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Validation Testing of Quadrax Wire Seal Boot - QSR Transfer Silicone Mold Process

1. INTRODUCTION

1.1 Purpose

Testing was performed on the TE Connectivity (TE) Quadrax Wire Seal Boot in order to validate a manufacturing change to a QSR transfer silicone mold process. This testing also serves as the baseline measure of performance for the transfer of assembly from the TE manufacturing facility in Mt. Joy, Pennsylvania, to the TE manufacturing facility in Hermosillo, Mexico. Testing of the TE Quadrax Rectangular connector assembled at the TE manufacturing facility in Hermosillo, Mexico, was completed and is documented under Engineering Test Report 502-134120, Rev. A.

1.2 Scope

Testing was performed in accordance with Boeing Part Specification BPS-C-193, Rev. A, at the TE Harrisburg Electrical Components Test Laboratory (HECTL) between August 27, 2014, and October 3, 2014. Detailed test data is on file and maintained at HECTL under test number EA20140484T.

1.3 Conclusion

All specimens, as identified in Paragraph 1.4, met the requirements for the tests performed as stated in Boeing Part Specification BPS-C-193, Rev. A, when tested per the test sequence as defined in Paragraph 1.5.

1.4 Test Specimens

Specimens identified with the following part numbers were used for test:

Table 1 – Test Specimens

Test Set	Qty	Part Number	Description
1	2	1604799-8	Quadrax Receptacle, 12 Position. Wire Seal Boot, p/n 181148-1, manufactured with QSR silicone transfer mold process. Assembled in Mt. Joy, Pennsylvania.
	2	1-1604800-4	Quadrax Plug, 12 Position. Wire Seal Boot, p/n 181148-1, manufactured with QSR silicone transfer mold process. Assembled in Mt. Joy, Pennsylvania.

1.5 Test Sequence

Table 2 – Test Sequence

Test or Examination	Test Sequence
Dielectric Withstanding Voltage	1, 5
Insulation Resistance	2, 4
Altitude Immersion	3
Contact Retention	6

1.6 Environmental Conditions

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

Temperature: 15°C to 35°C
Relative Humidity: 20% to 80%

2. SUMMARY OF TESTING

2.1 Dielectric Withstanding Voltage, Initial

All unmated plug and receptacle connectors exhibited no evidence of dielectric breakdown or flashover, and all leakage current measurements were less than the maximum requirement of 1 milliampere, as specified in Boeing Part Specification BPS-C-193, Rev. A. Leakage current results are contained in Table 3.

Table 3 – Initial Dielectric Withstanding Voltage Leakage Current

Sample ID	Connector Position	Leakage Current (milliamperes) (Note: R, B, G, and Y indicate signal contact wire insulation color.)			
		Y – R/B/G	R – Y/B/G	B – R/Y/G	All – Outer Body
101 Plug	1	0.016	0.013	0.016	0.029
	2	0.018	0.018	0.018	0.030
	3	0.017	0.016	0.018	0.029
	4	0.015	0.008	0.014	0.030
	5	0.008	0.008	0.009	0.029
	6	0.016	0.015	0.017	0.029
	7	0.014	0.015	0.015	0.028
	8	0.016	0.016	0.015	0.029
	9	0.016	0.015	0.016	0.029
	10	0.017	0.017	0.018	0.026
	11	0.015	0.016	0.016	0.030
	12	0.018	0.017	0.017	0.030
101 Receptacle	1	0.016	0.017	0.017	0.028
	2	0.016	0.017	0.016	0.030
	3	0.016	0.016	0.016	0.029
	4	0.017	0.016	0.017	0.028
	5	0.017	0.018	0.017	0.029
	6	0.018	0.018	0.018	0.029
	7	0.018	0.018	0.017	0.029
	8	0.018	0.018	0.018	0.029
	9	0.018	0.017	0.018	0.029
	10	0.017	0.017	0.017	0.027
	11	0.018	0.018	0.019	0.030
	12	0.018	0.017	0.018	0.029
102 Plug	1	0.019	0.019	0.018	0.030
	2	0.018	0.017	0.018	0.030
	3	0.017	0.018	0.017	0.030
	4	0.018	0.017	0.018	0.030
	5	0.018	0.017	0.018	0.030
	6	0.018	0.018	0.017	0.030
	7	0.018	0.018	0.018	0.029
	8	0.018	0.017	0.018	0.030
	9	0.019	0.017	0.016	0.029
	10	0.019	0.018	0.017	0.029
	11	0.019	0.018	0.019	0.029
	12	0.018	0.018	0.018	0.030
102 Receptacle	1	0.017	0.017	0.017	0.031
	2	0.017	0.017	0.017	0.029
	3	0.017	0.017	0.016	0.030
	4	0.016	0.015	0.015	0.030
	5	0.018	0.018	0.017	0.030
	6	0.017	0.018	0.017	0.030
	7	0.017	0.018	0.017	0.030
	8	0.018	0.018	0.018	0.030
	9	0.017	0.017	0.017	0.030
	10	0.018	0.017	0.018	0.030
	11	0.017	0.016	0.017	0.029
	12	0.017	0.017	0.017	0.028

2.2 Insulation Resistance, Initial

Insulation resistance measurements of all unmated plug and receptacle connectors were greater than the minimum requirement of 5.0 x 10^3 MegOhms, as specified in Boeing Part Specification BPS-C-193, Rev. A. Insulation resistance results are contained in Table 4.

Table 4 – Initial Insulation Resistance

Sample ID	Connector Position	Insulation Resistance (MegOhms) (Note: R, B, G, and Y indicate signal contact wire insulation color.)			
		Y – R/B/G	R – Y/B/G	B – R/Y/G	All – Outer Body
101 Plug	1	8.1 x 10^4	7.9 x 10^4	9.0 x 10^4	5.0 x 10^4
	2	9.1 x 10^4	6.5 x 10^4	6.3 x 10^4	3.7 x 10^4
	3	6.7 x 10^4	8.1 x 10^4	8.8 x 10^4	3.3 x 10^4
	4	7.6 x 10^4	4.8 x 10^4	7.2 x 10^4	3.2 x 10^4
	5	6.3 x 10^4	4.3 x 10^4	6.6 x 10^4	2.0 x 10^4
	6	6.9 x 10^4	8.2 x 10^4	6.8 x 10^4	3.8 x 10^4
	7	8.9 x 10^4	8.4 x 10^4	9.0 x 10^4	3.8 x 10^4
	8	4.4 x 10^4	4.3 x 10^4	5.5 x 10^4	4.3 x 10^4
	9	7.2 x 10^4	7.4 x 10^4	5.1 x 10^4	4.6 x 10^4
	10	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5
	11	9.1 x 10^4	5.3 x 10^4	5.8 x 10^4	3.9 x 10^4
	12	2.8 x 10^4	5.2 x 10^4	3.4 x 10^4	5.4 x 10^4
101 Receptacle	1	3.2 x 10^4	6.4 x 10^4	> 1.0 x 10^5	7.9 x 10^4
	2	6.8 x 10^4	> 1.0 x 10^5	5.8 x 10^4	3.2 x 10^4
	3	5.1 x 10^4	8.4 x 10^4	9.9 x 10^4	5.4 x 10^4
	4	> 1.0 x 10^5	> 1.0 x 10^5	1.0 x 10^5	2.9 x 10^4
	5	> 1.0 x 10^5	9.0 x 10^4	6.2 x 10^4	7.5 x 10^4
	6	7.9 x 10^4	7.4 x 10^4	8.4 x 10^4	5.3 x 10^4
	7	9.1 x 10^4	> 1.0 x 10^5	> 1.0 x 10^5	8.7 x 10^4
	8	8.7 x 10^4	> 1.0 x 10^5	8.3 x 10^4	9.0 x 10^4
	9	6.9 x 10^4	3.6 x 10^4	4.9 x 10^4	3.5 x 10^4
	10	9.0 x 10^4	7.0 x 10^4	> 1.0 x 10^5	1.0 x 10^5
	11	9.9 x 10^4	9.9 x 10^4	9.3 x 10^4	9.0 x 10^4
	12	9.0 x 10^4	5.9 x 10^4	>1.0 x 10^5	3.8 x 10^4
102 Plug	1	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5	9.0 x 10^4
	2	9.9 x 10^4	> 1.0 x 10^5	> 1.0 x 10^5	5.3 x 10^4
	3	2.4 x 10^4	> 1.0 x 10^5	> 1.0 x 10^5	7.0 x 10^4
	4	8.9 x 10^4	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5
	5	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5
	6	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5
	7	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5	9.0 x 10^4
	8	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5
	9	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5
	10	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5
	11	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5
	12	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5
102 Receptacle	1	7.3 x 10^4	> 1.0 x 10^5	9.0 x 10^4	9.9 x 10^4
	2	> 1.0 x 10^5	> 1.0 x 10^5	6.0 x 10^4	6.3 x 10^4
	3	6.3 x 10^4	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5
	4	9.1 x 10^4	9.9 x 10^4	9.9 x 10^4	9.0 x 10^4
	5	8.7 x 10^4	> 1.0 x 10^5	> 1.0 x 10^5	3.4 x 10^4
	6	> 1.0 x 10^5	7.5 x 10^4	> 1.0 x 10^5	1.7 x 10^4
	7	7.2 x 10^4	> 1.0 x 10^5	> 1.0 x 10^5	8.6 x 10^4
	8	4.9 x 10^4	> 1.0 x 10^5	> 1.0 x 10^5	5.0 x 10^4
	9	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5
	10	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5	2.8 x 10^4
	11	9.9 x 10^4	> 1.0 x 10^5	> 1.0 x 10^5	> 1.0 x 10^5
	12	> 1.0 x 10^5	8.2 x 10^4	> 1.0 x 10^5	> 1.0 x 10^5

2.3 Altitude Immersion

Following altitude immersion cycling, and while still immersed in the salt water solution, mated plug and receptacle connectors were subjected to insulation resistance measurements and dielectric withstanding voltage testing.

2.3.1 Insulation Resistance, Post Altitude Immersion

Following altitude Immersion cycling, insulation resistance measurements of all mated plug and receptacle connectors were greater than the minimum requirement of 5.0×10^3 MegOhms, as specified in Boeing Part Specification BPS-C-193, Rev. A. Post altitude immersion insulation resistance results are contained in Table 5.

Table 5 – Post Altitude Immersion Insulation Resistance

Sample ID	Connector Position	Insulation Resistance (MegOhms) (Note: R, B, G, and Y indicate signal contact wire insulation color.)			
		Y – R/B/G	R – Y/B/G	G – R/Y/B	All – Outer Body
101 Plug & Receptacle	1	> 1.0×10^5	3.3×10^4	8.6×10^4	6.3×10^4
	2	4.6×10^4	> 1.0×10^5	3.8×10^4	1.0×10^4
	3	> 1.0×10^5	7.7×10^4	> 1.0×10^5	4.5×10^4
	4	> 1.0×10^5	9.3×10^4	> 1.0×10^5	> 1.0×10^5
	5	3.4×10^4	5.1×10^4	5.1×10^4	> 1.0×10^5
	6	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5
	7	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5
	8	6.1×10^4	6.6×10^4	> 1.0×10^5	> 1.0×10^5
	9	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5	1.2×10^4
	10	> 1.0×10^5	3.4×10^4	> 1.0×10^5	> 1.0×10^5
	11	3.6×10^4	6.3×10^4	> 1.0×10^5	1.5×10^4
	12	3.2×10^4	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5
102 Plug & Receptacle	1	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5
	2	> 1.0×10^5	7.8×10^4	4.5×10^4	2.5×10^4
	3	3.7×10^4	> 1.0×10^5	1.0×10^5	> 1.0×10^5
	4	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5
	5	4.2×10^4	6.2×10^4	> 1.0×10^5	6.8×10^4
	6	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5	5.5×10^4
	7	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5	2.6×10^4
	8	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5	4.8×10^4
	9	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5	5.1×10^4
	10	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5	3.1×10^5
	11	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5
	12	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5	> 1.0×10^5

2.3.2 Dielectric Withstanding Voltage, Post Altitude Immersion

Following altitude Immersion cycling, all mated plug and receptacle connectors exhibited no evidence of dielectric breakdown or flashover, and all leakage current measurements were less than the maximum requirement of 1 milliampere, as specified in Boeing Part Specification BPS-C-193, Rev. A. Leakage current results are contained in Table 6.

2.3.2 Dielectric Withstanding Voltage, Post Altitude Immersion (cont.)

Table 6 – Post Altitude Immersion Dielectric Withstanding Voltage Leakage Current

Sample ID	Connector Position	Leakage Current (milliamperes) (Note: R, B, G, and Y indicate signal contact wire insulation color.)			
		Y – R/B/G	R – Y/B/G	B – R/Y/G	All – Outer Body
101 Plug & Receptacle	1	0.029	0.029	0.029	0.058
	2	0.029	0.026	0.026	0.058
	3	0.026	0.025	0.026	0.056
	4	0.026	0.027	0.026	0.056
	5	0.029	0.022	0.027	0.058
	6	0.027	0.027	0.025	0.058
	7	0.028	0.027	0.027	0.057
	8	0.027	0.026	0.027	0.058
	9	0.027	0.028	0.028	0.057
	10	0.025	0.026	0.026	0.053
	11	0.029	0.028	0.030	0.053
	12	0.027	0.029	0.029	0.058
102 Plug & Receptacle	1	0.028	0.029	0.028	0.059
	2	0.028	0.028	0.028	0.057
	3	0.028	0.028	0.029	0.058
	4	0.029	0.029	0.029	0.058
	5	0.027	0.026	0.027	0.057
	6	0.025	0.029	0.028	0.057
	7	0.027	0.027	0.028	0.057
	8	0.028	0.028	0.028	0.058
	9	0.027	0.028	0.028	0.058
	10	0.027	0.027	0.027	0.058
	11	0.028	0.028	0.028	0.057
	12	0.027	0.027	0.027	0.057

2.4 Contact Retention

Contact displacement measurements of all unmated plug and receptacle connectors were less than the maximum requirement of 0.015 inches, as specified in Boeing Part Specification BPS-C-193, Rev. A. There was no dislodging or damage to the contacts. Contact displacement results are contained in Table 7.

Table 7 – Contact Retention Contact Displacement

Connector Position	Contact Displacement (inches)			
	101 Plug	101 Receptacle	102 Plug	102 Receptacle
1	0.0070	0.0046	0.0077	0.0035
2	0.0078	0.0035	0.0076	0.0036
3	0.0062	0.0030	0.0074	0.0033
4	0.0073	0.0036	0.0061	0.0036
5	0.0075	0.0046	0.0057	0.0035
6	0.0067	0.0032	0.0053	0.0033
7	0.0070	0.0032	0.0064	0.0033
8	0.0064	0.0042	0.0058	0.0044
9	0.0061	0.0035	0.0064	0.0034
10	0.0071	0.0032	0.0080	0.0039
11	0.0071	0.0035	0.0059	0.0035
12	0.0066	0.0039	0.0063	0.0037

3. TEST METHODS

3.1 Dielectric Withstanding Voltage

The unmated plug and receptacle connectors were subjected to a dielectric withstanding voltage at sea level test in accordance with paragraphs 3.4.6 and 4.6.6.1 of Boeing BPS- C-193, Rev. A, and EIA 364-20, Rev. D (superseding Method 3001of MIL-STD-1344). A test voltage of 1,000 volts RMS (60 Hz) was applied between all adjacent center contacts, and a test voltage of 500 volts RMS (60 Hz) was applied between all center contacts and the outer body of each Quadrax contact. The maximum specified leakage current was 1 milliampere. The test voltage was applied at a rate of 500 volts per second, and maintained for a period of 60 seconds. Photographs of the initial test setup are contained in Figure 1 and Figure 2. Photographs of the post Altitude Immersion test setup are contained in Figure 3 and Figure 4.

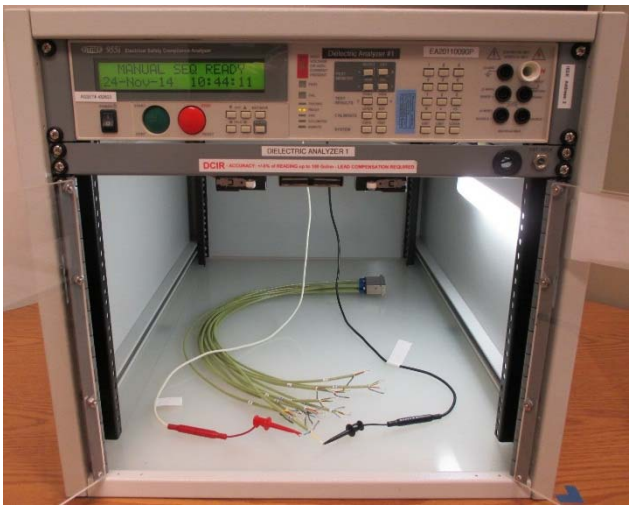

Figure 1 – Initial Dielectric Withstanding Voltage / Insulation Resistance Test Setup

Figure 2 – Initial Dielectric Withstanding Voltage / Insulation Resistance Test Setup

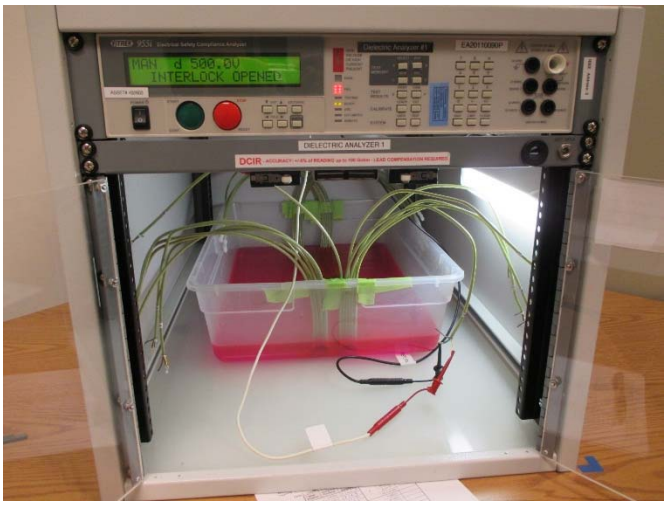

Figure 3 – Post Altitude Immersion Dielectric Withstanding Voltage / Insulation Resistance Test Setup

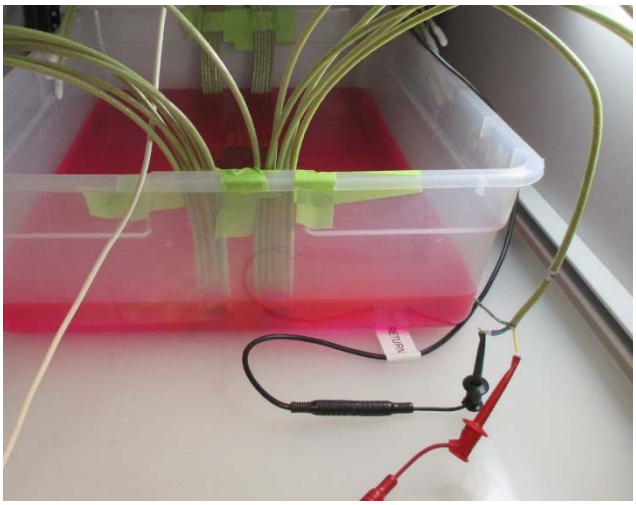

Figure 4 – Post Altitude Immersion Dielectric Withstanding Voltage / Insulation Resistance Test Setup

3.2 Insulation Resistance

The unmated plug and receptacle connectors were subjected to an insulation resistance at ambient temperature test in accordance with paragraphs 3.4.5.1 and 4.6.5.1 of Boeing BPS- C-193, Rev. A, and EIA 364-21, Rev. E (superseding Method 3003 of MIL-STD-1344). A test voltage of 500 volts DC was applied between all adjacent signal contacts, and between all signal contacts and the outer body of each contact. The test voltage was applied for a maximum of 2 minutes, or when a stable reading greater than the minimum specified requirement of 5.0×10^3 MegOhms was measured. Photographs of the initial test setup are contained in Figure 1 and Figure 2. Photographs of the post Altitude Immersion test setup are contained in Figure 3 and Figure 4.

3.3 Altitude Immersion

The mated plug and receptacle connectors were subjected to an altitude immersion test in accordance with paragraphs 3.4.16 and 4.6.16 of Boeing Specification BPS-C-193, Rev. A, and EIA 364-03, Rev. C (superseding Method 1004.1 of MIL-STD-1344). The specimens were placed in a container of 5% salt water and dye solution so that the uppermost point of the specimens was at least 1 inch below the surface of the solution. All wired ends were sealed in dielectric wax, located inside the chamber and exposed to the atmosphere, but not submerged in the solution. Photographs of the test setup are contained in Figure 5 and Figure 6.

The specimens were then subjected to 3 cycles of the following:

Step 1 – 5 Minutes transfer from ambient pressure to 50,000 feet above sea level
Step 2 – 30 minute dwell at 50,000 feet above sea level
Step 3 – 1 minute transfer from 50,000 feet above sea level to ambient pressure
Step 4 – 30 minute dwell at ambient pressure

Following the third cycle, the specimens were tested for dielectric withstanding voltage and insulation resistance measurements while still submerged in the salt solution.

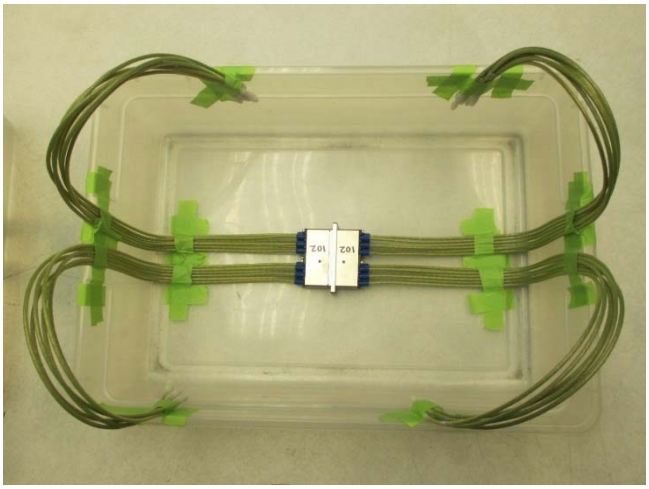

Figure 5 – Altitude Immersion Test Setup

Figure 6 – Altitude Immersion Test Setup

3.4 Contact Retention

The unmated plug and receptacle connectors were subjected to contact retention testing in accordance with paragraphs 3.4.10 and 4.6.10 of Boeing Specification BPS-C-193, Rev. A, and EIA 364-29, Rev. C. Unwired contacts were inserted into each cavity in place of the wired contacts to facilitate testing. The specimen under test was then mounted into a vise secured to an adjustable x-y table on the base of the tensile/compression machine. A steel gage pin was secured in a chuck attached to the load cell on the moveable crosshead of the tensile/compression machine. The contact under test was then pre-loaded to approximately 3 pounds in a direction tending to displace the contact to the rear. A minimum axial load of 35 pounds was then applied to the contact position under test at a crosshead rate of 0.3 inches per minute, and maintained for a minimum period of 6 seconds. Both during and following the application of the load, the contact displacement was measured using a deflectometer. Photographs of the test setup are contained in Figure 7 and Figure 8.

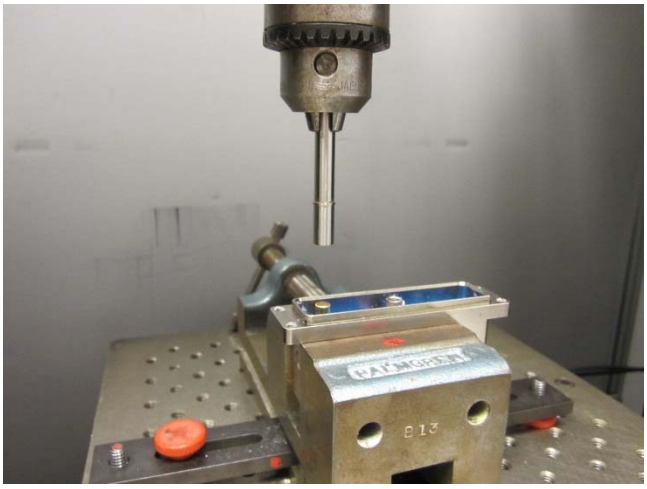

Figure 7 – Contact Retention Test Setup

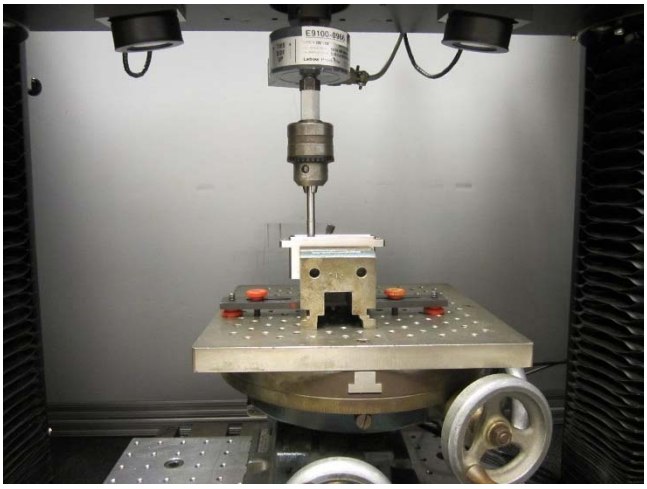

Figure 8 – Contact Retention Test Setup

4. EQUIPMENT

4.1 Calibration Statement

All equipment containing a calibration number is calibrated and traceable through TE Connectivity (TE) to the National Institute of Standards and Technology (NIST).

4.2 Equipment List

Equipment Name	Calibration Number
Dielectric Analyzer / High Resistance Meter	E9100-1754
Dielectric Analyzer / High Resistance Meter	E9100-1744
Altitude Chamber	E9100-1118
Tensile/Compression Tester	E9100-1505
Load Cell (100 lbs)	E9100-0966
Deflectometer	E9100-1436
Temperature/Humidity/Pressure Recorder	E9100-1703