FINAL REPORT
ON
MAGNETIC WIRE STRIPPING AND CONNECTION METHOD EVALUATION

to

Jet Propulsion Laboratory

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NASA CR 70721

by

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on

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ABSTRACT

The purpose of this investigation was to perform certain tests involving a variety of magnet wire types, sizes, and joining methods with the end goal being to accumulate sufficient test data to establish a preferred technique or techniques for stripping insulation from fine magnet wires and for connecting these fine magnet wires to heavier nickel wires. This evaluation included the preparation and testing of 1485 specimens (each specimen consisting of two interconnections) using the following materials and techniques:

- a) Three sizes of copper magnet wire (#42 AWG, #46 AWG, and #50 AWG).
- b) Three types of heavy wire insulation (Formvar, Isonel, and ML).
- c) Two wire stripping methods (chemical and mechanical stripping).
- d) Four joining techniques (manual soft soldering, fusing in a torch flame, soft solder pot dipping at 1000° F, and silver solder pot dipping at 1200° F). Manual soft soldering was done using stripped magnet wire, but the torch fusing and dipping techniques were done using wire from which the insulation was not removed.

Testing of the magnet wire specimens included:

- a) Electrical resistance before and after humidity exposure and temperature cycling.
- b) Tensile testing before and after humidity exposure and temperature cycling.
- c) Visual examination under 20X magnification before and after humidity exposure and temperature cycling.

All test results were recorded on a total of 33 Raw Data Sheets.

Since data analysis was precluded under the terms of this contract, definite recommendations as to the preferred stripping and connection techniques could not be made. However, it is felt that <u>manual soft</u>

soldering appeared superior to the other joining methods and that chemical wire stripping was superior to mechanical wire stripping (by manual abrasion methods) providing the potential corrosion hazard could be neglected.

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MAGNETIC WIRE STRIPPING AND CONNECTION METHOD EVALUATION

1. PURPOSE AND SCOPE

There are currently many techniques for removing insulation from fine magnet wires (#40 to #50 AWG) and connecting these magnet wires to heavier nickel wires used as lead terminals (#22 AWG). Each of these techniques has certain elements which contribute to high reliability and other elements which may contribute to early failure. This evaluation program is aimed at establishing the preferred technique or techniques which result in the highest reliability and least spoilage. Improved reliability, in this respect, will lower the incidence of failure due to opening of windings caused by corrosion or mechanical tests.

This evaluation will include the usage of: a) three sizes of copper magnet wire (#42 AWG, #46 AWG, #50 AWG); b) three types of heavy wire insulation (Formvar, Isonel-200, ML); c) two wire stripping methods (chemical and mechanical stripping); and d) four joining techniques (manual soft soldering, fusing in a torch flame, soft solder pot dipping at 1000° F, and silver solder pot dipping at 1200° F).

This testing evaluation was accomplished under JPL Purchase Order No. K5-330257 and was of 6 months duration covering the period from June 15, 1965 through December 11, 1965. The work accomplished was in accordance with JPL Statement of Work, Test No. 951.00-03 dated December 9, 1964 and JPL Exhibit 2 dated May 5, 1965. Mr. E. Wiler was the JPL Project Engineer on this program and Mr. F. Keister was the Hughes Project Engineer. A Detailed Test Procedure, dated September 13, 1965, was approved by JPL on September 16, 1965. This Detailed Test Procedure covered the methods of preparing and testing the 1485 magnet wire specimens for this program and is included, essentially in its original form, in Sections 2 through Section 7 of this final report.

The tests performed under this evaluation included:

a) Electrical resistance before and after moisture resistance per MIL-STD-202C, Method 103B, Test Condition A.

b) Electrical resistance before and after temperature cycling per MIL-STD-202C, Method 102A, Test Condition C.

c) Tensile testing before and after moisture resistance and temperature cycling.

Since data analysis was precluding under the terms of the contract, definite conclusions regarding the preferred interconnection methods could not be made.

2. MAGNET WIRE TYPES AND JOINING METHODS

Table I is a complete listing of the magnet wire types and sizes to be used in this program. These magnet wire types are all in accordance with MIL-W-583C. All wires are insulated with a heavy film coating. The Formex and Formvar wire is Class 105, Type T2. The Thermaleze and Isonel wire is Class 155, Type L2. The ML wire is Class 200, Type K2.

Table II lists the magnet wire types and sizes together with the five joining methods and the number of specimens. The 45 specimens in each applicable block in Table II will be divided into two groups. Group A will consist of 24 specimens joined by Operator A. Group B will consist of 21 specimens joined by Operator B. Thus two operators will participate in each joining method for each type of specimen. Operator A will be an experienced operator in that she has worked for a number of years with stripping and joining magnet wire for transformer and coil assemblies. Operator B is an inexperienced operator,

Magnet Wire Size (AWG)	Type of Insulation (heavy film)	Vendor	Bare Magnet Wire Diam. (inches)
42	Formex	General Electric	0.0025
46	Formvar	Hudson Wire	0.0016
50	Formvar	Hudson Wire	0.0010
42	Thermaleze-200	Phelps Dodge	0.0025
46	Isonel-200	Hudson Wire	0.0016
50	Isonel-200	Hudson Wire	0.0010
42	M.L.	Hudson Wire	0.0025
46	M.L	Hudson Wire	0.0016
50	M.L.	Hudson Wire	0.0010

Table I. Listing of magnet wire sizes and types.

Joining Method	#42H-Thermaleze	#46H-Isonel	#50H-Isonel	#42H-Formex	#46H-Formvar	#50H-Formvar	#42H-ML	#46H-ML	#50H-ML
	Magnet Wire Type and Size								
1. Mechanically strip and soft solder using Ersin SAVBIT #1.				45	45	45	45	45	45
2. Chemically strip and soft solder using Ersin SAVBIT #1.				45	45	45	45	45	45
3. Fuse in torch flame.	45	45	45	45	45	45	45	45	45
4. Solder pot using Ersin SAVBIT #1.	45	45	45	45	45	45			
5. Silver solder pot	45	45	45	45	45	45			

Table II. Listing of magnet wire types and sizes, joining methods, and number of specimens.

but has been certified for soldering per NASA Electrical Assembly Specification MSFC-PROC-158B and has been qualified and certified, for resistance microwelding.

A total of 1485 specimens per Table II will be prepared and tested. Since each specimen requires two interconnections, a total of 2970 interconnections will be involved.

Note: Ersin SAVBIT #1 solder is essentially an alloy of 50 percent tin/48.6 percent lead/1.4 percent copper.

3. SPECIMEN REQUIREMENTS

Each specimen will consist of a 6 inch length of the applicable magnet wire connected at each end to a 2 inch length of gold plated #22 AWG nickel wire as shown in Figure 1. Six turns of the magnet wire will be wrapped around the nickel wire in an approximate length of 1/4-inch. The nickel wire is 0.025 inch diameter and is per MIL-STD-1276, Type N2 with gold plating per MIL-G-45204, Type I, Class 1. The dimensions in Figure 1 are, of course, only approximate since this type of specimen cannot be held to accurate dimensional tolerances.

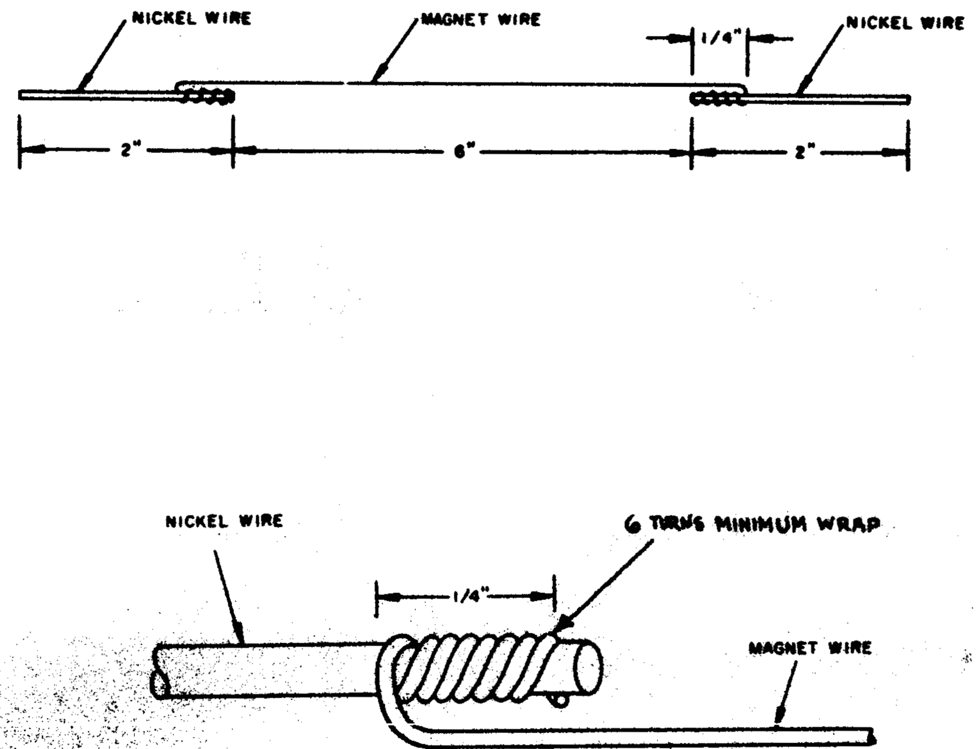

Figure 1. Configuration for joining magnet wire to nickel wire.

4. DATA HANDLING

Raw data shall be recorded on forms similar to Figure 2. A total of thirty-three (33) raw data sheets will be required to record the data for the 1485 specimens listed in Table II. No data analysis will be done. Specimens 1 thru 8, 16 thru 23, and 31 thru 38 will be prepared by Operator A. Specimens 9 thru 15, 24 thru 30, and 39 thru 45 will be prepared by Operator B.

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WIRE TYPE & SIZE__________ JOINING METHOD__________

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE	POINT OF BREAK
1 A					
2 A					
3 A					
4 A					
5 A					
6 A					
7 A					
8 A					
9 B					
10 B					
11 B					
12 B					
13 B					
14 B					
15 B					
16 A					
17 A					
18 A					
19 A					
20 A					
21 A					
22 A					
23 A					
24 B					
25 B					
26 B					
27 B					
28 B					
29 B					
30 B					
31 A					
32 A					
33 A					
34 A					
35 A					
36 A					
37 A					
38 A					
39 B					
40 B					
41 B					
42 B					
43 B					
44 B					
45 B					

Figure 2. Typical raw data form.

5. PREPARATION OF SPECIMENS FOR JOINING

5.1 Cutting Wires to Length

Magnet wire types as follows will be precut to lengths of 7 1/2" and laid in designated trays:

180 lengths each of #42, #46, #50 AWG Isonel and ML magnet wire.

300 lengths each of #42, #46, #50 AWG Formvar magnet wire.

Cutting of 15 extra wires in each group has been done to allow for spoilage during joining.

The nickel wire will be cut into 3000 lengths each 2" long. After cutting, the nickel wire lengths will be kept in a beaker of methyl alcohol until ready for joining. Of these 3000 lengths of nickel wire, 800 pieces will be notched with a small file in one end as shown in Figure 3. The purpose of notching will be explained later. These 800 notched pieces will be kept in a separate beaker of methyl alcohol.

5.2 Mechanical Stripping of Magnet Wire

Sixty lengths each of #42, #46, and #50 AWG Formvar and ML magnet wire will be manually stripped. Stripping of the #42 and #46 AWG wire will be done using 400 weight aluminum oxide cloth. Stripping of the #50 AWG wire will be done using 600 grit silicon carbide paper. Immediately prior to mechanical abrading, the magnet wire is passed very quickly over the flame of an alcohol burner. This softens the insulation enough so that gentle rubbing of the wire between the folds of the abrasive cloth using only light finger pressure will strip off the insulation with a minimum amount of spoilage. Each 7 1/2" length of magnet wire will be stripped approximately 1" back from each end as shown in Figure 4. Particular care must be used in stripping the #50 AWG wire to avoid breaking the wire. The stripped lengths of Formvar and ML magnet shall be placed in separate trays according to type and size. In no case shall the stripped end be touched with the bare hands. During stripping if any wire has been abraded such that the diameter has been reduced by 1/5, that length of wire shall be discarded. All

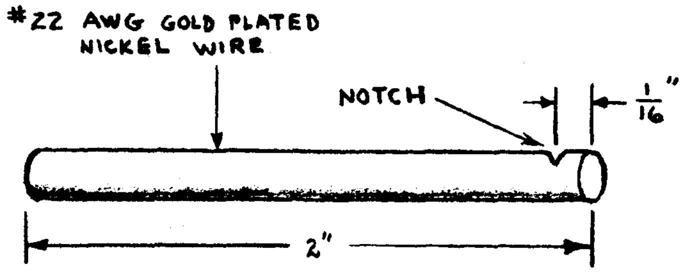


Figure 3. Notched nickel wire.

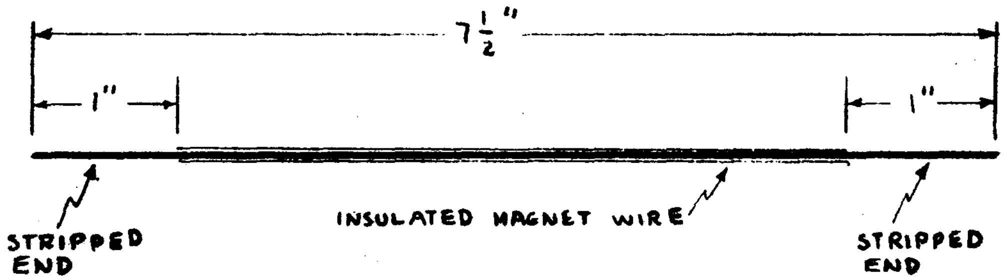


Figure 4. Stripped magnet wire.

manually stripped wires shall be inspected under 20 X magnification for complete insulation removal and any excessive abrading.

5.3 <u>Chemical Stripping of Magnet Wire</u>

5.3.1 Sixty lengths each of #42, #46, and #50 AWG Formvar magnet wire shall be chemically stripped using Lonco No. 416 Cold Wire Stripper. Bundles of wire may be stripped simultaneously providing each wire within the bundle is adequately stripped. Each 7 1/2" length of wire will be stripped for a minimum distance of 1" back from each end as shown in Figure 4.

Stripping shall be done as follows:

Step 1. Place stripper (Lonco No. 416) in a glass beaker at room temperature.

Step 2. Immerse one end of the magnet wire to a depth of approximately 1" in the stripper and hold for 45 seconds.

Step 3. Remove the wire and immediately wipe with a clean cloth to remove any insulation residue.

Step 4. Immerse in a beaker of neutralizer (equal parts of distilled water and isopropyl alcohol). Hold for 30 seconds.

Step 5. Remove and wipe dry with a clean cloth.

Step 6. Repeat Steps 2 thru 5 for the other end of the magnet wire.

Step 7. Inspect under 20 X magnification for complete insulation removal and place in a marked tray using care not to touch the stripped ends with the fingers.

5.3.2 Sixty lengths each of #42, #46, and #50 AWG ML magnet wire shall be chemically stripped using Fidelity #956 ML insulation stripper. Bundles of wire may be stripped simultaneously providing each wire within the bundle is adequately stripped. Each 7 1/2" length of magnet wire will be stripped for a minimum distance of 1" back from each end as shown in Figure 4. Stripping shall be done as follows:

Step 1. Place #956 Stripper in a glass beaker and heat to 212-225°F. Place a 5% solution of Fidelity Neutralizer (5 grams of Neutralizer to 100 grams of water) in a glass beaker and heat to 100-150°F. Place Fidelity #958 Drying Solution in a glass beaker at room temperature.

Step 2. Immerse one end of the ML magnet wire to a depth of approximately 1" in the #956 stripper and hold for 3 minutes.

Step 3. Remove and immerse in the Neutralizer for 30 seconds.

Step 4. Remove and immerse in the Drying Solution for 10 seconds.

Step 5. Remove and wipe dry with a clean cloth to remove any residue.

Step 6. Repeat Steps 2 thru 5 for the other end of the magnet wire.

Step 7. Inspect under 20 X magnification for complete insulation removal and place in a marked tray using care not to touch the stripped ends with the fingers.

6. JOINING METHODS

6.1 Manual Soft Soldering

In accordance with Table II, 90 specimens each of #42, #46, and #50 AWG Formvar and ML magnet wire will be manually soft soldered. Of these 90 specimens each, 45 each will be mechanically stripped and 45 each will be chemically stripped. Soft soldering techniques will be identical regardless of the stripping method.

6.1.1 Materials and Equipment:

a) Oryx Model 6A soldering iron (6 watts, 6 volts) with a P tip (1/16" diameter).
b) Ersin Savbit Type I Multicore Solder (No. 22 S. W. G. diameter, No. 364 flux core).
c) 1,1,1 Trichloroethane per O-T-620.

6.1.2 Procedures:

Step 1. Briefly clean each end of the stripped magnet wire by a quick dip in methyl alcohol followed by wiping dry with a clean cloth.

Step 2. Wrap the stripped magnet wire around the end of the nickel wire 6 turns minimum per Figure 1 using a pair of tweezers. Only the stripped portion of the magnet wire shall be wrapped.

Step 3. Place the nickel wire in a fixture, such as a small vise, with the wire inclined at an angle of approximately 45° to the vertical and located beneath a microscope at a magnification of 15x minimum. Refer to Figure 5.

Step 4. Place the hot tinned tip of the soldering iron at the end junction of the nickel wire and magnet wire and apply the flux cored solder to the other side of the joint until an adequate solder fillet has formed. Refer to Figure 6, and Figure 7.

Step 5. Remove the soldering iron tip and solder from the joint with a slight wiping motion. The solder should wet and cover the magnet wire - nickel wire joint such that the helical outline of the wrapped

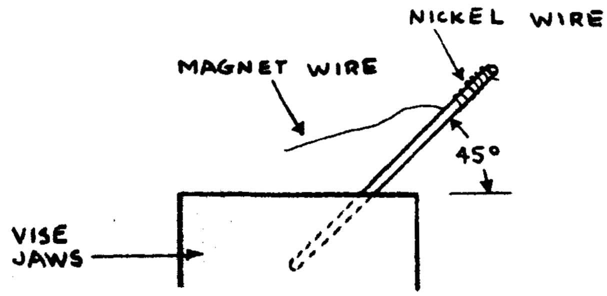


Figure 5. Nickel wire clamped in fixture.

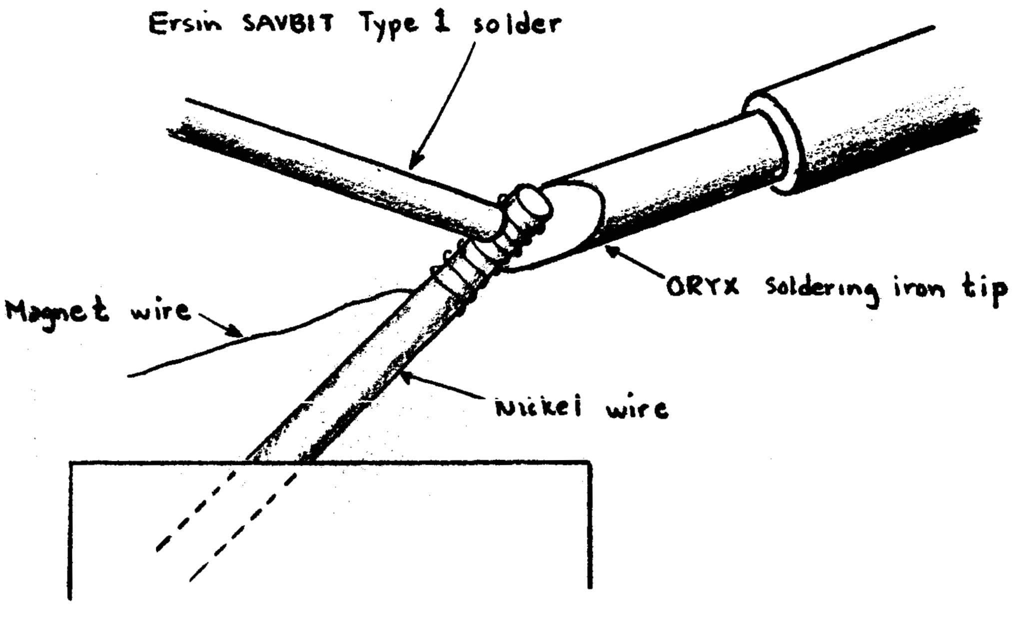


Figure 6. Manual soft soldering.

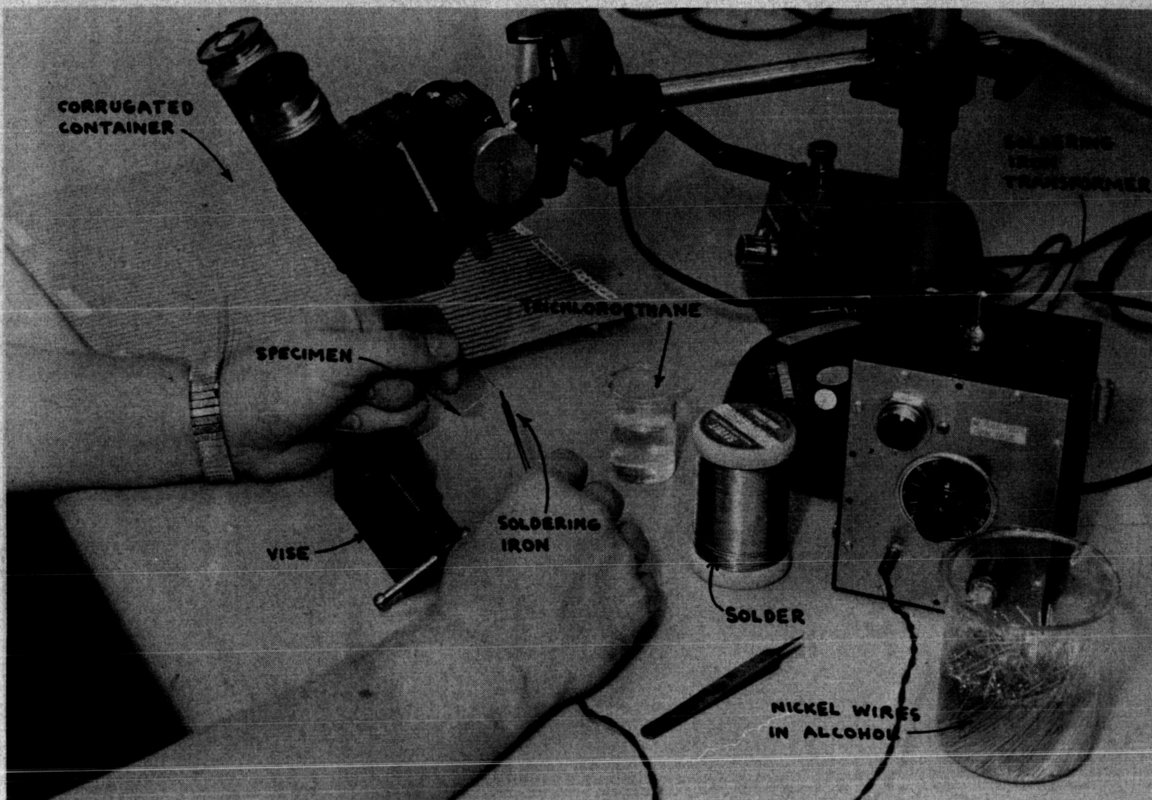


Figure 7. Manual soft soldering joining method. (R105890)

magnet wire is visible. The appearance of the solder joint should be continuous, bright, and shiny with a feather edge. Inspection shall be under 20 X magnification.

Step 6. Immerse the solder joint in a beaker of trichloroethane for 30 seconds or longer to remove flux residues.

Step 7. Repeat Steps 2 thru 6 for the other stripped end of the magnet wire. The final specimen should be dimensionally in accordance with Figure 1.

Step 8. Place the soldered specimen carefully in the proper slot of the special corrugated container so that it lays straight.

Note: During preparation of the soldered specimens, if any soldered joint is unsatisfactory or if the magnet wire breaks, that specimen shall be rejected and a new specimen shall be made to take its place. A record shall be kept of all spoiled specimens with the cause of spoilage, if known. This statement applies equally to all specimens in this program, including those which are joined by torch fusing, soft solder dipping, and silver solder dipping.

6.2 Torch Fusing

In accordance with Table II, 45 specimens each of unstripped #42, #46, and #50 AWG Formvar, Isonel (155°C), and ML magnet wire will be prepared by fusing in a torch flame. The method of torch fusing will be identical regardless of the type and size of magnet wire involved.

6.2.1 Materials and Equipment:

a) Henes Water Welder, Model S, with a Booster assembly, Variac, and #30 gage torch tip (0.0030" tip orifice inside diameter).
b) Silver solder - flux mixture prepared by mixing 55% Handy Flux with 45% Easy-Flo #35 silver brazing alloy (100 mesh powder) by weight. Add water to the mixture until a paste is formed. Note: Easy-Flo #35 has a composition: Silver - 35 percent, copper - 26 percent, zinc - 21 percent, cadmium - 18 percent.

c) Beaker of hot water.

6.2.2 Procedures:

Step 1. Adjust the Variac so as to have 84 volts input to the water welder. With the power switch in the LO position, light the #30 torch tip with a match.

Step 2. Wrap one end of the unstripped magnet wire around the end of the nickel wire 6 turns minimum per Figure 1 using a pair of tweezers.

Step 3. Dip the wrapped joint in the flux-silver brazing alloy paste, so that the wrapped portion of magnet wire is completely covered.

Step 4. Place the unwrapped end of the nickel wire in a fixture, such as a small vise, with the wire inclined at an angle of approximately 45° to the vertical and located beneath a microscope at a magnification of 15 X minimum. Refer to Figure 5.

Step 5. Apply the torch flame to the end of the nickel wire carefully, keeping the torch flame in constant motion to assure uniform heating. Heat the joint until the brazing alloy flows freely over the magnet wire. Fusing must be done carefully to avoid playing the flame directly over the magnet wire. Refer to Figure 8, and Figure 9.

Step 6. Immediately immerse the fused joint in the beaker of hot water (150 - 200°F) until the hard glassy flux residue is softened and removed. Gentle brushing of the flux residue will assist in its removal.

Step 7. Inspect the torch brazed joint under 20 X magnification. The helical turns of magnet wire should be completely covered with brazing alloy with only their outline visible. The joint should have a bright silvery appearance with evidence of good wetting of the nickel wire.

Step 8. Repeat Steps 2 thru 7 for the other end of the magnet wire. The final specimen should be dimensionally in accordance with Figure 1.

Step 9. Place the torch fused specimen carefully in the proper slot of the special corrugated container so that it lays straight.

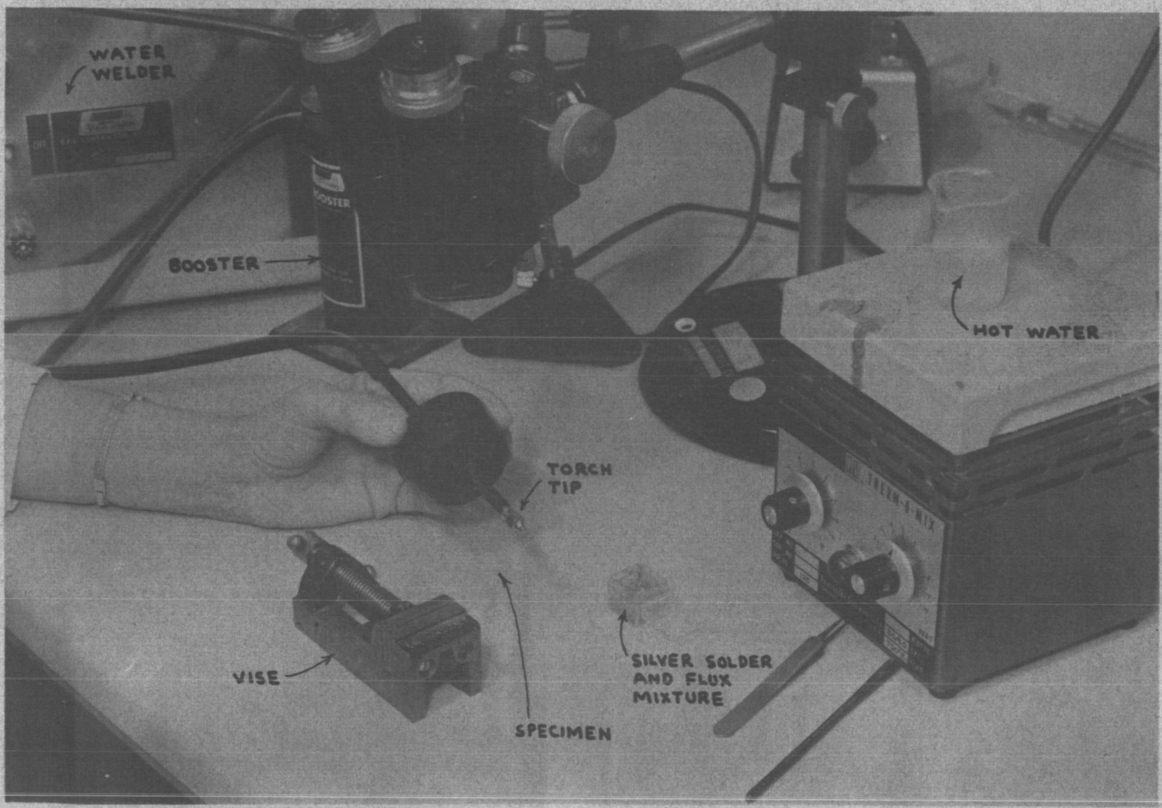


Figure 8. Torch fusing joining method. (R105889)

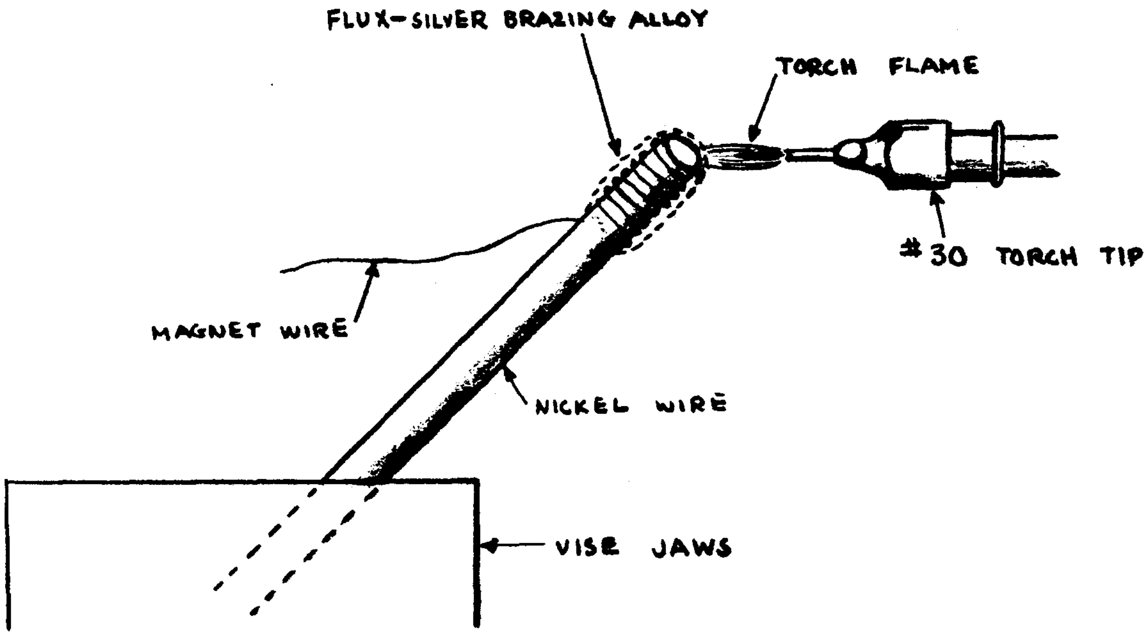


Figure 9. Torch fusing.

6.3 Soft Solder Pot Dipping

In accordance with Table II, 45 specimens each of #42, #46, and #50 AWG Formvar and Isonel (155°C) magnet wire will be prepared by dipping in a solder pot filled with Ersin Savbit No. 1 solder. The magnet wire will not be stripped for this joining operation.

6.3.1 Materials and Equipment:

a) Dee Model 12 melting pot (300 watts).
b) Ersin Savbit No. 1 solder (#14 S. W. G.).
c) Handy Flux Type TEC.
d) Beaker of hot water.

6.3.2 Procedures:

Step 1. Melt the Ersin Savbit No. 1 solder in the melting pot under a hood to burn off the flux core.

Step 2. Adjust the molten solder temperature to 990 - 1000°F. A thermocouple shall be used to periodically check the correctness of the solder temperature.

Step 3. Wrap one end of unstripped magnet wire around the end of the nickel wire 6 turns minimum per Figure 1 using tweezers. Wrapping of the #46 and #50 AWG magnet wire shall be done around a notched nickel wire (see Figure 3). The last wrap shall be around the notch to secure the magnet wire during the subsequent dipping operation.

Step 4. Dip the connection into a container of TEC flux so that the helical magnet wire wrap is covered.

Step 5. Using a suitable scraper (such as a tungsten blade) scrape the dross from the top of the molten solder surface and immediately dip the fluxed connection into the clean solder to a depth covering the helical magnet wire wrap. Dipping shall be done with a straight up-and-down motion. Dwell time in the solder pot shall be 1 - 2 seconds for the #46 and #50 AWG Magnet wire and 4 seconds for the #42 AWG magnet wire. See Figure 10 and Figure 11.

Step 6. Slowly withdraw the joint from the solder pot and allow the solder to solidify (approximately 10 seconds). Dip the joint into the beaker of hot water to remove any flux residue and allow to air dry.

Step 7. Inspect the solder joint under 20 X magnification. The solder joint should be of a bright, shiny appearance with the outline of the magnet wire visible beneath the solder. The nickel wire should be wet and the solder fillet should have a feather edge.

Step 8. Repeat Steps 3 thru 7 for the other end of the magnet wire. The final specimen should be dimensionally in accordance with Figure 1.

Step 9. Place the specimen carefully in the proper slot of the special corrugated container so that it lays straight.

6.4 Silver Solder Pot Dipping

In accordance with Table II, 45 specimens each of #42, #46, and #50 AWG Formvar and Isonel (155°C) magnet wire will be prepared by dipping in a solder pot filled with Easy-Flo #35 silver brazing alloy.

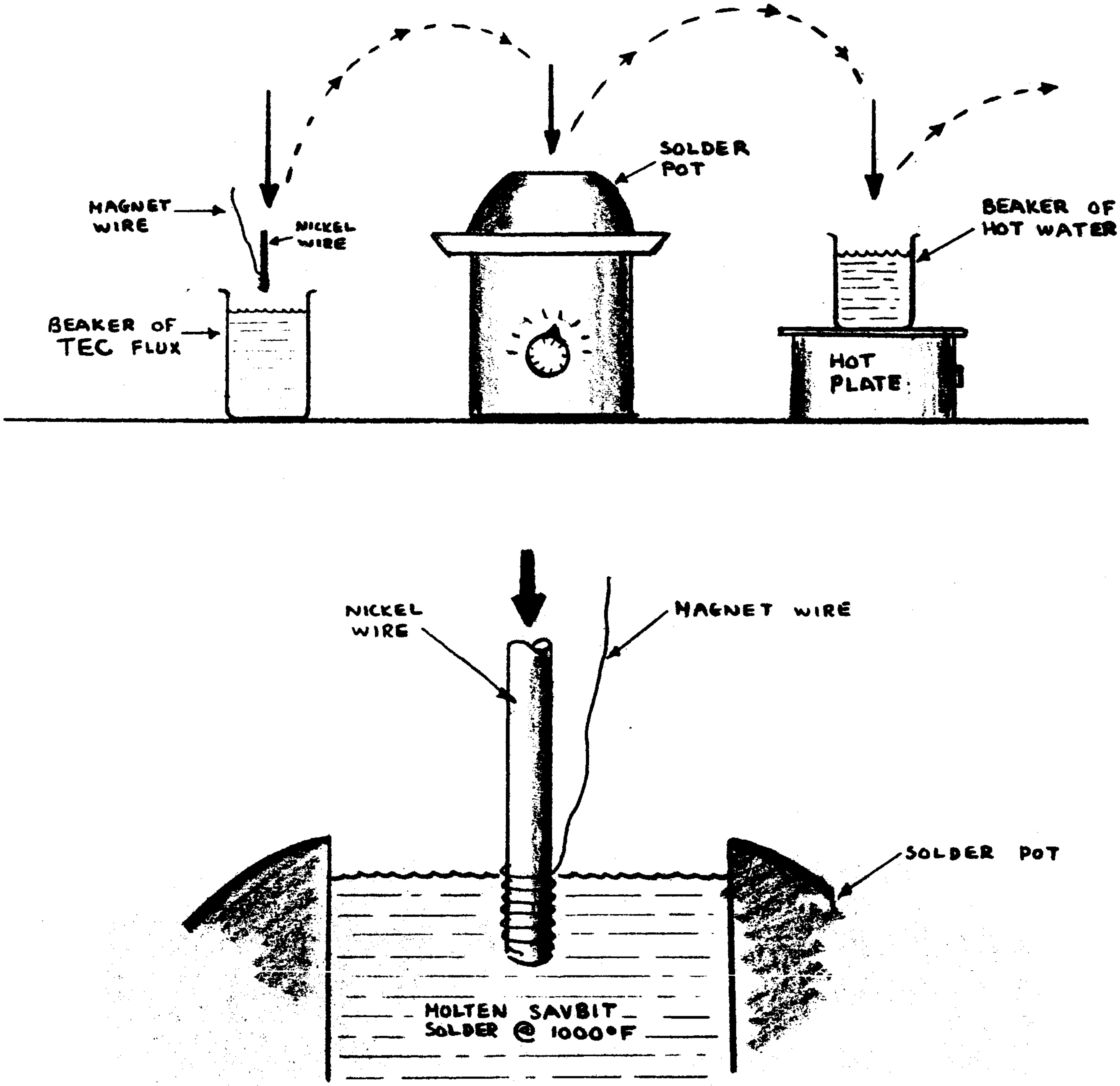


Figure 10. Soft solder pot dipping.

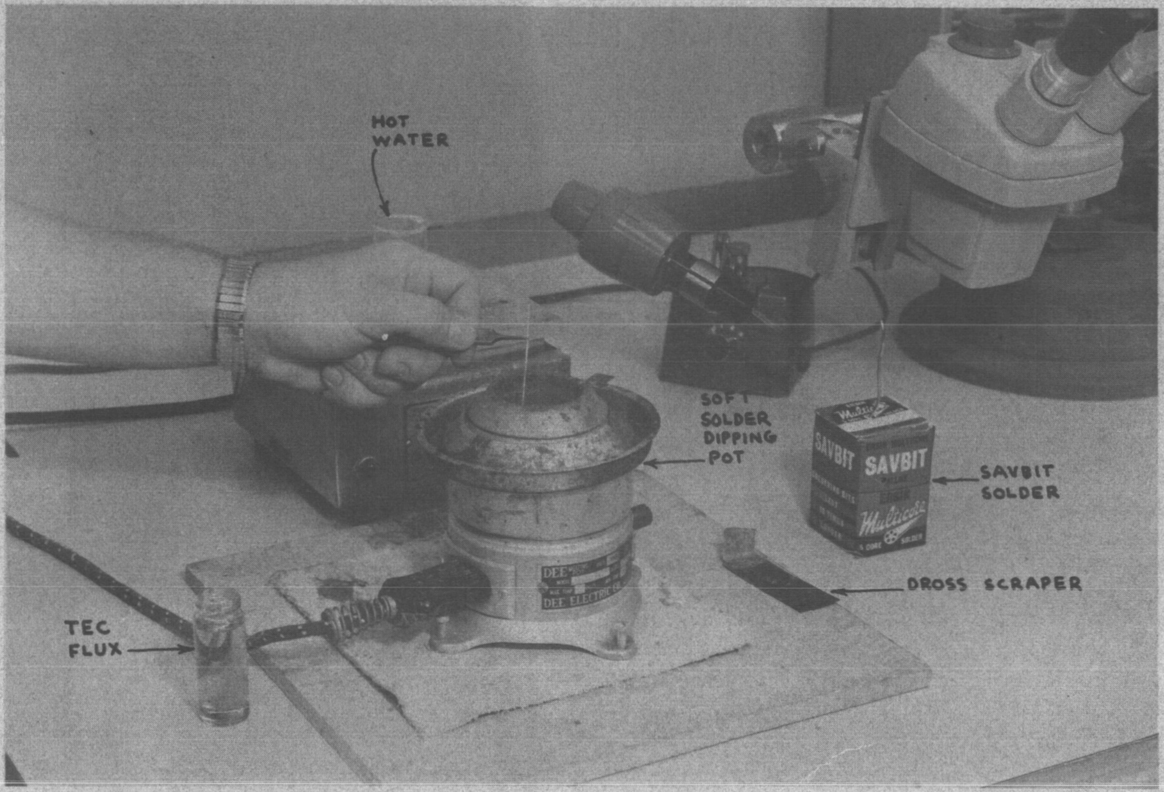


Figure 11. Soft solder pot dipping joining method. (R105891)

The magnet wire will not be stripped for this joining operation and no flux will be used.

6.4.1 Materials and Equipment:

a) Dee Model 11Y melting pot (400 watts).
b) Easy-Flo #35 silver brazing alloy.
c) Dross retardant made by mixing 4 pbv Handy Flux powder with 1 pbv boric acid.

6.4.2 Procedures:

Step 1. Melt the Easy-Flo #35 silver brazing alloy in the solder pot. The molten silver solder temperature shall be maintained between 1200-1250°F as monitored by a thermocouple.

Step 2. In order to inhibit dross formation on top of the molten silver solder it will be necessary to occasionally sprinkle a small amount of Handy Flux - boric acid powder on top of the silver solder. A cover shall be kept over the top of the solder pot when not in use.

Step 3. Wrap one end of the unstripped magnet wire around the end of the nickel wire 6 turns minimum per Figure 1 using tweezers. A notched nickel wire (see Figure 3) should be used for #46 and #50 AWG magnet wire with the last wrap being around the notch for mechanical security during dipping.

Step 4. With a suitable scraper (such as a tungsten blade), scrape any dross from the top of the molten silver solder and immediately dip the fluxed connection into the clean silver solder to a depth covering the helical wrap (approximately 1/4 inch). Dipping shall be done with a straight up-and-down motion. Dwell time in the silver solder shall be from 1 to 2 seconds (see Figure 12).

Step 5. Inspect the silver soldered joint under 20 X magnification. The joint should have a bright gold appearance. Coverage of the wrapped magnet wire shall be complete. No burning or charring of the unwrapped magnet wire shall be evident.

Step 6. Repeat steps 3 thru 5 for the other end of the magnet wire. The final specimen should be dimensionally in accordance with Figure 1.

Step 7. Place the specimen carefully in the proper slot of the special corrugated container so that it lays straight.

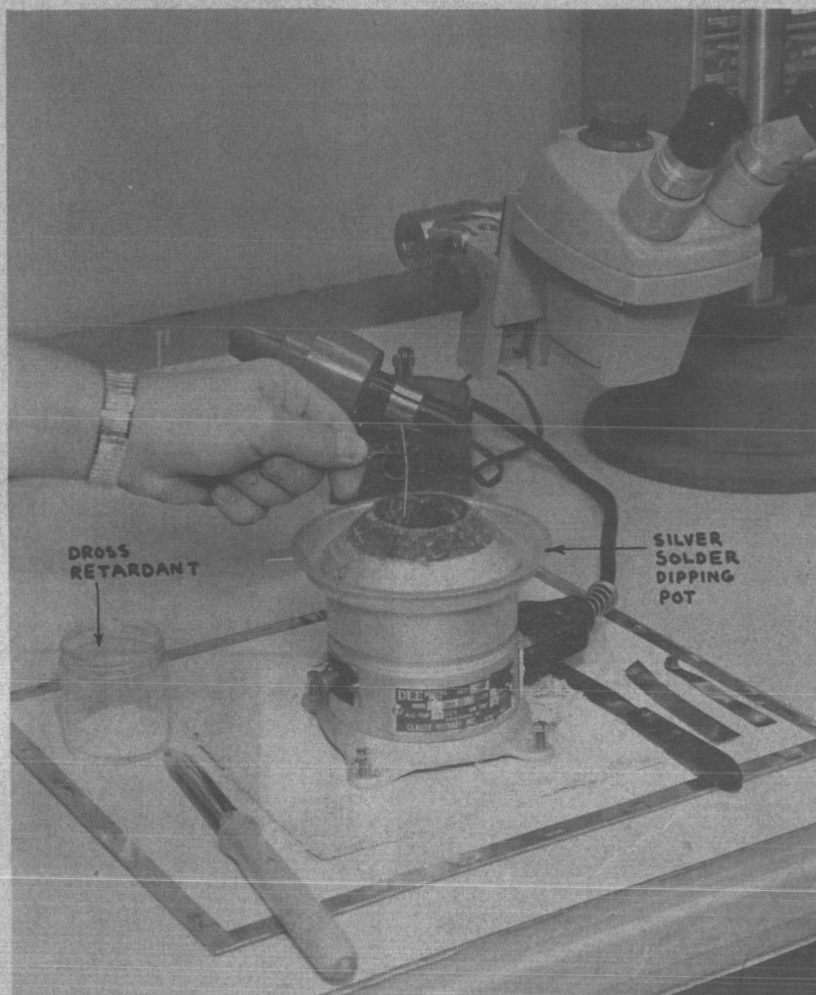


Figure 12. Silver solder pot dipping
joining method. (R105892)

7. TESTING

7.1 Test Flow Chart

The prepared specimens will be submitted to the tests in the sequence shown in Figure 13.

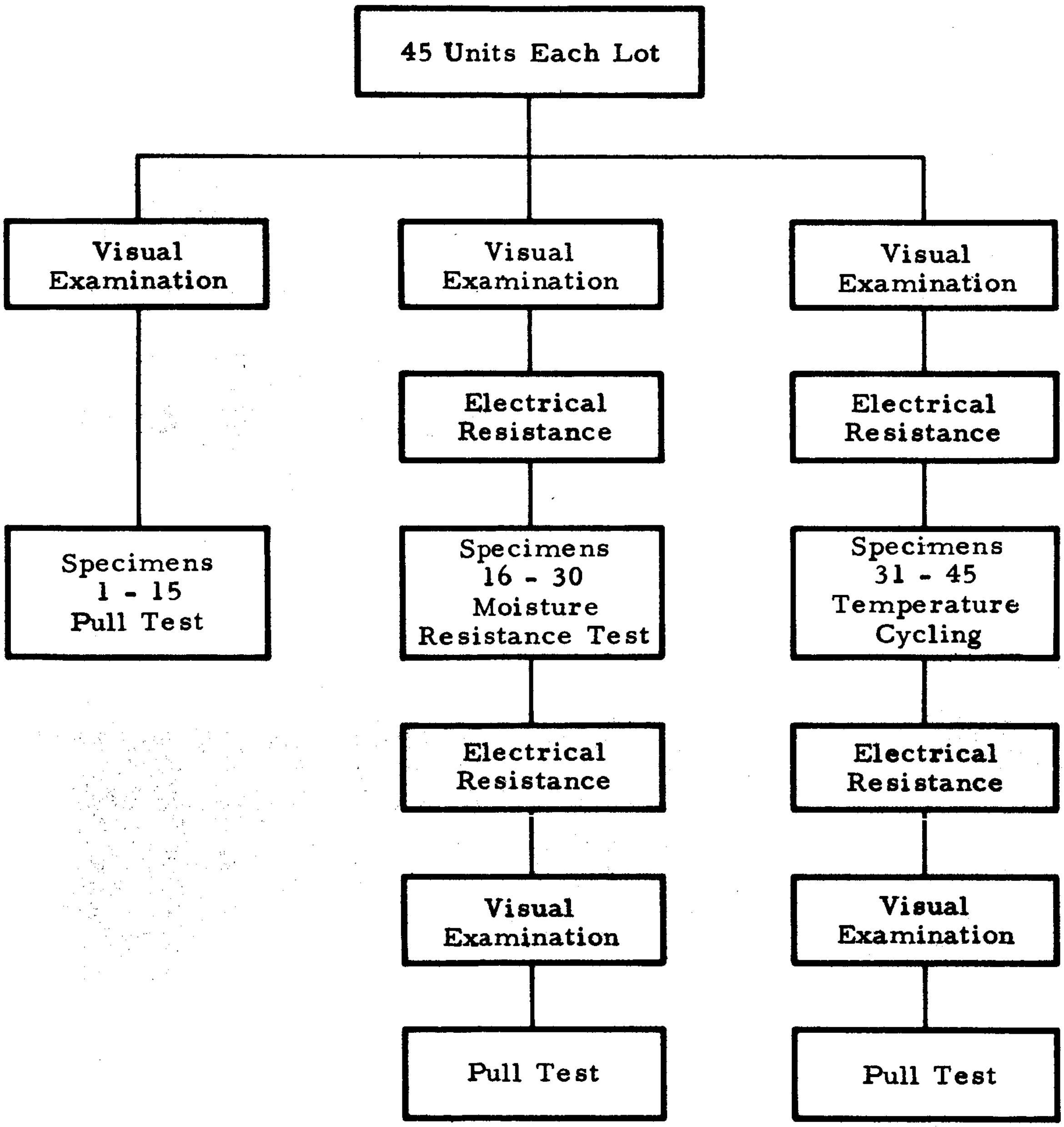


Figure 13. Flow chart for testing of specimens.

7.2 Visual Examination

Each specimen (2 joints) shall be visually inspected under 20X magnification using a Leitz Wetzlar binocular microscope assisted by an Americal Optical Illuminator Model 11144. Visual inspection will be done following initial fabrication as described in Paragraphs 6.1.2, 6.2.2, 6.3.2, and 6.4.2 and after moisture resistance testing and temperature cycling.

A specimen shall be considered to have failed if there is any corrosion evident following moisture resistance testing or temperature cycling or if the wire breaks at or near (within 1/8-inch) the termination during temperature cycling. If during stripping of the magnet wire the wire is abraded or etched to a depth in excess of 1/5 the wire diameter, it shall be considered a failure.

7.3 Pull Test

7.3.1 Equipment:

a) Instron Tensile Tester, Model TTC-M1-M4.
b) Parallel-grip jaws.
c) Tensile Load Cell B.

7.3.2 Procedures:

Step 1. Set up the Instron Tensile Tester on the 0-100 gram range using a crosshead speed of 12 inch/minute and a chart speed of 10 inch/minute.

Step 2. Align the specimen in the parallel-grip jaws as shown in Figure 14. The jaws should grab the nickel wire approximately 1/2-1 inch from the free end. Alignment shall be done carefully to avoid stressing the joints. See Figure 15.

Step 3. Apply a gradually increasing load to the specimen until either the magnet wire breaks or one of the two joints fail.

Step 4. Record the breaking force (in grams) on the applicable Raw Data Form and also record the location of the break (e.g., joint failure; wire failure 2" from joint, etc.). A failure within 1/8" of the

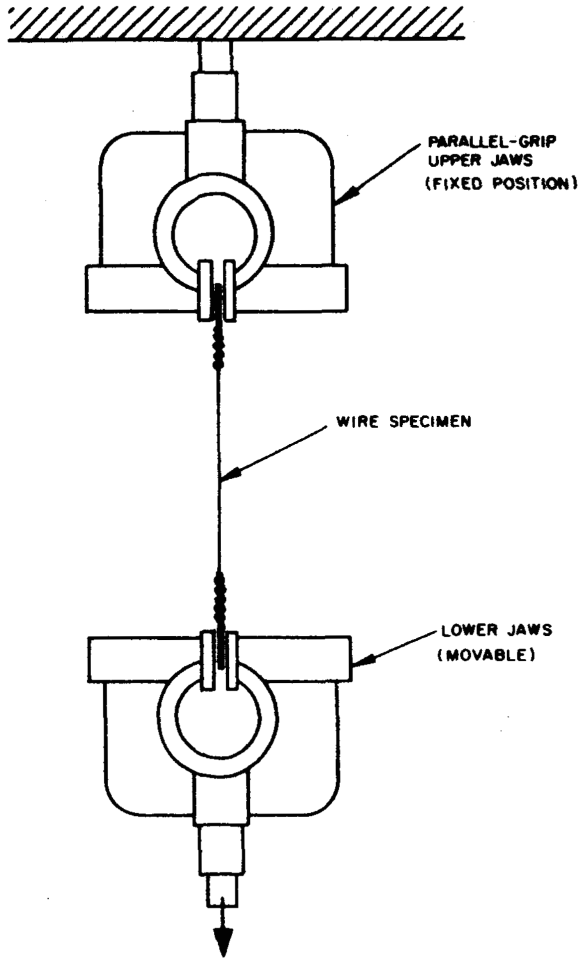


Figure 14. Sketch illustrating a typical wire specimen clamped in jaws of Instron Tensile Tester.

joint shall be considered a joint failure. Failures of the magnet wire shall be recorded in distance from the jóint clamped in the upper jaws.

Step 5. Remove the two pieces of the broken specimen from the jaws of the Instron Tensile Tester and tape them together with a suitable identification. All specimen pieces shall be bagged and identified for submittal to JPL at the end of the program.

7.4 Electrical Resistance Test

7.4.1 Equipment:

a) Electrical resistance test fixture with Daymarc Model 131-40 Four Terminal Kelvin Connection Jig and Model 131-401 Adapter Base.

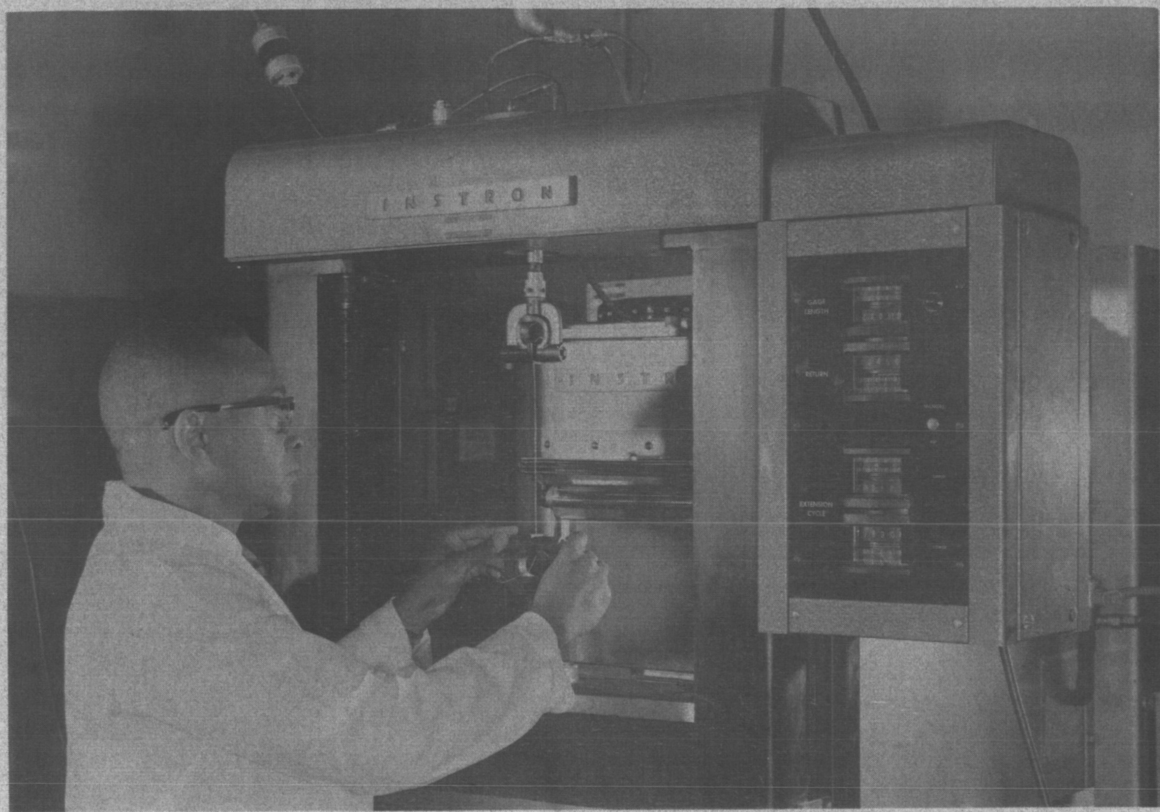


Figure 15. Operator adjusting a length of wire between parallel-grip jaws of Instron Tensile Tester prior to applying load. (R102822)

b) Weston Model 931 D. C. Milliammeter.

c) Kepco Model SM-36-5M Voltage Regulated D. C. Power Supply.

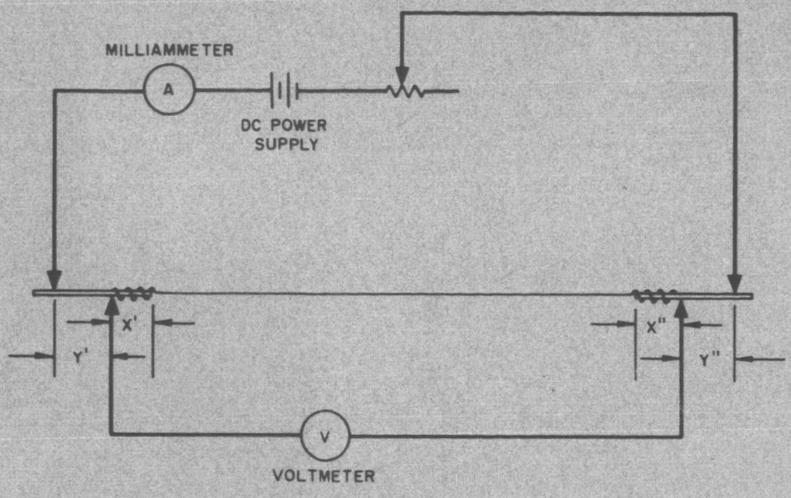
d) Kintel Model 203 Microvolt-Ammeter.

e) Helipot Model "A" Variable Potentiometer, 0.5% linearity.

7.4.2 Procedures. Electrical resistance of all specimens shall be measured before and after moisture resistance testing and temperature cycling per Figure 9.

Step 1. Set up electrical resistance measuring equipment per the schematic diagram shown in Figure 16.

Step 2. Place the specimen in the fixture (see Figure 17) with the nickel wires in the magnetic connection jigs.



X' = X" ≅ 1/2" (CONSTANT FOR ALL SPECIMENS)
Y' = Y" ≅ 1" (CONSTANT FOR ALL SPECIMENS)

Figure 16. Schematic diagram of test set-up for making resistance measurements using the voltmeter-ohmmeter method.

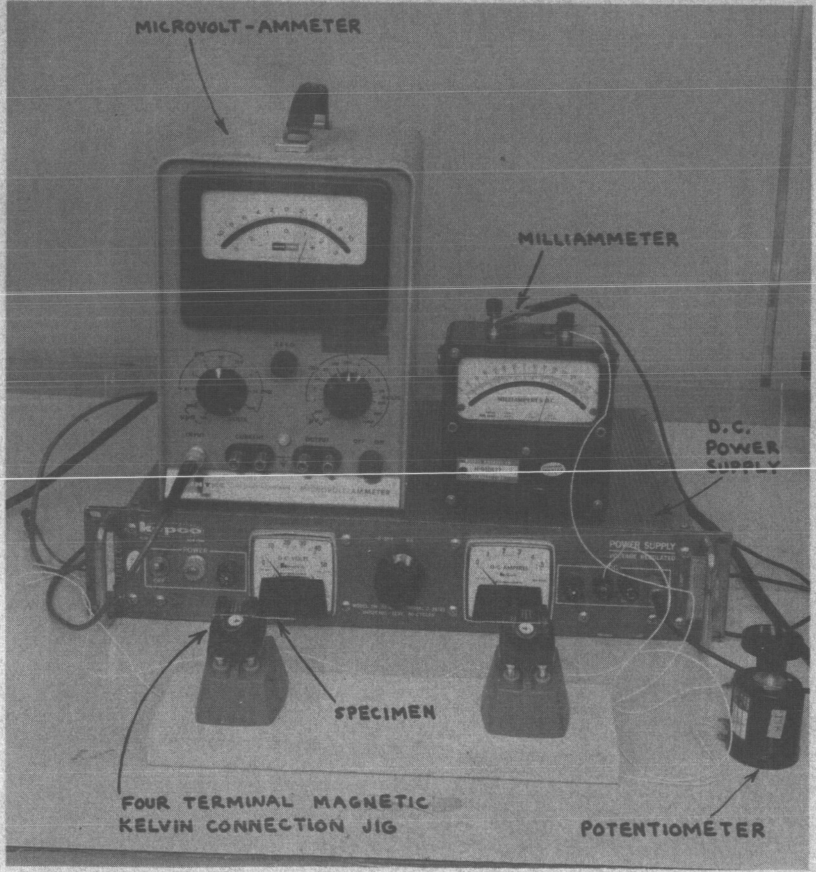


Figure 17. Electrical resistance measuring test apparatus. (R106653)

Step 3. Adjust the ends of the nickel wires in each magnetic connection jig so that they align with the outside edge of the jig.

Step 4. Using the potentiometer adjust the current on the milliammeter to 100 milliamperes.

Step 5. Wait one minute and then read the voltage across the two joints on the voltmeter.

Step 6. Record the resistance value (in ohms) on the applicable Raw Data Form. With an applied current of 100 milliamperes (0. 1 amperes), the resistance value (in ohms) is equal to the voltage reading (in volts) multiplied by 10.

7. 5 Moisture Resistance Test

7. 5. 1 Equipment:

a) Moisture resistance test fixture.

b) Conrad Temperature-Humidity Chamber, Model FD-8-1, equipped with a Honeywell temperature recorder.

7. 5. 2 Procedures. Moisture resistance testing of all specimens will be done in accordance with the conditions specified in MIL-STD-202C, Method 103B, Test Condition A.

Step 1. Load specimen in special test figure as shown in Figure 18. The specimen shall be placed through the hole in the phenolic top plate with the end of the nickel wire bent over the edge. The other end of the specimen shall hang through the corresponding hole in the phenolic upper guide plate. Thus all specimens will be suspended from one end with the other end hanging free. See Figure 20. All specimens are separated from each other and identified in accordance with the applicable hole pair. All joints are exposed to the environmental conditions. This test fixture is designed to hold all 495 specimens at once.

Step 2. Place the loaded test rack in the Temperature-Humidity Chamber. See Figure 19.

Step 3. Expose the specimens to a steady state environment of 90-95 percent relative humidity and 40°C ± 2°C for 240 hours. No polarizing voltage shall be applied.

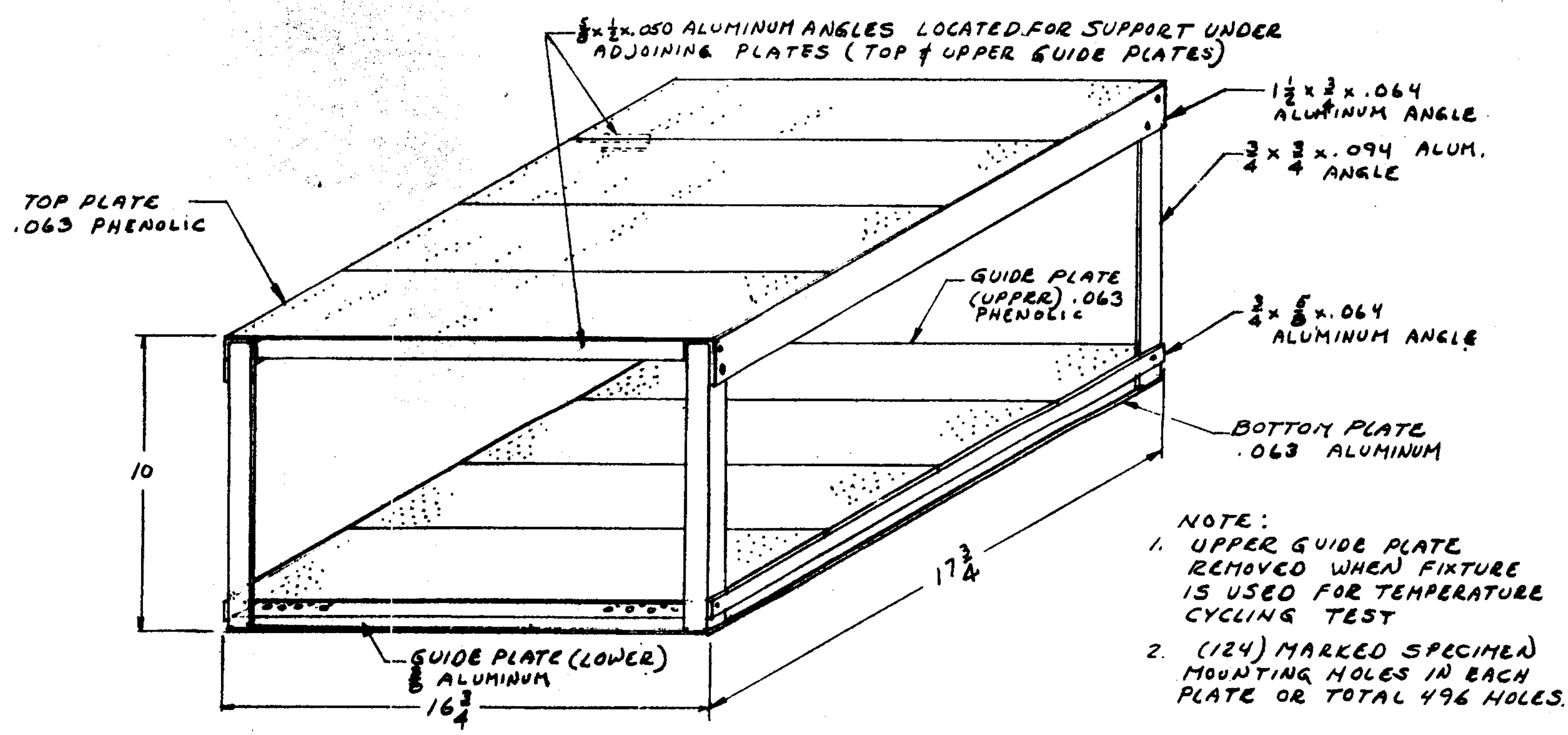


Figure 18. Dual purpose fixture for humidity test and temperature cycling test.

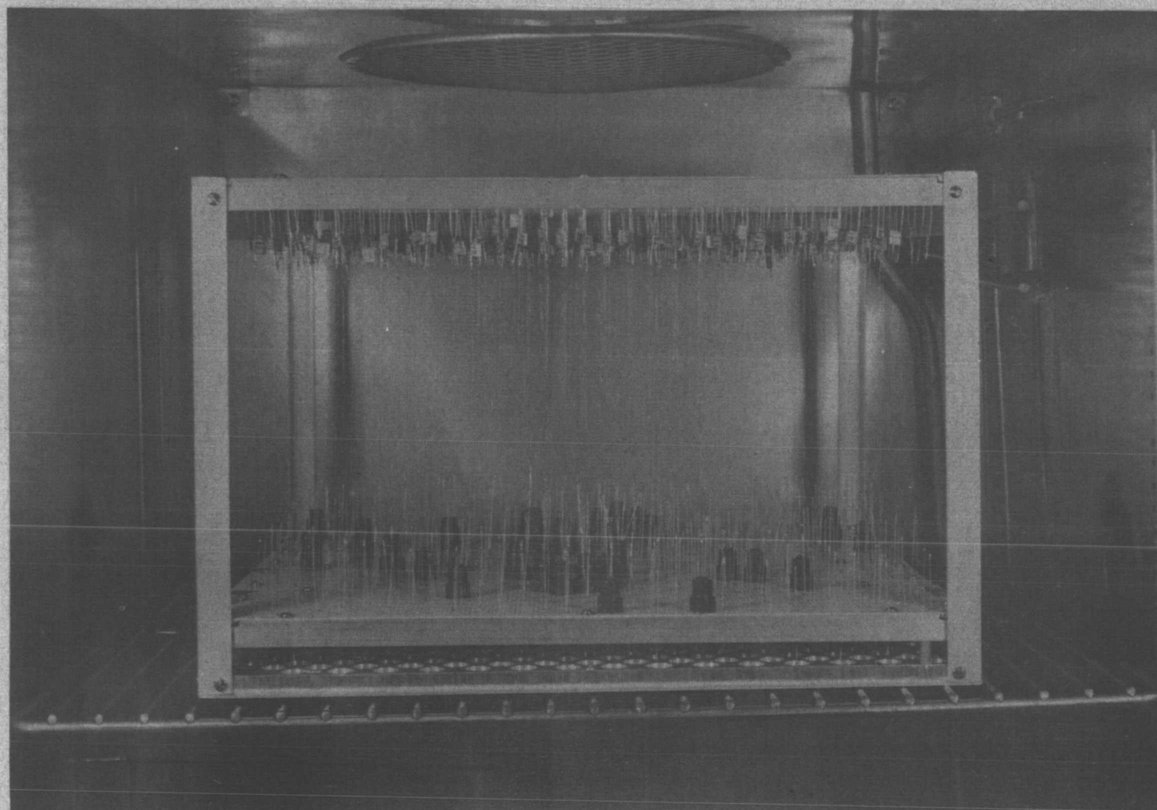


Figure 19. Moisture resistance test fixture in Conrad Temperature-Humidity Chamber. Note that all magnet wire specimens are individually labeled and each hangs free in its pair of alignment holes. The black tubes are for those few specimens which were slightly shorter than the others. (R106819)

Step 4. At the end of 240 hours remove the specimens from the chamber and wait at least 4 hours at room ambient prior to making any electrical measurements. Note and record any failed specimens on the applicable Raw Data Sheet.

7.6 Temperature Cycling Test

7.6.1 Equipment:

a) Conrad Temperature Chamber, Model FB-10-3-3

b) Despatch Oven, Model V-29.

c) Temperature cycling test fixture

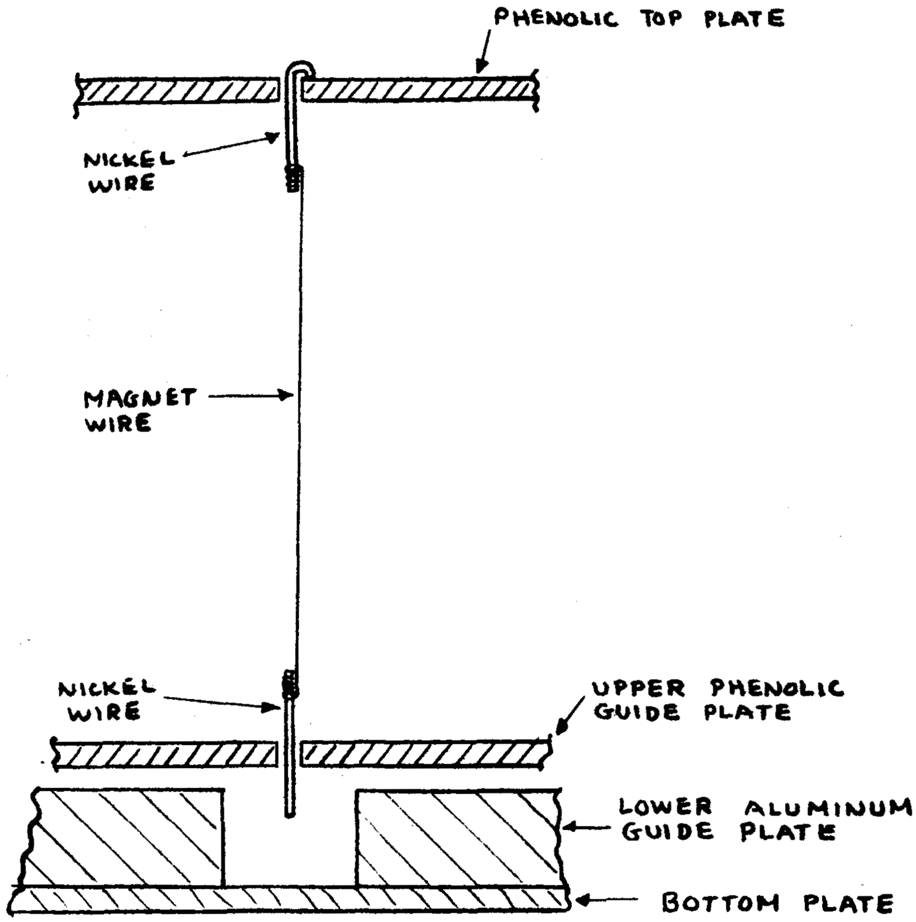


Figure 20. Moisture resistance test.

d) Set of calibrated weights (1/2" diameter brass rods cut to length).

7.6.2 Procedures. Temperature cycling of all specimens shall be done in accordance with the conditions specified in MIL-STD-202C, Method 102A, Test Condition C.

Step 1. Load specimen in special test fixture as shown in Figure 21. The specimen shall be placed through the hole in the phenolic top plate with the end of the nickel wire hooked over the edge of the hole. The other end of the specimen shall have a weight attached to the nickel wire equal to 1/2 the average strength of the specimens (disregarding any extremely high or low pull test values) under pull testing as

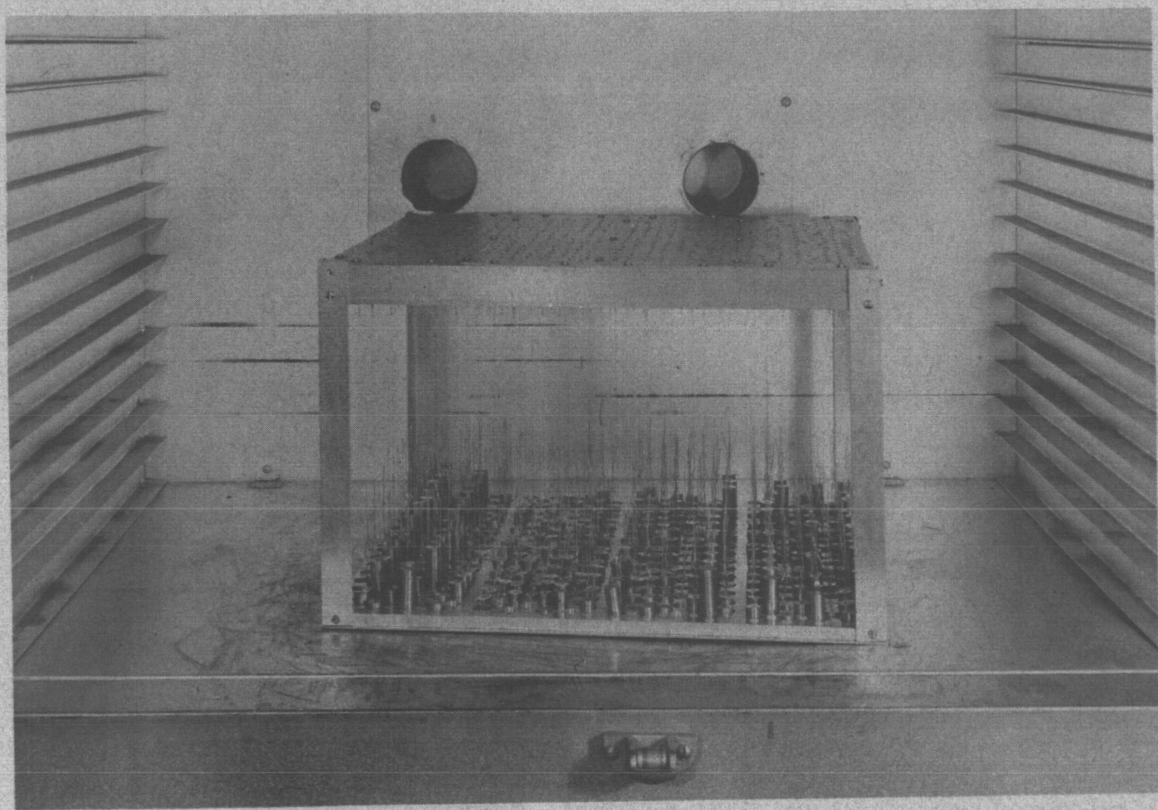


Figure 21. Temperature cycling test fixture in Despatch Oven. Note that each magnet wire specimen has a weight attached and that the weights vary according to the type of specimen. (R107111)

described in Paragraph 7.3 The upper guide plate has been removed from the dual purpose test fixture so that the weights will fall into individual cavities drilled in the lower aluminum guide plate if the joint fails. Thus a falling weight will not disturb any adjacent specimen. See Figure 22.

Step 2. When the fixture is completely loaded with specimens and all weights are in place, carefully place the fixture in the Conrad Temperature Chamber at -65° C.

Step 3. After 30 minutes at -65° C remove the fixture from the Conrad Temperature Chamber and hold at room temperature (+25° C) for 10-15 minutes.

Step 4. Next place the fixture in the Despatch Oven at +125° C.

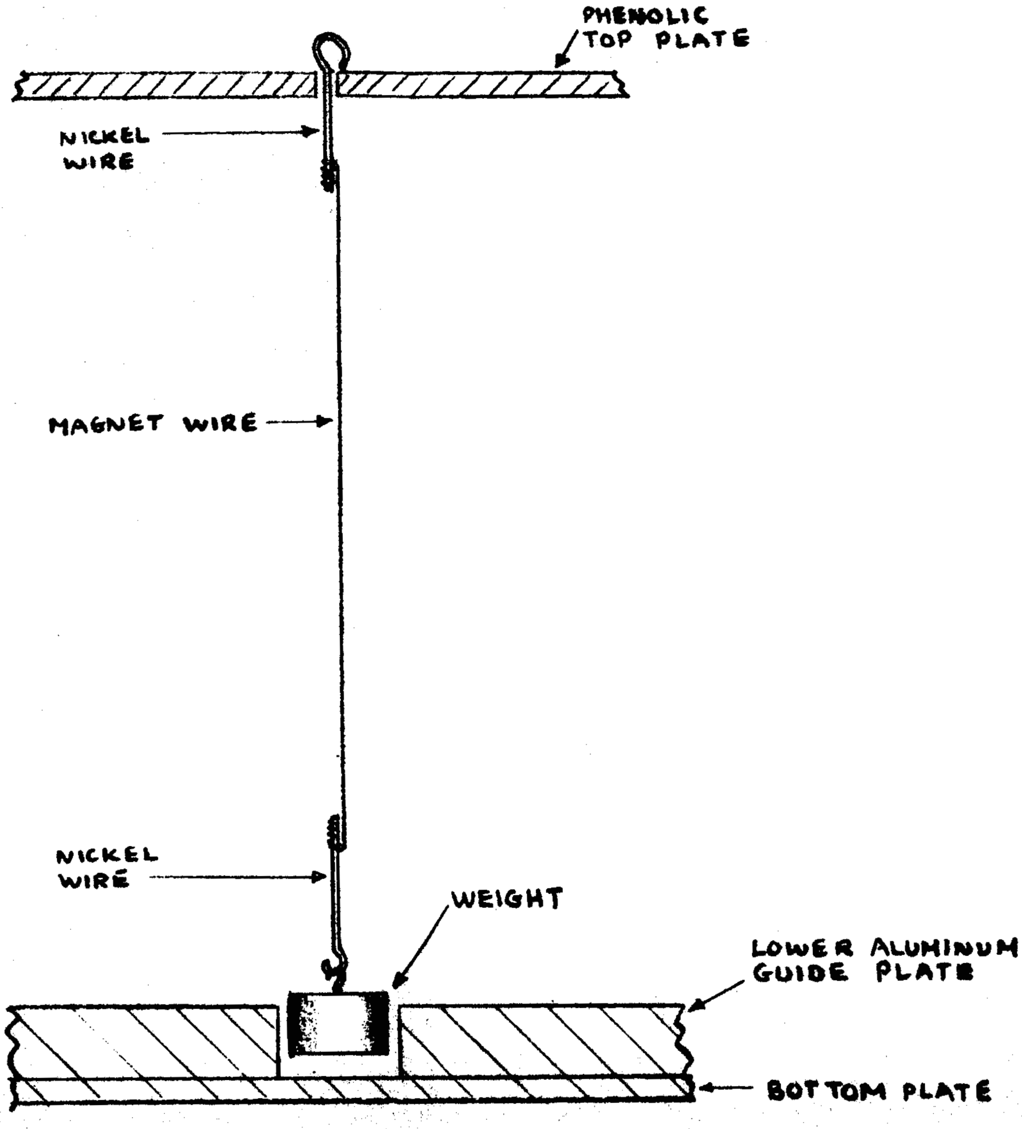


Figure 22. Temperature cycling test.

Step 5. After 30 minutes at +125° C remove the fixture from the Despatch Oven and hold at room temperature (+25° C) for 10-15 minutes.

Step 6. Repeat Steps 2 through 5 for four additional cycles (i. e., a total of 5 cycles).

Step 7. At the end of the fifth cycle, carefully remove the weights from the specimens and remove the specimens from the fixture. Note any failed specimens on the applicable Raw Data Sheet with the location of the break (i. e., joint failure or wire failure). All failed specimens shall have their halves taped together, identified, and bagged.

8. TEST RESULTS

8.1 Chemical Wire Stripping

Five different vendors were contacted regarding their recommendations for chemical stripping of fine gauge magnet wire insulation. London Chemical Company, Melrose Park, Illinois, and Fidelity Chemical Products Corp., Newark, New Jersey were responsive and their recommended products have been evaluated.

The London Chemical Company strippers evaluated were:

a) Lonco Cream Stripper No. 504

b) Lonco No. 3111 – HH Wire Stripper

c) Lonco Cold Wire Stripper No. 416

These strippers were all evaluated for stripping Formex insulation. London Chemical Co. also has a stripper (i. e., Lonco PT-5-ML) applicable for stripping high temperature insulation, such as DuPont ML, but since this stripper was not available at the time of the tests it was not evaluated.

The Fidelity strippers evaluated were:

a) Super X-Var Stripper No. 622

b) No. 990 Wire Stripper

c) ML Insulation Stripper No. 956

Walsco Electronics Corp. Stripvar was also evaluated as a chemical stripper for the Formex insulation. In view of the safety hazards involved with the use of hydrazine as a stripper, it was decided not to evaluate hydrazine since other less hazardous strippers were available which appeared to perform satisfactorily.

The results of the chemical stripping tests showed the Lonco No. 416 Cold Wire Stripper to be the best for the Formex insulation and the Fidelity No. 956 ML Insulation Stripper to be the best for stripping ML-type insulation.

Brief tests were also conducted concerned with the solubility of various chemical wire strippers in commercial solvents. The tests were conducted by placing two drops of the applicable chemical stripper in 15 ml of the solvent and observing the results after 10 minutes without agitation and after 5-10 seconds of agitation. These results are presented in Table III. The results varied considerably since certain of the strippers (i. e., #990 stripper) were insoluble in all solvents used while other strippers (i. e., #956 ml stripper) were soluble in all the solvents.

Chemical Wire Stripper	Solvent			
	Denatured Ethyl Alcohol	Acetone	Isopropyl Alcohol	Water
1) Super X-VAR #622	Partially soluble	Insoluble	Insoluble	Insoluble
2) #990 stripper	Insoluble	Insoluble	Insoluble	Insoluble
3) Lonco stripper #3111-H	Soluble	Soluble	Soluble	Insoluble
4) Strip Var	Insoluble	Soluble	Insoluble	Insoluble
5) Strip-X #26-2	*Slightly soluble	Slightly soluble	Insoluble	Insoluble
6) Stripper #956	*Slightly soluble	Soluble	Soluble	Soluble
7) Lonco cream wire stripper #504	*Slightly soluble	Soluble	Insoluble	Soluble
8) 956 ML stripper	Soluble	Soluble	Soluble	Soluble
9) Lonco wire stripper #416	Insoluble	Insoluble	Soluble	Soluble
*Colloidal suspension.				

Table III. Test results for the solubility of various chemical wire strippers in commercial solvents.

8.2 Mechanical Wire Stripping by Motor-Driven Strippers

Samples of #42, #46, and #50 AWG magnet wire with Formvar, Isonel, and ML insulations were sent to three manufacturers for stripping trials with their motor-driven brush strippers.

The Eraser Company did all stripping on their Rush Model R-1 Fine Wire Stripper using a pair of Rush GR 640 BEV FybRglass Stripping Wheels. They experienced difficulty only with the #50 AWG Formvar and the #50 AWG Isonel-200 magnet wire .

Ideal Industries did all stripping with the #45-102 Twin Cone Stripper using L-5279 fiberglass brushes. They pointed out that the brushes had to be dressed frequently and that from 6-12 seconds per strip were required, depending on the insulation type. They were unable to do any of the #50 AWG magnet wire samples without considerable breakage. The #42 AWG and #46 AWG specimens were stripped adequately.

Carpenter Manufacturing Company did their stripping tests using the Model 88 Twincone wheel type wire stripper with Grade 640 and Grade 601 fiberglass stripping wheels. In their judgement the #42 and #46 Formvar could be stripped using the Grade 640 wheels. The #42 and #46 Isonel could be stripped using either the Grade 640 or Grade 601 wheel. The Grade 601 wheels, being more abrasive, would require fewer passes. The #42 and #46 ML could be stripped with the Grade 601 wheels. Both the Isonel and ML wires would require more care than the Formvar wire. They stated that the #50 wire, regardless of the insulation, would present a problem and that they were unable to consistently strip the #50 Isonel or #50 ML.

In summation none of the companies contacted could consistently strip #50 AWG magnet wire. Although all mechanical stripping during this test program was done manually using a fine grit abrasive cloth, the spoilage with the #50 AWG magnet wire was very high and only a skilled operator could strip the wire cleanly without excessively weakening the wire. In no case did mechanical stripping equal chemical stripping where complete insulation removal was concerned.

8.3 Visual Inspection of Magnet Wire Interconnections

Throughout this test program, each magnet wire test specimen was visually inspected several times under 20X magnification. A series of photomicrographs at 15X magnification were taken of typical specimens fabricated by each of the four joining methods. These photomicrographs are presented in Figures 23, 24, 25, and 26 and serve to give the reader a view of the interconnection as seen by the operator or inspector. Each joining method is represented by two interconnections — one with #42 AWG magnet wire and one with #50 AWG magnet wire. It should be noted that the outline of the magnet wire is visible beneath the solder and that the solder coverage over the magnet wire and nickel wire is complete and shiny indicating good wetting and filleting.

The magnet wire in Figure 23 has been stripped chemically, but the insulation was not removed prior to joining in the methods shown in Figures 24, 25, and 26.

8.4 Raw Data Sheets

A total of thirty-three (33) Raw Data Sheets have been prepared recording the test data for the 1485 magnet wire specimens listed in Table II. These Raw Data Sheets can be found in the Appendix of this final report. Each Raw Data Sheet includes data for:

a) Initial resistance (in ohms)
b) Resistance after humidity (in ohms)
c) Resistance after temperature (in ohms)
d) Break force (in grams)
e) Point of break

Each data sheet includes values for 45 specimens of each of the nine (9) wire types and sizes and for each of the five (5) joining methods. After pull testing the specimen was examined and if the point of break was within 1/8-inch of the joint it was recorded as a "joint" failure. If the point of break was greater than 1/8-inch from the joint it was recorded as a "wire" failure and the distance (in inches) from the closest joint was measured and recorded.

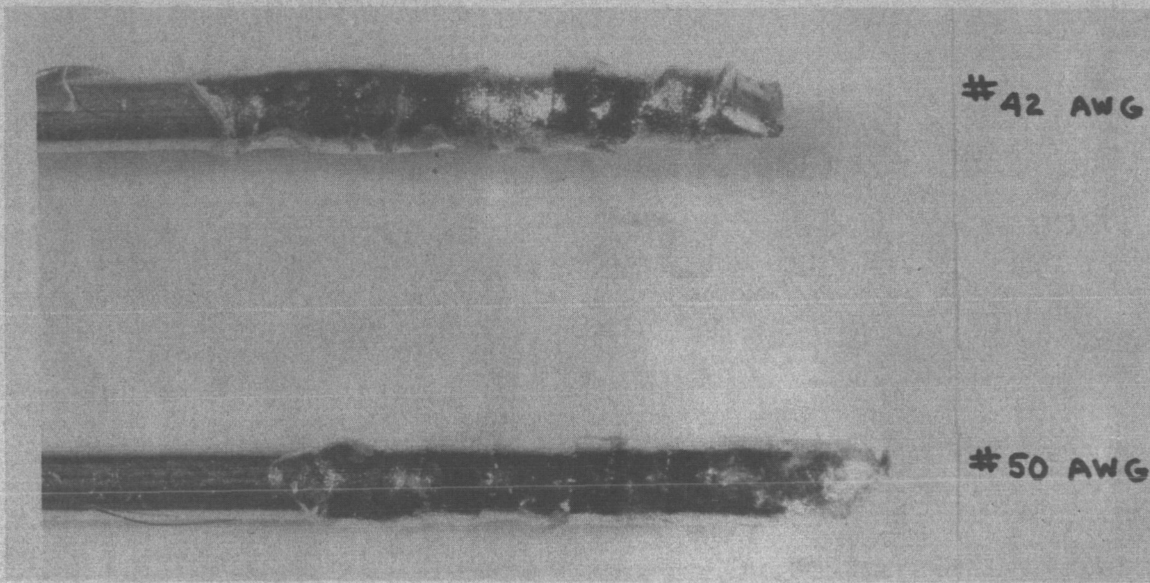


Figure 23. Photomicrograph at 15X magnification of magnet wire interconnection by manual soft soldering.

Figure 24. Photomicrograph at 15X magnification of magnet wire interconnection by torch fusing.

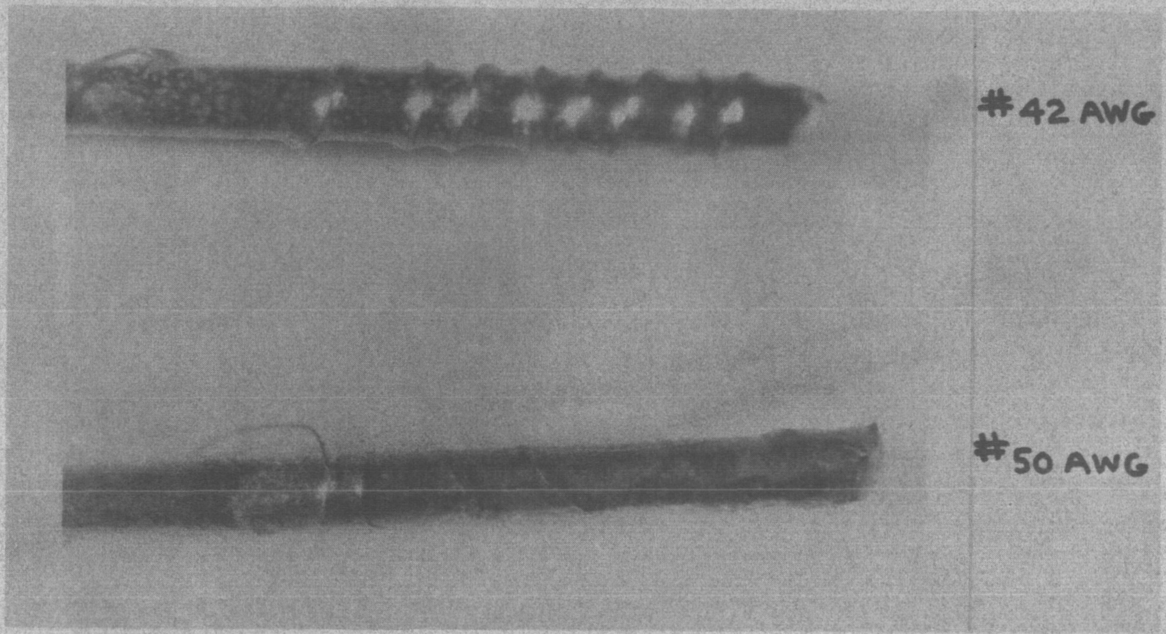


Figure 25. Photomicrograph at 15X magnification of magnet wire interconnection by soft solder dipping at 1000°F.

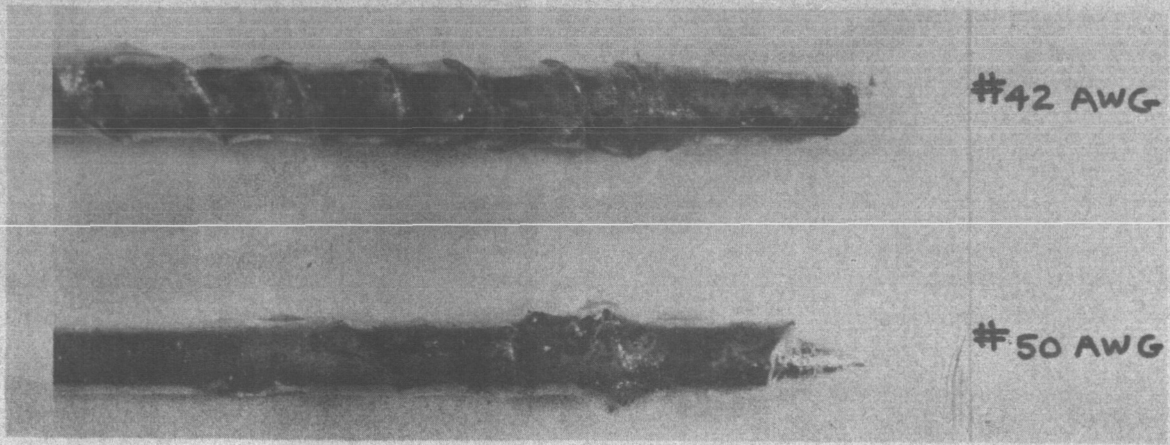


Figure 26. Photomicrograph at 15X magnification of magnet wire interconnection by silver solder dipping at 1200°F.

After humidity testing and after temperature cycling following the electrical resistance tests, each specimen was visually examined. If corrosion was evident at either joint, it was identified as "corrosion" on the data sheet. Certain specimens (particularly with the #50 AWG wire) were so delicate and weak that they were broken during handling—usually during loading in the tensile tester or in the electrical resistance connection jig. These specimens were identified on the data sheets as "broken during handling." Other weak specimens broke during loading of the rack for humidity testing or broke as soon as the weight was attached for the temperature cycling test. These specimens have been carefully identified on the Raw Data Sheets in the applicable row and column.

If a specimen broke during the humidity test (by its own weight) or during the temperature cycling test (by the attached weight) it was recorded on the data sheet as "failed."

All specimens after pull testing (or other means of failure) were taped together, labeled, and placed in plastic bags by separate categories. These specimens were delivered to the Jet Propulsion Laboratory. The labeling of the specimens was coded in accordance with the specimen number (1 through 45) and the number of the Raw Data Sheet (1 through 33). Thus specimen 41-23 would be specimen #41 from Raw Data Sheet 23. The colored tags on each specimen represent specimen numbers. Looking at Raw Data Sheet 23, this specimen was prepared by Operator B, was of #46 AWG Isonel magnet wire and was joined by soft solder pot dipping. Specimen 23-41 failed during temperature cycling.

The 33 Raw Data Sheets in the Appendix of this report actually represent the culmination of the efforts under this contract. Since, under the terms of the contract, all data analysis was eliminated, these data sheets must be considered as complete and final without summation or statistical calculations.

9. DISCUSSION OF TEST RESULTS

9.1 Pull Testing of Magnet Wire Types and Sizes

Prior to pull testing actual test specimens, 12-inch lengths of the 9 types and sizes of insulated magnet wire were tensile tested. The strength values are given in Table IV. It is interesting to note that the strength of the magnet wire is dependent, in part, on the type of insulation coating which covers the wire – the ML insulation being the strongest.

Comparing the values in Table IV with the break force values on the Raw Data Sheets, one notes that, in only a few isolated instances, did the breaking force of the magnet wire specimen approach the actual strength of the magnet wire itself – even when the point of break was more than an inch from the joint.

9.2 Time Study for Various Joining Methods

A random time study was made of the various joining methods by each of the operators. The results of this study are presented in Table V. The numbers within the blocks represent the time (in minutes) required to make 5 specimens (i. e., 10 joints – one at each end of the specimen) by that particular technique. Fusing with the micro torch took the longest time and was also the most demanding of the operator. As a general rule, as the wire size decreased the time required to make the specimen increased. Operator B was also slower than Operator A.

The two solder dipping joining methods require a minimum of operator skill and can be done equally as fast by either operator. Torch fusing and hand soldering require more skill (and a steady hand) and therefore the experienced operator is much faster.

9.3 Spoilage of Specimens

A record was maintained of the number of spoiled specimens by each operator. This record is presented in Table VI. Each block in the rows designated "A" (for Operator A) represents the fabrication of

	STRENGTH		STRENGTH		STRENGTH	
#42H THERMALEZE	(grams)	#42H FORMEX	(grams)	#42H ML	(grams)	
1	88	1	92	1	100	
2	90	2	92	2	100	
3	90	3	92	3	105	
AVG.	89.3	AVG.	92.0	AVG.	101.7	
#46H		#46H		#46H		
ISONEL		FORMVAR		ML		
1	35	1	38	1	43	
2	38	2	38	2	43	
3	37	3	38	3	43	
AVG.	36.7	AVG.	38.0	AVG.	43.0	
#50H		#50H		#50H		
ISONEL		FORMVAR		ML		
1	14	1	15	1	18	
2	14	2	15	2	17	
3	13	3	15	3	17	
AVG.	13.7	AVG.	15.0	AVG.	17.3	

Table IV. Pull test strength data on various types of insulated magnet wire.

JOINING METHOD		MAGNET WIRE TYPE AND SIZE								
		42 THERMALEZE	46 ISONEL	50 ISONEL	42 FORMEX	46 FORMVAR	50 FORMVAR	42 ML	46 ML	50 ML
1. MECHANICAL STRIP AND HAND SOLDER	A	—	—	—		10.1		8.2		14.8
	B	—	—	—		14.3	19.3			20.7
2. CHEMICAL STRIP AND HAND SOLDER	A	—	—	—						
	B	—	—	—						
3. FUSE WITH MICRO TORCH	A				21.5				23.3	24.9
	B				36.9	29.0				
4. SOFT SOLDER POT DIP (1000°F)	A					12.0		—	—	—
	B						16.9	—	—	—
5. SILVER SOLDER POT DIP (1200°F)	A	7.5	6.6	7.5				—	—	—
	B							—	—	—

Table V. Time study for various joining methods. Numbers within blocks represent time (minutes) required to make 5 specimens (i. e., 10 joints).

24 specimens. Each block in the rows designated "B" (for Operator B) represents the fabrication of 21 specimens. The numbers within the blocks represent the number of specimens which were spoiled by that operator. It should be noted that spoilage was especially high for joining methods: a) fusing with the micro torch; and b) by soft solder pot dipping. This is particularly true with the #50 AWG wire sizes. The least amount of spoilage occurred during joining by hand soldering and

JOINING METHOD	Operator	MAGNET WIRE TYPE AND SIZE								
		42 THERMALEZE	46 ISONEL	50 ISONEL	42 FORMEX	46 FORMVAR	50 FORMVAR	42 ML	46 ML	50 ML
1. MECHANICAL STRIP AND HAND SOLDER	A				0	0	0	0	0	0
	B				0	0	0	0	5	0
2. CHEMICAL STRIP AND HAND SOLDER	A				0	0	0	0	0	0
	B				0	0	6	0	0	0
3. FUSE WITH MICRO TORCH	A	5	7	4	0	5	11	3	2	3
	B	0	0	21	4	1	7	0	0	18
4. SOFT SOLDER POT DIP (1000°F)	A	6	1	18	15	2	18			
	B	8	0	0	1	0	6			
5. SILVER SOLDER POT DIP (1200°F)	A	1	1	3	0	4	5			
	B	5	0	1	0	1	1			

Table VI. Spoilage study for various joining methods. Numbers within blocks represent number of spoiled specimens by Operators A and B.

those specimens which were spoiled were by Operator B (the inexperienced operator). For all practical purposes <u>both</u> operators could be considered as inexperienced for joining methods by torch fusing, soft solder dipping, and silver solder dipping, since neither operator had ever used these joining techniques before.

The primary reasons for spoilage were as follows:

a) Hand Soldering – Incomplete stripping of the magnet wire.

b) Torch Fusing – Burning of the magnet wire with the torch flame and non-wetting of the silver solder-flux mixture with the magnet wire and gold plated nickel wire.

c) Soft Solder Pot Dipping – Magnet wire not wrapped around the nickel wire well enough to prevent burning of the magnet wire during the dipping operation. Spoilage also occurred due to the magnet wire sliding up the nickel wire during the dipping operation.

d) Silver Solder Pot Dipping – Spoilage occurred for the same reasons as with the soft solder pot dipping technique.

In general, spoilage of the #50 AWG wire sizes also resulted due to normal handling operations because of the fragility of this wire size.

9.4 Electrical Resistance Aging Tests

Fifteen specimens each of #46 AWG Formvar magnet wire by three different joining methods (i. e., hand solder, torch fuse, and silver solder dip) were aged at room ambient conditions for 30 days. The electrical resistance of these specimens was measured before and after aging to see if there was any significant change. These values are reported in Table VII. It appears that the resistance changes vary randomly and that no significant change has occurred.

These values can then be compared with the corresponding electrical resistance values after temperature cycling found on Raw Data Sheets 8, 17, and 32. This comparison will establish whether any change in resistance after temperature cycling is due to the temperature cycling environment or due to normal aging. Although a statistical analysis of these results must be done to establish a firm conclusion, a cursory glance at the test values seems to show that the resistance changes after temperature cycling are, in general, higher than one would expect due to normal aging alone.

	46 FORMVAR CHEMICAL STRIP AND HAND SOLDER		46 FORMVAR TORCH FUSE		46 FORMVAR SILVER SOLDER DIP	
SPECIMEN NUMBER	RESISTANCE (in ohms) NO AGING	RESISTANCE (in ohms) 30 DAYS AT ROOM AMBIENT	RESISTANCE (in ohms) NO AGING	RESISTANCE (in ohms) 30 DAYS AT ROOM AMBIENT	RESISTANCE (in ohms) NO AGING	RESISTANCE (in ohms) 30 DAYS AT ROOM AMBIENT
31	2.55	2.55	2.60	2.60	2.65	2.85
32	2.35	2.35	2.45	2.44	2.40	2.46
33	2.30	2.28	2.70	2.70	2.45	2.45
34	2.30	2.28	2.30	2.30	2.35	2.40
35	2.30	2.25	2.50	2.50	2.45	2.42
36	2.35	2.30	4.90	4.20	2.45	2.48
37	2.45	2.43	2.40	2.40	2.45	2.45
38	2.50	2.50	2.10	2.10	2.45	2.43
39	2.40	2.37	2.15	2.19	2.30	2.30
40	2.40	2.35	2.20	2.20	2.25	2.25
41	2.45	2.42	2.15	2.20	2.35	2.34
42	2.35	2.30	2.05	2.09	2.25	2.24
43	2.45	2.40	2.20	2.20	2.40	2.39
44	2.45	2.45	2.20	2.19	2.30	2.30
45	2.45	2.42	2.30	2.30	2.50	2.49

Table VIII. Electrical resistance before and after aging.

9.5 Discussion of Test Results on Raw Data Sheets

Unfortunately, under the terms of the contract, all data analysis was precluded. Without a statistical analysis of the data (e.g., calculations of the means, standard deviations, confidence intervals, etc.) and without a comparison of the summary calculations by means of curves or histograms, it is impossible to select, with any degree of confidence, the preferred magnet wire joining technique.

Certain trends, however, can be drawn from the Raw Data Sheets. It is noted that during pull testing, the vast majority of specimens failed at the joint rather than failing by separation of the magnet wire at some distance from the joint. Electrical resistance values, on the whole, appeared to increase slightly after both moisture resistance and temperature cycling tests. Corrosion was primarily observed on those specimens joined by torch fusing and silver solder dipping. Corrosion was more evident after moisture resistance testing than after temperature cycling. Specimen failure during temperature cycling (by virtue of the suspended weight) was more prevalent with those specimens prepared by soft solder dipping, especially with the #50 AWG wire sizes.

An examination of the breaking force data reveals that the strongest joints are those prepared by hand soldering chemically stripped magnet wire and the weakest joints are those prepared by soft solder pot dipping.

It is also interesting to note that corrosion was evident on only one specimen (out of 180 specimens environmentally tested) which had been chemically stripped. Chemical strippers are avoided by many companies due to the potential corrosion hazard resulting from residues not completely neutralized or removed.

10. CONCLUSIONS

Although the preclusion of any data analysis prevents any definite conclusions regarding the selection of a preferred magnet wire connection technique, it is felt that hand soldering is superior to the other methods evaluated. Hand soldering has these advantages:

a) Minimum amount of spoilage.
b) Joints can be made quickly.
c) Low resistance connections.
d) High joint strength.
e) Minimum of corrosion after humidity and temperature cycling.

If all residues can be neutralized or removed, it is felt that chemical wire stripping is superior to mechanical wire stripping (i. e., by manual abrasion methods). Chemical wire stripping has the disadvantage of a potential corrosion hazard but it also has the advantages of:

a) Clean stripping action.
b) Minimum wire spoilage.
c) Stripping can be done rapidly in that several wire groups can be stripped simultaneously.

Although not within the scope of this program, two other magnet wire joining techniques have been studied and show a certain amount of promise. Laser welding has been used successfully to join #38 AWG Formvar magnet wire to nickel wire without stripping the wire and without the use of fluxes. Resistance welding has also been used to join #42 and #50 AWG Formvar and Thermaleze magnet wire to gold plated nickel wire in less than 0.4 second without removing the insulation. This was accomplished using a Weltek Model AC-10 power supply with a Model 410-E weld head.

ACKNOWLEDGEMENT

This investigator wishes to express his appreciation to the following people for their participation in this program:

Mr. D. L. Teter for preparation of the test specimens as Operator B and for assistance in moisture resistance testing.

Mr. R. C. Browne for electrical resistance testing.

Miss Marion Case for preparation of the test specimens as Operator A and mechanical stripping of the magnet wire.

Mr. J. Cowan and Mr. M. Keegan for tensile testing.

Mr. D. L. Hirsch for the design and fabrication of the dual purpose test fixture and for his evaluation of the chemical wire strippers.

APPENDIX 1. LISTING OF ENVIRONMENTAL AND ELECTRICAL TEST EQUIPMENT

Equipment Type and Usage	Manufacturer	Model Number	Serial Number	Date of Latest Calibration	Next Calibration Due	Personnel Assigned to Measurement
1. Temperature – Humidity chamber used for moisture resistance test	Conrad	FD-8-1	7254	10-12-65	1-12-66	D. L. Teter
2. Temperature chamber used for -65° C temperature during temperature cycling	Conrad	FB-10-3-3	7302	9-23-65	12-23-65	F. Z. Keister
3. Oven used for +125° C temperature during temperature cycling	Despatch	V-29	52771	9-24-65	12-23-65	F. Z. Keister
4. Microvolt – Ammeter used for voltage measurements	Kintel	203	3639	10-15-65	2-15-66	R. C. Browne
5. DC milliammeter used for current measurements	Weston	931	35045	11-5-65	3-8-66	R. C. Browne
6. Voltage regulated DC power supply used in making electrical resistance measurements	Kepco	SM-36-5M	C-28793	As required	As required	R. C. Browne
7. Tensile tester used for pull strength tests	Instron	TTC-M1-M4	341	10-25-65	4-22-66	J. C. Cowan and M. E. Keegan

APPENDIX 2. CALCULATION OF WEIGHTS USED IN THE TEMPERATURE CYCLING TESTS

HUGHES AIRCRAFT CO.

ANALYSIS ________ MODEL REPORT NO. PAGE

PREPARED BY F. Keister 11/3/65

CHECKED BY ________

CALCULATION OF WEIGHTS USED IN TEMPERATURE CYCLING TESTS

CODE	WIRE SIZE	INSULATION	JOINING METHOD	½ WGT. REQ'D TO BREAK WEAKEST SAMPLE (grams) (based on pull tests of specimens 1-15)	WEIGHTS FOR TEMP. CYCLING TEST (grams) (based on pull tests of specimens 1-15)	
1	42	FORMEX	MECH. STRIP HAND SOLDER	23	32.1	
2	46	FORMVAR	"	7	10.7	
3	50	"	"	2	3.8	
4	42	ML	"	15	29.5	
5	46	"	"	8	11.5	
6	50	"	"	2.5	4.3	
7	42	FORMEX	CHEM. STRIP HAND SOLDER	35.5	41.1	
8	46	FORMVAR	"	6.5	14.3	
9	50	"	"	1.5	5.4	
10	42	ML	"	38	43.0	
11	46	"	"	7	16.4	
12	50	"	"	2	5.2	
13	42	THERMALEZE	TORCH FUSE	2.5	9.3	
14	46	ISONEL	"	1.5	10.7	
15	50	"	"	3.5	4.8	
16	42	FORMEX	"	10.5	25.0	
17	46	FORMVAR	"	6	11.0	
18	50	"	"	4	4.6	
19	42	ML	"	2	18.6	
20	46	"	"	0.5	12.1	
21	50	"	"	2	4.1	
22	42	THERMALEZE	SOFT SOLDER DIP	5	10.5	
23	46	ISONEL	"	2	8.2	
24	50	"	"	1	3.8	
25	42	FORMEX	"	4	14.7	
26	46	FORMVAR	"	2.5	8.2	
27	50	"	"	1.5	3.8	
28	42	THERMALEZE	SILVER SOLDER DIP	20	37.0	
29	46	ISONEL	"	8	14.2	
30	50	"	"	1	5.1	
31	42	FORMEX	"	21	38.4	
32	46	FORMVAR	"	12.5	14.5	
33	50	"	"	3	5.5	

FORM 703-C

APPENDIX 3. RAW DATA SHEETS (No. 1 THROUGH No. 33)

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 42 Formex JOINING METHOD Mechanically strip and hand solder

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A		Nov. 5, 1965	Nov. 24, 1965	54	JOINT
2 A				51	JOINT
3 A				61	JOINT
4 A				49	JOINT
5 A				46	WIRE - 1/2"
6 A				65	JOINT
7 A				61	WIRE - 1/4"
8 A				62	JOINT
9 B				73	JOINT
10 B				71	JOINT
11 B				77	JOINT
12 B				80	JOINT
13 B				80	JOINT
14 B				61	JOINT
15 B				71	JOINT
16 A	.930 Ω	.920 Ω		57	JOINT
17 A	.960 Ω	.950 Ω		72.5	JOINT
18 A	.980 Ω	.970 Ω		69.0	JOINT
19 A	.960 Ω	.958 Ω		46.0	7/16"
20 A	.960 Ω	.956 Ω		63.0	JOINT
21 A	.950 Ω	.940 Ω		74.5	JOINT
22 A	.970 Ω	.965 Ω		72.5	JOINT
23 A	.990 Ω	.930 Ω		68.5	JOINT
24 B	.890 Ω	.890 Ω		81.0	WIRE - 5/16"
25 B	.860 Ω	.860 Ω		74.5	JOINT
26 B	.890 Ω	.885 Ω		65.5	JOINT
27 B	.880 Ω	.875 Ω		78.0	JOINT
28 B	.910 Ω	.900 Ω		67.5	JOINT
29 B	.900 Ω	.895 Ω		38.0	JOINT
30 B	.900 Ω	.900 Ω		68.0	JOINT
31 A	.940 Ω		1.100 Ω	18.0	JOINT
32 A	.980 Ω		.970 Ω	21.0	JOINT
33 A	.810 Ω		1.070 Ω	4.5	JOINT
34 A	.990 Ω	–	FAILED	–	–
35 A	.960 Ω		1.000 Ω	44.5	JOINT
36 A	.960 Ω		.980 Ω	34.0	WIRE - 1/8"
37 A	.980 Ω		1.070 Ω	9.0	WIRE - 7/16"
38 A	.870 Ω		1.090 Ω	65.0	JOINT
39 B	.880 Ω		.880 Ω	53.0	JOINT
40 B	.860 Ω		.910 Ω	79.0	JOINT
41 B	.880 Ω		.895 Ω	79.0	JOINT
42 B	.890 Ω		FAILED	–	–
43 B	.880 Ω		.970 Ω	56.5	JOINT
44 B	.890 Ω		.920 Ω	56.0	JOINT
45 B	.840 Ω		.930 Ω	59.0	WIRE - 7/16"

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 46 Formvar JOINING METHOD Mechanically strip and hand solder

SPECIMEN NUMBER		INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE	POINT OF BREAK
1	A				—	Broke during handling
2	A				14 GRAMS	JOINT
3	A				19	JOINT
4	A				16	JOINT
5	A				22	JOINT
6	A				19	JOINT
7	A				18	JOINT
8	A				29	JOINT
9	B				27	JOINT
10	B				14	JOINT
11	B				30	JOINT
12	B				28	JOINT
13	B				30	JOINT
14	B				16	JOINT
15	B				20	JOINT
16	A	2.55 Ω	2.55 Ω		26	WIRE - 1/2"
17	A	2.35 Ω	2.35 Ω		21	JOINT
18	A	2.70 Ω	2.75 Ω		6	JOINT
19	A	2.45 Ω	2.47 Ω		24	JOINT
20	A	2.45 Ω	2.45 Ω		9	JOINT
21	A	2.35 Ω	2.35 Ω		22.5	JOINT
22	A	2.20 Ω	2.20 Ω		21.5	JOINT
23	A	2.00 Ω	2.00 Ω		32	JOINT
24	B	2.45 Ω	2.45 Ω		27	JOINT
25	B	2.45 Ω	2.47 Ω		25	JOINT
26	B	2.30 Ω	2.29 Ω		24.5	JOINT
27	B	2.35 Ω	2.35 Ω		3.0	JOINT
28	B	2.40 Ω	2.41 Ω		22	JOINT
29	B	2.40 Ω	2.41 Ω		13	JOINT
30	B	2.35 Ω	2.40 Ω		12	JOINT
31	A	2.15 Ω		* 2.20 Ω	18.5	JOINT
32	A	2.15 Ω		* 2.13 Ω	25.0	JOINT
33	A	2.15 Ω		* 2.17 Ω	35.5	JOINT
34	A	2.10 Ω		* 2.13 Ω	35.5	JOINT
35	A	2.15 Ω		* 2.15 Ω	33.5	JOINT
36	A	2.55 Ω		FAILED	—	—
37	A	2.10 Ω		* 2.13 Ω	10.5	JOINT
38	A	2.05 Ω		* 2.10 Ω	25.0	JOINT
39	B	2.50 Ω		2.55 Ω	12.5	JOINT
40	B	2.40 Ω		2.50 Ω	11.5	JOINT
41	B	2.35 Ω		2.40 Ω	21.5	JOINT
42	B	2.35 Ω		2.45 Ω	11.0	JOINT
43	B	2.50 Ω		2.55 Ω	15.0	JOINT
44	B	2.40 Ω		* 2.17 Ω	8.0	JOINT
45	B	2.35 Ω		2.40 Ω	30.0	JOINT

* Corrosion

PROJECT ENGR. - F. KEISTER

(3)

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 50 Formvar JOINING METHOD Mechanically strip and hand solder

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE	POINT OF BREAK
1 A				7 GRAMS	JOINT
2 A				7	JOINT
3 A				6	JOINT
4 A				6	JOINT
5 A				9	JOINT
6 A				9	JOINT
7 A				7	JOINT
8 A				8	JOINT
9 B				12	JOINT
10 B				11	JOINT
11 B				6	JOINT
12 B				9	JOINT
13 B				4	JOINT
14 B				7	JOINT
15 B				9	JOINT
16 A	5.80 Ω	5.70 Ω		12.0	JOINT
17 A	6.00 Ω	5.90 Ω		12.0	WIRE - 5/16"
18 A	7.00 Ω	6.90 Ω		4.5	JOINT
19 A	6.20 Ω	6.10 Ω		BREAK DURING	HANDLING
20 A	6.70 Ω	6.60 Ω		7.0	JOINT
21 A	6.10 Ω	6.20 Ω		6.0	WIRE - 3/4"
22 A	6.10 Ω	6.00 Ω		9.0	JOINT
23 A	5.30 Ω	5.20 Ω		12.5	JOINT
24 B	6.00 Ω	BROKEN CORROSION		—	—
25 B	5.80 Ω	5.70 Ω		5.0	JOINT
26 B	6.10 Ω	6.00 Ω		8.5	JOINT
27 B	6.00 Ω	5.95 Ω		3.0	JOINT
28 B	6.20 Ω	6.10 Ω		5.0	JOINT
29 B	5.80 Ω	5.75 Ω		13.5	JOINT
30 B	6.00 Ω	5.90 Ω		8.0	JOINT
31 A	5.40 Ω		5.55 Ω	10.5	JOINT
32 A	6.20 Ω		6.40 Ω	9.0	JOINT
33 A	6.70 Ω		6.95 Ω	8.5	JOINT
34 A	6.20 Ω		FAILED	—	—
35 A	5.00 Ω		5.05 Ω	10.5	JOINT
36 A	6.30 Ω		6.30 Ω	10.0	JOINT
37 A	6.40 Ω		6.50 Ω	12.5	JOINT
38 A	6.20 Ω		6.30 Ω	4.0	JOINT
39 B	6.30 Ω		6.30 Ω	10.5	JOINT
40 B	6.10 Ω		6.15 Ω	12.0	JOINT
41 B	6.10 Ω		6.10 Ω	9.5	JOINT
42 B	6.60 Ω		FAILED	—	—
43 B	6.20 Ω		6.50 Ω	10.5	JOINT
44 B	5.90 Ω		5.90 Ω	1.0	JOINT
45 B	5.70 Ω		5.90 Ω	BROKE DURING	HANDLING

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 42 ML JOINING METHOD Mechanically strip and hand solder

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				68	JOINT
2 A				74	JOINT
3 A				78	JOINT
4 A				30	JOINT
5 A				73	JOINT
6 A				70	JOINT
7 A				66	JOINT
8 A				55	JOINT
9 B				50	JOINT
10 B				46	JOINT
11 B				41	JOINT
12 B				43	JOINT
13 B				73	JOINT
14 B				58	JOINT
15 B				50	JOINT
16 A	1.09 Ω	1.07 Ω		35.5	WIRE - 3/8"
17 A	.980 Ω	.970 Ω		60.0	WIRE - 3/16"
18 A	.980 Ω	.975 Ω		75.5	WIRE - 3/8"
19 A	1.10 Ω	1.09 Ω		75.5	JOINT
20 A	.980 Ω	1.00 Ω		47.0	JOINT
21 A	.980 Ω	.990 Ω		71.0	WIRE: 9/16"
22 A	.880 Ω	.880 Ω		75.5	JOINT
23 A	.940 Ω	.935 Ω		86.0	WIRE - 1/4"
24 B	.940 Ω	.940 Ω		25.0	JOINT
25 B	.950 Ω	.959 Ω		74.0	JOINT
26 B	.900 Ω	.900 Ω		32.5	JOINT
27 B	.940 Ω	.900 Ω		12.0	JOINT
28 B	.960 Ω	.950 Ω		17.0	JOINT
29 B	.960 Ω	.960 Ω		31.0	JOINT
30 B	.980 Ω	.970 Ω		58.0	JOINT
31 A	.910 Ω		.980 Ω	39.0	JOINT
32 A	.980 Ω		1.120 Ω	15.5	JOINT
33 A	.960 Ω		.970 Ω	19.5	JOINT
34 A	.980 Ω		1.100 Ω	32.5	JOINT
35 A	.890 Ω		.910 Ω	67.5	JOINT
36 A	.900 Ω		.975 Ω	88.5	JOINT
37 A	.880 Ω		.910 Ω	51.0	JOINT
38 A	.930 Ω		.980 Ω	81.5	JOINT
39 B	.930 Ω	BROKE AS SOON	AS WEIGHT AT	TACHED →	29½ grams
40 B	.940 Ω		.970 Ω	69.0	JOINT
41 B	.940 Ω		.950 Ω	37.5	JOINT
42 B	.940 Ω		.970 Ω	41.5	JOINT
43 B	.890 Ω	BROKE AS SOON	AS WEIGHT AT	TACHED →	29 1/2 grams
44 B	.960 Ω		.985 Ω	63.0	JOINT
45 B	.960 Ω		.975 Ω	35.0	WIRE - 5/16"

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 46 ML JOINING METHOD Mechanically strip and hand solder

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				26	JOINT
2 A				24	JOINT
3 A				16	JOINT
4 A				30	JOINT
5 A				20	JOINT
6 A				21	JOINT
7 A				20	JOINT
8 A				19	JOINT
9 B				22	JOINT
10 B				29	JOINT
11 B				28	JOINT
12 B				25	JOINT
13 B				24	JOINT
14 B				17	JOINT
15 B				25	JOINT
16 A	2.45 Ω	2.45 Ω		31	JOINT
17 A	2.50 Ω	2.50 Ω		14.5	WIRE – 1/4"
18 A	2.70 Ω	2.72 Ω		23.0	JOINT
19 A	2.70 Ω	2.69 Ω		27.5	WIRE – 1/4"
20 A	2.45 Ω	2.47 Ω		22.0	JOINT
21 A	2.45 Ω	2.45 Ω		22.5	JOINT
22 A	2.40 Ω	2.39 Ω		23.0	JOINT
23 A	2.35 Ω	2.31 Ω		19.5	JOINT
24 B	2.45 Ω	2.43 Ω		30.5	JOINT
25 B	2.40 Ω	2.38 Ω		Broken when [illegible]	[illegible]
26 B	2.35 Ω	2.36 Ω		25.0	JOINT
27 B	2.40 Ω	2.40 Ω		20.5	JOINT
28 B	2.40 Ω	2.40 Ω		23.0	JOINT
29 B	2.45 Ω	2.47 Ω		12.5	JOINT
30 B	2.15 Ω	2.19 Ω		27.5	JOINT
31 A	2.45 Ω		2.55 Ω	22.5	JOINT
32 A	2.55 Ω		2.63 Ω	7.5	JOINT
33 A	2.35 Ω		2.40 Ω	12.0	WIRE – 5/16"
34 A	2.40 Ω		2.45 Ω	27.0	JOINT
35 A	2.60 Ω		2.65 Ω	22.5	JOINT
36 A	2.50 Ω		2.52 Ω	25.5	JOINT
37 A	2.30 Ω		2.35 Ω	24.5	JOINT
38 A	2.50 Ω		2.55 Ω	BROKE DURING	HANDLING
39 B	2.30 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	11 1/2 grams
40 B	2.90 Ω		2.47 Ω	15.5	WIRE – 5/16"
41 B	2.40 Ω		2.40 Ω	13.5	JOINT
42 B	2.30 Ω		2.28 Ω	5.5	JOINT
43 B	2.20 Ω	BROKE AS SOON	AS WEIGHT ATTACHED →		11 1/2 grams
44 B	2.35 Ω		MISSING ?	—	—
45 B	2.25 Ω		2.35 Ω	16.5	JOINT

PROJECT ENGR. – F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 50 ML JOINING METHOD Mechanically strip and hand solder

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				12	3/8 INCH
2 A				14	7/32 INCH.
3 A				8	11/16 INCH
4 A				8	JOINT
5 A				5	JOINT
6 A				8	JOINT
7 A				9	JOINT
8 A				11	JOINT
9 B				—	PRE BROKEN
10 B				7	JOINT
11 B				10	JOINT
12 B				6	JOINT
13 B				6	JOINT
14 B				8	JOINT
15 B				9	JOINT
16 A	6.40 Ω	BROKE WHILE	LOADING RACK	FOR HUMIDITY	TEST
17 A	6.20 Ω	BROKE WHILE	LOADING RACK	FOR HUMIDITY	TEST
18 A	6.50 Ω	6.55 Ω		6.5	JOINT
19 A	7.30 Ω	7.40 Ω		9.0	JOINT
20 A	6.80 Ω	6.80 Ω		8.5	JOINT
21 A	6.80 Ω	6.70 Ω		6.5	JOINT
22 A	6.00 Ω	6.05 Ω		—	BROKE DURING HANDLING
23 A	6.60 Ω	6.55 Ω		6.0	JOINT
24 B	6.00 Ω	6.20 Ω		4.5	JOINT
25 B	6.20 Ω	6.25 Ω		9.5	JOINT
26 B	6.20 Ω	6.20 Ω		5.5	JOINT
27 B	5.60 Ω	5.60 Ω		2.5	JOINT
28 B	6.30 Ω	6.30 Ω		10.0	JOINT
29 B	5.30 Ω	BROKE WHILE	LOADING RACK	FOR HUMIDITY	TEST
30 B	6.70 Ω	6.70 Ω		8.5	JOINT
31 A	5.60 Ω		5.70 Ω	12.5	JOINT
32 A	6.40 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	4.3 grams
33 A	6.60 Ω		6.90 Ω	—	BROKEN DURING HANDLING
34 A	6.80 Ω		6.90 Ω	—	BROKEN DURING HANDLING
35 A	6.30 Ω		FAILED	—	—
36 A	6.20 Ω		6.20 Ω	4.0	WIRE - 3/8"
37 A	5.60 Ω		FAILED	—	—
38 A	6.50 Ω		6.70 Ω	7.0	JOINT
39 B	6.40 Ω		6.70 Ω	12.0	JOINT
40 B	6.30 Ω		6.90 Ω	10.0	JOINT
41 B	6.00 Ω		6.20 Ω	—	BROKE DURING HANDLING
42 B	6.30 Ω		6.60 Ω	10.0	WIRE - 1/8"
43 B	5.80 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	4.3 grams
44 B	6.30 Ω		6.55 Ω	—	BROKE DURING HANDLING
45 B	6.20 Ω		6.20 Ω	14.0	JOINT

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 42 Formex JOINING METHOD Chemically strip and hand solder

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				72	JOINT
2 A				86	Wire - 1/2"
3 A				84	Wire - 1"
4 A				83	JOINT
5 A				84	JOINT
6 A				83	JOINT
7 A				83	JOINT
8 A				79	JOINT
9 B				84	JOINT
10 B				84	Wire - 3/4"
11 B				71	JOINT
12 B				82	Wire - 1/2"
13 B				82	JOINT
14 B				85	JOINT
15 B				74	Wire - 1/2"
16 A	.910 Ω	.920 Ω		77.0	WIRE - 2.0"
17 A	.870 Ω	.880 Ω		76.5	JOINT
18 A	.850 Ω	.860 Ω		70.5	JOINT
19 A	.880 Ω	.890 Ω		80.0	JOINT
20 A	.840 Ω	.850 Ω		77.0	JOINT
21 A	.840 Ω	.855 Ω		71.0	JOINT
22 A	.850 Ω	.860 Ω		80.0	WIRE - 1 1/8"
23 A	.860 Ω	.850 Ω		77.0	JOINT
24 B	.840 Ω	.860 Ω		77.0	JOINT
25 B	.860 Ω	.870 Ω		81.0	JOINT
26 B	.860 Ω	.860 Ω		80.0	JOINT
27 B	.860 Ω	.870 Ω		75.0	JOINT
28 B	.900 Ω	.910 Ω		72.0	JOINT
29 B	.860 Ω	.850 Ω		81.0	JOINT
30 B	.880 Ω	.890 Ω		71.5	JOINT
31 A	.890 Ω	BROKE DURING HANDLING		—	—
32 A	.840 Ω		.880 Ω	79.0	JOINT
33 A	.840 Ω		.890 Ω	77.0	JOINT
34 A	.850 Ω		.890 Ω	78.0	JOINT
35 A	.800 Ω		.860 Ω	35.0	JOINT
36 A	.830 Ω		.875 Ω	79.5	JOINT
37 A	.820 Ω		.870 Ω	82.5	JOINT
38 A	.820 Ω		.910 Ω	77.5	JOINT
39 B	.860 Ω		.900 Ω	83.5	JOINT
40 B	.830 Ω		.885 Ω	54.0	JOINT
41 B	.860 Ω		.920 Ω	83.0	JOINT
42 B	.870 Ω		.920 Ω	81.5	JOINT
43 B	.860 Ω		.890 Ω	83.5	JOINT
44 B	.860 Ω		.900 Ω	83.0	WIRE - 1 1/8"
45 B	.860 Ω		.900 Ω	83.5	WIRE 9/16"

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 46 Formvar JOINING METHOD Chemically strip and hand solder

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE	POINT OF BREAK
1 A				34 GRAMS	JOINT
2 A				33	JOINT
3 A				32	JOINT
4 A				33	JOINT
5 A				32	JOINT
6 A				13	WIRE - 1/4"
7 A				35	JOINT
8 A				27	JOINT
9 B				25	JOINT
10 B				28	JOINT
11 B				18	JOINT
12 B				28	JOINT
13 B				35	JOINT
14 B				25	JOINT
15 B				13	JOINT
16 A	2.30 Ω	2.30 Ω		32.5	WIRE 13/16"
17 A	2.20 Ω	2.19 Ω		35	JOINT
18 A	2.35 Ω	2.40 Ω		27.5	JOINT
19 A	2.25 Ω	2.25 Ω		32	JOINT
20 A	2.70 Ω	2.65 Ω		25	JOINT
21 A	2.60 Ω	2.55 Ω		20	WIRE - 3/8"
22 A	2.35 Ω	2.35 Ω		31.5	JOINT
23 A	2.50 Ω	2.45 Ω		25.5	WIRE 3/4"
24 B	2.30 Ω	2.28 Ω		34.5	JOINT
25 B	2.30 Ω	2.28 Ω		34.0	JOINT
26 B	2.40 Ω	2.40 Ω		BROKE DURING HANDLING	—
27 B	2.35 Ω	2.35 Ω		26.5	JOINT
28 B	2.45 Ω	2.42 Ω		8.5	JOINT
29 B	2.35 Ω	2.35 Ω		33.0	JOINT
30 B	2.55 Ω	2.40 Ω		26.5	JOINT
31 A	2.55 Ω		2.60 Ω	27.0	JOINT
32 A	2.35 Ω		2.40 Ω	26.0	JOINT
33 A	2.30 Ω		2.32 Ω	34.0	JOINT
34 A	2.30 Ω		2.34 Ω	33.5	JOINT
35 A	2.30 Ω		2.35 Ω	34.5	JOINT
36 A	2.35 Ω		2.39 Ω	31.5	JOINT
37 A	2.45 Ω		2.50 Ω	32.5	JOINT
38 A	2.50 Ω		2.60 Ω	26.5	JOINT
39 B	2.40 Ω		2.42 Ω	34.0	JOINT
40 B	2.40 Ω		2.45 Ω	29.5	JOINT
41 B	2.45 Ω		2.50 Ω	16.5	JOINT
42 B	2.35 Ω		2.39 Ω	34.5	WIRE - 11/16"
43 B	2.45 Ω		2.51 Ω	24.0	JOINT
44 B	2.45 Ω		2.55 Ω	21.0	JOINT
45 B	2.45 Ω		2.54 Ω	25.0	JOINT

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 50 Formvar JOINING METHOD Chemically strip and hand solder

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				10	JOINT
2 A				11	WIRE 2 3/4"
3 A				11	JOINT
4 A				13	JOINT
5 A				11	JOINT
6 A				13	WIRE - 9/16"
7 A				13	JOINT
8 A				12	JOINT
9 B				3	JOINT
10 B				10	WIRE - 7/8"
11 B				9	WIRE - 3/4"
12 B				7	WIRE - 3/4"
13 B				9	WIRE - 5/8"
14 B				3	WIRE - 1/2"
15 B				12	WIRE - 5/8"
16 A	5.80 Ω	5.60 Ω		6.5	WIRE 1 1/2"
17 A	5.70 Ω	5.55 Ω		9.0	JOINT
18 A	6.60 Ω	6.40 Ω		10.0	JOINT
19 A	5.40 Ω	5.30 Ω		12.5	JOINT
20 A	5.80 Ω	BROKE WHILE	LOADING RACK	FOR HUMIDITY	TEST
21 A	6.20 Ω	6.10 Ω		11.5	WIRE - 1.0"
22 A	5.80 Ω	5.60 Ω		12.5	WIRE - 1.0"
23 A	4.80 Ω	BROKE WHILE	LOADING RACK	FOR HUMIDITY	TEST
24 B	6.00 Ω	5.80 Ω		10.0	WIRE - 3/4"
25 B	5.90 Ω	5.70 Ω		10.0	WIRE - 3/4"
26 B	5.90 Ω	5.85 Ω		10.0	WIRE - 5/8"
27 B	5.80 Ω	5.75 Ω		10.0	WIRE - 5/8"
28 B	5.90 Ω	5.75 Ω		11.0	JOINT
29 B	6.00 Ω	6.00 Ω		7.0	WIRE - 1/4"
30 B	5.70 Ω	5.56 Ω	CORROSION	5.5	WIRE - 3/8"
31 A	5.80 Ω		6.10 Ω	13.5	WIRE - 9/16"
32 A	5.70 Ω		5.90 Ω	11.5	JOINT
33 A	5.60 Ω		5.90 Ω	13.5	JOINT
34 A	5.60 Ω		5.90 Ω	13.5	WIRE - 7/8"
35 A	5.50 Ω		5.75 Ω	3.5	JOINT
36 A	5.30 Ω		5.55 Ω	12.5	JOINT
37 A	5.50 Ω		5.70 Ω	12.5	JOINT
38 A	5.60 Ω		5.75 Ω	13.0	JOINT
39 B	5.80 Ω		FAILED	—	— 1/8"
40 B	5.90 Ω		FAILED	—	— 1/2"
41 B	5.90 Ω		6.10 Ω	10.5	WIRE - 13/16"
42 B	5.80 Ω		6.15 Ω	11.5	JOINT
43 B	5.90 Ω	BROKE DURING	HANDLING	—	—
44 B	5.80 Ω		6.15 Ω	11.5	WIRE - 3/4"
45 B	5.80 Ω		6.10 Ω	3.5	WIRE - 11/16"

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 42 ML JOINING METHOD Chemically strip and hand solder

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				87	11/16 INCH
2 A				84	9/16 INCH
3 A				87	5/16 INCH
4 A				87	JOINT
5 A				87	JOINT
6 A				87	7/16 INCH
7 A				86	JOINT
8 A				86	JOINT
9 B				87	JOINT
10 B				85	JOINT
11 B				84	JOINT
12 B				84	JOINT
13 B				76	JOINT
14 B				87	1 1/8 INCH
15 B				87	15/16 INCH
16 A	.950 Ω	.950 Ω		79.5	JOINT
17 A	.930 Ω	.940 Ω		84.5	WIRE - 1 5/8"
18 A	.920 Ω	.920 Ω		86.0	WIRE - 2.0"
19 A	.940 Ω	.940 Ω		72.0	JOINT
20 A	.920 Ω	.920 Ω		85.0	JOINT
21 A	.900 Ω	.910 Ω		86.0	WIRE - 5/8"
22 A	.900 Ω	.900 Ω		86.5	WIRE - 1 1/8"
23 A	.930 Ω	.935 Ω		85.5	WIRE - 1 1/4"
24 B	.920 Ω	.920 Ω		84.0	JOINT
25 B	.900 Ω	.910 Ω		82.0	JOINT
26 B	.910 Ω	.910 Ω		77.0	JOINT
27 B	.890 Ω	.890 Ω		72.0	JOINT
28 B	.890 Ω	.890 Ω		86.0	WIRE - 3/8"
29 B	.910 Ω	.910 Ω		84.0	JOINT
30 B	.900 Ω	.910 Ω		79.5	JOINT
31 A	.890 Ω		.910 Ω	82.5	JOINT
32 A	.940 Ω		.975 Ω	79.0	JOINT
33 A	.890 Ω		.945 Ω	86.5	JOINT
34 A	.940 Ω		.970 Ω	85.0	JOINT
35 A	.920 Ω		.960 Ω	87.0	JOINT
36 A	.930 Ω		.970 Ω	88.5	WIRE - 1 1/2"
37 A	.930 Ω		.980 Ω	87.5	JOINT
38 A	.940 Ω		.990 Ω	86.5	JOINT
39 B	.920 Ω		.960 Ω	74.0	JOINT
40 B	.900 Ω		.980 Ω	77.0	JOINT
41 B	.880 Ω		.920 Ω	81.0	JOINT
42 B	.890 Ω		.955 Ω	77.0	JOINT
43 B	.920 Ω		.975 Ω	78.0	JOINT
44 B	.900 Ω		.945 Ω	78.5	JOINT
45 B	.900 Ω		.960 Ω	85.5	JOINT

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 46 ML JOINING METHOD Chemically strip and hand solder

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE	POINT OF BREAK
1 A				31 GRAMS	JOINT
2 A				29	JOINT
3 A				36	JOINT
4 A				30	JOINT
5 A				31	JOINT
6 A				32	JOINT
7 A				35	JOINT
8 A				14	WIRE - 7/16
9 B				33	JOINT
10 B				35	JOINT
11 B				33	JOINT
12 B				31	JOINT
13 B				35	JOINT
14 B				34	WIRE 1/4"
15 B				33	JOINT
16 A	2.15 Ω	2.19 Ω		30.0	Joint
17 A	2.15 Ω	2.19 Ω		32.5	Joint
18 A	2.15 Ω	2.13 Ω		33.5	Joint
19 A	2.15 Ω	2.15 Ω		35.0	Joint
20 A	2.15 Ω	2.15 Ω		28.5	Joint
21 A	2.25 Ω	2.23 Ω		32.0	Joint
22 A	2.20 Ω	2.15 Ω		30.5	Joint
23 A	2.15 Ω	2.15 Ω		26.5	Joint
24 B	2.25 Ω	2.25 Ω		26.5	Joint
25 B	2.20 Ω	2.19 Ω		33.0	Joint
26 B	2.25 Ω	2.25 Ω		30.5	Joint
27 B	2.25 Ω	2.25 Ω		26.5	WIRE- 3/8"
28 B	2.15 Ω	2.16 Ω		32.5	Joint
29 B	2.25 Ω	2.25 Ω		29.0	Joint
30 B	2.25 Ω	2.23 Ω		33.0	Joint
31 A	2.25 Ω		2.31 Ω	34.0	Joint
32 A	2.15 Ω		2.31 Ω	33.5	Joint
33 A	2.15 Ω		2.23 Ω	36.0	Joint
34 A	2.25 Ω		2.34 Ω	27.5	Joint
35 A	2.30 Ω		2.35 Ω	33.0	Joint
36 A	2.25 Ω		2.32 Ω	35.5	WIRE - 1 3/4"
37 A	2.10 Ω		2.20 Ω	34.5	Joint
38 A	2.20 Ω		2.35 Ω	28.0	Joint
39 B	2.25 Ω		2.35 Ω	35.5	Joint
40 B	2.20 Ω		2.30 Ω	34.0	Joint
41 B	2.20 Ω		2.31 Ω	34.5	WIRE- 5/16"
42 B	2.15 Ω		2.26 Ω	31.5	Joint
43 B	2.20 Ω		2.30 Ω	34.0	Joint
44 B	2.20 Ω	BROKE AS SOO	N AS WEIGHT	ATTACHED →	16.4 grams
45 B	2.20 Ω	BROKE AS SOO	N AS WEIGHT	ATTACHED →	16.4 grams

PROJECT ENGR. - F KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 50 ML JOINING METHOD Chemically strip and hand solder

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				12	JOINT
2 A				—	PRE BROKEN
3 A				8	7/8 INCH
4 A				11	JOINT
5 A				4	11/16 INCH
6 A				9	1 1/16 INCH
7 A				8	7/16 INCH
8 A				4	7/16 INCH
9 B				7	11/16 INCH
10 B				10	3/8 INCH
11 B				13	JOINT
12 B				13	JOINT
13 B				10	5/16 INCH
14 B				12	JOINT
15 B				12	JOINT
16 A	5.80 Ω	BROKE WHILE	LOADING RACK	FOR HUMIDITY	TEST
17 A	6.00 Ω	6.10 Ω		9.5	1 1/16 INCH
18 A	5.60 Ω	Broke During	Handling	—	—
19 A	6.00 Ω	6.10 Ω		8.5	JOINT
20 A	5.50 Ω	BROKE WHILE	LOADING RACK	FOR HUMIDITY	TEST
21 A	5.40 Ω	5.50 Ω		7.5	Joint
22 A	6.00 Ω	FAILED		—	—
23 A	5.20 Ω	5.40 Ω		2.5	1 1/8 inch.
24 B	6.00 Ω	6.10 Ω		4.5	1/2 "
25 B	6.00 Ω	6.10 Ω		8.5	13/16 "
26 B	6.40 Ω	6.50 Ω		8.5	3/4 "
27 B	6.00 Ω	6.10 Ω		6.5	JOINT
28 B	6.00 Ω	6.19 Ω		11.5	3/4"
29 B	6.00 Ω	6.19 Ω		Broken in	handling
30 B	6.10 Ω	6.10 Ω		3.5	JOINT
31 A	6.00 Ω		6.00 Ω	2.5	WIRE - 1/2"
32 A	5.40 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	5.2 grams
33 A	5.90 Ω		6.00 Ω	1.5	JOINT
34 A	5.60 Ω		5.75 Ω	4.5	WIRE - 13/16"
35 A	6.00 Ω		FAILED	—	- 1/2"
36 A	6.00 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	WIRE - 3/8"
37 A	6.20 Ω		FAILED	—	—
38 A	6.20 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	5.2 grams
39 B	6.20 Ω		FAILED	—	- 1"
40 B	6.00 Ω	BROKE AS SOON	AS WEIGHT ATT	ACHED → 5.2 g	WIRE - 3/4"
41 B	6.00 Ω		FAILED	—	- 7/8"
42 B	6.10 Ω		6.15 Ω	13.0	WIRE - 9/16"
43 B	5.90 Ω		5.95 Ω	13.5	WIRE - 11/16"
44 B	6.00 Ω		6.10 Ω	10.0	WIRE - 11/16"
45 B	6.00 Ω		6.10 Ω	4.0	WIRE - 11/16"

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 42 Thermaleze JOINING METHOD Torch fuse

SPECIMEN NUMBER		INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1	A				7	JOINT
2	A				21	JOINT
3	A				11	JOINT
4	A				5	JOINT
5	A				58	JOINT
6	A				30	JOINT
7	A				39	JOINT
8	A				15	JOINT
9	B				13	JOINT
10	B				69	JOINT
11	B				10	JOINT
12	B				70	JOINT
13	B				70	JOINT
14	B				10	JOINT
15	B				6	JOINT
16	A	.970 Ω	BROKE WHILE	LOADING RACK	FOR HUMIDITY	TEST
17	A	.840 Ω	.855 Ω	CORROSION	56.0	JOINT
18	A	1.150 Ω	1.180 Ω		33.5	JOINT
19	A	1.200 Ω	1.220 Ω	CORROSION	21.0	WIRE - 3/8"
20	A	.880 Ω	.880 Ω	CORROSION	63.5	JOINT
21	A	.900 Ω	.918 Ω	CORROSION	57.0	JOINT
22	A	1.150 Ω	1.150 Ω	CORROSION	—	BROKE DURING HANDLING
23	A	.930 Ω	.935 Ω	CORROSION	60.0	JOINT
24	B	1.100 Ω	1.100 Ω	CORROSION	27.5	JOINT
25	B	.990 Ω	1.000 Ω	CORROSION	13.5	JOINT
26	B	.990 Ω	.999 Ω	CORROSION	26.5	JOINT
27	B	.990 Ω	1.080 Ω	CORROSION	63.5	JOINT
28	B	.960 Ω	4.3×10^4 Ω	CORROSION	47.5	JOINT
29	B	.950 Ω	.950 Ω	CORROSION	33.0	JOINT
30	B	.890 Ω	.910 Ω	CORROSION	33.0	JOINT
31	A	.900 Ω		* .900 Ω	67.0	JOINT
32	A	.970 Ω		FAILED	—	—
33	A	.840 Ω		.840 Ω	22.5	JOINT
34	A	.930 Ω		.925 Ω	33.5	JOINT
35	A	1.050 Ω		* 1.080 Ω	48.0	JOINT
36	A	1.100 Ω		* 1.100 Ω	12.0	JOINT
37	A	.980 Ω		* .975 Ω	23.0	JOINT
38	A	.990 Ω		.990 Ω	34.0	JOINT
39	B	.980 Ω		* .975 Ω	64.0	JOINT
40	B	.910 Ω		* .910 Ω	53.0	JOINT
41	B	.880 Ω		* .870 Ω	70.5	JOINT
42	B	.950 Ω		* .950 Ω	69.0	JOINT
43	B	.930 Ω		* .920 Ω	71.0	JOINT
44	B	.980 Ω		* .980 Ω	69.5	JOINT
45	B	.970 Ω		.960 Ω	69.5	JOINT

* CORROSION

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 46 Isonel JOINING METHOD Torch fuse

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE	POINT OF BREAK
1 A				5 GRAMS	JOINT
2 A				13	JOINT
3 A				24	JOINT
4 A				29	JOINT
5 A				27	JOINT
6 A				27	JOINT
7 A				26	JOINT
8 A				13	JOINT
9 B				27	WIRE - 1/4"
10 B				25	JOINT
11 B				25	JOINT
12 B				0.5 (UNTWIST)	JOINT
13 B				3	JOINT
14 B				14	JOINT
15 B				15	JOINT
16 A	2.45 Ω	Broke During	Handling	—	—
17 A	* 2.15 Ω	BROKE WHILE	LOADING RACK	FOR HUMIDITY	TEST
18 A	2.45 Ω	2.47 Ω	CORROSION	20.5	JOINT
19 A	2.35 Ω	FAILED	CORROSION	—	—
20 A	2.55 Ω	6×10^4 ohms		MISSING	—
21 A	4.10 Ω	8×10^2 ohms	CORROSION	5.5	JOINT
22 A	2.40 Ω	2.42 Ω	CORROSION	23.0	JOINT
23 A	2.30 Ω	BROKE WHILE	UNLOADING	TEST RACK —	CORROSION
24 B	2.30 Ω	2.34 Ω	CORROSION	31.0	JOINT
25 B	2.40 Ω	Broke During	Handling	—	—
26 B	2.35 Ω	2.35 Ω	CORROSION	26.5	JOINT
27 B	2.25 Ω	2.29 Ω	CORROSION	26.5	JOINT
28 B	2.45 Ω	2.45 Ω	CORROSION	28.0	JOINT
29 B	2.10 Ω	2.13 Ω	CORROSION	FAILED DURING	HANDLING
30 B	2.35 Ω	2.39 Ω	CORROSION	MISSING	—
31 A	4.80 Ω		* 2.62 Ω	29.5	JOINT
32 A	2.35 Ω		FAILED	—	—
33 A	2.55 Ω		2.55 Ω	25.5	JOINT
34 A	2.20 Ω		* 2.19 Ω	28.0	JOINT
35 A	2.45 Ω		* 2.47 Ω	10.5	JOINT
36 A	2.45 Ω		FAILED	CORROSION —	—
37 A	2.40 Ω		2.41 Ω	21.0	JOINT
38 A	2.45 Ω		2.48 Ω	8.5	JOINT
39 B	2.45 Ω		* 2.48 Ω	16.5	JOINT
40 B	2.35 Ω		* 2.35 Ω	29.0	JOINT
41 B	2.30 Ω		* 2.30 Ω	27.0	JOINT
42 B	2.25 Ω		* 2.30 Ω	27.5	JOINT
43 B	2.30 Ω		* 2.30 Ω	28.5	JOINT
44 B	2.40 Ω		* 2.41 Ω	26.5	JOINT
45 B	2.45 Ω		* 2.49 Ω	25.0	JOINT

* Corrosion

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 50 Isonel JOINING METHOD Torch fuse

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				8.0	JOINT
2 A				12.0	JOINT
3 A				9.0	JOINT
4 A				10.0	JOINT
5 A				9.0	JOINT
6 A				10.0	JOINT
7 A				11.0	JOINT
8 A				9.0	JOINT
9 B				—	JOINT FAILED DURING HANDLING
10 B				7.0	JOINT
11 B				11.0	JOINT
12 B				—	JFDH
13 B				9.0	JOINT
14 B				8.0	JOINT
15 B				—	JFDH
16 A	6.30 Ω	6.30 Ω		6.5	JOINT
17 A	5.90 Ω	FAILED		NONE	—
18 A	6.20 Ω	6.20 Ω	CORROSION	9.0	JOINT
19 A	7.00 Ω	7.00 Ω	CORROSION	9.0	JOINT
20 A	6.40 Ω		BROKE DURING	HANDLING –	CORROSION
21 A	7.20 Ω	7.20 Ω	CORROSION	2.0	JOINT
22 A	6.30 Ω	FAILED	CORROSION	NONE	—
23 A	6.60 Ω	6.60 Ω		8.0	JOINT
24 B	6.90 Ω	FAILED	CORROSION	NONE	—
25 B	6.00 Ω	6.00 Ω	CORROSION	—	BROKE DURING HANDLING
26 B	6.00 Ω	6.10 Ω	CORROSION	—	BROKE DURING HANDLING
27 B	6.40 Ω	BROKE WHILE	LOADING RACK	FOR HUMIDITY	TEST
28 B	6.70 Ω	FAILED	CORROSION	NONE	—
29 B	6.30 Ω	6.45 Ω	CORROSION	3.0	JOINT
30 B	6.20 Ω	BROKE DURING	HANDLING	NONE	—
31 A	6.60 Ω		6.70 Ω	10.0	JOINT
32 A	6.50 Ω		6.59 Ω	11.0	JOINT
33 A	6.50 Ω		6.60 Ω	5.5	JOINT
34 A	6.70 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	4.8 grams
35 A	5.90 Ω		6.00 Ω	7.0	JOINT
36 A	6.70 Ω		6.75 Ω	2.0	JOINT
37 A	6.40 Ω		6.50 Ω	7.5	JOINT
38 A	6.60 Ω		6.70 Ω	10.5	JOINT
39 B	5.90 Ω		* 6.00 Ω	6.5	JOINT
40 B	6.30 Ω		* 6.35 Ω	4.5	JOINT
41 B	6.20 Ω		* BROKEN DURING	HANDLING	—
42 B	6.20 Ω		FAILED	—	—
43 B	6.40 Ω		* 6.50 Ω	2.5	JOINT
44 B	6.20 Ω		* 6.30 Ω	10.0	JOINT
45 B	6.00		FAILED	—	—

NOTE:
JFDH = JOINT FAILED DURING HANDLING

* = Corrosion

PROJECT ENGR. – F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 42 Formex JOINING METHOD Torch fuse

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE	POINT OF BREAK
1 A				31 GRAMS	JOINT
2 A				46	JOINT
3 A				60	JOINT
4 A				38	JOINT
5 A				34	JOINT
6 A				80	JOINT
7 A				72	JOINT
8 A				69	JOINT
9 B				39	JOINT
10 B				81	JOINT
11 B				60	WIRE – 5/32"
12 B				21	JOINT
13 B				45	JOINT
14 B				75	JOINT
15 B				30	JOINT
16 A	.830 Ω	.840 Ω	CORROSION	78.0	JOINT
17 A	.880 Ω	.880 Ω		58.5	JOINT
18 A	.840 Ω	.840 Ω		69.5	JOINT
19 A	.840 Ω	.840 Ω	CORROSION	81.5	JOINT
20 A	.880 Ω	.880 Ω		23.0	JOINT
21 A	.870 Ω	.875 Ω	CORROSION	29.5	JOINT
22 A	.860 Ω	.860 Ω	CORROSION	59.0	JOINT
23 A	.850 Ω	.860 Ω	CORROSION	27.0	JOINT
24 B	.870 Ω	.880 Ω	CORROSION	2.5	JOINT
25 B	.910 Ω	.910 Ω	CORROSION	25.5	JOINT
26 B	.870 Ω	Broken Dur	ing handling	—	—
27 B	.890 Ω	.925 Ω	CORROSION	8.0	JOINT
28 B	.860 Ω	.860 Ω	CORROSION	26.0	JOINT
29 B	.920 Ω	.925 Ω	CORROSION	78.5	WIRE - 3/8"
30 B	.910 Ω	.910 Ω	CORROSION	36.5	JOINT
31 A	.860 Ω		.850 Ω	43.5	JOINT
32 A	.810 Ω		.800 Ω	4.5	JOINT
33 A	.880 Ω		.880 Ω	36.0	JOINT
34 A	.880 Ω		.880 Ω	67.0	JOINT
35 A	.860 Ω		.875 Ω	20.0	JOINT
36 A	.870 Ω		.875 Ω	32.0	JOINT
37 A	.860 Ω		.861 Ω	8.0	JOINT
38 A	.810 Ω		.810 Ω	15.5	JOINT
39 B	.860 Ω		.860 Ω	23.0	JOINT
40 B	.910 Ω	BROKE AS SOON	AS WEIGHT ATTACHED →	25 grams	WIRE – 1 1/8"
41 B	.840 Ω		* .850 Ω	21.0	JOINT
42 B	.890 Ω		* .890 Ω	10.0	JOINT
43 B	.900 Ω		Broke due	to handl	ing —
44 B	.950 Ω		.950 Ω	10.0	JOINT
45 B	.790 Ω		.780 Ω	84.0	JOINT

* = CORROSION

PROJECT ENGR. – F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 46 Formvar JOINING METHOD Torch fuse

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				23	JOINT
2 A				19	JOINT
3 A				27	JOINT
4 A				16	JOINT
5 A				25	JOINT
6 A				24	JOINT
7 A				18	JOINT
8 A				10	JOINT
9 B				20	JOINT
10 B				26	JOINT
11 B				12	JOINT
12 B				17	JOINT
13 B				28	JOINT
14 B				15	JOINT
15 B				27	JOINT
16 A	2.50 Ω	2.48 Ω		26.0	JOINT
17 A	2.45 Ω	2.41 Ω		5.0	JOINT
18 A	2.45 Ω	2.42 Ω		24.5	JOINT
19 A	2.35 Ω	2.32 Ω		27.0	JOINT
20 A	2.35 Ω	2.33 Ω		17.5	WIRE - 1/4"
21 A	2.35 Ω	2.35 Ω		26.0	JOINT
22 A	2.20 Ω	2.19 Ω		22.5	JOINT
23 A	2.25 Ω	2.22 Ω		18.5	JOINT
24 B	2.30 Ω	2.19 Ω	CORROSION	25.0	JOINT
25 B	2.40 Ω	2.32 Ω		24.5	JOINT
26 B	2.45 Ω	2.33 Ω	CORROSION	22.5	JOINT
27 B	2.20 Ω	2.20 Ω	CORROSION	5.5	JOINT
28 B	2.30 Ω	FAILED	CORROSION	NONE	—
29 B	2.20 Ω	2.23 Ω	CORROSION	30.0	JOINT
30 B	2.05 Ω	FAILED	CORROSION	NONE	—
31 A	2.60 Ω		* 2.60 Ω	23.5	JOINT
32 A	2.45 Ω		* 2.46 Ω	13.0	JOINT
33 A	2.70 Ω		* 2.70 Ω	19.0	JOINT
34 A	2.30 Ω		* 2.32 Ω	24.5	JOINT
35 A	2.50 Ω		* 2.52 Ω	21.0	WIRE - 1/8"
36 A	4.90 Ω		* BroKEN	DURING HANDLING	—
37 A	2.90 Ω		* 2.45 Ω	7.5	WIRE - 1/8"
38 A	2.10 Ω		* 2.15 Ω	—	BROKE DURING HANDLING
39 B	2.15 Ω		* 2.20 Ω	15.5	JOINT
40 B	2.20 Ω		* 2.25 Ω	15.0	JOINT
41 B	2.15 Ω		* 2.20 Ω	34.5	JOINT
42 B	2.05 Ω		* 2.12 Ω	5.0	JOINT
43 B	2.20 Ω		* 2.23 Ω	32.5	JOINT
44 B	2.20 Ω		* 2.20 Ω	10.5	JOINT
45 B	2.30 Ω		* 2.30 Ω	5.0	JOINT

* CORROSION

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 50 Formvar   JOINING METHOD Torch fuse

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (grams)	POINT OF BREAK
1 A				9 GRAMS	JOINT
2 A				—	BROKE DURING HANDLING
3 A				10	JOINT
4 A				10	WIRE - 1/4"
5 A				9	JOINT
6 A				8	JOINT
7 A				—	Broke during handling
8 A				9	JOINT
9 B				9	JOINT
10 B				11	WIRE - 3/16"
11 B				8	JOINT
12 B				7	JOINT
13 B				—	BROKE DURING HANDLING
14 B				11	JOINT
15 B				10	JOINT
16 A	5.80 Ω	5.90 Ω	CORROSION	2.0	JOINT
17 A	5.90 Ω	5.90 Ω	CORROSION	3.5	JOINT
18 A	9.00 Ω	FAILED	CORROSION	NONE	—
19 A	6.20 Ω	6.22 Ω	CORROSION	—	BROKE DURING HANDLING
20 A	5.50 Ω	FAILED	CORROSION	NONE	—
21 A	6.00 Ω	6.20 Ω	CORROSION	3.5	JOINT
22 A	6.40 Ω	FAILED	CORROSION	NONE	—
23 A	5.30 Ω	BROKEN DURING HANDLING		NONE	—
24 B	5.90 Ω	6.00 Ω	CORROSION	9.0	JOINT
25 B	5.50 Ω	FAILED	CORROSION	NONE	—
26 B	6.50 Ω	6.60 Ω	CORROSION	6	JOINT
27 B	6.00 Ω	6.19 Ω	CORROSION	3	JOINT
28 B	6.20 Ω	6.35 Ω	CORROSION	10.5	JOINT
29 B	6.20 Ω	6.20 Ω		10.0	JOINT
30 B	5.40 Ω	5.50 Ω	CORROSION	8.5	JOINT
31 A	5.70 Ω	BROKE AS SOON AS WEIGHT ATTACHED →			4.6 grams
32 A	6.20 Ω		6.45 Ω	9.5	JOINT
33 A	5.60 Ω		5.70 Ω	9.5	JOINT
34 A	6.00 Ω		6.19 Ω	11.0	JOINT
35 A	6.60 Ω		6.70 Ω	12.0	JOINT
36 A	6.20 Ω		6.30 Ω	9.0	JOINT
37 A	6.00 Ω		6.15 Ω	8.0	JOINT
38 A	6.20 Ω	BROKE AS SOON AS WEIGHT ATTACHED → 4.6 g			WIRE - 3/16"
39 B	5.60		MISSING ?	—	—
40 B	6.30 Ω		6.40 Ω	9.0	JOINT
41 B	5.90 Ω		6.00 Ω	10.0	JOINT
42 B	5.90 Ω	BROKE AS SOON AS WEIGHT ATTACHED →			4.6 grams
43 B	6.50 Ω		6.65 Ω	9.5	JOINT
44 B	5.90 Ω		6.00 Ω	3.0	JOINT
45 B	5.90 Ω		6.05 Ω	9.5	JOINT

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 42 ML JOINING METHOD Torch fuse

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				6	JOINT
2 A				8	JOINT
3 A				38	JOINT
4 A				74	JOINT
5 A				59	JOINT
6 A				31	JOINT
7 A				64	JOINT
8 A				46	JOINT
9 B				24	JOINT
10 B				19	JOINT
11 B				4	JOINT
12 B				50	JOINT
13 B				28	JOINT
14 B				13	JOINT
15 B				38	JOINT
16 A	.930 Ω	.930 Ω	CORROSION	55.0	JOINT
17 A	.940 Ω	.960 Ω	CORROSION	9.0	JOINT
18 A	2.700 Ω	FAILED		—	—
19 A	.980 Ω	.980	CORROSION	19.0	JOINT
20 A	2.100 Ω	5.7×10⁴ Ω		65.0	JOINT
21 A	1.000 Ω	.999 Ω	CORROSION	48.0	JOINT
22 A	.990 Ω	.990 Ω	CORROSION	60.0	JOINT
23 A	.990 Ω	.995 Ω	CORROSION	55.5	JOINT
24 B	.950 Ω	.960 Ω	CORROSION	16.5	JOINT
25 B	.910 Ω	.920 Ω	CORROSION	20.0	JOINT
26 B	1.000 Ω	1.090 Ω	CORROSION	BROKEN WHEN	REM'D
27 B	.960 Ω	.970 Ω	CORROSION	15.0	JOINT
28 B	.950 Ω	BROKE DURING	HANDLING	—	—
29 B	.900 Ω	.910 Ω	CORROSION	BROKE DURING	HANDLING
30 B	.980 Ω	.990 Ω	CORROSION	34.0	JOINT
31 A	.960 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	18.6 grams
32 A	1.100 Ω		* 1.090 Ω	11.5	JOINT
33 A	.950 Ω		.950 Ω	70.0	JOINT
34 A	1.150 Ω		1.150 Ω	21.5	JOINT
35 A	1.000 Ω		1.080 Ω	39.5	JOINT
36 A	1.000 Ω		* 1.070 Ω	12.0	JOINT
37 A	.930 Ω		FAILED	—	—
38 A	.980 Ω		* .970 Ω	39.5	JOINT
39 B	.930 Ω		* .940 Ω	13.5	JOINT
40 B	.940 Ω		* .950 Ω	BROKE DURING	HANDLING
41 B	.910 Ω	BROKE DURING	Resistance	Check	—
42 B	.910 Ω		* .910 Ω	79.0	JOINT
43 B	.960 Ω		* .970 Ω	33.5	JOINT
44 B	.890 Ω		* .890 Ω	78.5	JOINT
45 B	.870 Ω	BROKEN	DURING HANDLING	—	—

* = Corrosion NOTED

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 46 ML JOINING METHOD Torch fuse

SPECIMEN NUMBER		INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1	A				21	JOINT
2	A				20	JOINT
3	A				—	JOINT FAILED DURING HANDLING
4	A				19	JOINT
5	A				30	JOINT
6	A				27	JOINT
7	A				29	JOINT
8	A				10	JOINT
9	B				1	JOINT
10	B				29	JOINT
11	B				1	JOINT
12	B				34	JOINT
13	B				2	JOINT
14	B				29	JOINT
15	B				28	JOINT
16	A	2.25 Ω	2.15 Ω	CORROSION	15.5	JOINT
17	A	2.15 Ω	2.29 Ω	CORROSION	4.0	JOINT
18	A	2.20 Ω	BROKE WHILE	LOADING RACK	FOR HUMIDITY	TEST
19	A	2.20 Ω	2.20 Ω		21.0	JOINT
20	A	2.30 Ω	2.32 Ω		23.0	JOINT
21	A	2.30 Ω	BROKE WHILE	LOADING RACK	FOR HUMIDITY	TEST
22	A	2.20 Ω	2.22 Ω		23.5	JOINT
23	A	2.20 Ω	FAILED	CORROSION	—	—
24	B	2.20 Ω	2.35 Ω	CORROSION	2.5	JOINT
25	B	2.20 Ω	2.25 Ω	CORROSION	30.0	JOINT
26	B	2.10 Ω	2.22 Ω	CORROSION	1.5	JOINT
27	B	2.30 Ω	Broke while	Handling	—	—
28	B	2.05 Ω	2.30 Ω	CORROSION	10.5	JOINT
29	B	2.20 Ω	2.10 Ω	CORROSION	15.5	JOINT
30	B	2.25 Ω	2.20 Ω	CORROSION	17.0	JOINT
31	A	2.30 Ω		2.32 Ω	9.0	JOINT
32	A	2.20 Ω		FAILED	—	—
33	A	2.30 Ω		2.32 Ω	8.5	JOINT
34	A	2.25 Ω		2.25 Ω	12.0	JOINT
35	A	2.20 Ω		2.29 Ω	17.0	JOINT
36	A	2.25 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED	→ 12.1 grams
37	A	2.25 Ω		2.27 Ω	21.5	JOINT
38	A	2.15 Ω		1.65 Ω	9.0	JOINT
39	B	2.20 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED	→ 12.1 grams
40	B	2.20 Ω		2.21 Ω	8.5	JOINT
41	B	2.15 Ω		2.19 Ω	33.0	JOINT
42	B	2.20 Ω		2.18 Ω	8.5	JOINT
43	B	2.20 Ω		2.23 Ω	6.0	JOINT
44	B	2.20 Ω		2.22 Ω	14.0	JOINT
45	B	2.10 Ω		2.13 Ω	25.0	JOINT

PROJECT ENGR. – F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 50 ML JOINING METHOD Torch fuse

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				9	JOINT
2 A				4	JOINT
3 A				9	JOINT
4 A				7	JOINT
5 A				7	JOINT
6 A				6	JOINT
7 A				7	JOINT
8 A				—	PRE BROKEN AT JOINT
9 B				9	JOINT
10 B				10	JOINT
11 B				—	PRE-BROKEN @ JOINT
12 B				9	JOINT
13 B				12	JOINT
14 B				8	JOINT
15 B				10	JOINT
16 A	6.00 Ω	6.01 Ω	CORROSION	11.5	JOINT
17 A	5.90 Ω	5.90 Ω	CORROSION	3.5	JOINT
18 A	5.50 Ω	5.55 Ω	CORROSION	10.0	JOINT
19 A	5.60 Ω	FAILED	CORROSION	—	—
20 A	6.70 Ω	6.70 Ω		1.5	JOINT
21 A	5.40 Ω	5.41 Ω	CORROSION	5.0	JOINT
22 A	5.70 Ω	5.70 Ω	CORROSION	7.5	JOINT
23 A	6.50 Ω	6.55 Ω	CORROSION	9.5	JOINT
24 B	6.20 Ω	BROKE DURING	HANDLING	—	—
25 B	6.25 Ω	6.30 Ω	CORROSION	6.5	JOINT
26 B	6.20 Ω	6.25 Ω	CORROSION	6.5	JOINT
27 B	6.25 Ω	6.30 Ω	CORROSION	FAILED DURING	HANDLING
28 B	6.60 Ω	FAILED		FAILED DURING	HANDLING
29 B	6.25 Ω	FAILED		BROKEN WHEN	REC'd.
30 B	5.80 Ω	5.80 Ω	CORROSION	FAILED DURING	HANDLING
31 A	5.90 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	4.1 grams
32 A	5.50 Ω		5.90 Ω	3.0	JOINT
33 A	6.00 Ω		5.60 Ω	11.0	JOINT
34 A	6.00 Ω		6.10 Ω	6.5	JOINT
35 A	5.80 Ω	BROKE AS SOON	AS WEIGHT AT	TACHED →	4.1 grams
36 A	5.90 Ω		5.80 Ω	1.5	JOINT
37 A	5.60 Ω		5.85 Ω	1.0	JOINT
38 A	5.80 Ω		5.60 Ω	10.0	JOINT
39 B	6.40 Ω		5.80 Ω	5.0	JOINT
40 B	6.00 Ω	BROKE AS SOON A	S WEIGHT ATTAC	HED → 4.1 grams	WIRE – 3/16"
41 B	6.70 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	4.1 grams
42 B	6.20 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	4.1 grams
43 B	6.40 Ω		FAILED →	CORROSION	—
44 B	5.90 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	4.1 grams
45 B	6.10 Ω		5.90 Ω	8.5	JOINT

PROJECT ENGR. – F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 42 Thermaleze JOINING METHOD Soft solder pot dip

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE	POINT OF BREAK
1 A				23 GRAMS	JOINT
2 A				34	JOINT
3 A				25	JOINT
4 A				30	JOINT
5 A				15	JOINT
6 A				20	JOINT
7 A				36	JOINT
8 A				23	JOINT
9 B				10	JOINT
10 B				—	BROKE DURING HANDLING
11 B				30	JOINT
12 B				11	JOINT
13 B				37	JOINT
14 B				17	JOINT
15 B				13	JOINT
16 A	.930 Ω	.940 Ω		30.0	JOINT
17 A	.890 Ω	.890 Ω		30.0	JOINT
18 A	.950 Ω	.955 Ω		38.5	JOINT
19 A	.830 Ω	.830 Ω		29.5	JOINT
20 A	.920 Ω	.920 Ω		27.0	JOINT
21 A	.920 Ω	FAILED		—	—
22 A	.880 Ω	.890 Ω		29.5	JOINT
23 A	.960 Ω	.970		BROKEN WHEN	Re[illegible]
24 B	.900 Ω	.935		31.0	JOINT
25 B	1.100 Ω	1.100 Ω		18.5	JOINT
26 B	.930 Ω	.910		30.0	JOINT
27 B	.920 Ω	.930 Ω		23.0	JOINT
28 B	.940 Ω	.950 Ω		45.5	JOINT
29 B	.970 Ω	.980 Ω		46.0	JOINT
30 B	.970 Ω	.990 Ω		35.0	JOINT
31 A	.880 Ω		.882 Ω	36.0	JOINT
32 A	.880 Ω		FAILED	—	—
33 A	.900 Ω		Broke During	Resistance Check	—
34 A	.920 Ω		FAILED	—	—
35 A	.880 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	10 1/2 grams
36 A	.910 Ω		FAILED	—	—
37 A	.920 Ω		.922 Ω	11.5	JOINT
38 A	.860 Ω		.870 Ω	23.0	JOINT
39 B	.970 Ω		.975 Ω	23.5	JOINT
40 B	.940 Ω		FAILED	—	—
41 B	.980 Ω		.995 Ω	10.5	JOINT
42 B	1.000 Ω		1.090 Ω	19.0	JOINT
43 B	1.100 Ω		1.100 Ω	48.5	JOINT
44 B	.990 Ω		1.100 Ω	32.5	JOINT
45 B	.980 Ω		FAILED	—	—

PROJECT ENGR. – F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 46 Isonel JOINING METHOD Soft solder pot dip

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (grams)	POINT OF BREAK
1 A				15 Grams	JOINT
2 A				15	JOINT
3 A				15	JOINT
4 A				18	JOINT
5 A				4	JOINT
6 A				16	JOINT
7 A				22	JOINT
8 A				17	JOINT
9 B				13	JOINT
10 B				29	JOINT
11 B				16	JOINT
12 B				—	BROKE DURING HANDLING
13 B				18	JOINT
14 B				14	JOINT
15 B				17	JOINT
16 A	2.55 Ω	2.55 Ω		17.5	JOINT
17 A	2.40 Ω	2.39 Ω		15.5	JOINT
18 A	2.30 Ω	2.30 Ω		17.5	JOINT
19 A	2.40 Ω	2.40 Ω		14.0	JOINT
20 A	2.50 Ω	2.50 Ω		17.5	JOINT
21 A	2.45 Ω	2.45 Ω		18.5	JOINT
22 A	2.40 Ω	2.40 Ω		18.0	JOINT
23 A	2.45 Ω	2.45 Ω		15.5	JOINT
24 B	2.30 Ω	2.32 Ω		21.5	JOINT
25 B	2.55 Ω	2.52 Ω		5.5	JOINT
26 B	2.55 Ω	2.53 Ω		18.5	JOINT
27 B	2.30 Ω	2.30 Ω		18.5	JOINT
28 B	2.30 Ω	2.31 Ω		12.0	JOINT
29 B	2.35 Ω	2.32 Ω		14.5	JOINT
30 B	2.25 Ω	2.25 Ω		15.0	JOINT
31 A	2.55 Ω		2.65 Ω	4.0	JOINT
32 A	2.35 Ω		2.40 Ω	23.0	JOINT
33 A	2.35 Ω		2.49 Ω	10.5	JOINT
34 A	2.30 Ω		FAILED	—	—
35 A	2.35 Ω		2.50 Ω	28.5	JOINT
36 A	2.50 Ω		2.57 Ω	14.5	JOINT
37 A	2.40 Ω		2.40 Ω	19.5	JOINT
38 A	2.55 Ω		2.65 Ω	20.5	JOINT
39 B	2.40 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	8.2 grams
40 B	2.35 Ω		2.45 Ω	15.0	JOINT
41 B	2.45 Ω		FAILED	—	—
42 B	2.30 Ω		FAILED	—	—
43 B	2.30 Ω		2.38 Ω	6.5	JOINT
44 B	2.30 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	8.2 grams
45 B	2.35 Ω		2.48 Ω	4.5	JOINT

PROJECT ENGR. – F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 50 Isonel JOINING METHOD Soft solder pot dip

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				7	JOINT
2 A				7	JOINT
3 A				8	JOINT
4 A				8	JOINT
5 A				2	JOINT
6 A				9	JOINT
7 A				6	JOINT
8 A				4	JOINT
9 B				10	JOINT
10 B				7	JOINT
11 B				6	JOINT
12 B				—	BROKE DURING HANDLING
13 B				8	JOINT
14 B				8	JOINT
15 B				6	JOINT
16 A	6.60 Ω	FAILED		—	—
17 A	6.70 Ω	6.75 Ω		12.5	JOINT
18 A	6.60 Ω	6.60 Ω		12.0	JOINT
19 A	6.40 Ω	6.40 Ω		8.5	JOINT
20 A	6.40 Ω	BROKE WHILE	LOADING RACK	FOR HUMIDITY	TEST
21 A	6.40 Ω	6.41 Ω		8.0	JOINT
22 A	6.40 Ω	6.50 Ω		8.5	JOINT
23 A	6.20 Ω	6.25 Ω		7.0	JOINT
24 B	6.90 Ω	7.00 Ω		7.0	JOINT
25 B	6.40 Ω	6.45 Ω		7.0	JOINT
26 B	6.50 Ω	6.60 Ω		7.0	JOINT
27 B	6.50 Ω	6.59 Ω		7.0	JOINT
28 B	6.60 Ω	6.65 Ω		7.0	JOINT
29 B	6.50 Ω	6.55 Ω		BROKE DURING	HANDLING
30 B	6.30 Ω	6.35 Ω		7.0	JOINT
31 A	6.60 Ω		FAILED	—	—
32 A	6.40 Ω		FAILED	—	—
33 A	6.40 Ω		FAILED	—	—
34 A	6.20 Ω		FAILED	—	—
35 A	5.70 Ω		FAILED	—	—
36 A	6.40 Ω		FAILED	—	—
37 A	6.40 Ω		FAILED	—	—
38 A	6.10 Ω		FAILED	—	—
39 B	6.40 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	3.8 grams
40 B	6.20 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	3.8 grams
41 B	6.80 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	3.8 grams
42 B	6.40 Ω		FAILED	—	—
43 B	6.60 Ω		FAILED	—	—
44 B	6.30 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	3.8 grams
45 B	6.80 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	3.8 grams

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 42 Formex JOINING METHOD Soft solder pot dip

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				29	JOINT
2 A				17	JOINT
3 A				49	JOINT
4 A				23	JOINT
5 A				33	JOINT
6 A				26	JOINT
7 A				37	JOINT
8 A				34	JOINT
9 B				30	JOINT
10 B				8	JOINT
11 B				30	JOINT
12 B				34	JOINT
13 B				26	JOINT
14 B				37	JOINT
15 B				27	JOINT
16 A	.880 Ω	.895 Ω	CORROSION	15	JOINT
17 A	.840 Ω	.850 Ω	CORROSION	34	JOINT
18 A	.910 Ω	.920 Ω	CORROSION	11.5	JOINT
19 A	.900 Ω	.910 Ω	CORROSION	10.0	JOINT
20 A	.800 Ω	.810 Ω	CORROSION	25.5	JOINT
21 A	.950 Ω	.960 Ω	CORROSION	21.5	JOINT
22 A	.960 Ω	.970 Ω	CORROSION	59.0	JOINT
23 A	.940 Ω	.990 Ω		24.5	JOINT
24 B	.920 Ω	.930 Ω	CORROSION	24.5	JOINT
25 B	.850 Ω	.860 Ω	CORROSION	33.5	JOINT
26 B	.920 Ω	.930 Ω	CORROSION	19.5	JOINT
27 B	.910 Ω	.920 Ω	CORROSION	10.5	JOINT
28 B	.900 Ω	.910 Ω	CORROSION	12.0	JOINT
29 B	.920 Ω	.930 Ω	CORROSION	31.5	JOINT
30 B	.840 Ω	.850 Ω	CORROSION	34.5	JOINT
31 A	.830 Ω		.840 Ω	8.0	JOINT
32 A	.870 Ω		.870 Ω	44.5	JOINT
33 A	.860 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	14.7 grams
34 A	.920 Ω		.920 Ω	78.5	JOINT
35 A	.940 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	14.7 grams
36 A	.850 Ω		FAILED	—	—
37 A	.820 Ω		.820 Ω	BROKE DURING	HANDLING
38 A	.850 Ω		.900 Ω	3.5	JOINT
39 B	.860 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	14.7 grams
40 B	.830 Ω		.850 Ω	9.0	JOINT
41 B	.810 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	14.7 grams
42 B	.860 Ω		.890 Ω	38.5	JOINT
43 B	.840 Ω		Broke DURING	Resistance	Check
44 B	.850 Ω		FAILED	—	—
45 B	.870 Ω		Broke DURING	Resistance	Check

PROJECT ENGR. – F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 46 Formvar JOINING METHOD Soft solder pot dip

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE	POINT OF BREAK
1 A				20 Grams	JOINT
2 A				19	JOINT
3 A				16	JOINT
4 A				22	WIRE - 1/2"
5 A				5	JOINT
6 A				16	JOINT
7 A				22	JOINT
8 A				23	JOINT
9 B				25	JOINT
10 B				11	JOINT
11 B				—	BROKE DURING HANDLING
12 B				8	JOINT
13 B				8	JOINT
14 B				15	JOINT
15 B				16	JOINT
16 A	2.35 Ω	2.32 Ω		15.0	Joint
17 A	2.20 Ω	2.20 Ω		18.5	Joint
18 A	2.40 Ω	2.42 Ω		17.5	Joint
19 A	2.35 Ω	2.32 Ω		24.5	Joint
20 A	2.15 Ω	2.10 Ω		15.0	Joint
21 A	2.20 Ω	2.20 Ω		15.0	Joint
22 A	2.25 Ω	2.23 Ω		14.5	Joint
23 A	2.30 Ω	2.29 Ω		26.0	Joint
24 B	2.45 Ω	2.42 Ω		16.0	Joint
25 B	2.45 Ω	2.49 Ω		15.0	Joint
26 B	2.45 Ω	2.50 Ω		12.5	Joint
27 B	2.30 Ω	2.33 Ω		13.5	Joint
28 B	2.45 Ω	2.45 Ω		15.5	Joint
29 B	2.40 Ω	2.43 Ω		13.5	Joint
30 B	2.25 Ω	BROKE WHILE	LOADING RACK	FOR HUMIDITY	TEST
31 A	2.50 Ω		2.55 Ω	4.5	Joint
32 A	2.45 Ω		2.52 Ω	15.0	Joint
33 A	2.40 Ω		2.45 Ω	22.5	Joint
34 A	2.25 Ω		2.30 Ω	16.0	Joint
35 A	2.30 Ω		2.35 Ω	21.0	Joint
36 A	2.20 Ω		2.28 Ω	19.5	Joint
37 A	2.40 Ω		2.47 Ω	18.0	Joint
38 A	2.40 Ω		2.45 Ω	16.0	Joint
39 B	2.55 Ω		FAILED	—	—
40 B	2.35 Ω		2.39 Ω	11.0	Joint
41 B	2.40 Ω		2.40 Ω	5.5	Joint
42 B	2.40 Ω		2.41 Ω	13.0	Joint
43 B	2.40 Ω		2.45 Ω	2.0	Joint
44 B	2.25 Ω		Broken during	Handling	—
45 B	2.20 Ω		FAILED	—	—

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 50 Formvar   JOINING METHOD Soft solder pot dip

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE	POINT OF BREAK
1 A				7 GRAMS	JOINT
2 A				9	JOINT
3 A				9	JOINT
4 A				8	JOINT
5 A				—	BROKE DURING HANDLING
6 A				8	JOINT
7 A				6	JOINT
8 A				7	JOINT
9 B				8	JOINT
10 B				7	JOINT
11 B				8	JOINT
12 B				7	JOINT
13 B				—	BROKE DURING HANDLING
14 B				3	JOINT
15 B				4	JOINT
16 A	5.80 Ω	5.80 Ω		7	JOINT
17 A	6.10 Ω	6.10 Ω		BROKEN WHEN	REC'd
18 A	5.90 Ω	5.90 Ω		7.5	JOINT
19 A	5.90 Ω	5.95 Ω		9.0	JOINT
20 A	6.00 Ω	6.10 Ω		7.0	JOINT
21 A	5.30 Ω	5.30 Ω		7.0	JOINT
22 A	5.50 Ω	5.50 Ω		9.0	JOINT
23 A	6.00 Ω	6.00 Ω		BROKEN WHEN	REC'd
24 B	5.90 Ω	6.00 Ω		2.5	JOINT
25 B	6.00 Ω	6.10 Ω		4.5	JOINT
26 B	6.00 Ω	6.00 Ω		2.0	JOINT
27 B	5.80 Ω	BROKE WHILE	LOADING RACK	FOR HUMIDITY	TEST
28 B	5.90 Ω	5.90 Ω		8.0	JOINT
29 B	6.10 Ω	6.20 Ω		7.0	JOINT
30 B	5.70 Ω	5.75 Ω		7.5	JOINT
31 A	5.50 Ω		5.75 Ω	5.5	JOINT
32 A	5.10 Ω	BROKE AS SOON	AS WEIGHT AT	TACHED →	3.8 grams
33 A	5.80 Ω		FAILED	—	—
34 A	5.80 Ω		FAILED	—	—
35 A	5.60 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	3.8 grams
36 A	5.70 Ω		5.80 Ω	BROKE DURING	HANDLING
37 A	5.60 Ω		5.80 Ω	2.2	JOINT
38 A	5.90 Ω		FAILED	—	—
39 B	5.80 Ω		FAILED	—	—
40 B	5.80 Ω		FAILED	—	—
41 B	6.00 Ω		FAILED	—	—
42 B	6.00 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	3.8 grams
43 B	6.70 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	3.8 grams
44 B	5.90 Ω		6.50 Ω	BROKEN WHEN	REC'd.
45 B	5.60 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	3.8 grams

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 42 Thermaleze   JOINING METHOD Silver solder pot dip

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE	POINT OF BREAK
1 A				40 grams	JOINT
2 A				68	WIRE - 1/2"
3 A				72	JOINT
4 A				70	JOINT
5 A				67	JOINT
6 A				63	JOINT
7 A				73	JOINT
8 A				77	JOINT
9 B				77	JOINT
10 B				78	JOINT
11 B				77	JOINT
12 B				87	WIRE - 3/4"
13 B				85	JOINT
14 B				82	WIRE - 1 1/8"
15 B				72	WIRE - 3/4"
16 A	1.15 Ω	1.17 Ω		68.0	WIRE - 1 3/16"
17 A	6.20 Ω	3.10 Ω		72.0	JOINT
18 A	1.10 Ω	1.20 Ω		59.5	JOINT
19 A	1.15 Ω	1.13 Ω		51.0	JOINT
20 A	1.15 Ω	1.15 Ω		32.5	JOINT
21 A	2.85 Ω	1.0×10^4 Ω		72.0	JOINT
22 A	1.30 Ω	1.30 Ω		73.5	JOINT
23 A	1.15 Ω	1.15 Ω		71.5	JOINT
24 B	1.09 Ω	1.12 Ω	CORROSION	19.5	JOINT
25 B	.960 Ω	.970 Ω		61.5	JOINT
26 B	1.05 Ω	1.10 Ω		74.5	JOINT
27 B	1.20 Ω	1.28 Ω		71.0	JOINT
28 B	1.35 Ω	2.60 Ω	CORROSION	51.5	JOINT
29 B	1.85 Ω	2.05 Ω		69.5	WIRE - 7/8"
30 B	1.10 Ω	1.10 Ω		73.5	JOINT
31 A	1.10 Ω		1.12 Ω	76.5	JOINT
32 A	1.05 Ω		1.09 Ω	39.5	JOINT
33 A	2.15 Ω		1.22 Ω	33.5	JOINT
34 A	1.05 Ω		FAILED	—	—
35 A	1.05 Ω		1.09 Ω	8.0	JOINT
36 A	1.20 Ω		1.20 Ω	35.0	JOINT
37 A	1.10 Ω		1.15 Ω	69.0	JOINT
38 A	1.10 Ω		1.13 Ω	41.0	JOINT
39 B	1.10 Ω		1.15 Ω	50.5	WIRE - 3/8"
40 B	1.05 Ω		1.09 Ω	75.5	JOINT
41 B	4.20 Ω		2.78 Ω	46.0	JOINT
42 B	1.15 Ω		1.14 Ω	64.0	JOINT
43 B	2.55 Ω		2.58 Ω	66.0	JOINT
44 B	1.05 Ω		1.11 Ω	49.0	JOINT
45 B	1.05 Ω		1.10 Ω	62.5	JOINT

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 46 Isonel JOINING METHOD Silver solder pot dip

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE	POINT OF BREAK
1 A				32 GRAMS	JOINT
2 A				35	JOINT
3 A				28	JOINT
4 A				30	JOINT
5 A				31	JOINT
6 A				37	JOINT
7 A				24	JOINT
8 A				34	JOINT
9 B				29	JOINT
10 B				27	JOINT
11 B				27	JOINT
12 B				16	JOINT
13 B				21	JOINT
14 B				25	JOINT
15 B				26	JOINT
16 A	2.45 Ω	2.45 Ω		30.5	JOINT
17 A	2.50 Ω	2.52 Ω		36.0	JOINT
18 A	2.50 Ω	2.49 Ω	CORROSION	3.0	JOINT
19 A	2.40 Ω	2.31 Ω	CORROSION	1.5	JOINT
20 A	2.50 Ω	2.48 Ω		—	BROKE DURING HANDLING
21 A	2.30 Ω	2.31 Ω	CORROSION	18.5	JOINT
22 A	2.50 Ω	2.50 Ω	CORROSION	29.5	JOINT
23 A	2.50 Ω	2.50 Ω		37.0	JOINT
24 B	2.55 Ω	2.55 Ω	CORROSION	27.0	JOINT
25 B	2.55 Ω	2.55 Ω		27.0	JOINT
26 B	2.40 Ω	2.44 Ω		32.5	JOINT
27 B	2.65 Ω	2.61 Ω	CORROSION	36.0	JOINT
28 B	2.70 Ω	2.75 Ω	CORROSION	21.5	JOINT
29 B	2.70 Ω	3.0×10^4 Ω		29.5	JOINT
30 B	2.70 Ω	2.73 Ω		30.0	JOINT
31 A	2.35 Ω		* 2.39 Ω	32.5	JOINT
32 A	3.60 Ω		* 4.30 Ω	39.5	WIRE 2.0"
33 A	4.60 Ω		* 4.60 Ω	33.5	JOINT
34 A	3.60 Ω		* 4.60 Ω	39.5	JOINT
35 A	2.50 Ω		* 2.59 Ω	33.5	JOINT
36 A	2.45 Ω		2.55 Ω	30.0	JOINT
37 A	2.65 Ω		4.70 Ω	37.0	JOINT
38 A	2.45 Ω		2.45 Ω	33.5	JOINT
39 B	2.45 Ω		2.49 Ω	32.5	WIRE 3/16"
40 B	2.60 Ω		2.61 Ω	24.5	JOINT
41 B	2.65 Ω		2.71 Ω	20.0	JOINT
42 B	2.75 Ω		2.70 Ω	36.5	JOINT
43 B	2.65 Ω		2.70 Ω	14.5	JOINT
44 B	2.55 Ω		2.56 Ω	31.5	JOINT
45 B	2.70 Ω		2.79 Ω	15.5	JOINT

*= Corrosion

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 50 Formvar JOINING METHOD Silver solder pot dip

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				11	JOINT
2 A				11	JOINT
3 A				11	1 1/8 INCH
4 A				6	JOINT
5 A				10	JOINT
6 A				11	JOINT
7 A				11	JOINT
8 A				12	JOINT
9 B				10	JOINT
10 B				12	JOINT
11 B				11	JOINT
12 B				11	JOINT
13 B				11	JOINT
14 B				11	JOINT
15 B				11	JOINT
16 A	6.20 Ω	BROKEN DURING HANDLING		—	NONE
17 A	6.40 Ω	6.45 Ω		10.0	JOINT
18 A	6.50 Ω	6.60 Ω	CORROSION	—	BROKE DURING HANDLING
19 A	6.50 Ω	6.60 Ω		9.0	JOINT
20 A	6.00 Ω	FAILED		—	NONE
21 A	5.40 Ω	BROKEN	CORROSION	—	NONE
22 A	6.40 Ω	6.60 Ω	CORROSION	5.0	JOINT
23 A	5.20 Ω	5.35 Ω	CORROSION	—	BROKE DURING HANDLING
24 B	5.60 Ω	5.75 Ω	CORROSION	11.5	JOINT
25 B	6.10 Ω	6.25 Ω	CORROSION	3.0	JOINT
26 B	5.90 Ω	6.00 Ω	CORROSION	10.0	JOINT
27 B	5.80 Ω	5.90 Ω		11.5	JOINT
28 B	5.80 Ω	5.95 Ω	CORROSION	10.5	JOINT
29 B	5.80 Ω	6.00 Ω	CORROSION	10.0	2 3/8"
30 B	6.10 Ω	BROKEN DURING HANDLING		—	NONE
31 A	5.90 Ω		6.10 Ω	5.0	JOINT
32 A	6.00 Ω		6.40 Ω	6.0	JOINT
33 A	5.90 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	5½ grams
34 A	6.20 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	5½ grams
35 A	6.10 Ω		6.20 Ω	4.5	JOINT
36 A	6.10 Ω		6.30 Ω	10.5	JOINT
37 A	5.70 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	5½ grams
38 A	5.90 Ω		6.05 Ω	11.0	JOINT
39 B	5.90 Ω		6.10 Ω	4.0	JOINT
40 B	5.[illegible]		6.00 Ω	11.0	JOINT
41 B	6.00 Ω		6.20 Ω	9.0	WIRE – 1/2"
42 B	5.80 Ω		6.10 Ω	11.0	WIRE – 1 7/8"
43 B	7.70 Ω		8.00 Ω	11.5	JOINT
44 B	5.70 Ω		5.90 Ω	11.5	JOINT
45 B	5.60 Ω		FAILED	—	—

PROJECT ENGR. – F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 46 Formvar JOINING METHOD Silver solder pot dip

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				33	JOINT
2 A				30	JOINT
3 A				26	JOINT
4 A				30	JOINT
5 A				31	JOINT
6 A				28	JOINT
7 A				27	JOINT
8 A				30	JOINT
9 B				28	JOINT
10 B				26	JOINT
11 B				31	JOINT
12 B				25	JOINT
13 B				31	JOINT
14 B				32	JOINT
15 B				28	JOINT
16 A	2.60 Ω	2.69 Ω	Corrosion	22.0	JOINT
17 A	2.60 Ω	2.61 Ω	Corrosion	24.0	JOINT
18 A	2.50 Ω	2.50 Ω	CORROSION	28.0	JOINT
19 A	2.40 Ω	2.40 Ω	Corrosion	31.0	JOINT
20 A	2.60 Ω	2.63 Ω	Corrosion	27.5	WIRE - 1/2"
21 A	2.40 Ω	2.40 Ω	Corrosion	28.5	JOINT
22 A	2.65 Ω	2.69 Ω	Corrosion	27.0	JOINT
23 A	4.00 Ω	4.30 Ω	Corrosion	16.5	JOINT
24 B	2.30 Ω	2.32 Ω		31.5	JOINT
25 B	2.35 Ω	2.35 Ω	Corrosion	32.0	JOINT
26 B	2.30 Ω	2.30 Ω	Corrosion	31.0	JOINT
27 B	2.40 Ω	2.41 Ω	Corrosion	28.0	JOINT
28 B	2.45 Ω	2.50 Ω	Corrosion	24.0	JOINT
29 B	2.25 Ω	2.25 Ω	Corrosion	32.0	JOINT
30 B	2.15 Ω	2.68 Ω	Corrosion	33.0	JOINT
31 A	2.65 Ω		3.70 Ω	31.0	JOINT
32 A	2.40 Ω		2.55 Ω	29.5	JOINT
33 A	2.45 Ω		2.46 Ω	29.5	JOINT
34 A	2.35 Ω		2.49 Ω	19.5	JOINT
35 A	2.45 Ω		2.51 Ω	28.0	JOINT
36 A	2.45 Ω		2.55 Ω	28.0	JOINT
37 A	2.45 Ω		2.50 Ω	33.0	JOINT
38 A	2.45 Ω		2.50 Ω	27.0	JOINT
39 B	2.30 Ω		2.35 Ω	33.0	JOINT
40 B	2.25 Ω		2.30 Ω	21.0	JOINT
41 B	2.35 Ω		2.35 Ω	10.5	JOINT
42 B	2.25 Ω		2.30 Ω	11.0	JOINT
43 B	2.40 Ω		2.45 Ω	30.0	JOINT
44 B	2.30 Ω		2.35 Ω	16.0	JOINT
45 B	2.50 Ω		FAILED	—	— 7/8"

PROJECT ENGR. - F. KEISTER

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 42 Formex JOINING METHOD Silver solder pot dip

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				80	JOINT
2 A				80	JOINT
3 A				76	JOINT
4 A				42	JOINT
5 A				80	JOINT
6 A				75	JOINT
7 A				80	JOINT
8 A				84	JOINT
9 B				82	JOINT
10 B				83	JOINT
11 B				74	JOINT
12 B				85	JOINT
13 B				51	JOINT
14 B				82	JOINT
15 B				63	JOINT
16 A	.930 Ω	.935 Ω		81.5	JOINT
17 A	.900 Ω	.900 Ω	CORROSION	82.0	JOINT
18 A	.900 Ω	.900 Ω		76.0	JOINT
19 A	.930 Ω	.930 Ω		72.5	JOINT
20 A	.930 Ω	.925 Ω	CORROSION	78.0	JOINT
21 A	.900 Ω	.920 Ω	CORROSION	73.0	JOINT
22 A	.950 Ω	.960 Ω	CORROSION	75.5	JOINT
23 A	.920 Ω	.930 Ω	Corrosion	81.0	JOINT
24 B	.880 Ω	.920 Ω	CORROSION	78.5	JOINT
25 B	.900 Ω	.920 Ω	Corrosion	78.0	JOINT
26 B	.860 Ω	.860 Ω	Corrosion	80.0	JOINT
27 B	.840 Ω	.850 Ω	corrosion	82.5	JOINT
28 B	.850 Ω	.840 Ω		85.0	JOINT
29 B	.880 Ω	1.000 Ω	Corrosion	81.5	JOINT
30 A	.900 Ω	2.61 Ω	Corrosion	83.5	JOINT
31 A	.920 Ω		.950 Ω	76.0	WIRE - 1 3/8"
32 A	.890 Ω		.900 Ω	55.5	JOINT
33 A	.910 Ω		.930 Ω	82.5	JOINT
34 A	.920 Ω		.955 Ω	82.5	JOINT
35 A	.910 Ω		.920 Ω	65.0	JOINT
36 A	.890 Ω		.900 Ω	71.0	JOINT
37 A	.900 Ω		.920 Ω	61.0	JOINT
38 A	.910 Ω		.950 Ω	82.5	JOINT
39 B	.850 Ω		.930 Ω	79.5	WIRE - 1/2"
40 B	.900 Ω		.950 Ω	83.0	JOINT
41 B	.880 Ω		.935 Ω	83.0	JOINT
42 B	.880 Ω		.940 Ω	84.0	JOINT
43 B	.870 Ω		.920 Ω	78.0	JOINT
44 B	.860 Ω		.910 Ω	33.5	JOINT
45 B	.830 Ω		.945 Ω	90.0	JOINT

PROJECT ENGR. - F. KEIS[illegible]

JPL CONTRACT K5-330257

WIRE TYPE & SIZE 50 Isonel JOINING METHOD Silver solder pot dip

SPECIMEN NUMBER	INITIAL RESISTANCE	RESISTANCE AFTER HUMIDITY	RESISTANCE AFTER TEMPERATURE	BREAK FORCE (GRAMS)	POINT OF BREAK
1 A				12	JOINT
2 A				11	JOINT
3 A				10	JOINT
4 A				10	JOINT
5 A				12	JOINT
6 A				10	2 1/2 INCH.
7 A				10	9/16 INCH
8 A				11	JOINT
9 B				9	JOINT
10 B				9	JOINT
11 B				9	JOINT
12 B				10	JOINT
13 B				10	JOINT
14 B				2	JOINT
15 B				9	JOINT
16 A	6.50 Ω	6.90 Ω		11.0	JOINT
17 A	6.40 Ω	6.90 Ω		10.5	JOINT
18 A	6.50 Ω	6.90 Ω		10.5	JOINT
19 A	6.40 Ω	6.60 Ω		10.0	JOINT
20 A	6.35 Ω	6.60 Ω		5.0	JOINT
21 A	6.35 Ω	BROKE WHILE	UNLOADING TEST	RACK –	CORROSION
22 A	6.35 Ω	FAILED –	CORROSION	—	—
23 A	7.20 Ω	7.10 Ω	CORROSION	5.0	JOINT
24 B	6.40 Ω	6.80 Ω	CORROSION	Broke during	handling
25 B	6.30 Ω	FAILED –	CORROSION	–	–
26 B	6.25 Ω	6.50 Ω	CORROSION	Broke during	handling
27 B	6.35 Ω	6.90 Ω	CORROSION	Broke during	handling
28 B	6.20 Ω	Failed	CORROSION	–	–
29 B	6.25 Ω	6.75 Ω	CORROSION	< 0.5	Joint
30 B	6.30 Ω	2.35 Ω	CORROSION	26.5	Joint
31 A	6.40 Ω		* 6.90 Ω	11.5	JOINT
32 A	6.50 Ω		* 7.00 Ω	12.0	JOINT
33 A	9.50 Ω	BROKE AS SOON	AS WEIGHT	ATTACHED →	5.1 grams
34 A	6.05 Ω		6.20 Ω	3.0	JOINT
35 A	6.35 Ω		* 6.90 Ω	9.5	JOINT
36 A	6.55 Ω		7.70 Ω	12.5	JOINT
37 A	6.60 Ω		7.20 Ω	11.5	JOINT
38 A	8.40 Ω		8.30 Ω	11.0	JOINT
39 B	6.30 Ω		6.80 Ω	9.5	JOINT
40 B	6.20 Ω		FAILED	—	– 3/16"
41 B	6.10 Ω		6.30 Ω	7.0	JOINT
42 B	6.20 Ω		6.75 Ω	10.0	JOINT
43 B	6.00 Ω		* 6.25 Ω	2.5	JOINT
44 B	6.30 Ω		6.80 Ω	7.0	JOINT
45 B	6.10 Ω		6.35 Ω	10.5	JOINT

* Corrosion

PROJECT ENGR. – F. KEISTER