# R U S Acceptance Procedures for Splice Connectors for Copper and Fiber Optic

In addition to the requirements shown under the general listing procedures, the following information should be included in a request for initial acceptance of connectors for copper and fiber optic splices.

## Item cm

### Connectors

### Splicing Connectors for Copper Conductors

I. **Materials/General:**

☑ The plastic components used in splicing connectors shall be resistant to chemical attack, fungus growth, and growth of contaminating films as specified in ASTM G 21-96. Metallic materials used in splicing connectors shall have a corrosion resistance equivalent to nickel-chrome stainless steel in accordance with ASTM A 276-98a.

☑ Copper cable spicing connectors have the function of splicing one or more combinations of No. 19 through No. 26 American Wire Gauge (AWG) copper conductors. Cable used for these tests shall be RUS accepted.

☑ The manufacturer shall specify the wire gauge range for the connector or connectors submitted to RUS for acceptance. The stripping of conductor insulation shall not be permitted.

☑ All splicing connectors shall be filled.

☑ The manufacturer shall demonstrate that a quality assurance program, satisfactory to RUS, is in place to guarantee all material and product specifications are met. The program shall include the following:

a. Incoming inspection of raw materials;

b. In-process inspection of the splice components;

c. Final inspection of the splice product;

d. Calibration procedures for all test equipment used in the qualification of the product; and

e. Recall procedures in the event out-of-calibration equipment is identified.

☑ Unless otherwise specified, all tests shall be performed at a temperature of 24 ± 3°C (75 ± 5°F) and a relative humidity (RH) of up to 55 percent (%).

II. **Test Samples**:

1. Unless otherwise specified, all test samples shall be assembled for each connector type as follows:

   a) Largest specified gauge wire connected with largest specified gauge wire;

   b) Smallest specified gauge wire connected with smallest specified gauge wire; and

   c) Smallest specified gauge wire connected with largest specified gauge wire. For connectors which can connect more than 2 wires, assemble the greatest number of smallest gauge wires connected with one of the largest gauge wires.

2. For each test required, 5 samples from each of the categories in paragraph one (1) of this section shall be tested. A total of 15 samples will be needed for each test.

3. The test results for each sample shall be submitted in tabulated form.

III. **Connection Resistance Test:**

☑ Thirty (30) 4 inch (in.) [102 millimeter (mm)] pieces shall be cut from appropriate gauged wire and assembled in the connectors in accordance with section II, Test Samples, using the connector manufacturer's instructions. For resistance measurements, expose the copper conductors of the test leads by removing 0.5 in. to 1 in. (12 mm to 25 mm) of insulation from the end of the test leads.

☑ Fifteen (15) 8 in. (203 mm) pieces shall be cut from the appropriate gauged wire for use as control wire samples.

☑ The resistance of each test sample and a corresponding control wire shall be measured and recorded. The resistance of each test sample shall not exceed the resistance of the corresponding control wire sample by more than 7 percent.

☑ Each test sample shall be held and each connector shall be twisted 90 degrees around the wire axis once in each direction. After twisting, the resistance of the test sample shall be measured and recorded. The resistance of

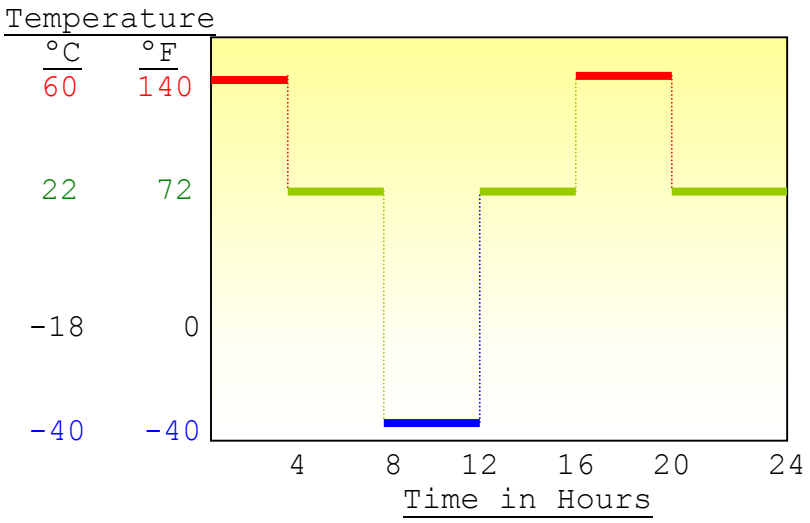
each test sample shall not exceed the resistance of the corresponding control wire sample by more than 9 percent.

IV. **Heat-Cold Cycling Test**:

After completion of the connection resistance test, the test samples shall be subjected to the heat-cold cycling test.

☑ The test samples shall be placed in an environmental test chamber and exposed to the temperature cycle of Figure 1 for five complete cycles. The step function nature of the temperature changes may be achieved by insertion and removal of the test samples from the chamber. The soak time at each temperature shall be four hours. The test samples shall be removed from the test chamber at the conclusion of the five-cycle period and shall be allowed to return to room temperature.

Figure 1




☑ No measurements shall be made at this time.

V. **Vibration**:

After the completion of the heat-cold cycling test, the test samples shall be subjected to the vibration test.

☑ A vibration machine shall be used which produces a simple harmonic motion having .06 inch (1.52 mm) maximum total excursion, cycling from 10 to 55 to 10 Hertz within 1 minute. A monitoring circuit shall be used which is capable of detecting momentary opens of 10 microseconds or longer.

☑ Each test sample shall be supported by a pegboard as indicated in Figure 2, which is attached to the vibration machine. The test samples and monitoring circuit shall be electrically connected in series. Wires shall not be cut short.

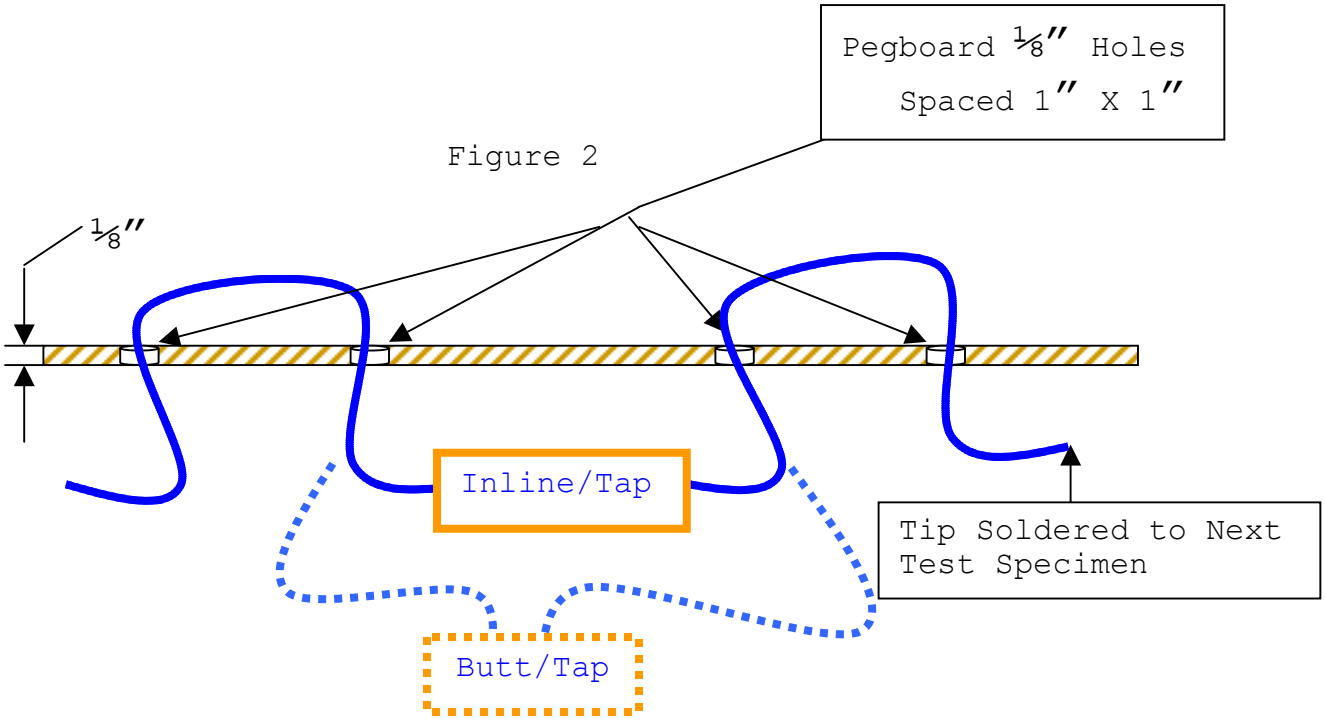
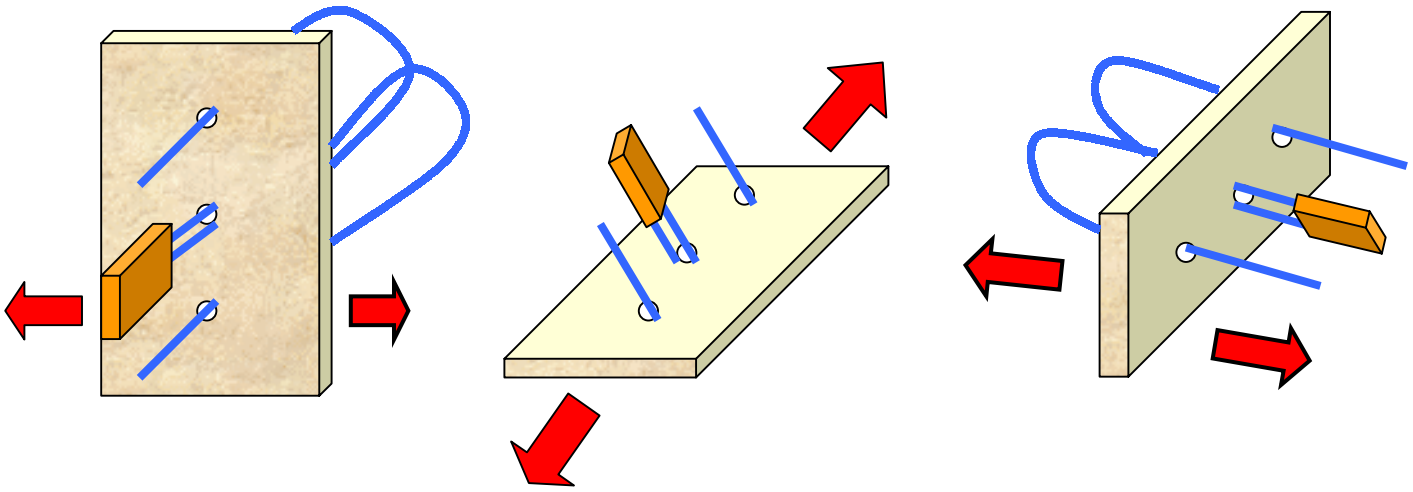



Figure 2

☑ The test samples shall be vibrated for a total of 3 hours, 1 hour in each of the 3 mutually exclusive planes as indicated in Figure 3. The direct current (dc) through the test samples shall be monitored for any fluctuations or momentary opens. Fluctuations or momentary opens shall be less than or equal to 10 microseconds.

Figure 3



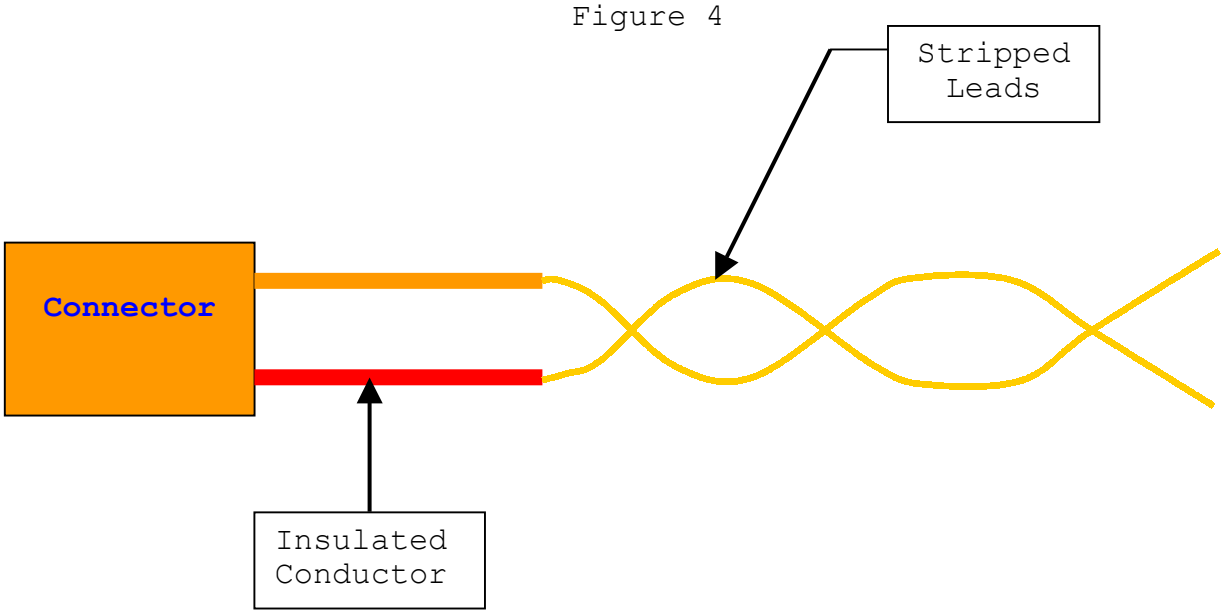
- ☑ After completion of the vibration test, the test samples shall be removed from the vibration machine and the connection resistance of each test sample shall be measured. The resistance of each test sample shall not exceed the resistance of the corresponding control wire sample by more than 13 percent.

- ☑ The test samples may be discarded after completion of the vibration test.

VI. **Insulation Resistance - Humidity Cycle:**

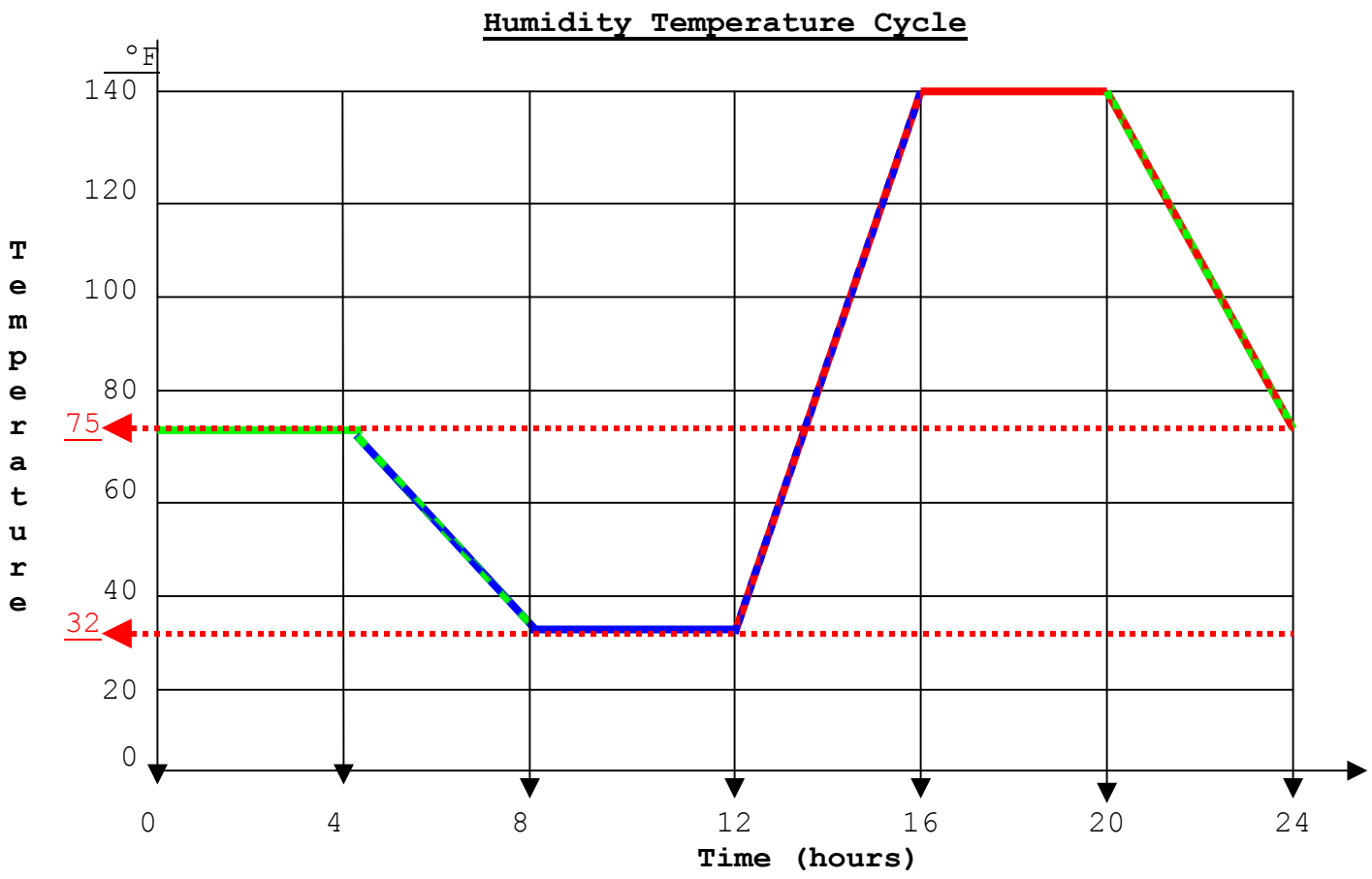
- ☑ Thirty (30) 15 in. (381 mm) pieces shall be cut from the appropriate gauged wire and assembled in the connectors in accordance with section II, Test Samples, using the connector manufacturer's instructions. For insulation resistance measurements, expose the copper conductors of the test leads by removing 0.5 in. to 1 in. (12 mm to 25 mm) of insulation from the ends of the test leads. The exposed copper conductors of the test leads shall be twisted together as indicated in Figure 4.

Figure 4




☑ The test samples shall be placed in an environmental test chamber at 95 ± 3 % RH and temperature cycled per Figure 5 for a period of 30 days.

Figure 5




**Note: Relative Humidity = 95% +/- 3%**

- ☑ After the test samples have been allowed to stabilize at room temperature and humidity, the insulation resistance of the test sample leads to ground shall be greater than or equal to 100,000 megohms when tested in accordance with ASTM D 4566-94 using a test voltage of 250 volts dc.

VII. **Insulation Resistance - Water Soak**:

- ☑ Thirty (30) 15 in. (381 mm) pieces shall be cut from the appropriate gauged wire and assembled in the connectors in accordance with section II, Test Samples, using the connector manufacturer's instructions. For insulation resistance measurements, expose the copper conductors of the test leads by removing 0.5 in. to 1 in. (12 mm to 25 mm) of insulation from the ends of the test leads. The exposed copper conductors of the test leads shall be twisted together as indicated in Figure 4.

- ☑ A solution of distilled or tap water and sodium chloride (5 percent by weight) shall be prepared and placed in a glass container.

- ☑ The connectors of the test samples shall be immersed in the solution except for the twisted test leads of the test samples. A copper electrode shall be inserted into the solution.

- ☑ After the system (immersed connectors and solution) has stabilized for 2 hours, the first insulation resistance measurement of the test sample leads to the copper electrode shall be taken. The insulation resistance shall be performed in accordance with ASTM D 4566-94 using 100 volts dc.

- ☑ The test samples shall be removed from the solution after 72 hours and allowed to stabilize at room temperature and humidity for an additional 72 hours. The procedure shall be repeated for a total of 5 cycles. Insulation resistance measurements of the test sample leads to the copper electrode shall be taken for each day that the test samples are immersed in solution. Report resistance readings in megohms. The insulation resistance shall be performed in accordance with ASTM D 4566-94 using 100 volts dc.

- ☑ The insulation resistance of the test sample leads to the copper electrode shall be greater than or equal to 100 megohms.

VIII. **Dielectric Breakdown (Dry)**:

1. Thirty (30) 15 in. (381 mm) pieces shall be cut from the appropriate gauged wire and assembled in the connectors in accordance with section, Test Samples, using the connector manufacturer's instructions. For dielectric breakdown measurements, expose the copper conductors of the test leads by removing 0.5 in. to 1 in. (12 mm to 25 mm) of insulation from the ends of the test

leads. The exposed copper conductors of the test leads shall be twisted together.

2. An alternating current (ac) power source capable of applying 8,000 volts in 500 volt root-mean-squared per second (rms/s) steps shall be used. The unit shall be equipped with a circuit breaker to disconnect the power source at breakdown and a voltmeter to indicate the rms voltages.

3. The high voltage lead of the power source shall be attached to the test sample lead and the ground voltage lead of the power source shall be attached to ground. The voltage shall be applied to the test sample in 500 volt rms/s steps until either breakdown or 8,000 volts rms is reached. The dielectric strength shall be recorded in rms voltage at the point of breakdown. Breakdown occurring at less than 2,500 volts rms shall constitute a failure.

4. The dielectric breakdown test shall be repeated for all the remaining test samples prepared in accordance with paragraph one of this section. The test results shall be reported for each test sample.

IX. **Dielectric Breakdown (Wet)**:

1. Thirty (30) 15 in. (381 mm) pieces shall be cut from the appropriate gauged wire and assembled in the connectors in accordance with section II, Test Samples, using the connector manufacturer's instructions. For dielectric breakdown measurements, expose the copper conductors of the test leads by removing 0.5 in. to 1 in. (12 mm to 25 mm) of insulation from the ends of the test leads. The exposed copper conductors of the test leads shall be twisted together.

2. A solution of distilled or tap water and sodium chloride (5 percent by weight) shall be prepared and placed in a glass container.

3. An alternating current (ac) power source capable of applying 8,000 volts in 500 volt root-mean-squared per second (rms/s) steps shall be used. The unit shall be equipped with a circuit breaker to disconnect the power source at breakdown and a voltmeter to indicate the rms voltages.

4. The connectors of the test samples shall be immersed in the solution except for the twisted test leads of the test samples. Insert a copper ground electrode into the solution. The high voltage lead of the power source shall be attached to the test sample lead and the ground voltage lead of the power source shall be attached to ground. The voltage shall be applied to the test sample in 500 volt rms/s steps until either breakdown or 8,000 volts rms is reached. The dielectric strength shall be recorded in rms voltage at the point of breakdown. Breakdown occurring at less than 2,500 volts rms shall constitute a failure.

5. The dielectric breakdown test shall be repeated for all the remaining test samples prepared in accordance with paragraph one

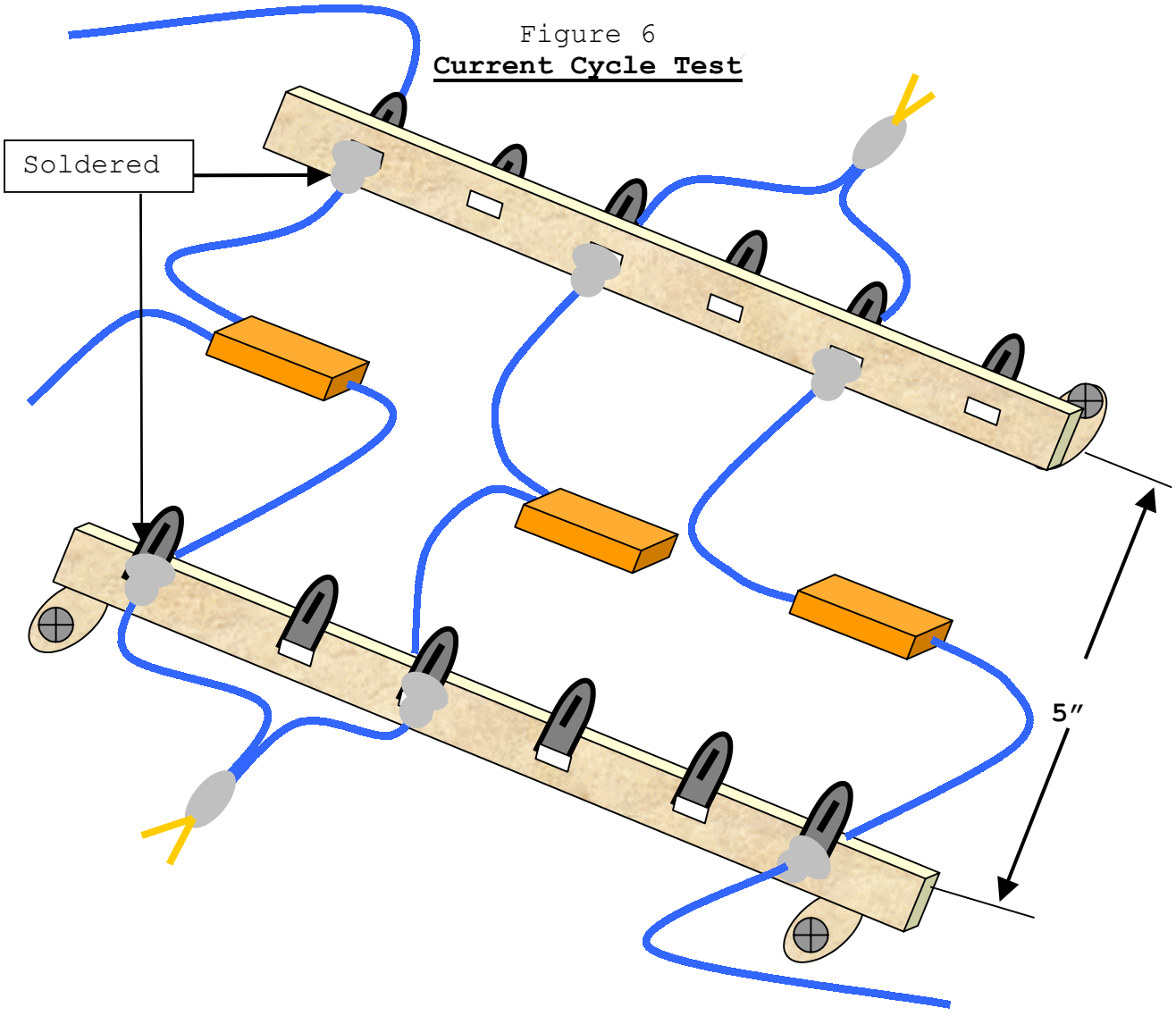
(1) of this section. The test results shall be reported for each test sample.

X. **Current Cycle**:

1. Twenty (20) 4 in. (102 mm) pieces shall be cut from the appropriate gauged wire and assembled in the connectors in accordance with section II, Test Samples, using the connector manufacturer's instructions. For the current cycling, only the first two types of samples specified in section II, Test Samples, paragraph one (1), shall be used for a total of ten (10) samples to be tested. For the current cycling test, expose the copper conductors of the test leads by removing 0.5 in. to 1 in. (12 mm to 25 mm) of insulation from the ends of the test leads.

2. A rack with mounting lugs spaced 5 in. (127 mm) apart shall be used for the test. The test leads of the first five (5) test samples shall be carefully bent and straightened so that the test samples lie approximately midway between the mounting lugs. The test leads between the mounting lugs shall be under no tension. The ends of the test leads shall be soldered to the mounting lugs. The test setup shall be as shown in Figure 6.

Figure 6
**Current Cycle Test**



3. The first set of five (5) test samples shall be connected in series with an ammeter and a power source. The power source shall be adjusted to the "Initial" current specified in Table 1. The voltage drop across each test sample at the mounting lugs shall be measured. The power source shall then be adjusted to the "Test" current specified in Table 1. The "Test" current shall be applied to the test samples for 45 minutes and then off for 15 minutes. The application of the "Test" current for a period of 45 minutes on and a period of 15 minutes off shall constitute one (1) cycle. Fifty (50) current cycles shall be applied to the test samples.

TABLE 1
Test Currents

| Wire Size (AWG) | "Initial" & "Final" Current (Amps) | Test Current (Amps) |
|---|---|---|
| 19 | 11 | 14 |
| 22 | 9 | 11 |
| 24 | 4.5 | 5.6 |
| 26 | 3 | 3.8 |

4. At the completion of the fifty (50) cycles, the current on the test samples shall be reduced to the "Final" current indicated in Table 1. The voltage drop across each test sample at the lug shall be measured and compared with the initial measurements specified in paragraph three of this section. An increase in the voltage drop greater than 5 percent for each test sample shall constitute failure.

5. The second set of five (5) samples shall be tested in accordance with the procedures specified in paragraphs three (3) and four (4) of this section. The connectors shall be tested using the appropriate current for the specific wire size indicated in Table 1.

XI. **Tensile Test**:

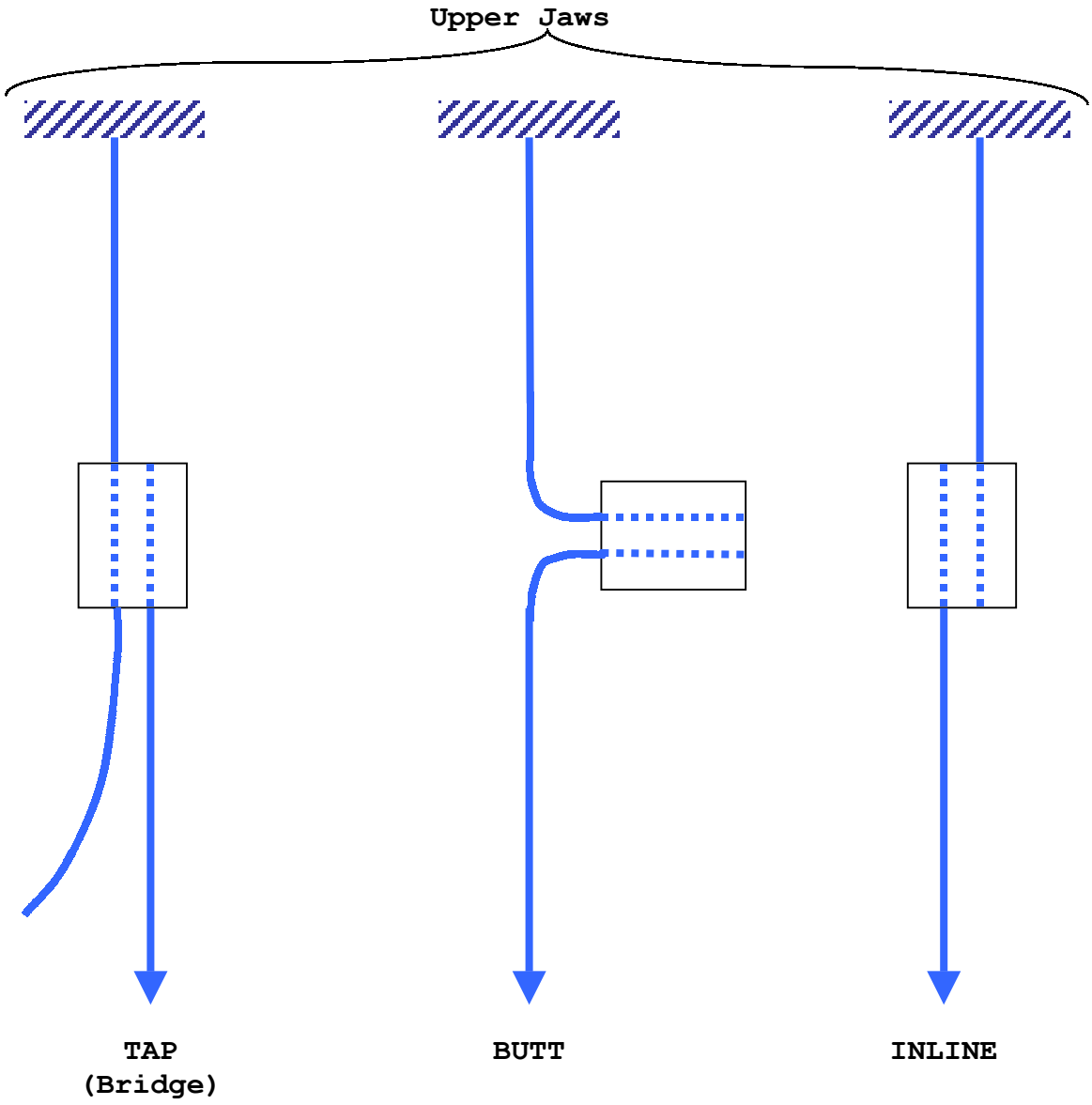
1. Thirty (30) 10 in. (254 mm) pieces shall be cut from appropriate gauged wire and assembled in the connectors in accordance with section II, Test Samples, of this specification using the connector manufacturer's instructions.

2. Three (3) samples of each control wire gauge shall be tested using a tensile machine with a jaw separation speed of 2 in. (51 mm) per minute, to determine average breaking strength of each control wire gauge.

3. Each test sample assembled in accordance with paragraph one (1) of this section shall be tested for either "Pull-out" or "Break" using a tensile machine with a jaw separation speed of 2 in. (51 mm) per minute. The test setup for the "Pull-out" or "Break" test shall be in accordance with Figure 7. The "Pull-out" or "Break" shall not be less than 60 percent of the average breaking strength of each control wire size recorded in paragraph two (2) of this section.

For the five (5) test samples that include the largest and smallest gauge wires, the "Pull-out" or "Break" measurement shall be compared to the smallest control wire gauge breaking strength recorded in paragraph two (2) of this section.

Figure 7
**Tensile Test**




## XII. PERFORMANCE CRITERIA AND TEST PROCEDURES FOR MECHANICAL FIBER OPTIC SPLICES

1. **Mechanical fiber optic splices shall be classified according to their functions listed below:**

☑ Passive splicing - mechanically joining two fibers.

☑ Tunable splicing - mechanically joining two fibers using an active loss measuring system for adjusting splice elements for the lowest loss during assembly.

☑ Mass splicing - mechanically joining multiple fibers simultaneously.

2. A mechanical fiber optic splice shall be so constructed that when assembled it shall have a resistance to optical decoupling. The mechanical splice assembly shall not optically decouple at less than a specified value of axial tension.

3. Optical requirements for multimode and single mode optical splices shall be in accordance with Table 2. Methods of test to determine insertion and return loss shall be in accordance with EIA-455-34, EIA-455-171, or EIA/TIA-455-107.

TABLE 2
Optical Requirements
Mechanical Fiber Optic Splices

| | Single Mode | | Multimode |
|---|---|---|---|
| Splice Type | Insertion Loss [Decibels (dB)] | Return Loss (dB) | Insertion Loss (dB) |
| Passive | 0.20 dB | -35 dB | 0.15 dB |
| Tunable | 0.05 dB | -35 dB | 0.15 dB |
| *Mass | 0.50 dB | -35 dB | 0.15 dB |

* Loss results for mass splicing techniques must be averaged.

4. Mechanical fiber optic splices shall be capable of resisting mechanical stresses associated with installation and service without impairment of the splice integrity.

5. Single mode and multimode mechanical fiber optic splices shall be tested for mechanical reliability in accordance with the test methods specified in Table 3. After each mechanical test, the single mode and multimode mechanical fiber optic splices shall be in accordance with the requirements specified in Table 2 of paragraph 3 of this section.

TABLE 3
Mechanical Tests
Mechanical Fiber Optic Splices

| Test | Procedure | Requirement |
|---|---|---|
| Re-coupling Durability (if appropriate) | EIA-455-21A | 25 Cycles |
| Fiber Retention | EIA/TIA-455-6B | 0.45 Kilograms Force (1.0 Pounds) |
| Vibration | TIA/EIA- 455-11B | 10-55 Hertz, 10 Grams |

6. Single mode and multimode mechanical fiber optic splices shall be tested for environmental reliability in accordance with the test methods specified in Table 4. After each environmental test, the single mode and multimode mechanical fiber optic splices shall be in accordance with the requirements specified in Table 2 of paragraph 3 of this section.

TABLE 4
Environmental Tests
Mechanical Fiber Optic Splices

| Test | Procedure | Requirement |
|---|---|---|
| Humidity | TIA/EIA-455-5B | > 90% Relative Humidity, 40°C, 240 Hours |
| Thermal Cycling | EIA/TIA-455-3A | -40°C to 80°C, 100 Cycles |
| Water Immersion | EIA/TIA-455-12A | 40° C, 240 Hours |
| Material Aging | EIA-455-4A | 84° C, 2000 Hours |

## XIII. PACKAGING, IDENTIFICATION, AND DOCUMENTATION

☑ The packaging shall include identification of the manufacturer, splice model number, and date of manufacture. All necessary parts shall be shipped in one container unless significant advantages to the user will result otherwise.

☑ Complete documentation shall be included with the packaging to provide the following information:

a. Use and application;

b. Set-up and assembly;

c. Testing;

d. Repair;

e. Field installation;

f. Auxiliary Equipment; and

g. Storage Instructions.

## XIV. RUS ACCEPTANCE PROCEDURE

☑ The tests described in this specification are required for acceptance of product designs and major modifications of accepted designs. All modifications shall be considered major unless otherwise declared by RUS. These tests are intended to demonstrate the capability of the manufacturer to produce splice components which meet service requirements of RUS Telecommunications borrowers.

☑ For initial acceptance the manufacturer shall:

a. Certify that the product fully complies with each paragraph of this specification, and submit supporting test data;

b. Submit catalog numbers for the splice;

c. Submit quality assurance data which is representative of at least three production lots and which demonstrate the reliability of an ongoing quality assurance program;

d. Certify whether the product complies with the domestic origin manufacturing provisions of the "Buy American" Requirement of the Rural Electrification Act of 1938 (7 U.S.C 903 note), as amended (the "REA Buy American Provision");

e. Submit at least three user testimonials concerning field performance of the product;

f. Submit descriptive information concerning the splice;

g. Submit assembly and usage instructions for the splice;

h. Submit product identification information;

i. Submit information concerning the packaging and shipment of the splice to customers;

j. Submit an Occupational Safety and Health Administration (OSHA) Material Safety Data Sheet for the appropriate splice components;

k. Submit one production sample of the splice;

l. Submit one sample of a completed splice;

m. Agree to provide plant inspections by RUS; and

n. Provide any other nonproprietary data deemed necessary by the Chief, Outside Plant Branch (Telecommunications).