written Test	80%
	Inspection	80%
Inspectors	Fabrication	80%
	Written Test	80%
	Inspection	85%

COURSE AGENDA

The Crimping, Cabling, and Harnessing training course consists of five (5) 8- hour days for a total of 40 hours. The agenda for each day is outlined in this workbook. Retraining consists of two (2) 8-hour days for operators and inspectors.

Instructor training requires an additional (2) 8-hour days of specialized classroom methods and teaching techniques. Retraining consists of two (2) 8-hour days

MONDAY

8:00 - 8:15	Introduction A. General Information B. Hours C. Grading
8:15 - 9:00	Wire Stripping and Tinning A. Mechanical and Thermal Wire Stripping Demo B. Iron and Solder Pot Tinning Demo C. Connector Cup Gold Removal Demo D. Insulation Stripping Exercise- Students
9:00- 9:15	*Break*
9:15 - 9:45	Crimping Tools Review A. Go/ No Go B. Crimp Tools Set-Up C. Crimping Exercise - students
9:45 - 11:30	Pull Test Crimp Schedule
11:30 - 12:30	*Lunch*
12:30 - 2:00	<u>Methods on Shield Termination</u> Floating Shield Termination A. Demo B. Termination Exercise- students
2:00 - 2:15	*Break*
2:15 - 3:45	Shield Termination using Solder Sleeve A. Demo B. Termination Exercise - Students
3:45 - 4:00	*Clean-up*
4:00	*End of class*

TUESDAY

8:00 - 8:30	Quiz
8:30 - 9:00	Splicing Methods A. Solder Sleeve B. Stub Splice C. Splice Exercises- Students
9:00 - 9:15	Break
9:15 - 11:30	Splicing Methods (continued) A. Crimped Contact Method B. Shield Terminating Wire Tap C. Splice Exercise- Students
11:30 -12:30	*Lunch*
12:30 - 2:00	Group Grounding of Staggered Shields Fabrication - Students
2:00 - 2:15	*Break*
2:15 - 3:45	Group Grounding of Staggered Shields (continued)
3:45 - 4:00	*Clean-up*
4:00	*End of Class*

WEDNESDAY

8:00- 8:30	Quiz
8:30 - 9:00	Contact Insertion/Extraction Push Test A. Demo Contact Insertion/Extraction B. Demo Push Test
9:00 - 9:15	*Break*
9:15 - 11:30	Post Fabrication Electrical Test Group Grounding of Staggered Shields
11:30 - 12:30	*Lunch*
12:30 - 2:00	Fabrication of Coax Connectors A. SMA B. Mark III C. N D. BNC
2:00 - 2:15	*Break*
2:15 - 3:45	Continue Coax Connector Fabrication
3:45 - 4:00	*Clean -up*
4:00	*End of Class*

THURSDAY

8:00 - 8:30	*Quiz*
8:30 - 9:00	Wire Twist, Braid Shielding, Mate Demate
9:00 - 9:15	*Break*
9:15 - 10:00	Harnessing A. Lacing Cord: Spot Tie; Running Lockstitch B. Breakouts C. Service Loops
10:00 - 11:30	Fabricate Chassis
11:30 - 12:30	*Lunch*
12:30 - 2:00	Fabricate Chassis (continued)
2:00 - 2:15	*Break*
2:15 - 3:45	Fabricate Chassis (continued)
3:45 - 4:00	*Clean-up*
4:00	*End of Class*

FRIDAY

8:00 - 9:00	Chassis Fabrication (continued)
9:00- 9:15	*Break*
9:15 - 11:30	Chassis Fabrication (continued)
11:30 - 12:30	*Lunch*
12:30 - 2:00	Written Test Inspection Test
2:00 - 2:15	*Break*
2:15 - 3:30	Inspection, Post Assembly Electrical Test (DITMCO) and Grading of Student Chassis Student Out-Briefing
3:45 - 4:00	*Clean-up*
4:00	*End of Training*

RETRAINING

DAY ONE

8:00 - 8:15	Introduction, Retraining course outline
8:15- 9:00	Review quizzes; slide presentation
9:00 - 9:15	*Break*
9:15 - 10:00	Continue slide presentation
10:00 - 11:30	Tensile strength exercise
11:30 - 12:30	*Lunch*
12:30 - 2:00	Fabrication of harness by students
2:00 - 2:15	*Break*
2:15 - 3:45	Continue fabrication of harness
3:45 - 4:00	*Clean-up*
4:00	*End of Class Day*

DAY TWO

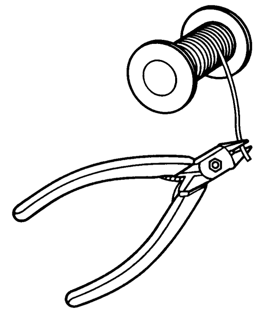
8:00 - 8:15	Review
8:15 - 9:00	Continue fabrication of harness
9:00 - 9:15	*Break*
9:15 - 11:30	Continue fabrication of harness
11:30 - 12:30	*Lunch*
12-30 - 1:30	Written test
1:30 - 2:00	Inspection test; harness/chassis
2:00 - 2:15	*Break*
2:15 - 3:30	Inspection and grading of student harness
3:30 - 3:45	Student out -Briefing
3:45 - 4:00	*Cleanup* *End of training*

Wire Stripping

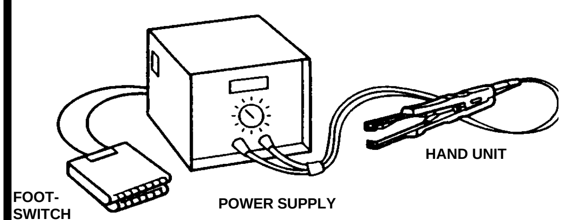
STEP 1. Wire Preparation

Prepare a wire by cutting the appropriate length using side cutters

- *Either precision mechanical tools or thermal strippers shall be selected for insulation stripping.*
  NS6.6-1

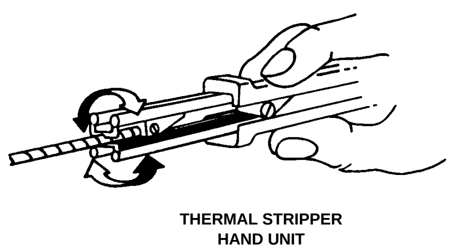


STEP 2. Using a Thermal Wire Stripper



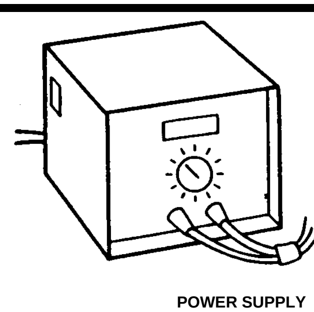
STEP 2a. Wire Stop Setting

Adjust the wire stop to the desired strip dimension. Always measure the insulation strip dimension from the outside edge of the electrode tips.



STEP 2b. Temperature Setting

Turn the power switch ON. Set the knob to the correct temperature for the type of insulation on the wire.



Wire Stripping (continued)

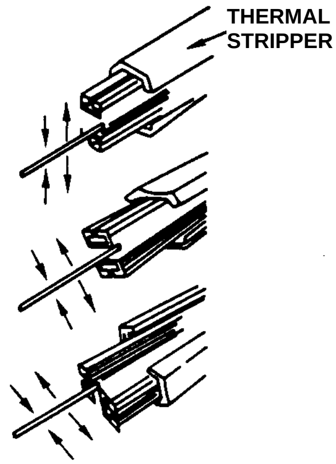
Step 2c. Thermal Wire Stripping

Hold the footswitch down to allow the electrodes to reach the operating temperature. Keep the switch depressed.

Holding the wire in one hand and the thermal stripper in the other hand, insert the wire until the cut end contacts the wire stop.

CLOSE the electrodes on the wire to melt the insulation. Now OPEN the electrodes and rotate them about 30 degrees, and again CLOSE the electrodes to melt another portion of the wire. Repeat the CLOSE to melt, OPEN to rotate operation until a complete ring has been melted around the insulation on the wire.

Remove the wire from the stripper. Release the footswitch. Place the thermal strippers where the electrodes will not cause any damage while they are cooling.



WHEN STRIPPER IS RED-HOT
CLOSE JAWS TO MELT INSULATION OPEN,
TURN STRIPPER, CLOSE, OPEN.

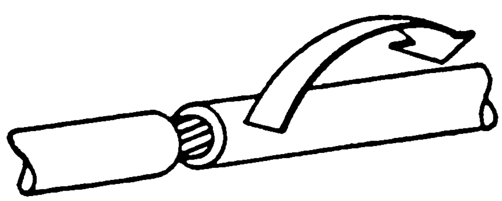
Step 2d. Removing the Insulation

Holding the wire in one hand, grasp the separated portion of the insulation with the thumb and forefinger of the other hand. Remove this portion with a smooth, even motion in the direction of the lay of the wire.

Clean the stripped end with an approved solvent, being careful not to disturb the lay of the wire.

- *The lay of wire strands shall be restored as nearly as possible to the original lay if disturbed.*

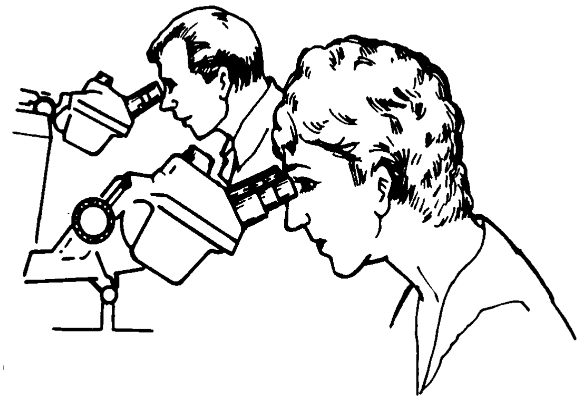
NS10.1-4



Wire Stripping (continued)

Step 2e. Inspection

Inspect in accordance with Step 4.

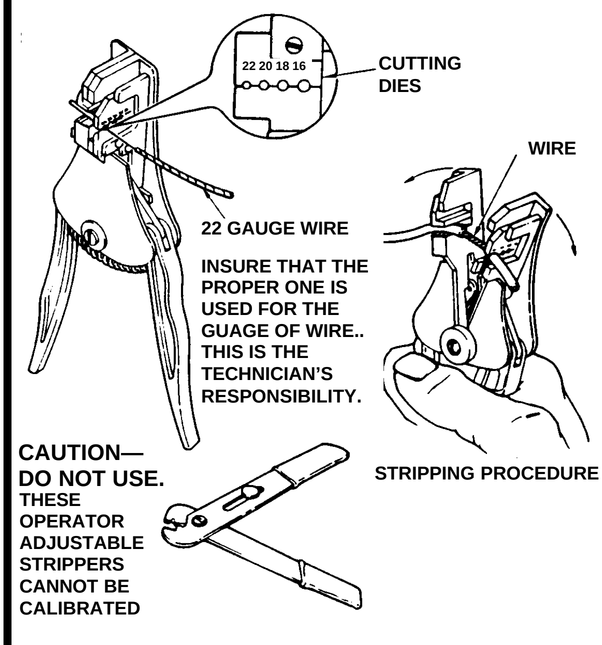


Step 3. Mechanical Wire Stripping

With the jaws open, place the wire in the appropriate die corresponding to the wire size being stripped.

Squeeze the handles to partially cut and separate the insulation only a short distance. Slightly release the pressure on the handles.

Remove the wire, close the strippers, and set the strippers down.

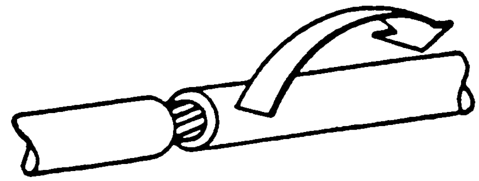


Wire Stripping (continued)

Step 3a. Remove the insulation per Step2d.

- *The lay of wire strands shall be restored as nearly as possible to the original lay if disturbed.*

NS10.1-4



Wire Stripping (continued)

Step 4. Inspection

Inspect under 4X to 10X magnification.

- *After removal of the insulation segment, the remaining conductor insulation shall not exhibit any damage such as nicks, cuts, crushing, or charring. Conductors with damaged insulation shall not be used. Scuffing from mechanical stripping or slight discoloration from thermal stripping is acceptable.*

  NS10.1-2

- *After removal of the conductor insulation, the conductor, shall not be nicked, cut, or scraped to the point that base metal is exposed. Conductors that were reduced in the cross-sectional area shall not be used.*

  NS10.1-3

- *Edge flash, due to improper stripping, should not exceed 1/4 of the outside diameter of the wire insulation.*

  NS, Appendix A

  Figure A-17

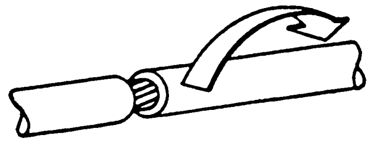
- *Mechanical or thermal shipped insulation irregularity is acceptable if it does not exceed 1/4 of the outside diameter of the wire.*

  NS10.1-6

Tinning: Solder Pot

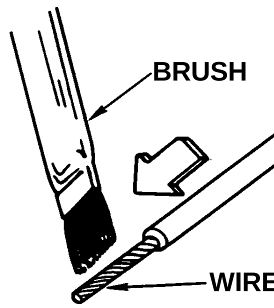
Step 1. Strip the Wire

Strip the wire according to Procedure 1.



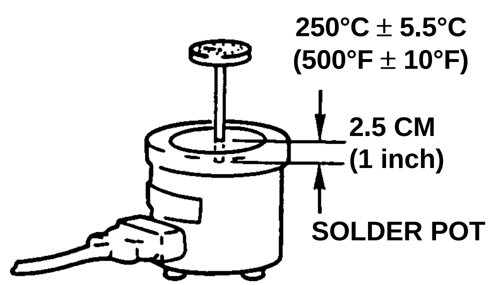
Step 2. Clean the wire

Clean the wire using approved solvent and brush.



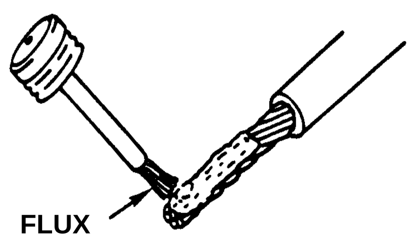
Step 3. Check Solder Pot Temperature

Check the temperature of the solder pot by immersing a calibrated thermometer approximately 2.5 cm (1 in.) into the solder at the center of the pot. For training the temperature reading is 260 deg C +5.5 deg C (500 deg F +10 deg F).



Step 4. Add Flux

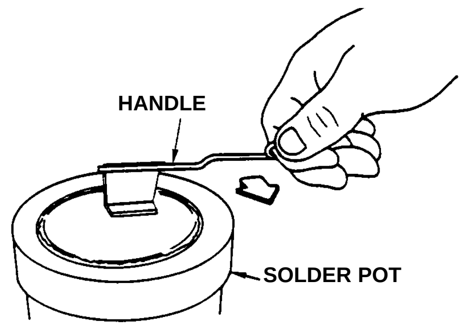
Put type R or RMA flux on the end of the stripped wire to be tinned.



Tinning: Solder Pot (continued)

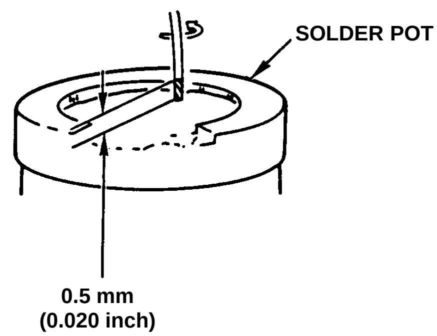
Step 5. Remove Dross

Remove the dross from the solder surface with the appropriate tool.



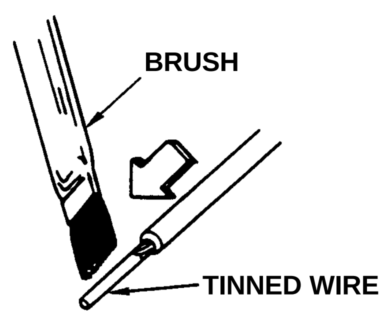
Step 6. Tin the lead

Dip the prepared wire into the molten solder no closer than 0.5 mm (0.020 in) of the insulation. Slowly rotate the wire for less than 5 seconds, and then slowly remove the wire from the solder.



Step 7. Clean the Wire

Clean the flux from the tinned portion of the wire with an acid brush; use the approved solvent and a shopwipe.



Tinning: Solder Pot (continued)

Step 8. Inspection

Inspect the tinned wire under 4X to 10X magnification.

- *Tinned surfaces shall be at least 100% covered.*

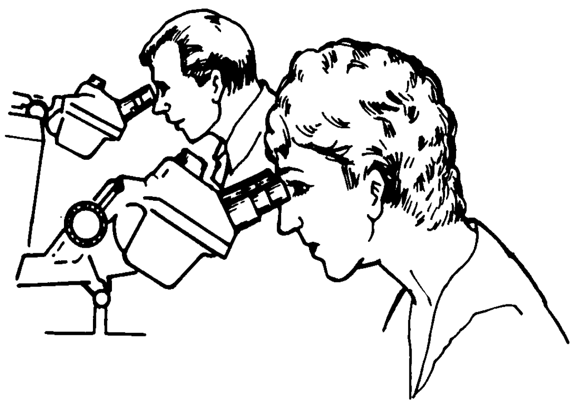
  NS8739.3 - 7.2-6

- *Wicking of solder along the conductor is permitted. Solder shall not make the presence of the individual wire strands indistinguishable.*

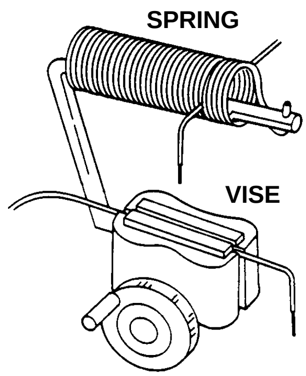
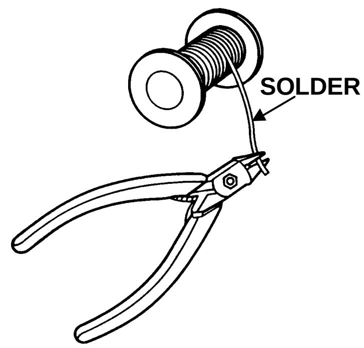
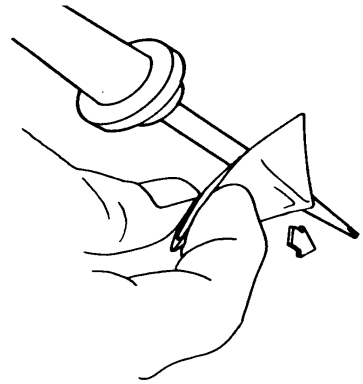
  NS8739.3 - 10.1-3

- *The appearance of the solder joint surface shall be smooth, nonporous, undisturbed, and shall have a finish that may vary from satin to bright depending on the type of solder used.*

  NS8739.3 - 13.6-1a



Tinning: Solder Iron

Step 1. Position the wire Place the stripped wire in a vise or spring to hold it in a vertical position. Gravity minimizes flow of solvent under the insulation. Clean the wire with a soft brush, using the approved solvent and a shopwipe.	
Step 2. Prepare the Solder Prepare the solder by cutting the end (to expose the flux in the core) and clean with an approved solvent.	
Step 3. Prepare the Iron Prepare the iron by wiping the solder from the tip with a shopwipe.	

Tinning: Solder Iron (continued)

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Step 4. Clean The Iron Tip

Lightly wipe the tip of the iron on a moist sponge to remove the oxides.

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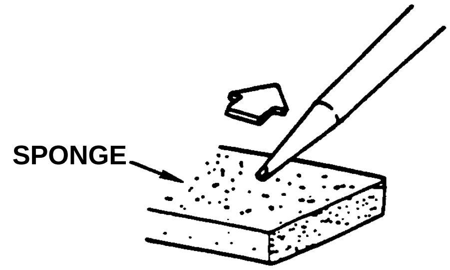

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Step 5. Tin the Wire

Place the soldering iron tip against the wire near the cut end.

Add solder at the junction of the tip and the wire, forming a solder bridge that will transfer the heat from the iron to the wire.

Simultaneously move the iron up the wire, adding solder to the wire until the tinning has reached to within 0.5 mm (0.020 in) of the insulation.

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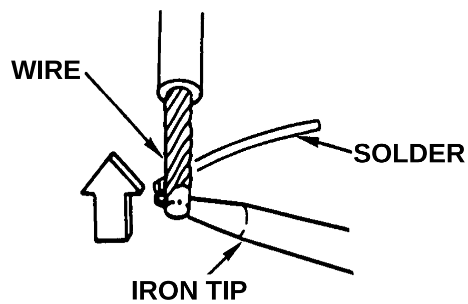

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Step 6. Remove the Iron

Slide the iron down and off the end of the wire, adding solder only as needed.

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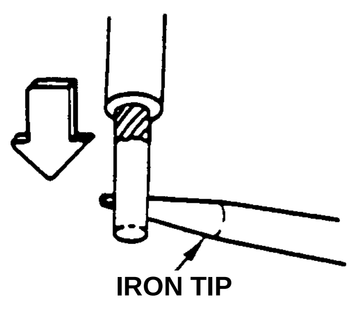

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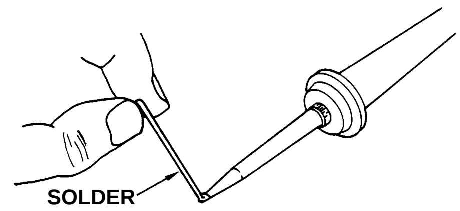
Tinning: Solder Iron (continued)

Step 7. Tin the Iron

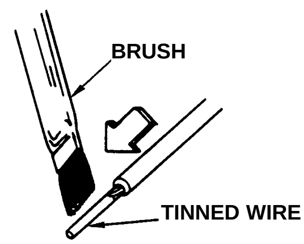
Tin the iron tip, while the connection is cooling at room temperature. A small amount of solder should remain on the tip.

Return the iron to the holder.



Step 8. Clean The Wire

Clean the flux from the tinned portion of the wire with an acid brush, using the approved solvent and a shopwipe.



Step 9. Inspection

Inspect the tinned wire under 4X to 10X magnification.

- *Tinned surfaces shall be at least 100% covered.*

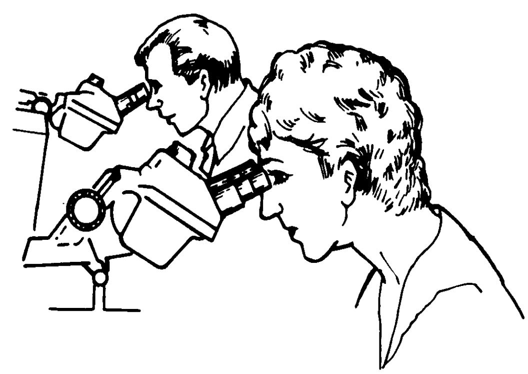
  NS8739.3-7.2-6

- *Wicking of solder along the conductor is permitted. Solder shall not make the presence of the individual wire strands indistinguishable.*

  NS8739.3-10.1-3

- *The appearance of the solder joint surface shall be smooth, nonporous, undisturbed, and shall have a finish that may vary from satin to bright depending on the type of solder used.*

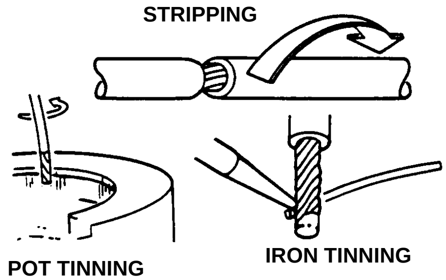
  NS8769.3-13.6-1a



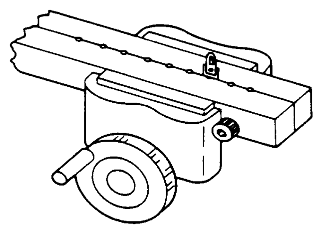
Connector Cup

Step 1. Prepare the connection

1a. Prepare a stranded wire in accordance with Procedure 1 on stripping, and Procedures 2 and 3 on tinning



1b. Insert a terminal into a phenolic block (or equivalent). Secure the block in a vise.



1c. Place the end of the stripped and tinned wire into the cup.

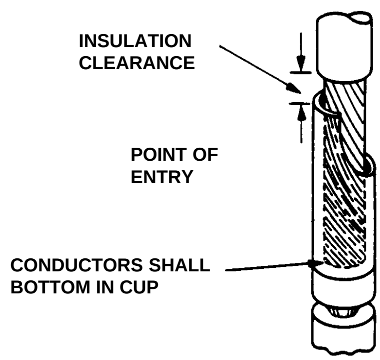
- *The insulation shall not be imbedded in the solder joint, and shall be less than 2 insulation diameters.*

NS8739.3-9.1-1, 2

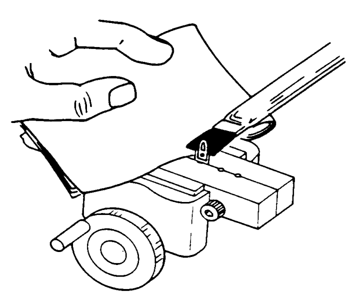
Remove the wire and use wire cutters to cut the wire to the desired length. Re-cut the end of the wire as necessary.

- *The conductors shall be bottomed in the cup and shall be in contact with the inner wall of the cup.*

NS8739.3-9.6



1d. Clean the terminal with an acid brush, using the approved solvent and a shopwipe.



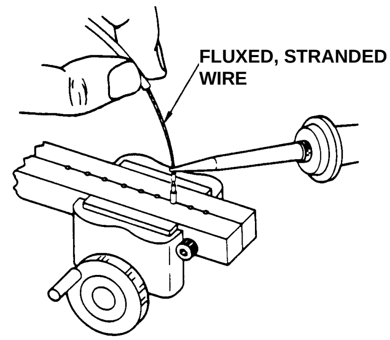
Connector Cup (continued)

1e. Tin the terminal by inserting the end of the solder into the cup and placing the iron so that it touches the solder and the side of the terminal at the same time.

Fill the cup with solder to cover all of the inside surface.

- *Solder along the outside surface of the solder cup is permissible to the extent that it approximates tinning and does not interfere with the assembly or function of the connector.*

NS8739.3-10.1-3b



1f. To wick the solder from the terminal, insert a stranded wire that has been coated with flux.

Position the iron tip against the wire. The wire will get hot and melt the solder, which will then wick up into the strands of wire.

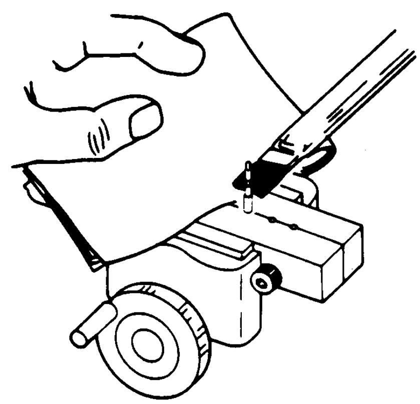
Cut off the wire that has the solder wicked into it.

Repeat the wicking process until there is no solder left to move. The inside of the terminal will show a tinned surface.

Repeat tinning and wicking until all gold is removed.

- *Gold plating on all surfaces, that become part of the finished solder connection, shall be removed by two or more successive tinning operations.*

NS8739.3-7.2-5c



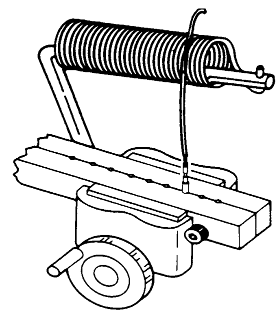
Connector Cup (continued)

1g. Clean the terminal with an acid brush, using the approved solvent and a shopwipe.

Step 2. Position the wire

Attach the wire from the terminal to the spring, which will hold the wire during the soldering.

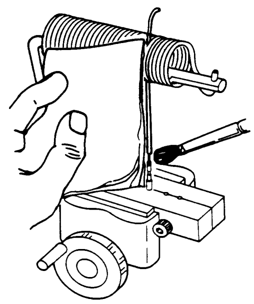
Adjust the wire for the proper tension, centering, and position.



Step 3. Clean the connection

Clean the connection with a soft brush, using the approved solvent and a shopwipe.

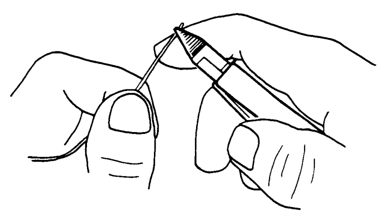
Do not disturb the position of the wire.



Step 4. Cut the solder

Cut the end of the solder to expose the flux in the core of the solder.

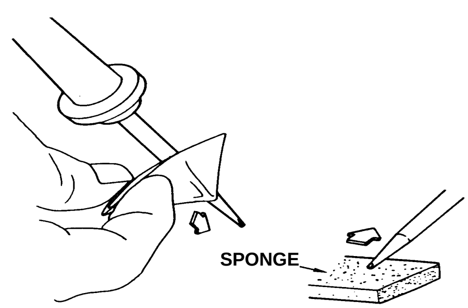
Wipe the solder with a shopwipe and solvent to remove any contaminants.

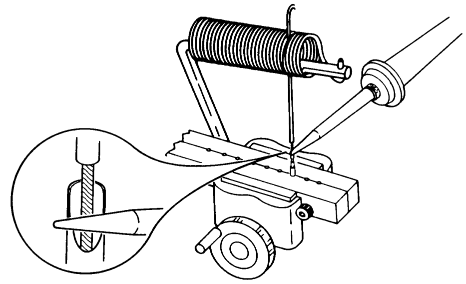
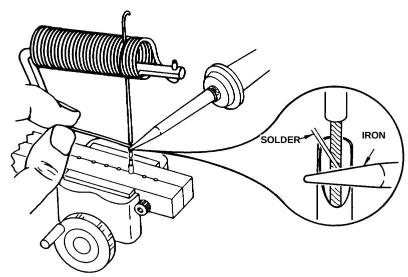
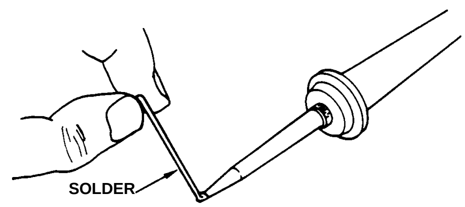
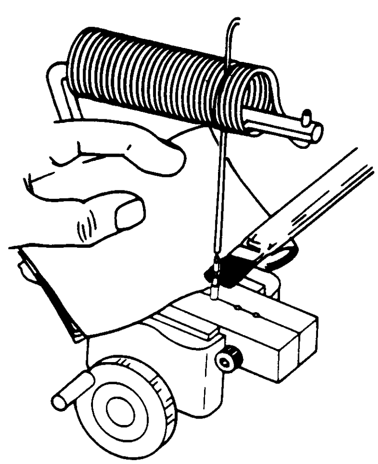


Step 5. Clean the soldering iron

Prepare the iron by wiping the tip with a dry shopwipe.

Lightly wipe the tip on a moist sponge to remove the oxides.



Connector Cup (continued)	
Step 6. Position the iron Place the clean soldering iron tip against the terminal so as to contact both the wire and the terminal at the same time.	
Step 7. Apply Solder Apply a small amount of solder to the junction where the wire, terminal, and tip meet in order to make a solder bridge. Add solder as needed to complete the soldered connection. Remove the solder; remove the iron.	
Step 8. Tin the iron Tin the iron tip while the connection is cooling at room temperature. A small amount of solder should remain on the tip. Return the iron to the holder.	
Step 9. Clean the connection Clean the flux from the soldered connection with an acid brush, using the approved solvent and a shopwipe.	

Connector Cup (continued)

Step 10. Inspect The Connection

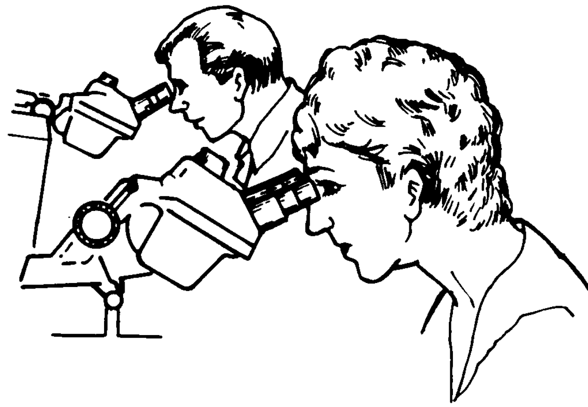
Inspect the solder joint under 4X to 10X magnification to the specified requirements.

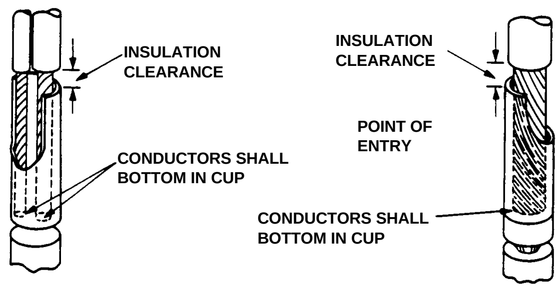
- *The maximum number of conductors shall be limited to those which can be bottomed in the cup and in contact with the full height of the inner wall of the cup.*

NS8739.3-9.6

- *Free of flux residue and other contaminants.*
- *The surface shall be smooth and nonporous.*
- *It shall be undisturbed and have a finish that may vary from satin to bright.*
- *The solder shall wet all elements of the connection.*
- *The solder shall fillet between connection elements over the complete periphery of the connection.*
- *The lead contour shall be visible.*
- *Proper insulation clearance.*

NS8739.3-13.6





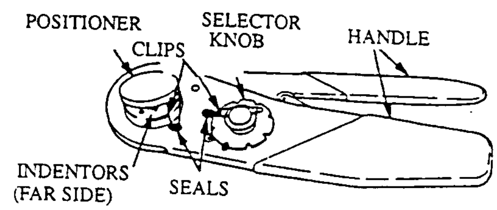
Go No-Go Gage

Step 1. Go/No-Go Gage

The Go No-Go gage is used to verify the correct spacing of the indents created by the crimp tool.

Step 2. Gage Limits

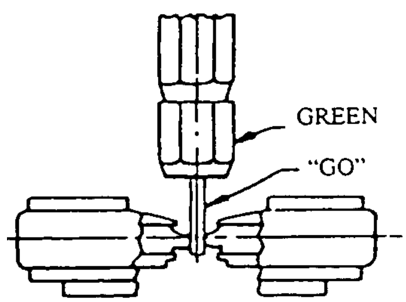
Remove the locking pin from the selector knob on the crimp tool. With the crimp tool in the fully opened position, set the selector knob to the position on the Go/No-Go gage for that crimp tool.



Step 3. Go Gaging

Cycle the tool to the fully closed position. Insert the "GO" gage end as shown between the indentor tips. The gage should pass freely between the indentor tips.

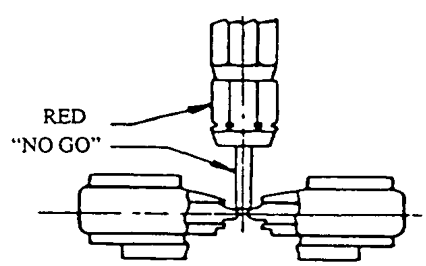
Caution: Do not crimp the Go/No-Go gage.



Step 4. No-Go Gaging

With the tool in the fully closed position, insert the "No Go" gage end as shown. The gage must not pass between the indenter tips.

Note: If either Step 3 or 4 fails, do not use the crimp tool under test. Return tool for recalibration.



Set-Up of Crimp Tool

Crimp Tool Requirements: Crimp tools shall be of the full cycle ratchet type, and be nonadjustable or have adjustment sealed prior to application. Tools shall have a minimum of four indenter blades, preferably double indenter type blades.

Step 1. Attachment of positioner

Check calibration of the crimping tool.

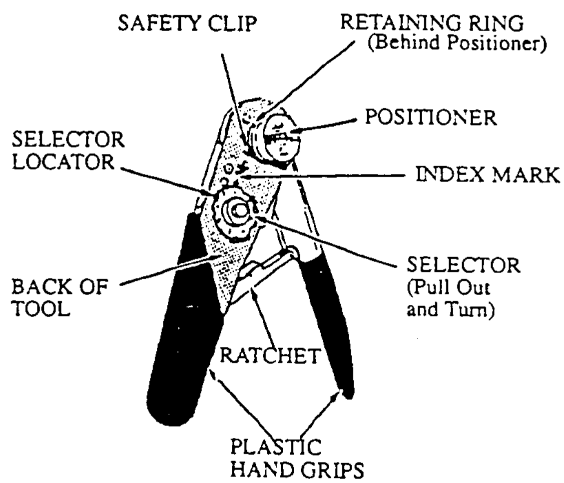
Cycle the crimp tool to the open position. Remove the locking pin from the positioner guide.

Select the appropriate positioner for the contact to be crimped.

Insert positioner into the tool positioner guide and turn 90 degrees until the bayonet pin locks. An audible click indicates a locked positioner. Reinsert the safety clip and seal.

- *Crimp tools shall contain a full cycle ratcheting mechanism which shall prevent the indenters from releasing before the crimp cycle has been completed.*
- *Each crimp tool shall have a minimum of four indenter blades (preferably double-indenter blades.)*
- *All adjustable crimp tools shall be calibrated, set, and sealed prior to their application.*

NS12.3-1a, b, d



Set-Up of Crimp Tool (continued)

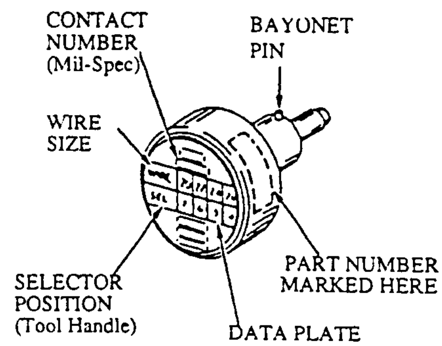
Step 2. Selector Setting

The positioner data plate determines the selector setting based on the contact and wire size used.

Cycle the crimp tool to the OPEN position. Remove the locking pin from the selector knob.

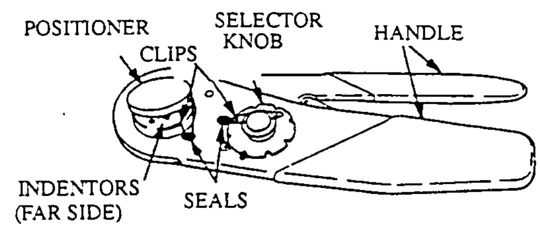
Determine the selector setting based on the contact and wire sizes from the positioner data plate.

Raise and rotate the selector knob until the selector setting number is in line with the SEL. NO. arrow.



Step 3. Lock and Seal

Place the safety clip on top of the selector knob and seal.



Set-Up Crimp Tool with Turret Assembly

Step 1. Turret Position Selection

Check calibration of the crimping tool.

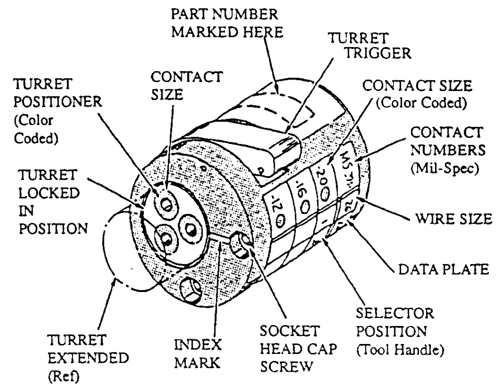
Cycle the crimp tool to the OPEN position

Determine the size of the contact and wire to be crimped. Using the data plate, determine the color for that contact/conductor combination.

Press the turret trigger to raise the turret positioner if not already raised.

Rotate the turret until the desired color coded positioner is lined up with the index mark on the top of the head assembly.

Press the turret until it snaps into the locked position.



Step 2. Selector Knob Setting

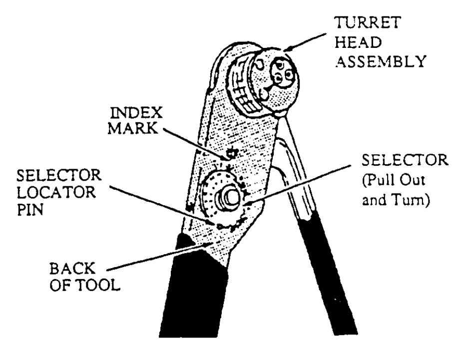
Using the data plate, determine the selector knob setting.

Remove the safety clip from the selector knob.

Cycle the crimp tool to the open position.

Raise and rotate the selector knob until the selector setting number indicated on the data plate is in line with the SEL NO. arrow.

Replace the safety clip and seal.



Crimping Contact to Wire

General Information: Compression crimping is the joining together of a stranded wire to a contact by compressing the contact barrel around the wire. This process forms a gas tight metal-to-metal contact called a crimp or solderless connection.

The reliability of a crimped connection is dependent on: (1) base material and its plating; (2) the wire size versus the crimp barrel size; (3) the crimp tool used, its calibration and setting; (4) the method used; and (5) cleanliness of the materials to be joined. The double four indent or crimping dies produce a good crimp with very little distortion which works well with the harder contact materials found in crimped connectors.

Step 1. Preparation

Strip the insulation from wire in accordance with Procedure 1 on wire stripping.

Identify, inspect, and clean the contact to be crimped.

Identify the appropriate crimp tool, positioner or turret assembly for crimping.

Set up and seal the applicable crimp tool in accordance with Procedures 6 or 7.

- *Crimping of solid wire and stranded wire that has been tinned is prohibited. Stranded wire shall be used.*

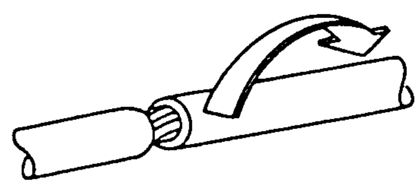
  NS4.3-4

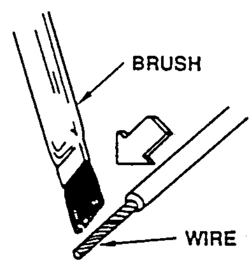
- *Conductors which have been reduced in cross sectional area shall not be used. Damaged wires shall not be used.*

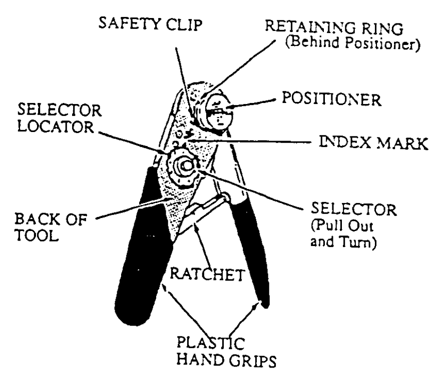
  NS10.1-3

- *Contacts with cracks in the plating or base metal, plating removal or flaking, out-of-roundness of the wire well entrance, exposed base metal shall not be used.*

  NS12.2-1, 2, 3, 4, 5



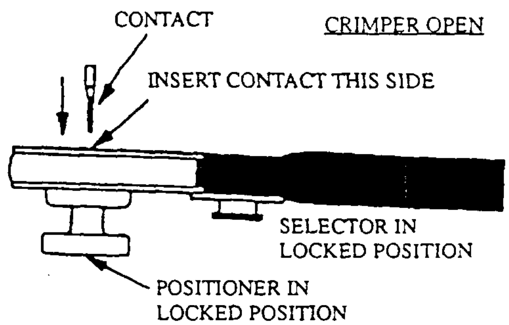




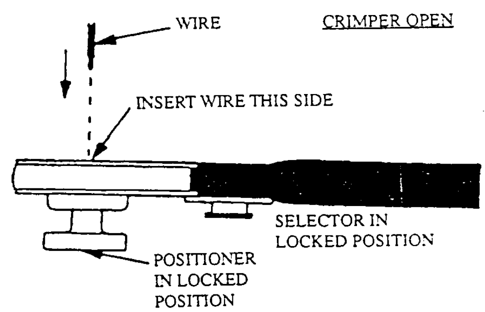
Crimping Contact to Wire (continued)

Step 2. Contact and Wire Insertion

Insert the contact through the indenter opening into the positioner.

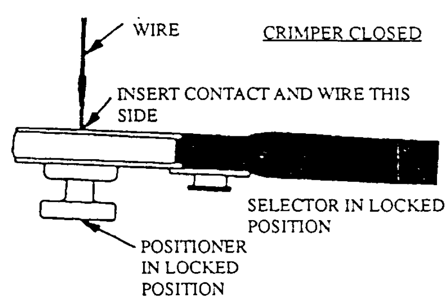


Insert the stripped end of the wire into the contact and ensure that the wire bottoms and all strands are inside the contact.



Step 3 Crimp Cycle

Close the crimp tool handle until the ratchet releases. The handle will return to an open position.



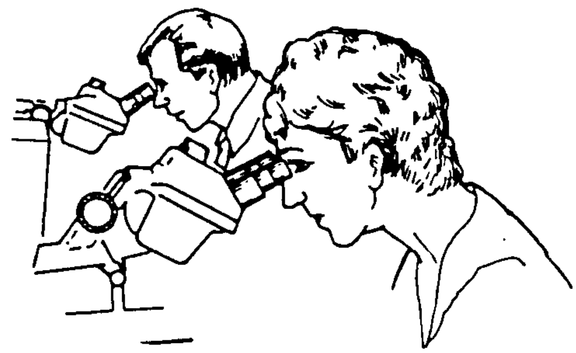
Crimping Contact to Wire (continued)

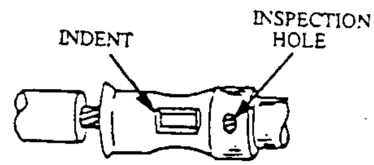
Step 4. Inspection

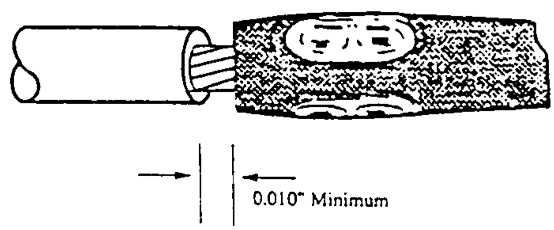
Inspect under 4X to 10X magnification.

- *Contact deformed only by tool indentations.*
- *Crimp indents properly located in the correct area of the contact.*
- *Wire strands visible in the inspection hole.*
- *Insulation clearance is between 0.25 to 0.75 mm (0.01 to 0.03) for wire sizes AWG 20 and smaller, and 0.25 to 1.27mm (0.01 to 0.05 in) for wire size AWG 18 and larger.*

NS19.6-1c







Crimp Tensile Test

General Information: The force required to pull the wire from the crimp barrel (tensile strength) increases with the indent force until the wire strands are weakened by crimp deformation. The relative conductivity increases with the indent force until the stranded wires cross sectional area begins to decrease. Undercrimping will result in insufficient connection tensile strength, whereas, wire deformation, broken strands, or high electrical resistance is the result of an overcrimp due to reduction in the wire section.

The crimped connection is designed to approach but not exceed the tensile strength of the wire.

Step 1. Preparation

Crimp three (3) contact/conductor combination in accordance with Procedure 7.

Complete the Tensile Test Daily Log.

- *A minimum of three test samples shall be prepared for each crimp tool and crimp contact combination, at the start and at the end of each work shift or production run whichever is shorter.*

NS12.3-4a, b

(SAMPLE)

TENSILE TEST DAILY LOG

Project / Program:__________
Fabricator:__________
Inspector:__________

<u>Tensile Tester:</u>
NASA #__________
Calibration Date:__________
Recalibration Date:__________

<u>Crimp Tool Data:</u>
NASA#:__________
Calibration Date:__________
Recalibration Date:__________
Positioner:__________

<u>Location of Break (*):</u>
(a) Break at Crimp
(b) Break Outside Crimp
(c) Fray Break
(d) Pull Out

Wire Data	Contact Data	Select Setting	Operator		Tensile Strength Test					Inspector	
Size	Size	No. / color	Sign	Date	Pull rate per inch	Gage reading (lbs)	Loc of break (*)	Min tensile strngth (lbs)	A-accept R-reject	Sign	Date

Step 2. Tensile Strength Test

Tensile strength test the prepared samples in accordance with the operating instruction of the tensile device in use.

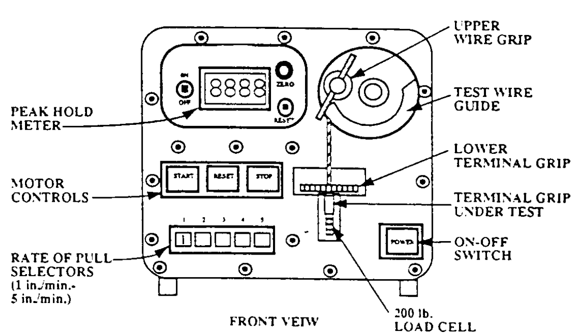
Inspect 4X to 10X.

Record test results on the Tensile Test Daily Log.

- *The head travel speed of the tensile device shall be 1.0 ±0.25 inch (25.4±6.3mmm) per minute.*

NS12.3-4c

Sample Motorized Pull Tester



Crimp Tensile Test (continued)

Step 3. Interpreting the Tensile Test Results

Evaluate each tensile test according to the four crimp joint tensile failure categories given in NS8739.4-4, Table 12-1.

Category A - Break at Crimp
Illustrates overcrimping resulting in reduced cross sectional area of the conductor.

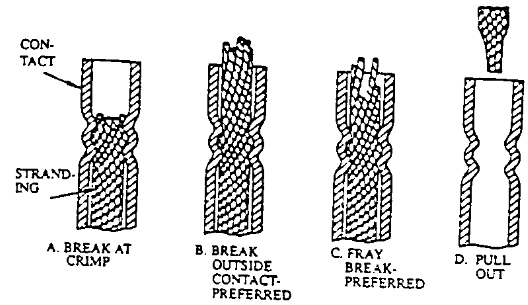
Category B - Break Outside Contact
Preferred

Category C - Fray Break
Preferred.

Category D - Pull Out
Illustrates undercrimping.

- *NOTE: All categories are acceptable if separation occurs above minimum tensile strength per 12.3.4.d.*

NS12.3-4, Fig. 12-1



Optimum Crimp Tool Settings

General Information: A crimp schedule may be developed for the particular tool and contact/conductor combination in order to verify the procedures and requirements of Table 12-1, NAS8739.4. A crimp schedule is used to determine the optimum crimp tool setting for a specific contact/conductor combination. A crimp schedule is normally developed at the beginning of a program when it is found that either: (1) the manufacturer's recommended crimp tool setting is not adequate to produce the minimum tensile strength required by Table12-1; or (2) when the contact/conductor combination is not listed in the crimp tool manufacturer's data. After the crimp schedule is developed, fabrication procedures must be documented. Approval is required if the crimp schedule data is to be used.

Step 1. Preparation

Cut, strip, clean, inspect , and serialize 15 stranded conductors. Instructor will provide the wire size.

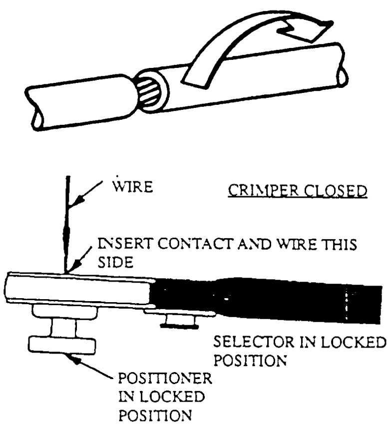
Clean and inspect 15 contacts. Instructor will provide contact size.

Crimp 5 contact/conductor combination each:

(a) one step below the recommended positioner setting.

(b) at the recommended setting.

(c) one step above the recommended positioner setting.



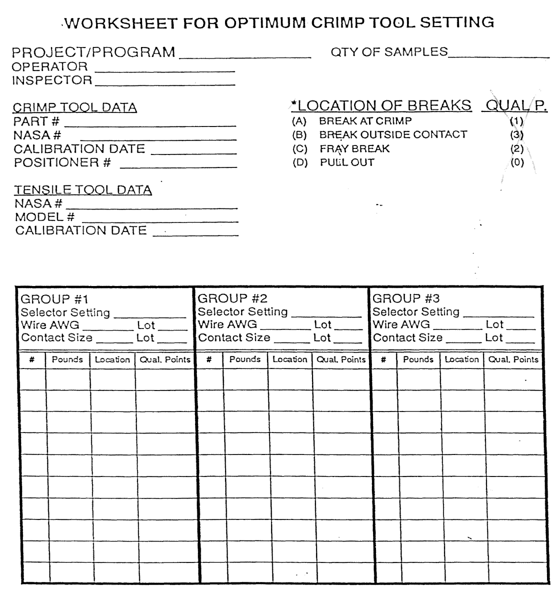
Step 2. Tensile test

Perform the crimp tensile strength test in accordance with Procedure 9.

Record results on the Worksheet for Optimum Crimp Tool Setting noting the failure category and peak force.

- *The crimp tool setting which produces the maximum number of fray breaks and breaks outside the contact shall be used for assembly.*
- *If multiple settings provide identical tensile strengths for a crimp joint, the setting selected shall be the one that provides more wire breaks than pull-outs.*

NS12.3-4e



WORKSHEET FOR OPTIMUM CRIMP TOOL SETTING

PROJECT/PROGRAM ______________ QTY OF SAMPLES ____________
OPERATOR ________________
INSPECTOR ________________

CRIMP TOOL DATA
PART # ________________
NASA # ________________
CALIBRATION DATE __________
POSITIONER # ______________

*LOCATION OF BREAKS — QUAL P.
(A) BREAK AT CRIMP (1)
(B) BREAK OUTSIDE CONTACT (3)
(C) FRAY BREAK (2)
(D) PULL OUT (0)

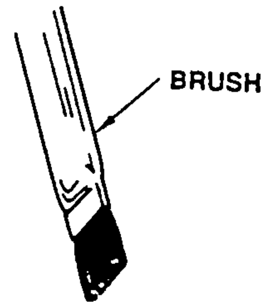
TENSILE TOOL DATA
NASA # ________________
MODEL # ________________
CALIBRATION DATE __________

GROUP #1 Selector Setting ______ Wire AWG ______ Lot ____ Contact Size _____ Lot ____				GROUP #2 Selector Setting ______ Wire AWG ______ Lot ____ Contact Size _____ Lot ____				GROUP #3 Selector Setting ______ Wire AWG ______ Lot ____ Contact Size _____ Lot ____			
#	Pounds	Location	Qual. Points	#	Pounds	Location	Qual. Points	#	Pounds	Location	Qual. Points

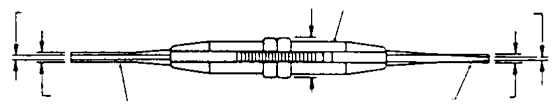
Contact Insertion and Extraction

Step 1. Preparation

Connectors and crimped contacts shall be cleaned and inspected prior to contact insertion/extraction.



Each contact has a dedicated insertion/extraction tool. Ensure the correct tool is used.



The lighter color end is for extraction; the darker color is for insertion.

- *In all instances, non-metal contact insertion and removal tool shall be used to prevent conductor damage, to connectors, contacts, or conductors.*
- *CAUTION: Any damaged plastic tool shall be discarded immediately and replaced with a new tool. Should part of the tip of a plastic tool break off, all pieces of the tip must be accounted for. If all pieces of the tip cannot be accounted for, document the incident and the responsible engineering and/or quality representative shall be notified immediately.*

NS13.2-1

Contact Insertion and Extraction (continued)

Step 2. Insertion

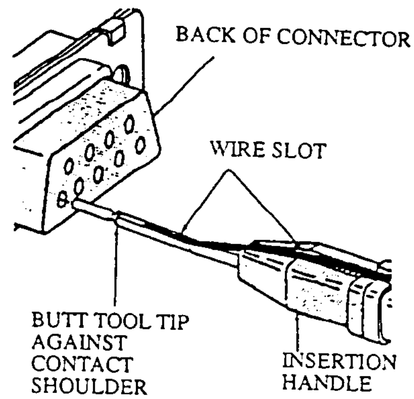
Inspect insertion tool for damage. Do not use damaged tools.

Place insertion tool (dark color end) around the conductor and slide the tool such that it seats against the contact shoulder.

Insert the contact straight into the "retained" position noted by a firm stop. DO NOT TWIST THE TOOL DURING INSERTION.

Remove the tool by pulling straight out without twisting.

Inspect the tool for damage or missing parts. If damaged, check connector and remove parts.



Step 3. Extraction

Inspect the extraction tool for damage. Do not use damaged tool.

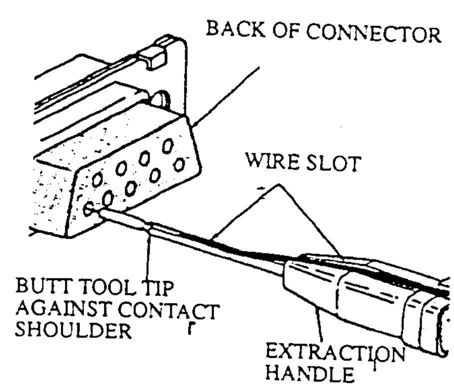
Place the extraction tool (lighter color end) around the conductor and contact to be extracted.

Push the tool into the back of the connector and ensure the tool tip butts against the contact shoulder.

Firmly hold the conductor against the serrated area of the tool.

Pull the tool with the conductor and contact away from the connector body. DO NOT TWIST THE TOOL DURING EXTRACTION.

Inspect the tool for damage or missing parts. If damaged, check connector and remove parts.



Contact Retention Test

General Information: Most connectors employ the use of clips or tines as locking mechanisms. Knowing the type of locking mechanism is important prior to contact retention testing. After crimped contacts are installed in connectors, contact seating retention test shall be performed on all contacts.

Step 1. Preparation

Check calibration of push tester.

Install proper test fixture to accommodate the contact type in use.

- *Push testing shall utilize a tool that minimizes the possibility of accidental contact bending and applies a controlled, preset pressure to the contact before releasing the force.*
- *Socket testing probes shall be undersized compared to mating-pin diameters and shall not cause a mating cycle to take place.*

NS12.8-2a

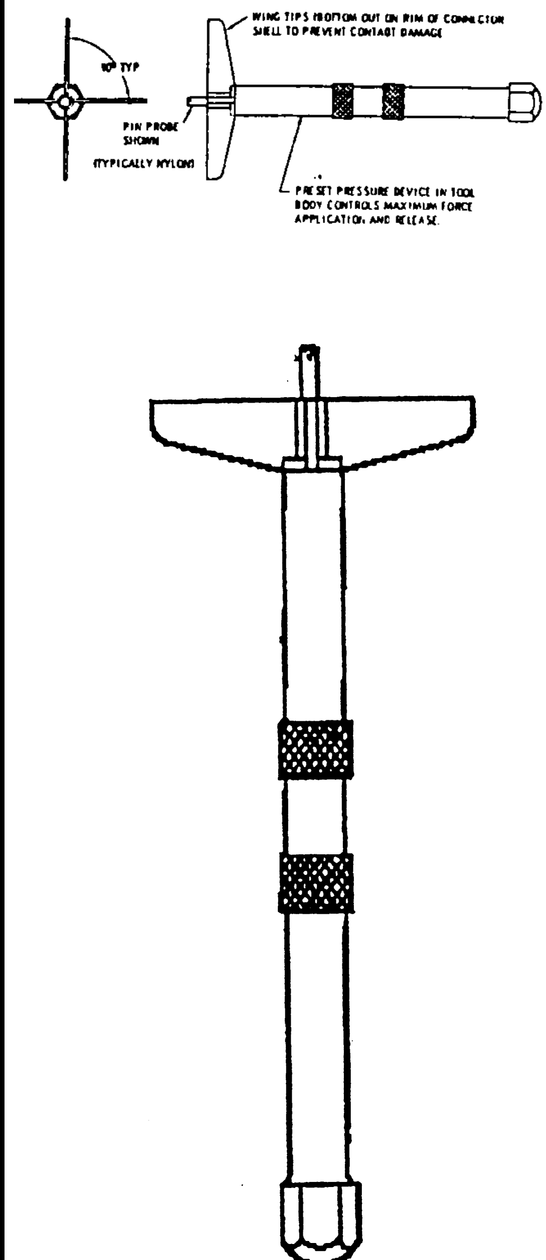
Step 2. Push Testing

Place test fixture for the appropriate contact to be used.

Apply pressure in a direction opposite to the force used to insert the contact.

Do not twist or bend the contact under test.

Typical push tester tools



Contact Retention Test (continued)

Step 3. Conditions

If the initial push test fails, perform a visual examination of the contact and connector.

Clean contact and connector.
Reseat contact and repeat push test.

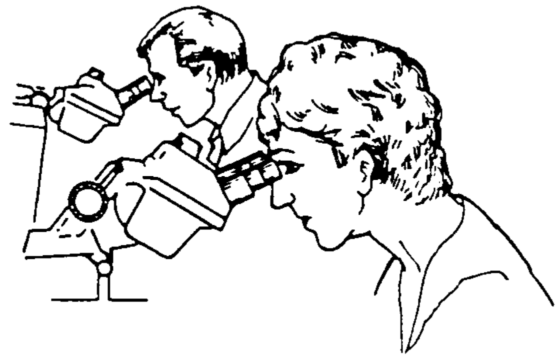
If the second push test fails:

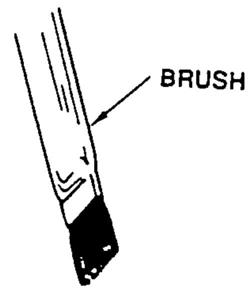
Replace contact per procedure
Reseat in connector shell.
Repeat push test.

If the third test fails, replace connector.

- *Each contact in connectors utilizing retention clips or tines shall be pushed or pull tested 100 % for seating, and results shall be recorded.*

NS13.8-2





Cable Shielding and Shield Termination

1. General Information on Radio Frequency Interference (RFI) and Electromagnetic Interference (EFI) Practices

Interconnecting cables and harnesses shall be designed and constructed to minimize electromagnetic couplings between wires within the assembly that are sensitive to induced interference. Methods by which program isolation requirements can be achieved are:

A. Isolation of Signals
Signals can be isolated by using separate connectors and wire harnesses.

B. Wire and Cable Types
RFI/EMI can be reduced in harnesses by careful selection of wire types that provide control of radiated fields. Listed in order of increasing control are:

a. Twisted pairs
b. Shielded wires
c. Single-braid coaxial cable
d. Double-braid coaxial cable
e. Triaxial cable

C. Overall Shielding of Interconnecting Cable and Harness
Copper braid is the most effective RF shielding.

2. SHIELD TERMINATION

Cable shields may be terminated using one or more of the following methods and as dictated by the engineering documentation. Methods C and E will be used in this training program.

A. Overall shielding using conductive RFI/EMI backshell adapters.
B. Large compression ring grounding or bands.
C. Individual shields using solder sleeves.
D. Individual shields using two-piece crimps.
E. Floating shield.

Floating Shield Termination

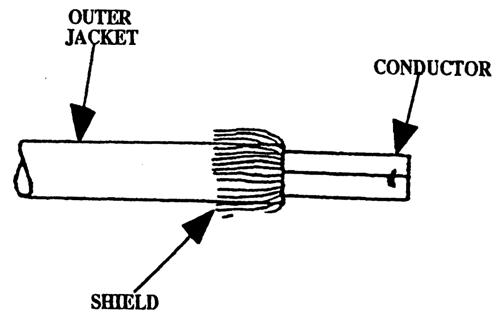
Step 1. Cable Preparation

Strip the outer jacket using thermal stripper to expose a minimum of 5mm (0.2 inch) of the shielding braid.

Fold the braid over the jacket. Braid maybe comb before folding.

- *Combing the braid is optional.*

NS11.8



Step 2. Sleeving

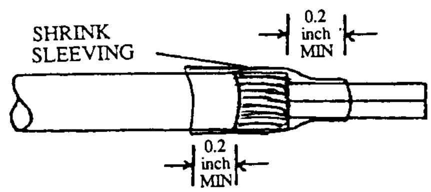
Use appropriate size shrink sleeving allowing 5mm (0.2 inch) minimum beyond the exposed shield, both ends.

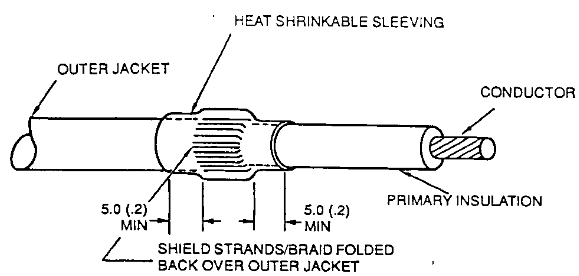
Shrink sleeving with heat gun.

- *Shield termination shall:*

1. *Shall be free of projecting strands.*
2. *The wire insulation and shrink sleeving shall be free of punctures, cuts, and nicks.*
3. *The insulation sleeving shall be uniformly shrunk and provide covering of the termination*

NS19.6-1b





Individual Shield Termination Using Solder Sleeves

STEP 1. Preparation

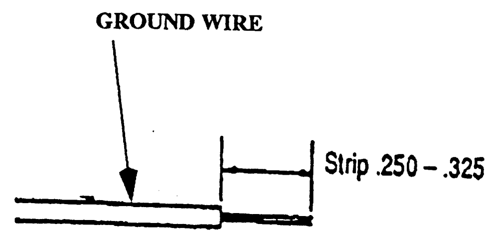
a. Strip the insulation from one end of the grounding wire exposing 6.4 to 8.3mm (0.250 to 0.325 inch) of the conductor in accordance with Procedure 1 on wire stripping.

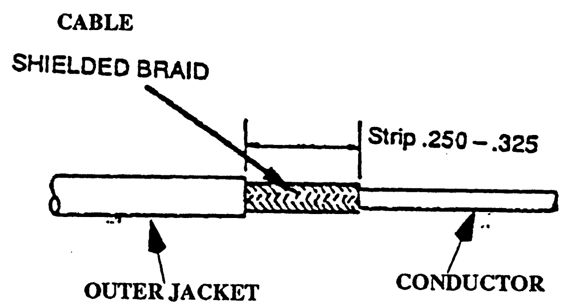
b. Remove the outer jacket using either thermal or mechanical means from one end of a cable exposing 6.4 to 8.3mm (0.250 to 0.325 inch) of shield.

Clean with approved solvent.

- *Nicked shield strands shall not exceed 10% of the total number of strands. There shall be no severed strands.*

NS10.2

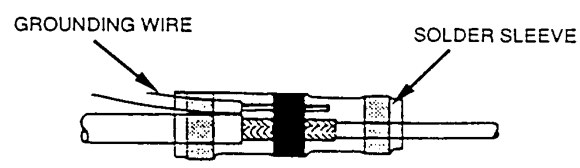




STEP 2. Positioning

Select the proper size solder sleeve that will accommodate the termination.

Position grounding wire over shield and insert solder sleeve over termination. Ensure sleeve ring is centered in the shield.



STEP 3. Soldering

Insert the termination in the nozzle of the heat gun and initiate the heat cycle.

Uniform heating is necessary to assure proper solder flow and shrinking of the sleeve.

Individual Shield Termination Using Solder Sleeves (continued)

STEP 4. Inspect

4X to 10X magnification

- *(1) Shield terminations shall be free of projecting strands.*
  (4) The solder inside the solder sleeve shall show evidence of proper flow and fillet to the ground wire and shield braid.
  (5) The solder sleeve may exhibit discoloration.
  (8) The solder fillets along the interfaces shall have a smooth, concave appearance.

NS19.6-2g

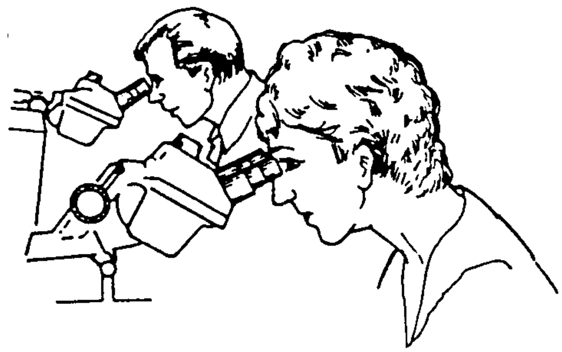
(1) Solder shall be visible through the insulation sleeving

(3) Solder sleeves shall not be damaged

(4) Solder sleeves shall cover all exposed metal in the spliced area.

(5) There shall be no pretruding wire strands form under or through solder sleeves.

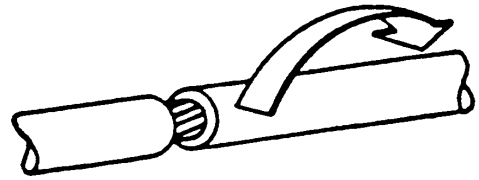
NS19.6-1g



Individual Shield Termination Using Two-Piece Crimp Rings

STEP 1. Preparation

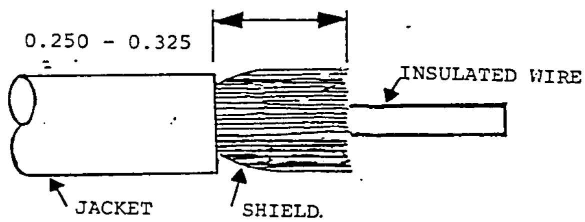
a. In accordance with Procedure 1 on wire stripping, strip the insulation from one end of a grounding wire exposing 0.250 to 0.325 inch of the conductor.



Do not tin the ground wire.

Clean with brush and approved solvent and inspect (4X to 100X).

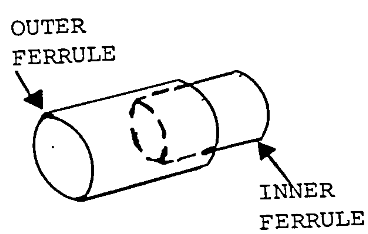
b. Using thermal or other mechanical means, remove the jacket from one end of a cable exposing 6.4 to 8.3 mm (0.250 to 0.325 inch) of shield (7.4mm/0.28 inch nominal).



Clean with brush and approved solvent and inspect (4X to 10X).

c. Select inner and outer ferrules appropriate to the size of the cable termination.

Clean and inspect (4X to 10X).



- *The inner crimp ring(ferrule) shall be sized so that any inward distortion caused by crimping will not affect the insulated wires it contains.*

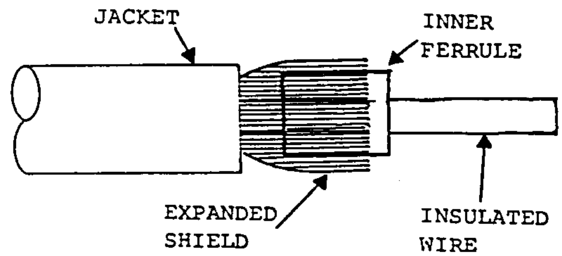
NS11.5

Individual Shield Termination Using Two-Piece Crimp Rings (continued)

STEP 2. Positioning

a. Inner Ferrule

Insert the inner ferrule between the shield and the insulation of the conductor.



b. Outer Ferrule

Place the ground wire over the shield. Wire may dress forward or rearward.

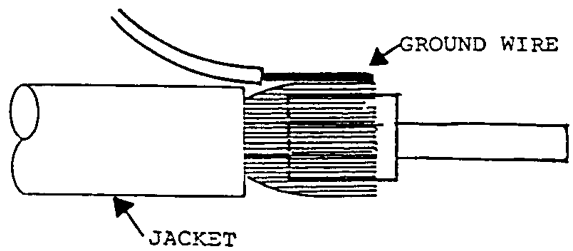
Slowly place the outer ferrule over the wire/shield connection and push inward.

Insulation clearance between ferrule and ground wire insulation, 0.030 inch maximum. Insulation shall not enter the crimp joint.

Trim shield and flush with the outer ferrule.

- The end of the grounding wire shall be flush with the outer ferrule, but shall not overhang the inner ferrule.

NS11.5



STEP 3. Crimping

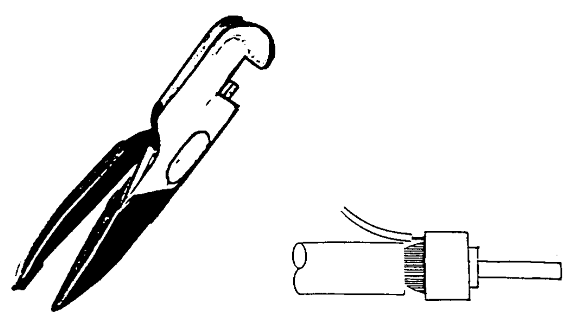
a. Insert the termination in the crimp tool. Align ferrules/ground wire to meet the requirements.

b. Close the crimp tool handle until cycle is complete.

c. Clean and inspect.

- Metal crimp rings/ferrules are tightly and symmetrically crimped.

NS19.4-c4)



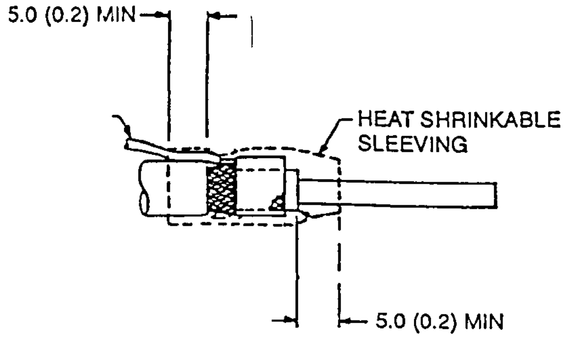
Individual Shield Termination Using Two-Piece Crimp Rings (continued)

STEP 4. Shrink sleeving

a. Place appropriate size and length sleeving over the termination.

b. Shrink sleeving using a heat gun, concentrating on the cut ends first and then move gun to the center.

c. Allow for at least 5mm (0.20 inch) shrink sleeve beyond the exposed shield and the inner ferrule.

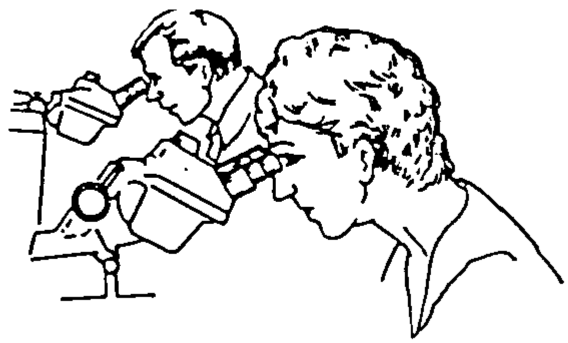


STEP 5. Inspection

- *Insulation (grounding wire) shall not enter the crimp joint minimum.*

  Braid flush with outer ferrule.

  Grounding wire flush with the outer ferrule, but shall not overhang the inner ferrule. *NS11.3*

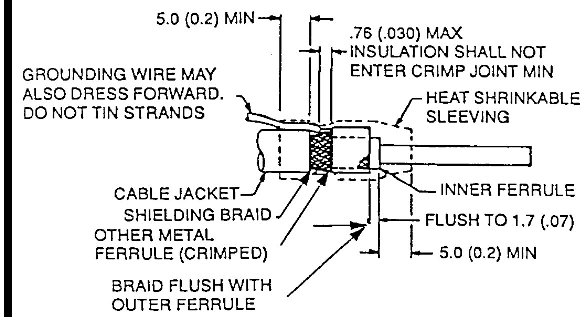


STEP 6. Tensile test

Perform the required tensile test.

- *Sufficient force shall be applied to pull each individual wire to the value the specified in Table 9-1 without movement or pulling of the wire from the crimped ring or breaking of the wire or the crimped ring.*

NS13.7-3



Splicing

1. GENERAL INFORMATION:

Unless specified in the engineering documentation, splicing of conductors is considered a repair. All repairs not shown in the engineering documentation shall be performed only in compliance with applicable contractual requirements and after authorization by the procuring NASA Installation. Repairs shall be accomplished using documented methods previously approved in writing by the procuring NASA Installation. For in-house NASA projects, repairs shall be authorized in writing, for each incident by the appropriate office and quality management.

When splices are required, they shall be located in the backshell area if possible, provided sufficient antiflexing support is obtainable.

2. SPLICING METHODS

The following procedures describe splicing methods for training purposes. The actual method used shall be defined in the engineering documentation or as approved by the procuring NASA Installation.

A. *SOLDER SLEEVE METHOD*

B. *SHIELD TERMINATING WIRE TAP METHOD*

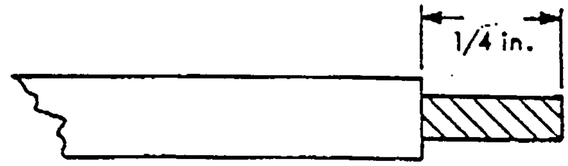
C. *CRIMPED CONTACT METHOD*

Splicing: Solder Sleeve Method

STEP 1. Preparation

Strip 0.24in to 0.30in of insulation from wires to be spliced. Follow Procedure 1 on wire stripping.

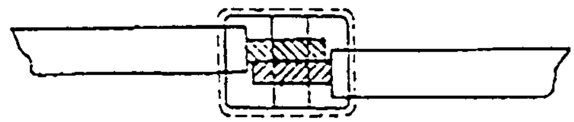
Clean and inspect conductors.



STEP 2. Positioning

Select the appropriate size solder sleeve to accommodate the wires to be spliced.

Position solder sleeve over the stripped section of wires. Ensure solder sleeve ring is centered on the stripped conductors forming the splice.



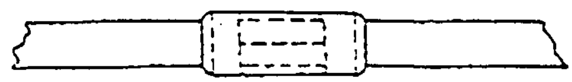
STEP 3. Soldering

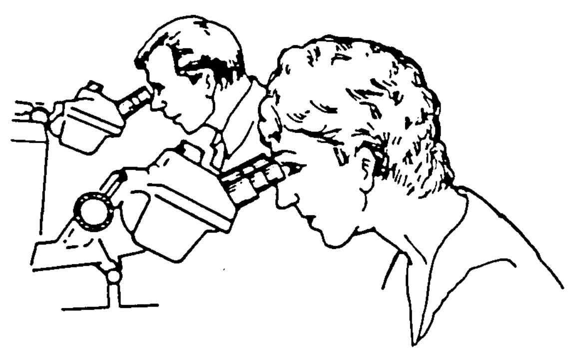
Insert the splice in the nozzle of the blower heat gun and initiate the heat cycle.

Uniform heating is necessary to assure proper solder flow and shrinking of sleeve.

- *Solder Sleeves:*
  (1) *The solder shall be visible through the solder sleeving.*
  (2) The solder fillets along the interfaces shall have a smooth, concave appearance.
  (3) Solder sleeves shall not be damaged. Slight discoloration resulting from the heating process is permissible.
  (4) Solder sleeves shall cover all exposed metal in the spliced area.
  (5) There shall be no protruding wire strands from under or through the solder sleeves.

NS19.6-1g





Shield Terminating Wire Tap

STEP 1. Preparation

a. Using a thermal stripper or other mechanical means, remove the outer cable jacket exposing a window between 5mm (0.20in) and 7.6mm (0.30in).

Clean and inspect (4X to 10X).

- *Nicked shield strands shall not exceed 10% of the total number of strands. There shall be no severed strands.*

NS10.2

b. Strip one end of the grounding wire exposing a maximum of 3.8mm (0.15inch) of the conductor.

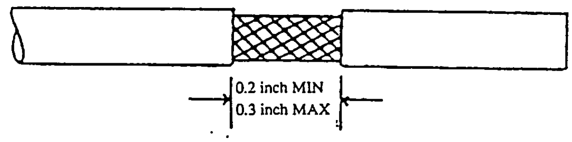
Clean, tin, clean and inspect (4X to 10X).

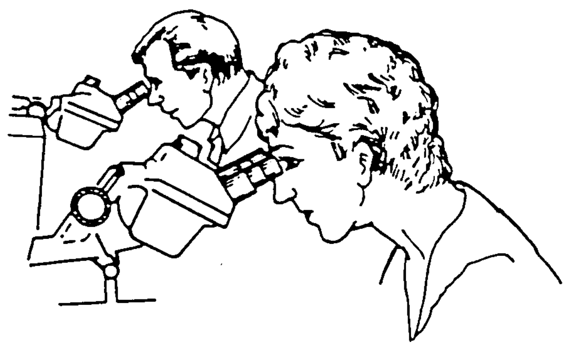
- *The lay of the wire strands shall be restored as nearly as possible to the original lay.*

NS10.1-4

- *The conductor shall not be nicked, cut, or scraped to the point base metal is exposed. Conductors that were reduced in the cross-sectional area shall not be used.*

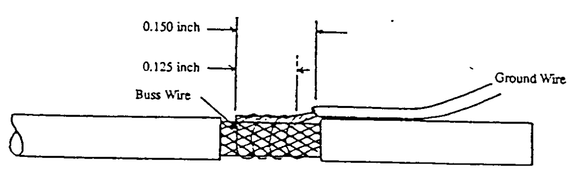
NS10.1-3





STEP 2. Ground Wire Placement

Align the grounding wire in the window maintaining a minimum effective contact surface length of 3.2mm (0.125in).



Shield Terminating Wire Tap (continued)

STEP 3. Making the Connection

The following methods for shield terminating wire tap are described for training purposes. The NASA approved engineering documentation dictates the method used.

a. Solder Method

Align the grounding wire maintaining a minimum effective contact surface length of 3.2mm (0.125 inch).

Clean

Solder connection in accordance with soldering procedures.

Inspect (4X to 10X).

Insulate the connection using shrink sleeve or other types of insulating material.

CAUTION: Dwell time must be as short as possible to prevent damage to the insulation under the shield.

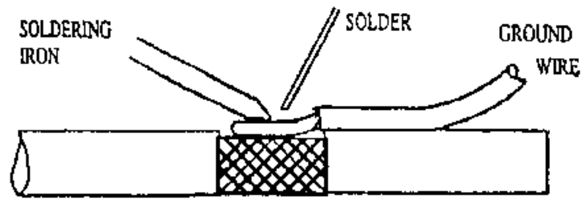
b. Solder Sleeve Method

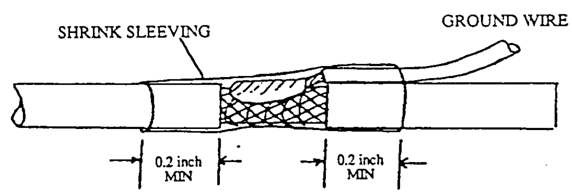
Clean the connection.

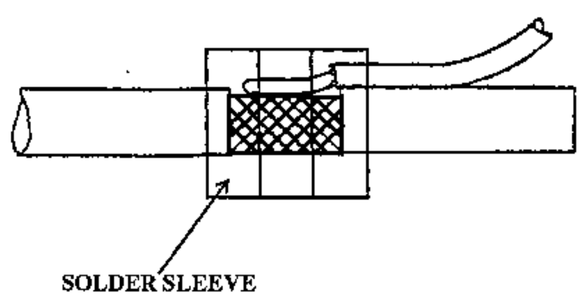
Select a solder sleeve that will accommodate the connection. Center the solder sleeve ring over the window.

Insert the connection in the nozzle of the heat gun and initiate the heat cycle. Applied temperature shall not damage the wire insulation.

Inspect (4X to 10X)







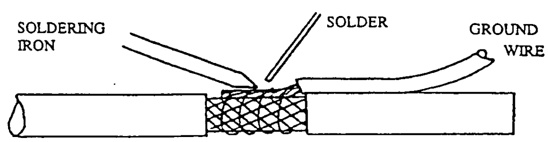
Shield Terminating Wire Tap (continued)

- Solder Sleeves:
  (1) The solder shall be visible through the solder sleeving.
  (2) The solder fillets along the interfaces shall have a smooth, concave appearance.
  (3) Solder sleeves shall not be damaged. Slight discoloration resulting from the heating process is permissible.
  (4) Solder sleeves shall cover all exposed metal in the spliced area.
  (5) There shall be no protruding wire strands from under or through the solder sleeves.

NS19.6-1g

d. Bus Wire Wrap Method (Alternative)

Align the grounding wire in the window maintaining a minimum effective contact surface length of 3.2mm (0.125inch).



Clean and wrap the bus wire in an open spiral around the wire and shield forming a mechanical connection.

Clean and solder connection in accordance with the soldering procedure. Note Caution above.

Clean and inspect (4X to 10X).

Insulate the connection using shrink sleeve or other types of insulating material.

- *(1) Shield terminations shall free of projecting strands.*
  (6) The insulation sleeving shall be uniformly shrunk and provide proper covering of the termination.
  (8) The solder fillets along the interfaces shall have a smooth, concave appearance.

NS19.6-1b

Splicing: Crimped Contact Method

STEP 1 Preparation

Equivalent Wire Size Calculation:

a. Determine the wire size/s to be spliced.

AWG of wire number: 1________
2________
3________
4________
5________

b. Determine the total Circular Mill Area (CMA) of the wires to be spliced.

CMA of wire number: 1 ________
2 ________
3 ________
4 ________
5 ________

Total CMA ⟶ ________

c. Using the AWG/Metric Stranded Conductor Chart, determine the wire size based on the total CMA.

Equivalent wire size: ⟶ ________

- *No more than four conductors plus a drain wire shall be terminated in one splice.*

NS11.6

Contact Barrel Size Selection:

a. Refer to NS12.3-4, Table 12-1.

b. Select the contact size according to the "equivalent" wire size.

Contact Size ⟶ ___________

c. Inspect contact and clean.

AWG/Metric Stranded Conductor Chart

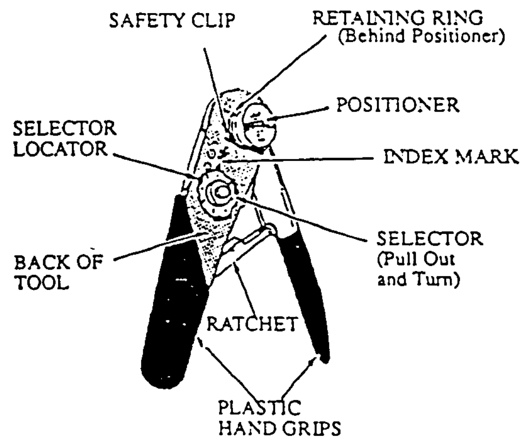
AWG	Strand	Approx. O.D.		Area			Weight	
		Inches	mm	Circular MIL	Square Inches	Square mm	Lbs/kft	kg/km
36	7/44	.006	.15	28.00	—	.014	.085	.12
34	7/42	.007	.19	43.75	—	.022	.132	.19
32	7/40	.008	.20	67.27	.0001	.034	.203	.30
32	19/44	.009	.22	76.00	.0001	.038	.230	.34
30	7/38	.012	.30	112.00	.0001	.057	.339	.50
30	19/42	.012	.30	118.75	.0001	.060	.359	.53
28	7/36	.015	.38	141.75	.0001	.072	.529	.78
28	19/40	.016	.40	182.59	.0001	.093	.553	.82
27	7/35	.018	.45	219.52	.0002	.112	.664	.98
26	10/36	.021	.53	250.00	.0002	.127	.757	1.12
26	19/38	.020	.50	304.00	.0002	.155	.920	1.36
26	7/34	.019	.48	277.83	.0002	.141	.841	1.25
24	7/32	.024	.60	448.00	.0004	.228	1.356	2.01
24	10/34	.023	.58	396.90	.0003	.202	1.201	1.78
24	19/36	.024	.60	475.00	.0004	.242	1.430	2.12
24	41/40	.023	.58	384.40	.0003	.196	1.160	1.72
22	7/30	.030	.76	700.00	.0006	.357	2.120	3.15
22	19/34	.031	.78	754.11	.0006	.384	2.280	3.39
22	26/36	.030	.76	650.00	.0005	.331	1.970	2.93
20	7/28	.038	.96	1111.00	.0009	.562	3.490	5.19
20	10/30	.035	.88	1000.00	.0008	.510	3.025	4.50
20	19/32	.037	.93	1216.00	.0010	.620	3.680	5.47
20	26/34	.036	.91	1031.94	.0008	.526	3.120	4.64
20	41/36	.036	.91	1025.00	.0008	.522	3.100	4.61
18	7/26	.048	1.21	1769.60	.0014	.902	5.360	7.97
18	16/30	.047	1.19	1600.00	.0013	.816	4.840	7.20
18	19/30	.049	1.24	1900.00	.0015	.969	5.750	8.55
18	41/34	.047	1.19	1627.29	.0013	.829	4.920	7.32
18	65/36	.047	1.19	1625.00	.0013	.828	4.910	7.30
16	7/24	.060	1.52	2828.00	.0022	1.442	8.560	12.73
16	65/34	.059	1.49	2579.85	.0020	1.315	7.810	11.62
16	26/30	.059	1.49	2600.00	.0021	1.326	7.870	11.71
16	19/29	.058	1.47	2426.30	.0019	1.237	7.350	10.93
16	105/36	.059	1.49	2625.00	.0021	1.338	7.950	11.83
14	7/22	.073	1.85	4480.00	.0035	2.284	13.560	20.17

Splicing: Crimped Contact Method (continued)

STEP 2. Crimping Tool Preparation

a. Use the appropriate crimping tool and positioner.

b. Determine the crimp tool selector setting and/or color based on the contact and "equivalent" wire sizes from Step 1.



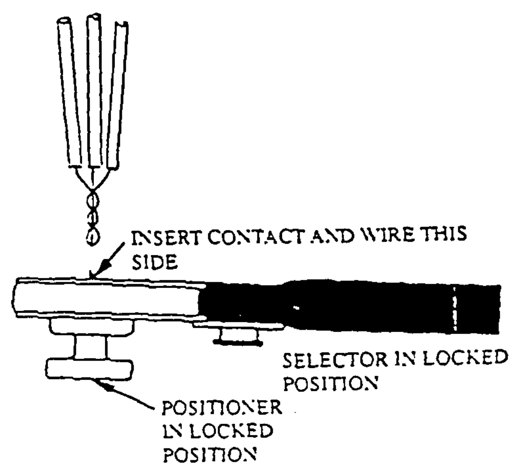
STEP 3. Wire Preparation

a. Strip the wires to be spliced in accordance with Procedure 1.

b. Twist the stripped ends together and clean. Length of twisted wires shall allow insulation clearance of at least 0.25mm (0.01inch).

STEP 4. Crimping

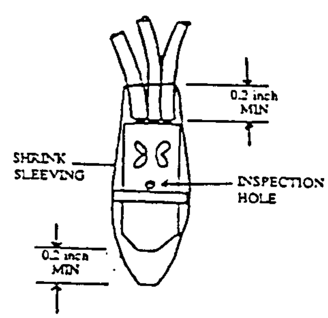
Insert the twisted conductors into the contact and crimp and inspect per Procedure 7.



STEP 5. Final Assembly

Using a heavy duty cutter, cut the pin portion of the contact and clean the connection with an approved solvent.

Install shrink sleeving over the connection maintaining the minimum 5mm (0.2inch) sleeving on both ends of the contact.



Electrical Testing

General Information:

Acceptance electrical testing on all interconnecting cable and harness assemblies, at a minimum, includes Continuity, Dielectric Withstanding Voltage (DWV), and Insulation Resistance (IR), performed in that order. Testing shall be performed following fabrication and after installation of cables or harness.

Continuity:

Continuity tests cable and harness assemblies for point-to-point electrical continuity.

Dielectric Withstanding Voltage (DWV):

DWV consists of the application of a voltage higher than the rated voltage for a specific time between mutually insulated portions of a component part or between insulated portions and ground. The test is used to determine whether the component part can operate safely at its rated voltage and withstand momentary overpotentials due to switching , surges, and other similar phenomena.

Insulation Resistance (IR):

IR measures the resistance offered by the insulating members of a component part to an impressed direct voltage tending to produce a leakage of current through or on the surface of these members. The test is helpful in determining the extent to which insulating properties are affected by deteriorative influences, such as heat, moisture, dirt, oxidation, or loss of volatile materials (outgassing).

NS18.2-1, 2, 3, 4, 8

Continuity Test: Point to Point - Post Fabrication

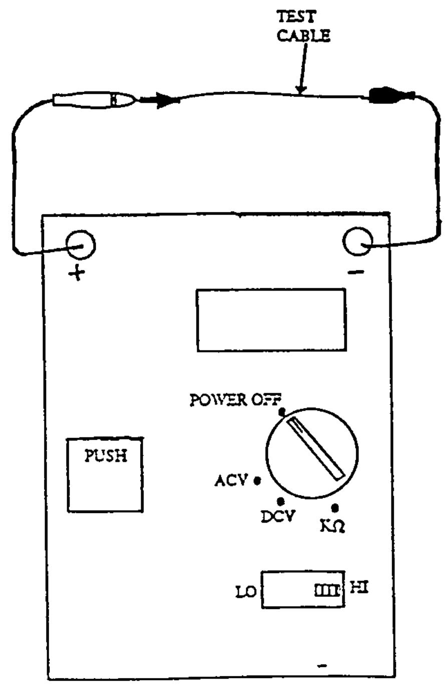
STEP 1. Preparation

a. Equipment

Check equipment calibration date. Set up appropriate test equipment for performing continuity testing.

b. Harness/cable for testing

Label test points as instructed.



STEP 2. Testing

Conduct continuity test.

- *Hand probes shall not be used directly in the cable or harness connectors.*

NS18.2-4

Visual inspection.

STEP 3. Data

Record test data.

Sample test results

Test Points	Results
A to 1	40 milli-ohm
B to 2	36 milli-ohm
etc.	

Dielectric Withstanding Voltage (Post Fabrication)

STEP 1. Preparation

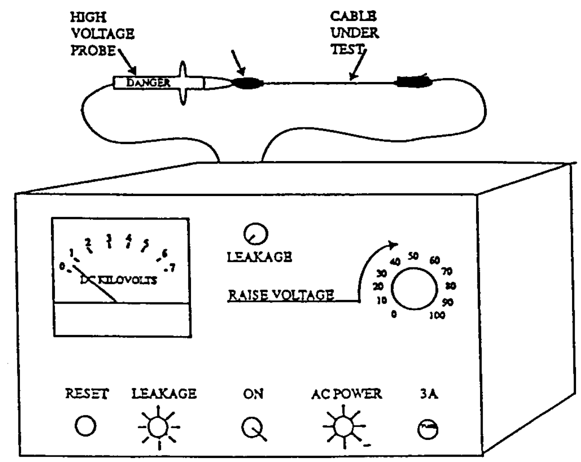
a. Equipment

Check equipment calibration date.

Set up appropriate test equipment.

b. Harness/cable for testing

Label test points as instructed.



STEP 2. Testing

Conduct test.

- *Hand probes shall not be used directly in the cable or harness connectors.*

NS18.2-4

- *Cable or harness assembly shall withstand the application of 1050+/- 50 volts RMS, 60Hz 0r 1500 +/- 75 Vdc, not to exceed the maximum connector rated test potential. Leakage current shall not exceed 1 milliampere when applied voltage is maintained for not more than 1 minute.*
- *There shall be no evidence of electrical breakdown or arc-over.*

NS18.2-6b

STEP 3. Data

Record test data

Sample test results

Test Points	Results
A to 2	0 milli-amp
B to 1	2 milli-amp (fail)

Insulation Resistance (Post Fabrication)

STEP 1. Preparation

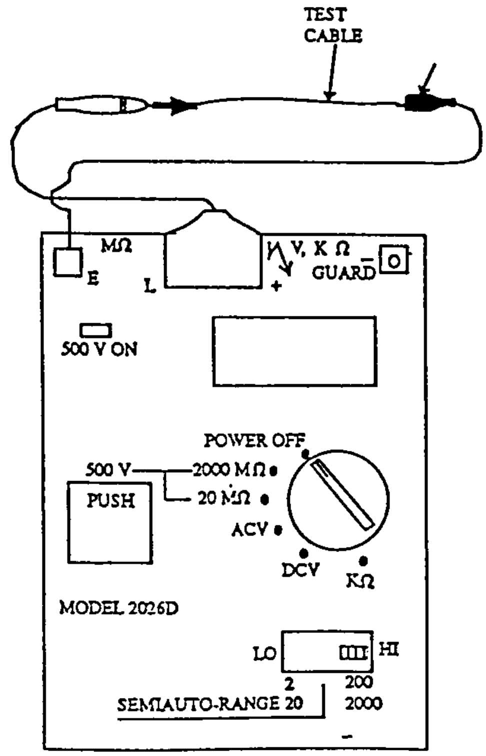
a. Equipment

Check equipment calibration date.

Set up appropriate test equipment.

b. Harness for testing

Label test points of harness to be tested.



STEP 2. Testing

Conduct test.

- *Hand probes shall not be used directly in the cable or harness connectors.*

NS18.2-4

- *The insulation resistance ... shall be greater than 100 Megohms at an applied voltage of 500+/- 50Vdc for a maximum of 1 minute.*

NS18.2-6c

STEP 3. Data

Record test data.

Sample test results

Test Points	Results
A to 2	6 Giga ohm
B to 1	120 Meg ohm
C to 1	6 Meg ohm (fail)

Coaxial Cabling and Connectors

General Information

Coaxial Cables: A coaxial cable is comprised of a center conductor, dielectric insulation, shield, and the outer jacket. Coaxial cabling is used to carry radio-frequency (RF) signals. RF signals suffer from skin effect when it is transmitted through multi-conductor cabling. Skin effect is a condition where current travels on the outer surface of the conductor and the adjacent insulation which causes high losses within the signal. The coaxial cable's primary purpose is to carry RF signals with minimum loss. Care must be taken in handling and in the installation of coaxial cables.

Coaxial Connectors: There are many types of coaxial connectors. Examples of coaxial connectors are the SMAs, BNCs, TNCs, Ns, and Mark IIIs.

- SMA (Subminiature Series A) connectors are the only type allowed for space flight use. SMA connectors offer the highest performance and are widely used in electronic warfare, radar and high performance test equipment application.
- BNC (Bayonet) connectors are the most common coaxial connectors because of the bayonet coupling. Most BNCs are 50 ohm connectors rated to 4 GHz. Used in computer peripheral interconnections, networks and instrumentation. Bayonet coupling allows fast connect/disconnect with a simple twist. The drawback is increased electrical noise when the connection is subjected to vibration.
- TNC (Threaded) connectors are high performance BNC, except the bayonet coupling is replaced with a threaded coupling. Because of the tight fit provided by the threaded connection, the screw coupling offers a higher degree of shock and vibration resistance.
- N-series connectors are screw-threaded connectors that were the first true RF connectors developed for microwave frequencies to 11 GHz. It is the standard coax connectors for many cable-based local networks (LANs).
- Mark III (ITT Cannon) connectors must have approval for spaceflight use.

Assembly: The connector manufacturer's assembly instructions shall be followed unless an alternate procedure is approved by the NASA procuring installation. Poor coaxial connector assembly techniques result in impedance mismatch between the connector and cable and/or EMI and RFI leakage through the connector.

Note: The dielectric insulation within the coaxial cable shall always be cut at a 90 degree angle to the center conductor.

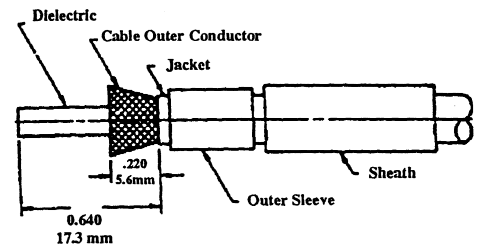
Training Exercise: The instructor will provide instructions on the fabrication of coaxial connectors used in this training program.

Subminiature Series A (SMA) Assembly Procedure

The following procedure is in accordance with Omni/Spectra SMA Assembly Procedure 20-052

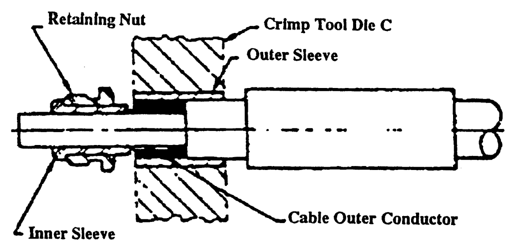
STEP 1. Preparation

`
a. Place sheath and outer sleeve (crimp ferrule) on RG 188 cable.
b. Remove end portion of cable jacket to expose cable outer conductor(shield)
c. Trim cable outer conductor (shield) to length.
d. Flare outer conductor.



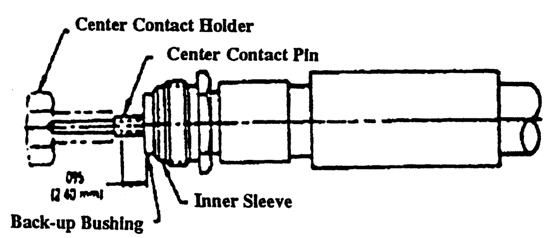
STEP 2. Crimping Inner Sleeve

a. Insert inner sleeve into retaining nut.
b. Position loose unit on dielectric as shown.
c. Slide outer sleeve over flared portion of outer conductor.
d. Hold retainer unit seated and crimp outer sleeve in place using the appropriate crimp tool and Die.
e. Trim and remove excess outer conductor (shield).



STEP 3. Solder Center Contact to Inner Cable Conductor

a. Trim cable dielectric flush with end of inner sleeve to expose cable inner conductor.
b. Trim exposed inner conductor to length as shown.
c. Tin inner conductor according to Procedure 2 or 3.
d. Insert small length of rosin core solder in the contact wire well.



Subminiature Series A (SMA) Assembly Procedure

e. Place center contact in Center Contact Holder.

f. Heat center contact with soldering iron and carefully insert the tinned inner conductor until the center contact rests firmly against the back-up bushing.

g. Clean and inspect.

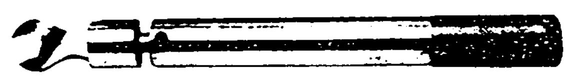
Spillage, if any, must resemble tinning.

STEP 4. Torque

a. Carefully insert the center contact into the dielectric bushing ID. of the housing sub-assembly.

b. Engage threads of the retaining nut to the housing assembly.

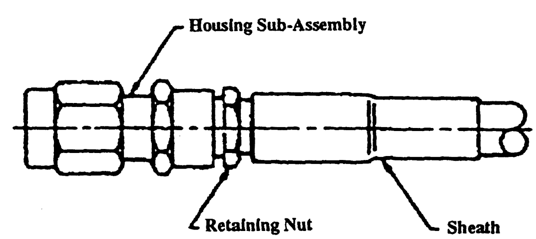
c. Torque to 12-15 inch pounds.



STEP 5. Shrink Sheath

a. Position sheath over outer sleeve as shown.

b. Shrink sheath using a heat gun.



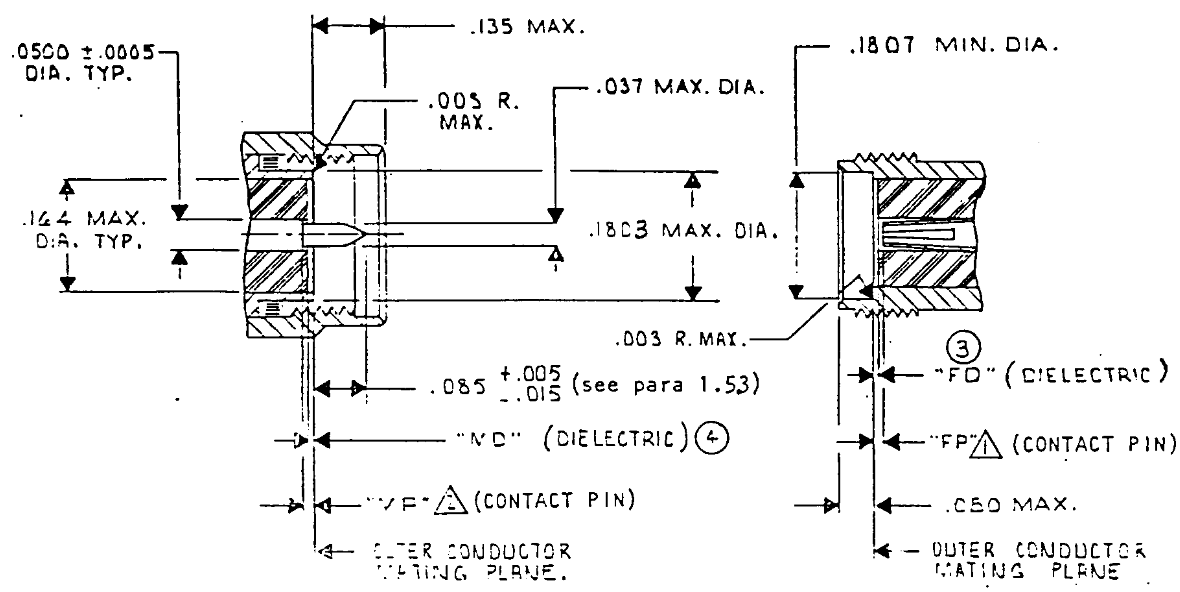
STEP 6. Critical Axial Interface Test

Follow Procedure 27 for this test.

SMA Critical Axial Interface Test

General Information: The critical axial interface refers to the dimensions of a coaxial connector that must be maintained in order to provide proper electrical performance and mechanical mating of male and female connectors.

To perform the critical interface test for the SMA connector fabricated in this training class, the Maury Microwave Gage , Model AO27 is used.



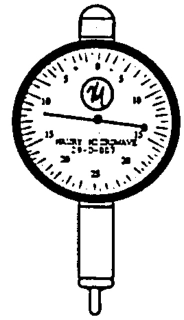
ITEM	SPECIFICATION	FP	FD	MP	MD	COMMENT
A	MIL-C-39012 CLASS 2	.000 +.030 -.000	-.002 MAX	.000 MIN.	-.002 MAX	Per MIL-C-39012/55 and /57.
B	MIL-C-39012 RECOMMENDED	.000 +.010 -.000	.000 +.002	.000 +.010 -.000	.000 +.002	Recommend tolerance for MIL-C-39012 Class 2

SMA Critical Axial Interface Test (continued)

STEP 1. Set-up of Maury Gage

a. Using the Master Seting Gage end marked "M", check the zero setting of the Maury Gage.

b. Zero by loosening the locking knob and rotate the bezel (large knurled ring that rotates the dial face) to zero the pointer. Lock the bezel in place.



MAURY GAGE

STEP 2. Measurement

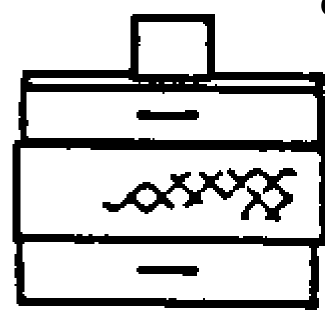
a. Carefully align the center contact of the male(MP) SMA connector so that it enters the opening in the pin of the Maury Gage.

b. Press the connector to the gage assembly until the gage bushing bottoms on the outer conductor mating plane of the male connector.

c. Record the test results and compare with the tolerance noted below.

d. For this training exercise, the SMA MP critical axial dimension is: +0.010
0.00
\- 0.000

METER SETTING GAGE

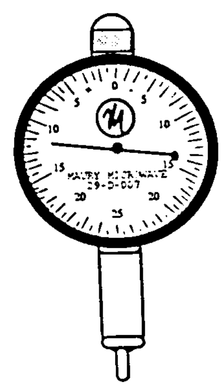


STEP 3. Interpreting the Results.

The pointer of the dial indicates the deviation from zero.

a). A plus(+) reading represents a recess condition or below the outer conductor mating plane. An excessive gap of the center contacts when mated produces high reflections and causes breakdown under peak power conditions.

MAURY GAGE



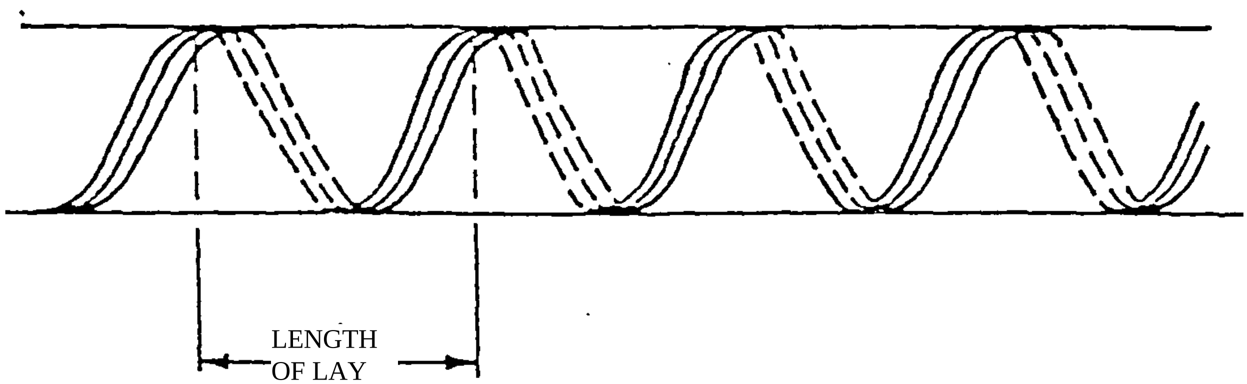
SMA Critical Axial Interface Test (continued)

b). A minus (-) reading represents a protrusion or above the outer conductor mating plane. Destructive interference may result if the pin protrudes beyond the outer conductor mating planes which may cause buckling of the female contact fingers or damage to associated equipment during mating.

Wire Twist

General Information: When twisting is specified, it shall begin as close to the termination as practical without causing undue stress on the connector. Examples of assemblies twisted to reduce the possibility of Electromagnetic Interference (EMI), are primary power, secondary power, thermocouple, and heater conductors. The more twists per foot, the more effective the magnetic field cancellation. Twisting, regardless of the number per foot, shall be symmetrical. The length of lay shall be 8 to 16 times the outer diameter of the harness.

Definition: Length of lay is the axial length of one complete turn of the helix.



- *Fabricate cables containing discrete wires in one or more layers by winding the wires together uniformly. Winding shall prevent the introduction of residual twist into individual conductors. The length of lay for each layer shall be between 8 and16 times the layer diameter.*

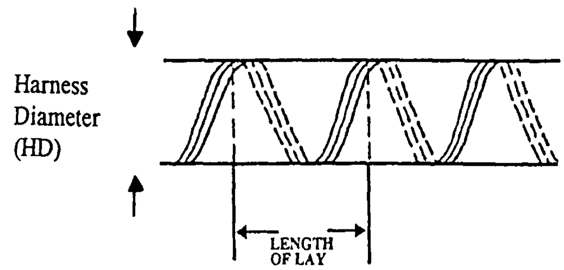
NS7.3-20

Wire Twist (continued)

STEP 1. Preparation

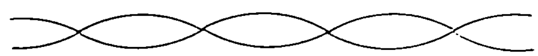
Determine harness diameter.

Harness diameter(HD) = ____________

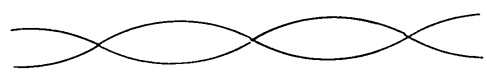


STEP 2. Calculation of Length of Lay (LL)

a. 8 Times harness diameter
   Harness Diameter(HD) =________
   Length of Lay
   (8 x HD) =________
   No. of twist per foot
   12 inches ÷ LL =________



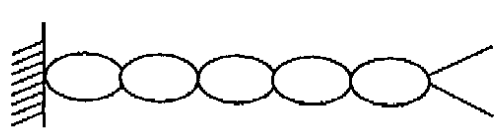
b. 16 Times harness diameter
   Harness Diameter(HD) =_______
   Length of Lay
   (16 x HD) =_______
   No. of twist per foot
   12 inches ÷ LL =_______



STEP 3. Twisting of Wires

Secure one end of the harness and twist.

The number of twists shall be within the calculated values in Step 2.



Application of Braid

General Information: Metal braid shielding (RF) can either be woven directly over a core or obtained in prewoven form and installed by sliding it over the wire bundle. Prewoven braid sleeving shall be slightly oversized so that it can be readily slid over the bundle and tightened down to contact the wire bundle.

STEP 1. Braid Application

A. Braid Preparation

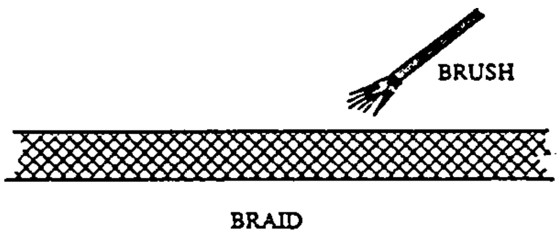
Cut the soft tinned copper braid to the required length. Take into account stress reliefs (service loops).

Clean thoroughly with brush and approved solvent.

B. Addition of separator (tape) to prevent damage to the wire bundle on approved tape may be applied over the bundle.

- *To prevent potential damage (cold flow) of the underlying wire insulation, a separator (e.g., a tape) may be applied over the wire bundle to give the wire continuous protection.*
- *Prewoven metallic braid shall be cleaned in a suitable solvent to remove contamination prior to installation over a harness.*

NS9.7

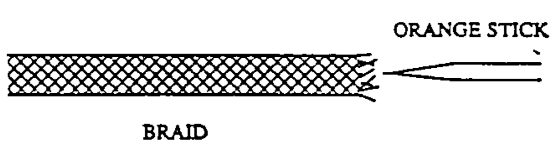


Braid Preparation

STEP 2. Braid Placement

Use an orange stick to open the end of the braid.

Slide the opened braid over the wire bundle. Do not disturb the lay of the bundle.



Braid Placement

Application of Braid (continued)

STEP 3. Braid Termination

Trim excessive frayed braid and for this training program fold back per floating shield termination.

To eliminate fraying or unraveling, secure braid with spot tie or plastic cable strap.

- *Braids shall be terminated as specified by the engineering documentation.*

NS9.7

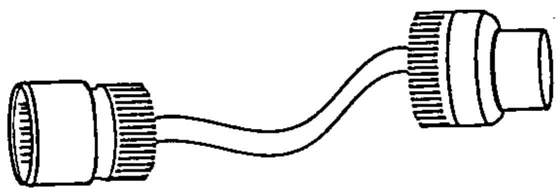
Mate and Demate

General Information: During testing and system checkout, certain connectors may be subject to frequent mating and demating. When this situation exists, wear and potential damage can be reduced by the use of "connector savers". The connector saver transfers the wear from the flight connector to nonflight jumper harness connectors.

STEP 1. Connector Savers

Use the connector saver in the training class to check the continuty of the completed chassis.

Sample Connector Saver



STEP 2. Mate/Demate Log

After the harness is placed in flight configuration, document the number of mates and demates on the Mate/Demate Log for the specific connector.

Remember to document the mating cycle of the connector saver.

Sample Mate/Demate Log

ITEM			SERIAL NO.			CONNECTOR			
P CYCLES					J CYCLES				
CYCLE	DATE	TECH.	Q.A.	AUTHORITY	CYCLE	DATE	TECH.	Q.A.	AUTHORITY
MATE					MATE				
DEMATE					DEMATE				
MATE					MATE				
DEMATE					DEMATE				
MATE					MATE				
DEMATE					DEMATE				
MATE					MATE				
DEMATE					DEMATE				
MATE					MATE				
DEMATE					DEMATE				
CLEAN					CLEAN				
TOTALS: PREVIOUS___ACCUMULATED____					TOTALS: PREVIOUS____ACCUMULATED__				

Harness Bundle

1. GENERAL INFORMATION

Wires and coax cables are grouped in bundles through the use of approved lacing cords and/or plastic straps. Offgassing and outgassing are two major criteria that lacing cord and straps must meet for use on flight hardware. The engineering documentation specifies the use of lacing cord, plastic strap or both and the stitch to employ.

2. LACING CORD

The following methods of bundling harnesses using lacing cord will be presented in this training document.

A. Spot Tie

Consists of a clove hitch followed by a square knot. Each spot tie is independent of adjacent ties and one unacceptable tie will not affect the integrity of other spot ties.

B. Running Lockstitch

Running lockstitch is one continuous lacing cord with a starting and closing stitch to prevent the lacing cord from unraveling at the ends.

Lacing cord is preferred over a plastic strap when the harness consists of a very small bundle, generally 2 to 3 wires.

3. PLASTIC STRAP

Plastic cable straps are usually installed by tooling. Tooling shall be tension controlled so that the wraps do not slide back and forth freely on the harness, nor shall they be tightened to cause noticeable indentation or distortion of the wires in the harness.

4. BREAKOUTS

Support of wiring, wire bundles, and harnesses shall be designed to control and minimize the transfer of shock and vibration into the connector and/or termination and to prevent excessive flexing or pressure over sharp or rough edges.

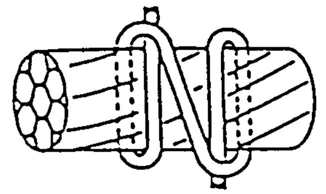
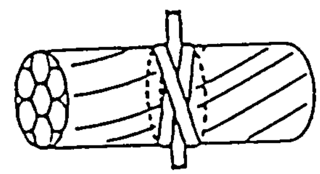
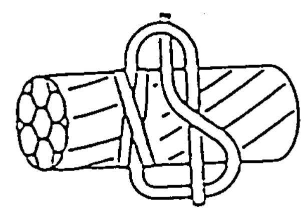
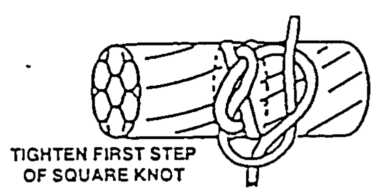
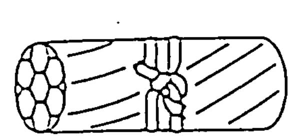
5. STITCH SPACING DIMENSION

Spot tie, plastic strap, and stitch spacing dimensions depend on the harness-bundle diameter. Refer to Table 9-1, NASA-STD-8739.4 for further guidance.

6. DISTANCE FROM CONNECTOR TO FIRST HARNESS TIE

The distance from the connector or connector accessory to the first tie depends on the harness-bundle diameter. Refer to Table 9-2, NASA-STD-8739.4 for further guidance.

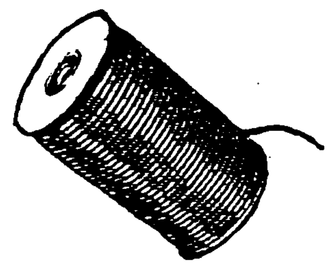
Spot Tie
(Clove Hitch and Square Knot)

Step 1. Preparation Cut the appropriate length of lacing material and start the "Clove" hitch as shown.	STEP 1  CLOVE HITCH
Step 2. Clove Hitch Complete the "Clove " hitch as shown.	STEP 2  TIGHTEN KNOT
Step 3. Square Knot Secure the "Clove" hitch with a " Square" knot as shown. Trim ends to 0.25 inch minimum. CAUTION: Lacing ties shall be tightened so that they do not slide back and forth on the assembly; however, they shall not be so tight as to cause noticeable indentation or distortion of the insulation or wires in the harness.	STEP 3  FIRST STEP OF SQUARE KNOT STEP 4  SECOND STEP OF SQUARE KNOT 

Running Lockstitch

STEP 1. Preparation

Cut the appropriate length of approved lacing cord .

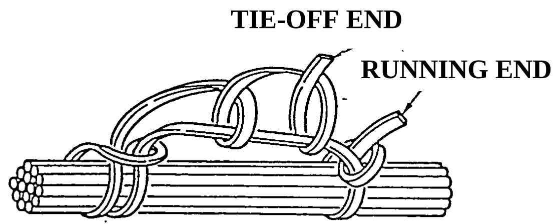


STEP 2. Starting Stitch

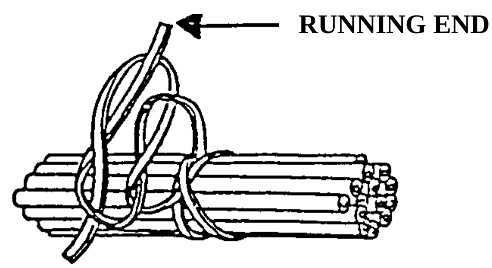
Complete the "Starting Stitch" as shown by the diagrams.

For a single-tape, starting stitch may begin as shown in A or B.

A. Closed End Two Half Stitches

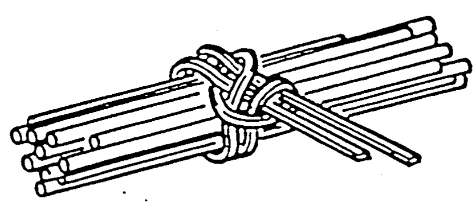


B. Spot Tie With A Running End



For double tape the starting stitch is shown in diagram C.

C.



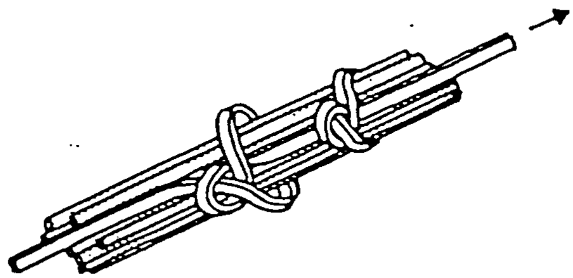
- *Starting stitches shall not place stress on wire terminations.*

NS9.2-1

Running Lockstitch (continued)

STEP 3. Running Lockstitch

Continuous lacing shall be achieved using running lockstitch as shown in the diagram.

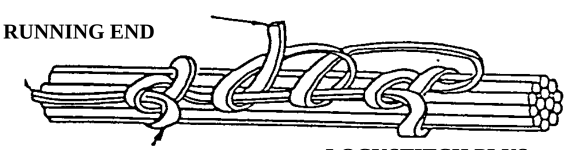


STEP 4. Closing Stitch

Complete the "Closing Stitch" as illustrated.

- *The stitching shall terminate close to the extremity of the harness but shall not stress the wire terminations.*

NS9.2-3

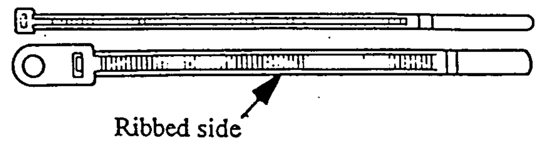


Plastic Straps

STEP 1 Preparation

Select the appropriate size strap that will accommodate the harness bundle size.

Inspect strap. Damaged or nicked straps shall not be used.



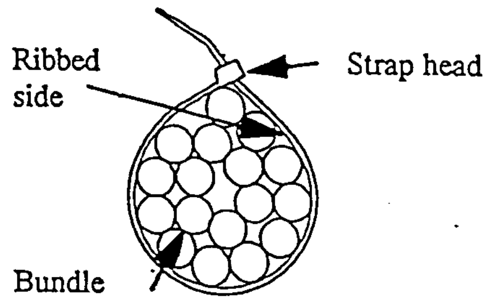
STEP 2. Placement of Strap

Place the strap around the harness bundle with the "ribbed" side against the wires.

Insert the tail inside the strap head and pull gently.

Adjust wires as necessary to minimize crossovers.

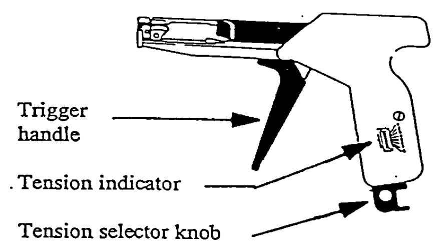
- *The "ribbed" side of a strap shall always be placed against the wires.*
  NS9.6-1



STEP 3. Tooling

Set the tool to the appropriate tension as given in the engineering documentation.

- *Tooling shall be tension-controlled to meet the strap-tightening requirements...*
  NS9.6-2

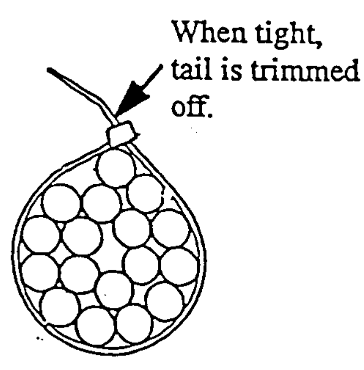


STEP 4. Tightening

Place the strap inside the gripping end of the tool.

Squeese the trigger of the tool several times until the surplus strap end is automatically trimmed off.

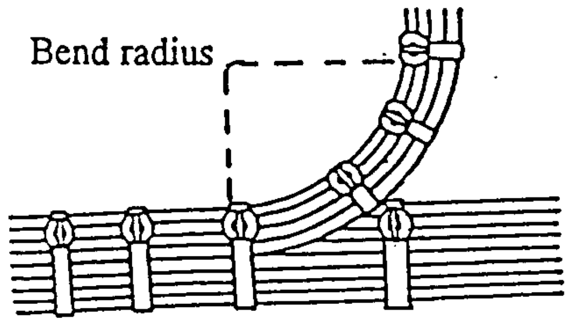
- *Straps shall be tightened so that they do not slide back and forth on the assemble; however, they shall not be so tight as to cause noticeable indentation or distortion of the wires in the harness.*
  NS9.6-1
- *Surplus strap ends shall be trimmed flush at the back end of the strap head.*
  NS9.6-2



Harness Breakouts

STEP 1. Bend Radius

Bend radius of harness bundles shall follow the requirements of Table 7-1, NS7.3-21.



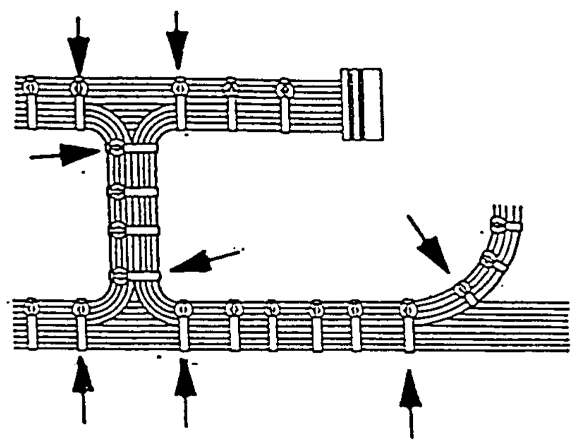
STEP 2. Placement of Lacing Cord and/or Tie Wrap

a. At Breakout

Lacing cord and / or tie wrap shall be located before and after the breakout.

· *Closing and starting stitches at branches and breakouts shall be next to the breakout.*

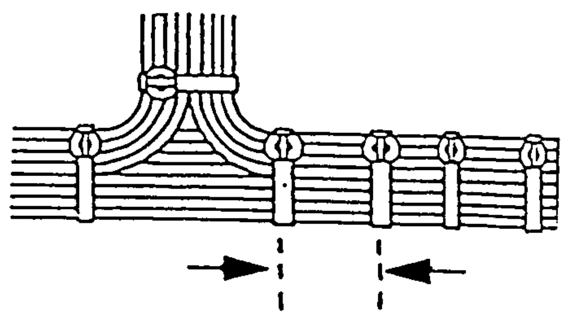
NS9.2-5



b. Stitch Spacing Dimension

Spot tie, plastic strap, and stitch spacing dimensions depend on the harness-bundle diameter.

See Table 9-1, NS9.2-3 for guidance.



c. Distance to Connector

The distance from the connector or connector accessories to the first harness tie depends on the harness-bundle diameter.

See Table 9-2, NS9.2-5 for guidance.