300 Series Poke-In MAG-MATE*, Material Thickness Performance Comparison

1. INTRODUCTION

1.1 Purpose

Testing was conducted to verify equal performance of the standard .016" thick and proposed .0126" thick C274 brass material used for the 300 Series Box MAG-MATE Terminal. Testing was conducted on single magnet wire and double magnet wire terminations per the electrical, mechanical and environmental performance requirements of TE Product Specification 108-2012, Rev H, when subjected to the test sequences listed in section 1.5.

1.2 Scope

This report covers the electrical, mechanical and environmental performance of 300 Series Box MAG-MATE Terminal on standard .016" thick and proposed .0126" thick C274 brass material. Testing was performed at the Harrisburg Electrical Components Test Laboratory (HECTL) between 23-April-2018 and 31-July-2018 and is on file under test number EA20180169T.

1.3 Conclusion

All .016" thick and proposed .0126" thick C274 brass material 300 Series Box MAG-MATE Terminals met all electrical, mechanical and environmental requirements of Product Specification 108-2012, Rev H. See section 2 for more detailed results.

1.4 Test Specimens

Test specimens identified with the following part numbers were used for this test program. Refer to Table 1 for the detailed part information.

Table 1 – Test Specimens

Test Set	Quantity	Part Number, Rev	Description
1	12	62420-1, Rev BZ	300 Series Poke-In MAG-MATE .016" thick terminated to (1) 20 AWG Cu Magnet Wire
	12	62897-1, Rev AE	Tab, Poke-In, MAG-MATE terminated to 20 AWG Cu Stranded Wire
2	12	2238161-1, Rev 1	300 Series Poke-In MAG-MATE .0126" thick terminated to (1) 20 AWG Cu Magnet Wire
	12	62897-1, Rev AE	Tab, Poke-In, MAG-MATE terminated to 20 AWG Cu Stranded Wire
3	12	62420-1, Rev BZ	300 Series Poke-In MAG-MATE .016" thick terminated to (1) 22 AWG Cu Magnet Wire
4	12	2238161-1, Rev 1	300 Series Poke-In MAG-MATE .0126" thick terminated to (1) 22 AWG Cu Magnet Wire
5	12	62420-1, Rev BZ	300 Series Poke-In MAG-MATE .016" thick terminated to (1) 19 AWG Al Magnet Wires
6	12	2238161-1, Rev 1	300 Series Poke-In MAG-MATE .0126" thick terminated to (1) 19 AWG Al Magnet Wires
7	12	62420-1, Rev BZ	300 Series Poke-In MAG-MATE .016" thick terminated to (1) 21 AWG Al Magnet Wires
8	12	2238161-1, Rev 1	300 Series Poke-In MAG-MATE .0126" thick terminated to (1) 21 AWG Al Magnet Wires
9	12	62420-1, Rev BZ	300 Series Poke-In MAG-MATE .016" thick terminated to (1) 20 AWG Cu Magnet Wire
	12	62897-1, Rev AE	Tab, Poke-In, MAG-MATE terminated to 20 AWG Cu Stranded Wire

Table 1 – Test Specimens (continued)

10	12	2238161-1, Rev 1	300 Series Poke-In MAG-MATE .0126" thick terminated to (1) 20 AWG Cu Magnet Wire
	12	62897-1, Rev AE	Tab, Poke-In, MAG-MATE terminated to 20 AWG Cu Stranded Wire
11	12	62420-1, Rev BZ	300 Series Poke-In MAG-MATE .016" thick terminated to (1) 22 AWG Cu Magnet Wire
12	12	2238161-1, Rev 1	300 Series Poke-In MAG-MATE .0126" thick terminated to (1) 22 AWG Cu Magnet Wire
13	12	62420-1, Rev BZ	300 Series Poke-In MAG-MATE .016" thick terminated to (1) 19 AWG Al Magnet Wires
14	12	2238161-1, Rev 1	300 Series Poke-In MAG-MATE .0126" thick terminated to (1) 19 AWG Al Magnet Wires
15	12	62420-1, Rev BZ	300 Series Poke-In MAG-MATE .016" thick terminated to (1) 21 AWG Al Magnet Wires
16	12	2238161-1, Rev 1	300 Series Poke-In MAG-MATE .0126" thick terminated to (1) 21 AWG Al Magnet Wires

1.5 Test Sequence

The specimens listed in Table 1 were subjected to the test sequences listed in Table 2.

Table 2 – Test Sequence

Test or Examination	Test Set(s)		
	1 & 2	3 thru 8	9 thru 16
	Test Sequence *(a)*		
Mating Force	1		
Low Level Contact Resistance (LLCR)	2,4,6,8	1,3,5,7	1,3
Temperature Life	3	2	
Humidity/Temperature Cycling	5	4	
Thermal Shock	7	6	
Current Cycling			2
Cross-Sectioning			4
Unmating Force	9		

NOTE

(a) The numbers indicate sequence in which tests were performed.

1.6 Environmental Conditions

Unless otherwise stated, the following environmental conditions prevailed during testing:

Temperature: 15℃ to 35℃
Relative Humidity: 20% to 80%

2. SUMMARY OF TESTING

2.1 Mating Force (Test Sets 1 & 2)

All specimens had measurements less than the 15 pound maximum force requirement specified in TE Product Specification 108-2012, Rev H. See Table 3 for a mating force summary.

Table 3 – Mating Force Summary (pounds)

	Test Set 1 .016" thick	Test Set 2 .0126" thick
Minimum	2.94	2.45
Maximum	4.65	6.44
Average	3.84	4.74
Std Deviation	2.94	1.07
Data Points	12	12
Maximum Requirement 15 pounds		

2.2 Low Level Contact Resistance, LLCR (All Test Sets)

2.2.1 LLCR – MAG-MATE and Magnet Wire Termination

All initial, interim and final low level contact resistance measurements were less than the maximum low level resistance and environmental testing values specified in Figure 3 of TE Product Specification 108-2012, Rev H. All measurements included approximately 1.5 inches of magnet wire bulk resistance. Refer to Tables 4 through 7 for data summaries for Test Sets 1 through 8 (environmental) and Tables 8 through 11 for data summaries for Test Sets 9 through 16 (current cycling), respectively.

Table 4 – Test Sets 1 & 2, Magnet Wire Termination LLCR Summary (milliohms)

	Initial	After Temp Life	After Temp/Hum Cycling	After Thermal Shock
Test Set 1 – (1) 20 AWG Cu Wire, .016" Thick				
Minimum	1.47	1.45	1.50	1.49
Maximum	1.54	1.55	1.59	1.60
Average	1.51	1.51	1.54	1.55
Std Deviation	0.02	0.04	0.03	0.03
Data Points	12	12	12	12
Test Set 2 – (1) 20 AWG Cu Wire, .0126" Thick				
Minimum	1.51	1.50	1.55	1.54
Maximum	1.59	1.57	1.63	1.67
Average	1.54	1.54	1.58	1.60
Std Deviation	0.03	0.02	0.02	0.03
Data Points	12	12	12	12
Maximum Requirement 2.1 m Ω				

Table 5 – Test Sets 3 & 4, Magnet Wire Termination LLCR Summary (milliohms)

	Initial	After Temp Life	After Temp/Hum Cycling	After Thermal Shock
Test Set 3 – (1) 22 AWG Cu Wire, .016" Thick				
Minimum	2.21	2.20	2.21	2.28
Maximum	2.35	2.35	2.38	2.38
Average	2.28	2.27	2.28	2.34
Std Deviation	0.05	0.05	0.05	0.04
Data Points	12	12	12	12
Test Set 4 – (1) 22 AWG Cu Wire, .0126" Thick				
Minimum	2.28	2.31	2.33	2.28
Maximum	2.44	2.48	2.45	2.46
Average	2.33	2.38	2.38	2.37
Std Deviation	0.04	0.06	0.03	0.05
Data Points	12	12	12	12
Maximum Requirement 3.3 m Ω				

Table 6 – Test Sets 5 & 6, Magnet Wire Termination LLCR Summary (milliohms)

	Initial	After Temp Life	After Temp/Hum Cycling	After Thermal Shock
Test Set 5 – (1) 19 AWG Al Wire, .016" Thick				
Minimum	1.76	1.87	1.88	1.90
Maximum	1.95	1.99	2.00	2.02
Average	1.90	1.92	1.93	1.97
Std Deviation	0.05	0.03	0.04	0.03
Data Points	12	12	12	12
Test Set 6 – (1) 19 AWG Al Wire, .0126" Thick				
Minimum	1.90	1.94	1.94	1.93
Maximum	2.04	2.05	2.07	2.07
Average	1.95	1.99	2.00	2.01
Std Deviation	0.04	0.04	0.04	0.04
Data Points	12	12	12	12
Maximum Requirement 3.4 m Ω				

Table 7 – Test Sets 7 & 8, Magnet Wire Termination LLCR Summary (milliohms)

	Initial	After Temp Life	After Temp/Hum Cycling	After Thermal Shock
Test Set 7 – (1) 21 AWG Al Wire, .016" Thick				
Minimum	2.82	2.82	2.84	2.89
Maximum	3.03	3.04	3.01	3.06
Average	2.89	2.92	2.92	2.97
Std Deviation	0.06	0.07	0.06	0.05
Data Points	12	12	12	12
Test Set 8 – (1) 21 AWG Al Wire, .0126" Thick				
Minimum	2.72	2.88	2.87	2.92
Maximum	2.95	3.06	3.04	3.06
Average	2.88	2.97	2.96	3.00
Std Deviation	0.06	0.06	0.05	0.04
Data Points	12	12	12	12
Maximum Requirement 5.4 m Ω				

Table 8 – Test Sets 9 & 10, Magnet Wire Termination LLCR Summary (milliohms)

	Test Set 9 – (1) 20 AWG Cu Wire, .016" Thick		Test Set 10 – (1) 20 AWG Cu Wire, .0126" Thick	
	Initial	After Current Cycling	Initial	After Current Cycling
Minimum	1.48	1.47	1.40	1.51
Maximum	1.58	1.59	1.58	1.57
Average	1.53	1.51	1.50	1.54
Std Deviation	0.03	0.04	0.05	0.02
Data Points	12	12	12	12
Maximum Requirement 2.1 m Ω				

Table 9 – Test Sets 11 & 12, Magnet Wire Termination LLCR Summary (milliohms)

	Test Set 11 – (1) 22 AWG Cu Wire, .016" Thick		Test Set 12 – (1) 22 AWG Cu Wire, .0126" Thick	
	Initial	After Current Cycling	Initial	After Current Cycling
Minimum	2.25	2.19	2.24	2.22
Maximum	2.32	2.30	2.40	2.37
Average	2.29	2.24	2.34	2.29
Std Deviation	0.03	0.03	0.04	0.04
Data Points	12	12	12	12
Maximum Requirement 3.3 m Ω				

Table 10 – Test Sets 13 & 14, Magnet Wire Termination LLCR Summary (milliohms)

	Test Set 13 – (1) 19 AWG Al Wire, .016" Thick		Test Set 14 – (1) 19 AWG Al Wire, .0126" Thick	
	Initial	After Current Cycling	Initial	After Current Cycling
Minimum	1.90	1.84	1.99	1.90
Maximum	1.96	1.96	2.09	2.00
Average	1.93	1.89	2.03	1.94
Std Deviation	0.02	0.04	0.03	0.03
Data Points	12	12	12	12
Maximum Requirement 3.4 m Ω				

Table 11 – Test Sets 15 & 16, Magnet Wire Termination LLCR Summary (milliohms)

	Test Set 15 – (1) 21 AWG Al Wire, .016" Thick		Test Set 16 – (1) 21 AWG Al Wire, .0126" Thick	
	Initial	After Current Cycling	Initial	After Current Cycling
Minimum	2.80	2.79	2.89	2.80
Maximum	2.99	2.91	3.08	3.01
Average	2.91	2.85	2.98	2.90
Std Deviation	0.05	0.05	0.05	0.06
Data Points	12	12	12	12
Maximum Requirement 5.4 m Ω				

2.2.2 LLCR - Poke-In Tab Mated to MAG-MATE Terminal

All measurements included approximately 1.5 inches of stranded copper wire bulk resistance. Refer to Tables 12 and 13 for data summaries for Test Sets 1, 2 (environmental) and 9, 10 (current cycling), respectively.

Table 12 – Test Sets 1 & 2, Poke-In Tab Mated to MAG-MATE Terminal LLCR Summary (milliohms)

	Initial	After Temp Life	After Temp/Hum Cycling	After Thermal Shock
Test Set 1 - .016" Thick				
Minimum	1.66	1.78	1.93	1.93
Maximum	2.05	2.03	2.18	2.24
Average	1.86	1.90	2.08	2.12
Std Deviation	0.10	0.08	0.08	0.10
Data Points	12	12	12	12
Test Set 2 – .0126" Thick				
Minimum	1.73	1.82	2.06	2.07
Maximum	1.93	2.44	2.25	2.41
Average	1.87	2.10	2.13	2.20
Std Deviation	0.05	0.17	0.06	0.10
Data Points	12	12	12	12
Poke-In Tab with 1.5", 22 AWG Strand Cu Lead Wire Mated to MAG-MATE Terminal				

Table 13– Test Sets 9 & 10, Poke-In Tab Mated to MAG-MATE Terminal Summary (milliohms)

	Test Set 9 .016" Thick		Test Set 10 .0126" Thick	
	Initial	After Current Cycling	Initial	After Current Cycling
Minimum	1.89	1.93	1.96	2.00
Maximum	2.02	2.14	2.12	2.22
Average	1.96	2.04	2.02	2.10
Std Deviation	0.04	0.07	0.05	0.07
Data Points	12	12	12	12
Poke-In Tab with 1.5", 22 AWG Strand Cu Lead Wire Mated to MAG-MATE Terminal				

2.3 Temperature Life (Test Sets 1 thru 8)

No evidence of physical damage was visible on any of the specimens as a result of temperature life exposure.

2.4 Humidity/Temperature Cycling (Test Sets 1 thru 8)

No evidence of physical damage was visible on any of the specimens as a result of exposure to humidity-temperature cycling.

2.5 Thermal Shock (Test Sets 1 thru 8)

No evidence of physical damage was visible on any of the specimens as a result of thermal shock exposure.

2.6 Current Cycling (Test Sets 9 thru 16)

No evidence of physical damage was visible as a result of exposure to current cycling and all low-level termination resistance measurements were less than the maximum (environmental) values specified in Figure 3 of TE Product Specification 108-2012, Rev H.

2.7 Cross-Sectioning (Test Sets 9 thru 16)

Cross-sections of the overall terminal and close-ups in the transverse direction showing the facial position of the magnet wires in the IDC slot were completed and submitted to the test requestor.

2.8 Unmating Force (Test Sets 1 & 2)

One data point was removed due to the terminal being damaged in the Poke-In area during termination. All other Test Set 1 and Test Set 2 specimens had measurements that were greater than the 5 pound minimum force requirement. See Table 14 for an unmating force summary.

Table 14 – Umating Force Summary (pounds)

	Test Set 1 .016" thick	Test Set 2 .0126" thick
Minimum	5.53	5.06
Maximum	14.77	10.06
Average	11.26	6.90
Std Deviation	2.84	1.58
Data Points	12	11*
Minimum Requirement 5 pounds		

NOTE

***** *One data point removed due to terminal being damaged in Poke-In area during termination.*

3. TEST METHODS

3.1 Mating Force (Test Sets 1 & 2)

The Poke-In Tabs were inserted into a drill chuck that was attached to the tensile/compression machine crosshead and load cell. The MAG-MATE terminal housings were held in a vise that was attached to a free floating table. The free floating table was secured to the tensile/compression machine base. The crosshead was manually lowered until the Poke-In Tab was oriented directly above the MAG-MATE terminal. The crosshead was then started in the compression direction at a speed of 1 inch per minute until the Poke-In Tab was fully mated with the MAG-MATE terminal. Testing was conducted in accordance with EIA-364-13E. See Figure 1 for a photo of the test setup.

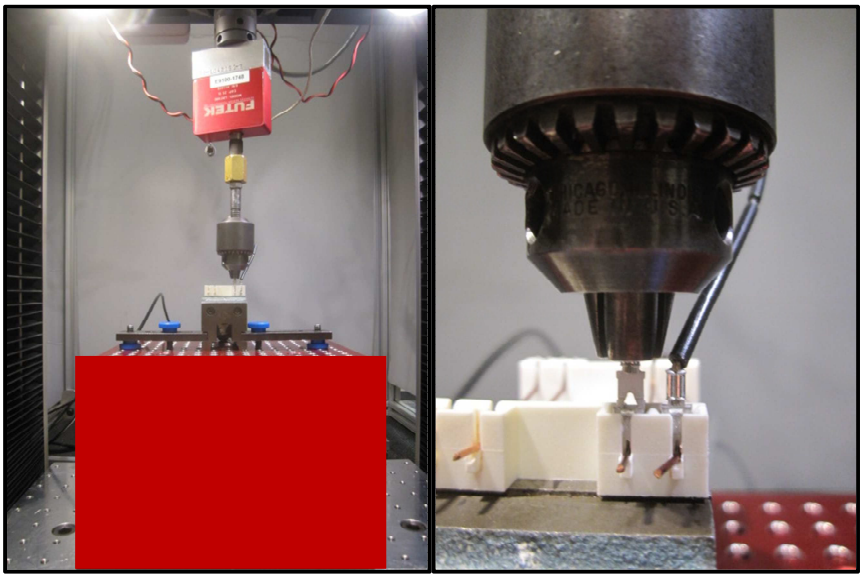

Figure 1 – Mating Force Test Setup

3.2 Low Level Contact Resistance, LLCR (All Test Sets)

3.2.1 LLCR – MAG-MATE and Magnet Wire Termination

Low level contact resistance measurements at low level current were made using a four terminal measuring technique. The test current was maintained at 100 milliamperes maximum with a 20 millivolt maximum open circuit voltage. Current and voltage (+) was applied to the top of the terminal with a pogo pin probe and current and voltage (-) was applied to the magnet wire with a Kelvin clip probe. Refer to Figure 2 for an image of the test setup and probe locations. Measurements were taken initially and after each environment or current cycling. Testing was performed in accordance with Figure 4 of TE Product Specification 108-2012 Revision H and EIA-364-23C.

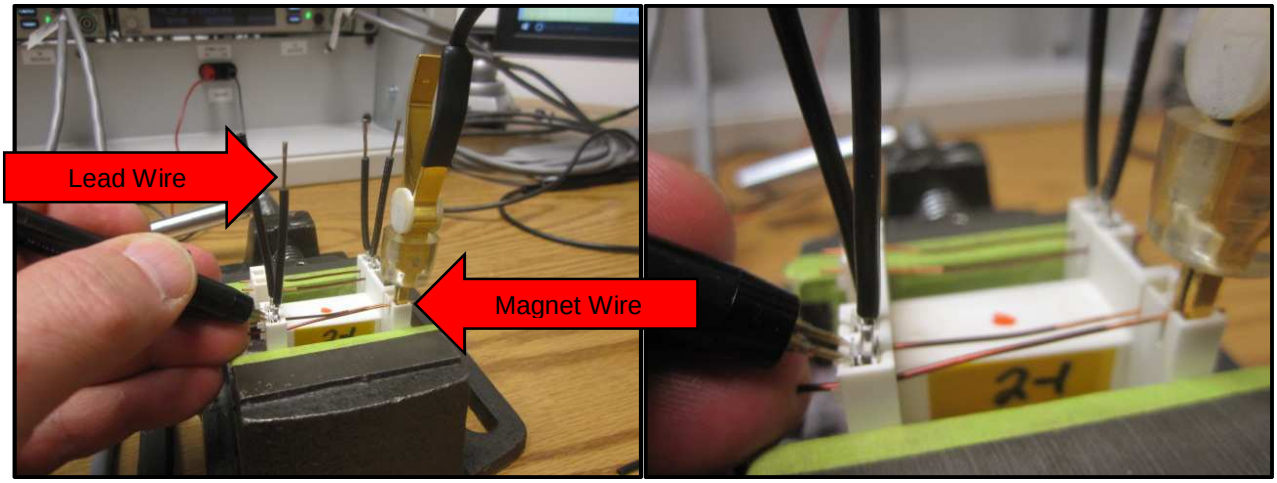

Figure 2 - LLCR Measurements

3.2.2 LLCR - Poke-In Tab Mated to MAG-MATE Terminal

Low level contact resistance measurements at low level current were made using a four terminal measuring technique. The test current was maintained at 100 milliamperes maximum with a 20 millivolt maximum open circuit voltage. Current and voltage (+) was applied to the top of the terminal with a pogo pin probe and current and voltage (-) was applied to the terminated Poke-In Tab and lead wire with a Kelvin clip probe. All measurements included the wire bulk resistance of 1.5 inches of copper stranded wire. Refer to Figure 2 for an image of the test setup and probe locations. Measurements were taken initially and after each environment or current cycling. Testing was performed in accordance with Figure 4 of TE Product Specification 108-2012 Revision H and EIA-364-23C.

3.3 Temperature Life (Test Sets 1 thru 8)

Specimens were subjected to 33 days (792 hours) at 118℃. Testing was conducted in accordance with TE Product Specification 108-2012 Rev G and EIA-364-17C, Method A.

3.4 Humidity/Temperature Cycling (Test Sets 1 thru 8)

Specimens were exposed to 10 cycles of humidity/temperature cycling. Each cycle lasted 24 hours and consisted of cycling the temperature between 25℃ a nd 65℃ twice while maintaining high humidity (betw een 80% and 100%). Testing was conducted in accordance with TE Product Specification 108-2012 Rev H and EIA-364-31E, Method IV.

3.5 Thermal Shock (Test Sets 1 thru 8)

Specimens were subjected to 25 cycles between -65 and 125℃ with 30 minute dwells at temperature extremes and less than 1 minute transitions between temperatures. Testing was conducted in accordance with TE Product Specification 108-2012 Rev H and EIA-364-32G, Test Condition III.

3.6 Current Cycling (Test Sets 9 thru 16)

The specimens were subjected to 480 cycles of 15 minutes ON and 15 minutes OFF per cycle. The ON cycle current was maintained at the current levels specified Table 15 and in Figure 3 of TE Product Specification 108-2012 Rev H. Refer to Figure 3 for an image of the test setup. Testing was performed in accordance with EIA-364-55A.

Figure 3 – Current Cycling Test Setup

Table 15 – Current Cycling Current Levels

Test Sets	Wire Type	AWG	Current (amperes)
9, 10	Cu	20	16
11, 12	Cu	22	12.5
13, 14	Al	19	12
15, 16	Al	21	9.5

3.7 Cross-Sectioning (Test Sets 9 thru 16)

Cross-sections in the transverse direction showing the facial position of the magnet wires in the IDC slot were conducted per the test request. Overall terminal and close-up photographs were taken.

3.8 Unmating Force (Test Sets 1 & 2)

A fixture with progressive tension and serrated jaws was attached to the tensile/compression machine crosshead and load cell and was used to clamp onto the Poke-In Tabs. The MAG-MATE terminal housings were secured to a free floating table with hold down bars. The free floating table was secured to the tensile/compression machine base. The crosshead was then started in the tensile direction at a speed of 1 inch per minute until the Poke-In Tab was fully unmated from the MAG-MATE terminal. Testing was conducted in accordance with EIA-364-13E. See Figure 4 for a photo of the test setup.

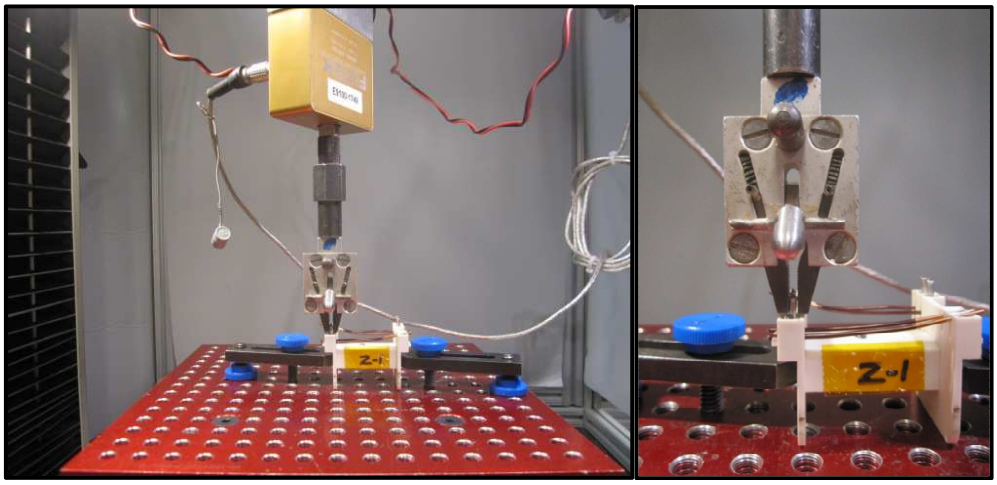

Figure 4 - Unmating Force Setup