Qualification of AMR Bot and Charging Connector

1. INTRODUCTION

1.1 Purpose

Testing was performed on the TE Connectivity AMR Bot and Charging connector to determine its conformance to the requirements of Design Objective 108-160493, Rev A.

1.2 Scope

This report covers the electrical, mechanical, and environmental performance of the TE Connectivity AMR Bot and Charging connector. Testing was performed at the Harrisburg Electrical Components Test Laboratory between January 10, 2023 and June 27, 2023. Detailed test data is on file and maintained at HECTL under EA20220414T and EA20230473T.

1.3 Conclusion

The specimens identified in paragraph 1.5, Table 1 conformed to the electrical, mechanical, and environmental performance requirements of Product Specification 108-160493, Rev A.

1.4 Product Description

TE Connectivity (TE)'s blind-mating mobile charging connectors are intended for smaller mobile robots and autonomous vehicles typically used in warehouse environments. Autonomous mobile robots (AMR) are currently used mostly for material handling (picking, movement, storage, and sorting) in the warehouse automation space. The charging connectors are available in two and three power-contact options with up to eight signal contacts to ease installation and rework cycle times.

1.5 Test Specimens

The test specimens were representative of normal production lots, and specimens identified with the following part numbers were used for test:

Table 1 – Test Specimens

Test Group	Test Set	Quantity	Part Number	Description
A	1	1	2399991-1 Rev 2	2P Bot Kit Assembly, Receptacle Docking AMR Charging Connector
		2	2390328-1 Rev 2	Power Socket Contact, Dia. 3.6, 8AWG Stranded Docking
		1	2399992-1 Rev 3	2P Kit Assembly, Plug Docking, Charger AMR Charging Connector
		2	2390329-1 Rev 1	Pin Contact, Dia. 3.6, 8AWG Docking
		2	794192-1 Rev F	Mini Universal MATE-N-LOKII Plug Housing
		16	1-794217-0 Rev N	Mini Universal MATE-N-LOKII Socket Contact
	2	3	2400405-1 Rev 1	3P BOT Kit Assembly Receptacle Docking AMR Charging Connector
		9	2390328-1 Rev 2	Power Socket Contact, Dia. 3.6, 8AWG Docking
		3	2400406-1 Rev 1	3P Kit Assembly, Plug Docking, Charger Amr Charging Connector
		9	2390329-1 Rev 1	Pin Contact, Dia. 3.6, 8AWG Docking
		6	794192-1 Rev F	Mini Universal MATE-N-LOKII Plug Housing
		48	1-794217-0 Rev N	Mini Universal MATE-N-LOKII Socket Contact

Table 1 – Test Specimens – continued

Test Group	Test Set	Quantity	Part Number	Description
B	3	4	2399991-1 Rev 2	2P Bot Kit Assembly, Receptacle Docking AMR Charging Connector
		8	2390328-1 Rev 2	Power Socket Contact, Dia. 3.6, 8AWG Stranded Docking
		4	2399992-1 Rev 3	2P Kit Assembly, Plug Docking, Charger AMR Charging Connector
		8	2390329-1 Rev 1	Pin Contact, Dia. 3.6, 8AWG Docking
	4	2	2400405-1 Rev 1	3P BOT Kit Assembly Receptacle Docking AMR Charging Connector
		6	2390328-1 Rev 2	Power Socket Contact, Dia. 3.6, 8AWG Docking
		2	2400406-1 Rev 1	3P Kit Assembly, Plug Docking, Charger Amr Charging Connector
		6	2390329-1 Rev 1	Pin Contact, Dia. 3.6, 8AWG Docking
C	5	2	2399991-1 Rev 2	2P Bot Kit Assembly, Receptacle Docking AMR Charging Connector
		4	2390328-1 Rev 2	Power Socket Contact, Dia. 3.6, 8AWG Stranded Docking
		2	2399992-1 Rev 3	2P Kit Assembly, Plug Docking, Charger AMR Charging Connector
		4	2390329-1 Rev 1	Pin Contact, Dia. 3.6, 8AWG Docking
		4	794192-1 Rev F	Mini Universal MATE-N-LOKII Plug Housing
		32	1-794217-0 Rev N	Mini Universal MATE-N-LOKII Socket Contact
	6	3	2400405-1 Rev 1	3P BOT Kit Assembly Receptacle Docking AMR Charging Connector
		9	2390328-1 Rev 2	Power Socket Contact, Dia. 3.6, 8AWG Docking
		3	2400406-1 Rev 1	3P Kit Assembly, Plug Docking, Charger Amr Charging Connector
		9	2390329-1 Rev 1	Pin Contact, Dia. 3.6, 8AWG Docking
		6	794192-1 Rev F	Mini Universal MATE-N-LOKII Plug Housing
		48	1-794217-0 Rev N	Mini Universal MATE-N-LOKII Socket Contact
D	7	2	2399991-1 Rev 2	2P Bot Kit Assembly, Receptacle Docking AMR Charging Connector
		4	2390328-1 Rev 2	Power Socket Contact, Dia. 3.6, 10AWG Stranded Docking
		2	2399992-1 Rev 3	2P Kit Assembly, Plug Docking, Charger AMR Charging Connector
		4	2390329-1 Rev 1	Pin Contact, Dia. 3.6, 10AWG Docking
		4	794192-1 Rev F	Mini Universal MATE-N-LOKII Plug Housing
		32	1-794217-0 Rev N	Mini Universal MATE-N-LOKII Socket Contact
	8	3	2400405-1 Rev 1	3P BOT Kit Assembly Receptacle Docking AMR Charging Connector
		9	2390328-1 Rev 2	Power Socket Contact, Dia. 3.6, 10AWG Docking
		3	2400406-1 Rev 1	3P Kit Assembly, Plug Docking, Charger Amr Charging Connector
		9	2390329-1 Rev 1	Pin Contact, Dia. 3.6, 10AWG Docking
		6	794192-1 Rev F	Mini Universal MATE-N-LOKII Plug Housing
		48	1-794217-0 Rev N	Mini Universal MATE-N-LOKII Socket Contact

Table 1 – Test Specimens – continued

Test Group	Test Set	Quantity	Part Number	Description
E	9	3	2399991-1 Rev 2	2P Bot Kit Assembly, Receptacle Docking AMR Charging Connector
		6	2390328-1 Rev 2	Power Socket Contact, Dia. 3.6, 8AWG Stranded Docking
		3	2399992-1 Rev 3	2P Kit Assembly, Plug Docking, Charger AMR Charging Connector
		6	2390329-1 Rev 1	Pin Contact, Dia. 3.6, 8AWG Docking
		6	794192-1 Rev F	Mini Universal MATE-N-LOKII Plug Housing
		48	1-794217-0 Rev N	Mini Universal MATE-N-LOKII Socket Contact
	10	2	2400405-1 Rev 1	3P BOT Kit Assembly Receptacle Docking AMR Charging Connector
		6	2390328-1 Rev 2	Power Socket Contact, Dia. 3.6, 10AWG Docking
		2	2400406-1 Rev 1	3P Kit Assembly, Plug Docking, Charger Amr Charging Connector
		6	2390329-1 Rev 1	Pin Contact, Dia. 3.6, 8AWG Docking
		4	794192-1 Rev F	Mini Universal MATE-N-LOKII Plug Housing
		32	1-794217-0 Rev N	Mini Universal MATE-N-LOKII Socket Contact
F	11	5	2390328-1 Rev 2	Power Socket Contact, 8AWG stranded wire
	12	5	2390328-1 Rev 2	Power Socket Contact, 10AWG stranded wire
	13	5	2390329-1 Rev 1	Power Pin Contact, 8AWG stranded wire
	14	5	2390329-1 Rev 1	Power Pin Contact, 10AWG stranded wire
G	15	2	2399991-1 Rev 2	2P Bot Kit Assembly, Receptacle Docking AMR Charging Connector
		4	2390328-1 Rev 2	Power Socket Contact, Dia. 3.6, 8AWG Stranded Docking
		2	2399992-1 Rev 3	2P Kit Assembly, Plug Docking, Charger AMR Charging Connector
		4	2390329-1 Rev 1	Pin Contact, Dia. 3.6, 8AWG Docking
	16	1	2400405-1 Rev 1	3P BOT Kit Assembly Receptacle Docking AMR Charging Connector
		3	2390328-1 Rev 2	Power Socket Contact, Dia. 3.6, 8AWG Docking
		1	2400406-1 Rev 1	3P Kit Assembly, Plug Docking, Charger Amr Charging Connector
		3	2390329-1 Rev 1	Pin Contact, Dia. 3.6, 8AWG Docking
	17	2	2399991-1 Rev 2	2P Bot Kit Assembly, Receptacle Docking AMR Charging Connector
		4	2390328-1 Rev 2	Power Socket Contact, Dia. 3.6, 10AWG Stranded Docking
		2	2399992-1 Rev 3	2P Kit Assembly, Plug Docking, Charger AMR Charging Connector
		4	2390329-1 Rev 1	Pin Contact, Dia. 3.6, 8AWG Docking
	18	1	2400405-1 Rev 1	3P BOT Kit Assembly Receptacle Docking AMR Charging Connector
		3	2390328-1 Rev 2	Power Socket Contact, Dia. 3.6, 10AWG Docking
		1	2400406-1 Rev 1	3P Kit Assembly, Plug Docking, Charger Amr Charging Connector
		3	2390329-1 Rev 1	Pin Contact, Dia. 3.6, 8AWG Docking

1.4 Qualification Test Sequence

The specimens listed in paragraph 1.4 were subjected to the test sequences outlined below in Table 2.

Table 2 – Qualification Test Sequence

Test or Examination	Test Groups						
	A	B(c)	C	D (c)	E	F	G
	Test Sequence (a)						
Initial Examination of Product	1	1	1	1	1	1	1
LLCR	2,5(b)	2,7(b)	2,9(b)	2,4	2,4		
Insulation Resistance			3,7				
Dielectric Withstanding Voltage			4,8				
Temperature Rise vs Current		3,8					
Random Vibration	3	6					
Mechanical Shock	4						
Crimp Tensile Strength (Power)						2	
Current Cycling				3			
Connector Mating Force							2
Connector Un-mating Force							3
Contact TPA Retention							4
Durability					3		
Thermal Shock			5				
Humidity-Temperature Cycling		4	6				
Temperature Life		5					
Final Examination of Product	6	9	10	5	5	3	5

(a) The numbers indicate sequence in which tests were performed
(b) Unmate and mate 1 time for reseating before LLCR.
(c) Signal contacts are not measured in this Test Group.

1.5 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 Initial Examination of Product – All Groups

All specimens submitted for testing were representative of normal production lots. A Certificate of Conformance was issued by Product Assurance. Where specified, specimens were visually examined and no evidence of physical damage detrimental to product performance was observed.

2.2 Low Level Contact Resistance – Groups A, B, C, D, E

All low level contact resistance (LLCR) measurements for Power contacts were less than 1 milliohms initially and had a change in resistance (ΔR) of less than 0.7 milliohms after testing. All Signal contacts had initial measurements less than 16 milliohm and had a change in resistance (ΔR) of less than 55 milliohms after testing. See Tables 3 through 12 for LLCR measurements.

Table 3 – Low Level Contact Resistance Summary (Milliohms), Test Set 1

Group A	Initial		Delta Post Mechanical Shock	
	Power	Signal	Power	Signal
	milliohms	milliohms	milliohms	milliohms
Max Requirement	1	16	0.7	55
Minimum	0.49	8.34	-0.04	1.19
Maximum	0.53	10.85	-0.03	21.32
Average	0.51	9.89	-0.04	9.06
Count	2	8	2	8

Table 4 – Low Level Contact Resistance Data (Milliohms), Test Set 2

Group A	Initial		Delta Post Mechanical Shock		Delta Post Reseating Cycle	
	Power	Signal	Power	Signal	Power	Signal
	milliohms	milliohms	milliohms	milliohms	milliohms	milliohms
Max Requirement	1	16	0.7	55	0.7	55
Minimum	0.50	7.33	-0.07	0.21	0.01	0.17
Maximum	0.58	10.94	0.00	4.41	0.09	6.51
Average	0.53	8.68	-0.02	2.21	0.06	2.49
Count	9	24	9	24	9	24

Table 5 – Low Level Contact Resistance Data (Milliohms), Test Set 3

Group B	Initial	Delta after Vibration
Power Contacts	milliohms	milliohms
Max Requirement	**1**	**0.7**
Minimum:	0.469	0.140
Maximum:	0.552	0.681
Average:	0.509	0.386
Count	8	8

Table 6 – Low Level Contact Resistance Data (Milliohms), Test Set 4

Group B	Initial	Delta after Vibration
	Power	Power
	milliohms	milliohms
Max Requirement	**1**	**0.7**
Minimum	0.441	0.126
Maximum	0.566	0.464
Average	0.513	0.320
Count	6	6

Table 7 – Low Level Contact Resistance Data (Milliohms), Test Set 5

Group C	Initial		Delta after Withstanding Voltage	
	Power	Signal	Power	Signal
	milliohms	milliohms	milliohms	milliohms
Max Requirement	**1**	**16**	**0.7**	**55**
Minimum	0.48	8.15	0.03	-1.68
Maximum	0.53	11.03	0.17	2.59
Average	0.51	9.48	0.09	-0.09
Count	4	16	4	16

Table 8 – Low Level Contact Resistance Data (Milliohms), Test Set 6

Group C	Initial		Delta after Withstanding Voltage	
	Power	Signal	Power	Signal
	milliohms	milliohms	milliohms	milliohms
Max Requirement	**1**	**16**	**0.7**	**55**
Minimum	0.49	8.46	0.02	-4.29
Maximum	0.60	15.44	0.17	7.45
Average	0.53	10.29	0.08	0.37
Count	9	24	9	24

Table 9 – Low Level Contact Resistance Data (Milliohms), Test Set 7

Group D	Initial	Delta after Current Cycling
	Power	Power
	milliohms	milliohms
Max Requirement	**1**	**0.7**
Minimum	0.63	-0.04
Maximum	0.70	0.02
Average	0.67	0.00
Count	4	4

Table 10 – Low Level Contact Resistance Data (Milliohms), Test Set 8

Group D	Initial	Delta after Current Cycling
	Power	Power
	milliohms	milliohms
Max Requirement	**1**	**0.7**
Minimum	0.54	-0.07
Maximum	0.64	0.06
Average	0.58	0.01
Count	9	9

Table 11 – Low Level Contact Resistance Data (Milliohms), Test Set 9

Group E	Initial		Delta after 12,000 Durability Cycles	
	Power	Signal	Power	Signal
	milliohms	milliohms	milliohms	milliohms
Max Requirement	**1**	**16**	**0.7**	**55**
Minimum	0.47	7.95	0.30	-3.15
Maximum	0.60	12.20	0.49	11.78
Average	0.53	9.58	0.39	0.28
Count	6	24	6	24

Table 12 – Low Level Contact Resistance Data (Milliohms), Test Set 10

Group E	Initial		Delta after 12,000 Durability Cycles	
	Power	Signal	Power	Signal
	milliohms	milliohms	milliohms	milliohms
Max Requirement	**1**	**16**	**0.7**	**55**
Minimum	0.53	8.47	-0.01	-2.43
Maximum	0.74	13.18	0.57	3.61
Average	0.66	9.83	0.39	-0.08
Count	6	16	6	16

2.3 Insulation Resistance – Group C

All insulation resistance measurements were greater than 100 megohms initially and following environmental exposure.

2.4 Dielectric Withstanding Voltage – Group C

No dielectric breakdown or flashover occurred.

2.5 Temperature Rise vs Current – Groups B

All of the specimens had a temperature rise (T-Rise) of less than 45°C above ambient when tested at specified current. Refer to Table 13 for temperature rise vs. current data in degrees Celsius.

Table 13 –Temperature Rise vs. Current Data in Degrees Celsius, Test Sets 3 and 4

Group B		Initial	Final
Temperature Rise Above Ambient, °C (45°C Maximum)			
Test Set 3 Power Contacts (40 amps)	Minimum	16.695	16.809
	Maximum	18.901	27.190
	Average	17.904	22.330
	Count	16	16
Test Set 3 Signal Contacts (0.5 amp)	Minimum	2.550	3.689
	Maximum	3.829	6.163
	Average	3.163	5.137
	Count	16	16
Test Set 4 Power Contacts (40 amps)	Minimum	15.203	15.508
	Maximum	20.091	26.515
	Average	17.631	22.380
	Count	1.002	4.214
Test Set 4 Signal Contacts (0.5 amp)	Minimum	2.383	5.309
	Maximum	1.939	4.666
	Average	1.002	4.214
	Count	8	8

2.6 Vibration – Groups A, B

Group A
All power contacts were wired to monitor discontinuities. No apparent physical damage or discontinuities of one microsecond or greater occurred on the power contacts during testing.

Group B
All power contacts were wired to monitor discontinuities. No apparent physical damage or discontinuities of one microsecond or greater occurred during testing.

2.7 Mechanical Shock – Group A

No apparent physical damage or discontinuities of one microsecond or greater occurred during testing.
Pulse Velocity Change 6.62 Ft/Sec

2.8 Crimp Tensile Strength (Power Contacts) – Group F

All specimens exceeded the minimum force requirement of 200N (8AWG) and 175N (10AWG) for crimp tensile strength. See Table 14 for individual test results.

Table 14 – Crimp Tensile Strength (Newtons)

Specimen ID	Tensile Strength (N)
Test Set 11 – Socket, 8AWG	
1101	1247.53
1102	1105.96
1103	1239.78
1104	1186.75
1105	1288.82
Test Set 12 – Socket, 10AWG	
1201	954.11
1202	979.92
1203	1058.11
1204	999.07
1205	984.1
Test Set 13 – Pin, 8AWG	
1301	1130.31
1302	1143.57
1303	1139.03
1304	1051.61
1305	1129.96
Test Set 14 – Pin, 10AWG	
1401	834.21
1402	774.31
1403	824.67
1404	790.7
1405	702.41

2.9 Current Cycling – Group D

All specimens had a temperature rise of less than 45°C above ambient when tested at specified current. The maximum temperature rise for Test Set 7 was 32.2°C and for Test Set 8 it was 26.0°C.

2.10 Connector Mating Force – Group G

All mating force measurements were less than 40N (2-position) or 60N (3-position). See Table 15 for individual test results.

Table 15 – Connector Mating and Um-mating Force (Newtons)

Specimen ID	Mating Force (N)	Un-mating Force (N)
Test Set 15 – 2-Position, 8AWG		
1501	24.70	14.95
1502	22.92	15.91
Test Set 16 – 3-Position, 8AWG		
1601	34.26	20.43
Test Set 17 – 2-Position, 10AWG		
1701	23.01	11.59
1702	26.02	12.48
Test Set 18 – 3-Position, 10AWG		
1801	35.96	21.44

2.11 Connector Un-mating Force – Group G

All un-mating force measurements were less than 30N (2-position) or 45N (3-position). See Table 15 for individual test results.

2.12 Contact TPA Retention – Group G

All specimens exceeded the minimum force requirement of 600N for contact TPA retention. See Table 16 for individual test results.

Table 16 – Contact TPA Retention (Newtons)

Specimen ID	TPA Retention Receptacle	TPA Retention Plug
Test Set 15 – 2-Position, 8AWG		
1501	1198.72	1195.04
1502	1211.63	1204.8
Test Set 16 – 3-Position, 8AWG		
1601	1544.19	1566.25
Test Set 17 – 2-Position, 10AWG		
1701	1211.36	1182.02
1702	1217.35	1166.69
Test Set 18 – 3-Position, 10AWG		
1801	1542.97	1515.53

2.13 Durability – Group E

Other than obvious plating wear of the power contacts, specimens showed no signs of visible damage detrimental to any further testing as a result of mating and un-mating the specimens 12,000 times.

2.14 Thermal Shock – Group C

No evidence of physical damage was visible as a result of exposure to thermal shock.

2.15 Humidity-Temperature Cycling – Groups B, C

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

2.16 Temperature Life – Group B

No evidence of physical damage was visible as a result of exposure to temperature life.

2.17 Final Examination of Product – All Groups

Specimens were visually examined and no evidence of physical damage detrimental to product performance was observed.

3. TEST METHODS

3.1 Examination of Product

A Certification of Conformance was issued stating that all specimens in this test package have been produced, inspected, and accepted as conforming to product drawing requirements, and made using the same core manufacturing processes and technologies as production parts.

3.2 Low Level Contact Resistance

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. Testing was performed in accordance with EIA 364-23D.

3.3 Insulation Resistance (IR)

Insulation Resistance was measured between adjacent contacts of mated specimens. A test voltage of 500 volts DC was applied for two minutes before the resistance was measured. Testing was performed in accordance with EIA-364-21F.

3.4 Dielectric Withstanding Voltage (DWV)

A test potential of 1250 volts AC was applied between the adjacent contacts of mated specimens. The potential was applied for one minute and then returned to zero. Testing was performed in accordance with EIA-364-20F, Condition 1.

3.5 Temperature Rise vs Current

30 AWG type T thermocouples approximately 42 inches long were beaded and epoxied to the wire crimps of the power contacts. The thermocouple bead was welded to the crimp area of the signal contacts. The specimens were connected together in series. The specimens were then energized to 40.0 amps DC for 8 AWG power contacts or 0.5 amps for the signal contacts. The temperature of each thermocouple was recorded when a minimum of three consecutive readings taken over a minimum duration of 10 minutes did not differ by more than ±1°C (1.8°F). The ambient temperature was subtracted from the recorded temperature to obtain the temperature rise. Testing was performed in accordance with EIA-364-70D.

3.6 Vibration, Random

The test specimens were subjected to a random vibration test in accordance with specification EIA-364-28F, test condition VII, test condition letter D. The parameters of this test condition are specified by a random vibration spectrum with excitation frequency bounds of 20 and 500 Hertz (Hz). The spectrum remains flat at 0.02 G^2/Hz from 20 Hz to the upper bound frequency of 500 Hz. The root-mean square amplitude of the excitation was 3.10 GRMS. The test specimens were subjected to this test for 15 minutes in each of the three mutually perpendicular axes, for a total test time of 45 minutes per test specimen. The test specimens were monitored for discontinuities of 1 microsecond or greater using an energizing current of 100 milliamperes.

3.7 Mechanical Shock, Half-sine

The test specimens were subjected to a mechanical shock test in accordance with specification EIA-364-27D, test condition H. The parameters of this test condition are a half-sine waveform with an acceleration amplitude of 30 gravity units (g's peak) and a duration of 11 milliseconds. Three shocks in each direction were applied along the three mutually perpendicular axes of the test specimens, for a total of eighteen shocks. The test specimens were monitored for discontinuities of 1 microsecond or greater using an energizing current of 100 milliamperes.

3.8 Crimp Tensile Strength (Power Contacts)

Each contact was secured in a plate with a through-hole which was held in a goalpost fixture attached to the load cell and crosshead of the tensile / compression machine. The wire on the contact was firmly grasped in a mechanical clamping fixture which was secured to the base of the tensile/compression testing machine. The cross head was then started in the tensile direction at a rate of 25.4mm/min until the wire pulled out of the crimped power contact. Testing was performed in accordance with EIA-364-8C.

3.9 Current Cycling

Testing consisted of 84 cycles of current cycling using the same setup as Temperature Rise vs. Current test, with each cycle having current ON for 5 hours and current OFF for 1 hour. The test current was 35 amperes for 10AWG. Testing was performed in accordance with EIA-364-55B.

3.10 Connector Mating Force

Specimens were subjected to mating force using a tensile / compression machine in accordance with EIA-364-13E. The specimens were prepared by attaching the plug and receptacle to a 3D printed durability fixture that was provided by the requester. This fixture allowed for the springs in the plug docking assembly to provide the float necessary for connector mating. The plug portion of this fixture was secured to the base of the tensile / compression machine. The receptacle portion of the assembly was attached to a plate, which was attached to the load cell and crosshead of the tensile / compression machine and aligned above the plug. To ensure proper alignment, the crosshead was lowered until the receptacle was lightly contacting the plug, but the pins and sockets were not in contact. The crosshead was lowered at a rate of 12.7 mm/min until the specimen was fully mated. To ensure the correct mating dimension was achieved, a 20mm spacer was placed on the flange on both sides of the plug. The peak mating force and the force vs distance graph were recorded.

3.11 Un-mating Force

The same setup was used in the connector mating force test, but the crosshead moved in the tensile direction until the specimen was fully un-mated. The force required to un-mate individual specimens was measured with the rate of travel at 12.7mm/minute in accordance with EIA-364-13E.

3.12 Contact TPA Retention

Each plug/receptacle was individually secured to the base of the tensile/compression testing machine. A mechanical clamping fixture, which was secured in a swivel fixture, was attached to the load cell and crosshead of the tensile / compression machine. All wires that were crimped to the power contacts were firmly grasped in the mechanical clamping fixture. The cross head was then started in the tensile direction at a rate of 12.7mm/min until the contact TPA pulled out of the plug/receptacle housing. Testing was performed in accordance with EIA-364-8C.

3.13 Durability

Specimens were mated and unmated 12,000 times at a maximum rate of 360 cycles per hour in accordance with EIA-364-9D and 108-160493, Rev 2A. LLCR and T-Rise measurements were taken after every 4000 cycles.

3.14 Thermal Shock

Mated specimens were exposed to 50 cycles of thermal shock in accordance with EIA-364-32G. Each cycle consisted of 60-minute dwells at -30 and 75°C. The transition between temperatures was less than one minute.

3.15 Humidity-Temperature Cycling

Mated specimens were exposed to 10 cycles of humidity-temperature cycling in accordance with EIA-364-31F, Method IV. Each cycle lasted 24 hours and consisted of cycling the temperature between 25°C and 65°C twice while maintaining high humidity.

3.16 Temperature Life

Mated specimens were exposed to a temperature of 95°C for 500 hours in accordance with EIA-364-17C, Method A.

3.17 Final Examination of Product

Specimens were visually examined and no evidence of physical damage detrimental to product performance was observed. Testing was done in accordance with EIA-364-18B.