Basic Repair Method

Base Wire Preparation

1. Cut the number of wire pieces required for the particular test being run. Typically 3 pieces of wire are cut for voltage withstands testing. These pieces should be at least 24 inches in length. One inch of insulation is removed from each end of each voltage withstand wire. The bare ends of each wire are then twisted together to create a "loop". Five pieces of wire are cut for Instron testing. These pieces are cut to eight inches in length. The ends of these wires are not striped.

2. Using a razor blade or diametric wire stripper (only insulation), score each wire piece at its center completely around its circumference. The cut should be deep enough to just reach the conductor. After cutting all the way around the wire, flex the piece at the cut to facilitate the widening of the simulated ring crack. One should be able to easily see down to the bare metal conductor (Figure 1). Care must be taken in preparing the simulated ring crack via razor blade. It is important that the cut made circles the wire completely and ends exactly where the initial cut began. Once the cut has been made and the wire flexed to widen the crack, inspect the edges of the simulated ring crack for any protruding pieces of insulation that might be sticking up above the level of wire surface. Any protrusions should be eliminated before wire repairs are made.

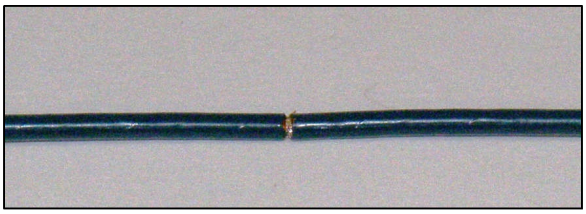

Figure 1. Ring Crack Test Specimen.

Repair Material Preparation

1. The repair film to be used should be cut to the proper size. The following table (Table 1) specifies the length of repair piece needed to deliver one, two, or three wraps of the film around a given size (gauge) of wire.

Table 1. Film dimensions used for manual repair process

Wire Gauge	1 wrap	2 wraps	3 wraps
12	¾" X 3/8"	¾" X 11/16"	¾" X 1 1/8"
20	¾" X 3/16"	¾" X ½"	¾" X ¾"

These lengths apply to repair films which are ~ 6 – 8 mils thick. The width of the repair piece is chosen based on the type damage being evaluated. Repairs of ¾" in width are used in Instron testing to standardize this variable.

Repair Procedure

1. The repair film piece cut in the previous step is applied to the individual scored wire to be repaired. It is placed so as to be centered on the simulated ring crack previously cut in the insulation. The edge of the repair piece being used is now firmly pressed to the wire insulation. Once in place the repair film is applied around the rest of the wire with the fingers using a "rolling or twirling" motion. Care is to be taken to ensure that the wrapping of the repair layer is accomplished as tightly as possible (Figure 2). A tack strip can be used, as necessary, to enhance contact between the repair film and test specimen.

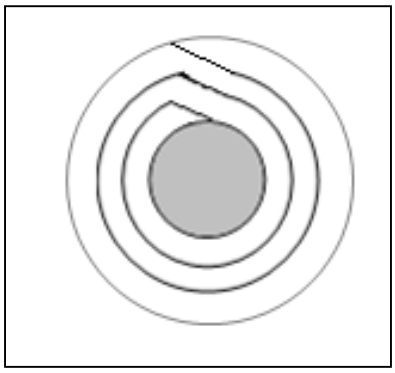

Figure 2. Wrapping Method for Repair Tape.

2. The repaired section of the wire is now spirally wrapped with a piece of Teflon tape (Figure 3). Enough Teflon tape is used to loosely cover the repair layer as well as allowing ~ ¼ inch of overlap on each edge. It is important that the Teflon tape be applied only loosely. Too much tension in this cover will cause the repair layer to flow unevenly when it is heat cured later.

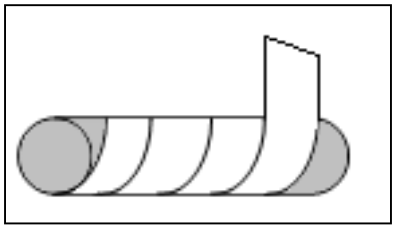

Figure 3. PTFE Tape Wrapping Method.

3. Heat cure the repair. This process is carried out using a special dual jaw soldering iron heater (Figure 4). The jaws of this heater are lined with Teflon tape to minimize any sticking that can occur during the cure process. The repair is placed between the jaws of the heater and secured snuggly via circle twist clamp. The jaws of the heater contain a groove that can be varied in size by changing jaws. The groove size should closely match the outer diameter of the repair. The temperature applied by this heater is controlled via a digital control box. Several preset temperatures have been programmed into this controller and are selected by a "push button" on the face of the box. Digital readouts of 434 °F and 483 °F deliver heater outputs of 200 °C and 250 °C respectively. A heat cure is typically done for 20 minutes. The heater is plugged into a digital timer to allow for a consistent

time of heating from one repair to the next. Once the timer has been activated (via push button) the temperature control box will become active and the desired temperature can be selected. When the repair heating process is being carried out care should be taken to minimize any external forces that might be exerted by allowing the wire extending out of the heater to push against a surface. Such forces can cause thin/thick spots in the repair layer. Once the repair time has expired the heater is allowed to cool. The repair is then removed from the heater jaws and the Teflon tape covering is removed. The repair is then inspected for any gross flaws that may determine a poor repair (Figure 5).

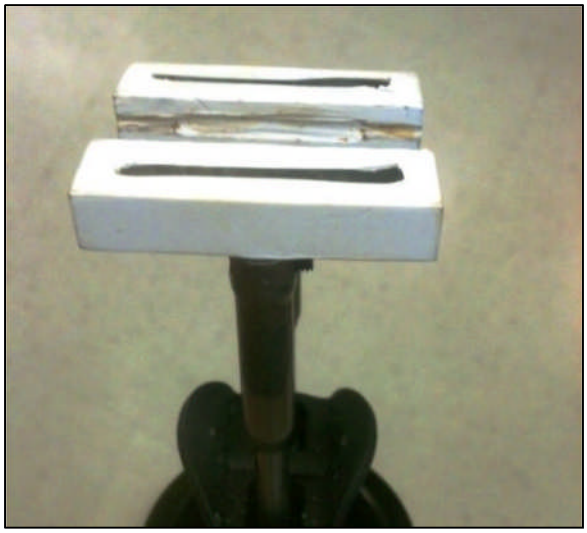

Figure 4. Soldering Iron-Based Heating Tool.

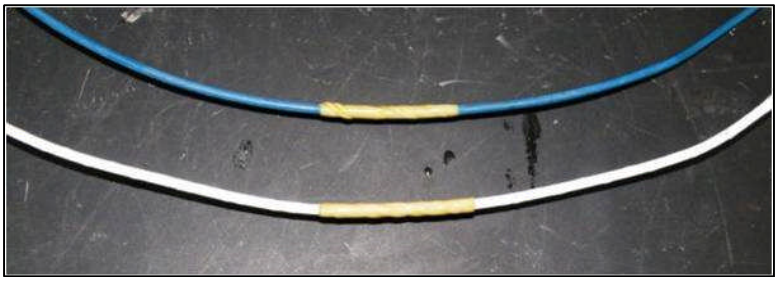

Figure 5. Wire Repair Test Specimens.

Testing

Test Specimen Documentation

All prepared test specimens were documented for thickness of overall repair and length of repair.

Optical Microscopy

Test specimens fabricated were evaluated using optical microscopy to determine the quality of repair (visually). The presence of bubbles, edge effects, gaps, and other notable defects were documented. Photographs were taken of each test specimen for future reference.

Bend Radius

Test specimens were wrapped around a 10X mandrel (based on diameter of wire under test) to determine if any cracking of the repair material occurred during the wrapping process (Figure 6). The specimens were analyzed using optical microscopy.

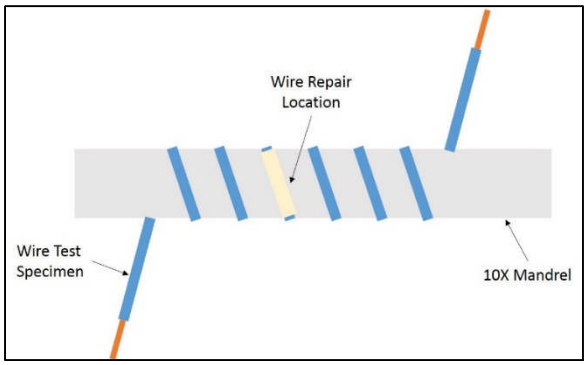

Figure 6. Bend Radius Testing.

Voltage Withstand

Wire repair samples were prepared using the candidate repair materials and evaluated per ASTM D 3032-04 (Standard Test Methods for Hookup Wire Insulation, Test 8, Voltage Withstand Test). The power supply used was a Keithley Model 248 High Voltage Supply. This test is carried out by immersing a minimum of three identical wire repair samples in an aqueous solution containing 5% sodium chloride and 0.5% Triton X-100 surfactant for four hours at room temperature (Figure 7). Each wire repair test specimen is then, while still submerged in the test solution, evaluated first in an initial resistance test to see if any test solution has encroached through the repair layer and has come in contact with the bare wire underneath. If the repair specimen passes the initial resistance test, then it is subjected to applied voltages ranging from 500 V up to 2500 V, in increments of 500 V. Each voltage increment is held under load for one minute. The repair must pass through this full course of voltage steps all the way through 2500 V to obtain a passing result.

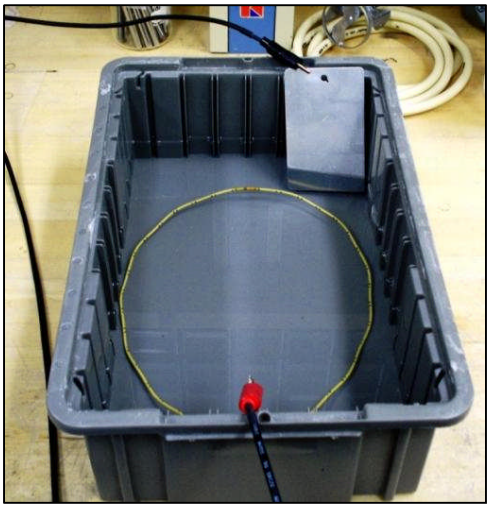

Figure 7. Voltage Withstand Test.

Instron Slip Testing

Slip resistance evaluation was performed to determine the adhesion of the repair material to the insulation of current aerospace wiring. The specimens were evaluated using a custom fixture and an Instron 3344 Universal Testing Machine (Figure 8). The specimens were placed in the tensile testing machine with the specimens being pulled thru a hole in the top of the holding fixture that prevents the repair material from passing thru the fixture hole. The specimens were gripped by the jaws at one end and the other end was free. Sufficient force was applied to cause slip failure. The travel speed of the head was 1 inch per minute.

Figure 8. Slip Resistance Evaluation Test Setup.