AMPSEAL 16* hybrid lever Connector System

1. INTRODUCTION

1.1. Purpose

Testing was performed on AMPSEAL 16 hybrid lever connector system to determine conformance to the requirements given in Product Specification 108-32036.

1.2. Scope

This report covers the mechanical, electrical, and environmental sealing performance of the AMPSEAL 16 hybrid lever connector system. Testing was performed at the Winston-Salem Electronic Components Test Laboratory in 2013 and 2014. The test file numbers are 20130107ACL, 20130190ACL, 20130191ACL, and 20140234ACL. This documentation is on file at, and available from, the Global Automotive Division Product Reliability Center.

1.3. Conclusion

The AMPSEAL 16 hybrid lever connectors conformed to the mechanical, electrical, and environmental sealing performance requirements given in Product Specification 108-32036.

1.4. Test Specimens

Test specimens were representative of normal production lots. Specimen part numbers listed in Figure 1 were used for the test.

PART NUMBER	DESCRIPTION
2138839-1	28-Position Plug Assembly Key A
2138846-1	28-Position Cap Assembly Key A
2138852-1	5-mm Panel Mounting Clip
2138853-1	Wire Cover
1924463-1	Size 16 Pin, 18-20 AWG
1924464-1	Size 16 Socket, 18-20 AWG
638078-1	Size 16 Pin, 18-14 AWG
776492-1	Size 16 Socket, 18-14 AWG
1060-12-0144	Size 12 Pin, 12-14 AWG
1062-12-0144	Size 12 Socket, 12-14 AWG
1060-12-0244	Size 12 Pin, 10 AWG
1062-12-0244	Size 12 Socket , 10 AWG

Figure 1. Test Specimen Part Numbers and Description

1.5. Environmental Conditions

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

Temperature: 15° to 35°C
Relative humidity (RH): 25 to 75%

| Indicates Change

1.6. Qualification Test Sequences

TEST OR EXAMINATION	TEST GROUP (a)				
	1	2	3	4	5
	TEST SEQUENCE (b)				
Initial Examination of Product	1	1	1	1	1
Durability	4	2	2	2	2
Terminal Retention		6 (c)	7 (c)	6 (c)	
Mating Forces	2,5				
Un-Mating Forces	3,6		5		
Maintenance Aging		7 (d)	8 (d)	7 (d)	
Connector Retention		4	4	4	4
Mismating		5	6	5	5
Thermal Shock		3			
Humidity/Temperature Cycling			3		
Temperature Life				3	
Fluid Immersion					3
Final Examination of Product	7	8	9	8	6

(a) See Paragraph 1.4.
(b) Numbers indicate sequence in which tests were performed.
(c) All circuit cavities must be tested.
(d) Maintenance aging performed on samples not used for terminal retention testing.

Figure 2. Mechanical Test Sequences

TEST OR EXAMINATION	TEST GROUP (a)					
	1 (c)	2 (c)	3 (c)	4 (d)	5 (d)	6 (d)
		TEST SEQUENCE (b)				
Initial Examination of Product	1	1	1	1	1	1
Insulation Resistance	2,4,6,9,11	2,4,6,10,12				
Random Vibration		8 (e)			5 (e)	
Thermal Shock		7			4	
Temperature Life	7			6		
Fluid Immersion			3			3
Pressure Washing	5,10	5,11		4,9	2,6	
Pressure/Vacuum Leak	3,8	3,9		2,7		2,4
Sealing Pressure			2,4			
Final Examination of Product	12	13	5	3,5,8,10	3,7	5

(a) See Paragraph 1.4.

(b) Numbers indicate sequence in which tests are performed.

(c) Test sequence tests integrity of the mat seal (sealing to the wires) and the peripheral seal (sealing between connector halves).

(d) Test sequence tests integrity of the flange seal (sealing between the cap assembly and the panel). Wire bundle length limited to 25 mm maximum for this sequence.

(e) Discontinuities not monitored.

Figure 3. Environmental Sealing Test Sequences

TEST OR EXAMINATION	TEST GROUP (a)				
	1	2	3	4	5
	TEST SEQUENCE (b)				
Initial Examination of Product	1	1	1	1	1
Low-Voltage Resistance	2,6 (c)	2,5	2,5		2,7
Connection Resistance	3,7 (c)	3,6	3,6		3,8
Withstanding Voltage				2,6	
Random Vibration	5 (d)				
Durability				3	
Maintenance Aging					4 (g)
Thermal Shock	4 (e)			4	
Humidity/Temperature Cycling		4 (f)		5	
Temperature Life			4 (f)		5
Salt Fog					6
Final Examination of Product	8	7	7	7	9

(a) See Paragraph 1.4.
(b) Numbers indicate sequence in which tests are performed.
(c) Measurements taken on at least 75% of size 12 terminal circuits and at least 25% of size 16 terminal circuits
(d) Discontinuities monitored on at least 25% of size 12 terminal circuits and at least 25% of size 16 terminal circuits.
(e) Samples mounted on a 5-mm plate using the mounting clip before thermal shock and remain mounted for the remainder of the test sequence.
(f) Pre-condition samples with 10 durability cycles.
(g) All circuit cavities subject to maintenance aging across the samples.

Figure 4. Electrical Test Sequences

2. SUMMARY OF TESTING

2.1. Mechanical Test Sequences

The summary of tests, as outlined in Figure 2, are as follows:

A. Initial Examination of Product—All Test Groups

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

B. Durability—All Test Groups

No physical damage occurred as a result of manually mating and un-mating the specimens 50 times.

C. Terminal Retention—Test Groups 2, 3, and 4

No contacts dislodged when subjected to an axial load of 111 N.

D. Mating Forces—Test Group 1

All mating force measurements were less than 90 N.

E. Un-Mating Forces—Test Groups 1 and 3

All un-mating force measurements were less than 90 N.

F. Maintenance Aging—Test Groups 2, 3, and 4

No evidence of physical damage was visible as a result of removing and inserting the terminals 10 times in three circuit cavities.

G. Connector Retention—Test Groups 2, 3, 4, and 5

The connector assembly did not un-mate and there was no evidence of physical damage when the mated connector was subject to an axial force of 444 N for 30 seconds.

H. Mismating—Test Groups 2, 3, 4, and 5

No specimen could be mated against the polarizing or keying feature when subjected to an axial force of 178 N.

I. Thermal Shock—Test Group 2

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

J. Humidity/Temperature Cycling—Test Group 3

No evidence of physical damage was visible as a result of humidity/temperature cycling.

K. Temperature Life—Test Group 4

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

L. Fluid Exposure—Test Group 5

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

M. Final Examination of Product—All Test Groups

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

2.2. Environmental Sealing Test Sequences

The summary of tests, as outlined in Figure 3, are as follows:

A. Initial Examination of Product—All Test Groups

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

B. Insulation Resistance—Test Groups 1 and 2

All insulation resistance measurements were greater than 20 MΩ.

C. Random Vibration—Test Groups 2 and 5

Discontinuities were not monitored during vibration testing. Following vibration testing, no cracks, breaks, or loose parts on the specimens were visible.

D. Thermal Shock—Test Groups 2 and 5

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

E. Temperature Life—Test Groups 1 and 4

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

F. Fluid Immersion—Test Groups 3 and 6

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

G. Pressure Washing—Test Groups 1, 2, 4 and 5

No evidence of water ingress or physical damage was visible as a result of pressure washing.

H. Pressure/Vacuum Leak—Test Groups 1, 2, 4, and 5

No bubbles were observed when the samples were subject to an internal pressure of 48 kPa initial and 28 kPa final for 15 seconds.

Samples met the requirements of insulation resistance after being subject to a vacuum of 48 kPa initial and 28 kPa final for 15 seconds.

I. Sealing Pressure—Test Group 3

No bubbles were observed after the first 15 minutes when specimens were subjected to an external pressure of 35 kPa for 30 minutes.

J. Final Examination of Product—All Test Groups

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

2.3. Electrical Test Sequences

The summary of tests, as outlined in Figure 4, are as follows:

A. Initial Examination of Product—All Test Groups

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

B. Low-Voltage Resistance—Test Groups 1, 2, 3, and 5

All low-voltage resistance measurements were less than 9 mΩ after subtracting the bulk resistance of equal wire length. See Figure 5.

C. Connection Resistance—Test Groups 1, 2, 3, and 5

All voltage drop measurements were less than 100 mV after subtracting the bulk resistance of equal wire length. See Figure 6.

D. Withstanding Voltage—Test Group 4

No dielectric breakdown or flashover occurred. Leakage current was less than 5 mA.

E. Random Vibration—Test Group 1

No discontinuities greater than or equal to 1 microsecond were detected during vibration testing. Following vibration testing, no cracks, breaks, or loose parts on the specimens were visible.

F. Durability—Test Group 4

No physical damage occurred as a result of manually mating and un-mating the specimens 50 times.

G. Maintenance Aging—Test Group 5

No evidence of physical damage was visible as a result of removing and inserting the terminals 10 times. All circuit cavities across the samples were subjected to maintenance aging.

H. Thermal Shock—Test Groups 1 and 4

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

I. Humidity/Temperature Cycling—Test Groups 2 and 4

No evidence of physical damage was visible as a result of humidity/temperature cycling.

J. Temperature Life—Test Groups 3 and 5

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

K. Salt Fog—Test Group 5

No evidence of physical damage was visible as a result of exposure to a salt-laden atmosphere.

L. Final Examination of Product—All Test Groups

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

28-POSITION CONNECTOR (Figure 4. Electrical Test Sequences)					
TEST GROUP	DESCRIPTION	MEASUREMENT (mΩ)			
		TERMINAL SIZE 12		TERMINAL SIZE 16	
		Initial	Final	Initial	Final
1	Minimum	1.45	1.51	1.25	1.21
	Maximum	1.77	1.81	1.52	1.56
	Average	1.605	1.625	1.349	1.346
	Standard Deviation	0.0770	0.0826	0.0630	0.0693
	Specimen Quantity	24	24	36	36
2	Minimum	1.36	1.36	1.22	1.22
	Maximum	1.54	1.63	1.39	1.41
	Average	1.438	1.448	1.291	1.297
	Standard Deviation	0.0532	0.0521	0.0404	0.0470
	Specimen Quantity	32	32	48	48
3	Minimum	1.37	1.35	1.22	1.14
	Maximum	1.60	1.48	1.43	1.28
	Average	1.492	1.401	1.303	1.203
	Standard Deviation	0.0567	0.0319	0.0388	0.0323
	Specimen Quantity	32	32	48	48
5	Minimum	1.11	0.97	1.35	1.27
	Maximum	1.27	1.18	1.66	1.64
	Average	1.166	1.052	1.469	1.425
	Standard Deviation	0.0426	0.0483	0.0601	0.0712
	Specimen Quantity	32	32	48	48

Figure 5. Low-Voltage Resistance Measurements

28-POSITION CONNECTOR (Figure 4. Electrical Test Sequences)					
TEST GROUP	DESCRIPTION	MEASUREMENT (mV)			
		TERMINAL SIZE 12		TERMINAL SIZE 16	
		Initial	Final	Initial	Final
1	Minimum	35.78	36.50	17.56	15.57
	Maximum	43.43	45.08	21.62	20.06
	Average	39.498	39.790	18.969	17.235
	Standard Deviation	2.1309	2.1877	0.9115	0.8627
	Specimen Quantity	24	24	36	36
2	Minimum	36.75	38.00	19.37	19.63
	Maximum	41.50	43.75	21.45	21.97
	Average	38.275	39.50	20.254	20.553
	Standard Deviation	1.185	1.1925	0.4446	0.5928
	Specimen Quantity	32	32	48	48
3	Minimum	37.00	36.50	19.37	17.42
	Maximum	42.00	39.75	22.62	20.15
	Average	39.425	37.85	20.683	18.694
	Standard Deviation	1.0225	0.7875	0.6461	0.6149
	Specimen Quantity	32	32	48	48
5	Minimum	15.09	12.63	8.03	7.06
	Maximum	17.15	14.68	9.66	9.10
	Average	15.808	13.761	8.744	7.874
	Standard Deviation	0.4796	0.5585	0.3148	0.4193
	Specimen Quantity	32	32	48	48

Figure 6. Voltage Drop Measurements

3. TEST METHODS

3.1. Initial Examination of Product

All samples were visually examined for identification, torn seals, and cracked plastic or any other defect detrimental to the performance of the product.

3.2. Low-Voltage Resistance

Each mated assembly was subjected to a maximum of 20 mV open-circuit voltage at 100 mA. Measurements were taken on the data acquisition system using the voltage and current probe bundles (4-wire probe method). The overall resistance included 6 inches of wire, pin terminal crimp resistance, bulk resistance of the pin terminal, terminal interface, bulk resistance of the socket terminal, socket terminal crimp resistance, and 6 inches of wire. The resistance of the 12 inches of wire was subtracted out of the final measurements so that the reported data only included the crimps, bulk resistance of the terminals, and the interface.

3.3. Connection Resistance

The mated assemblies were placed on a non-conductive surface. Measurements were taken on the data acquisition systems using the voltage probe bundles (2-wire probe method). All mated assemblies were placed in series. The current was set at 25 A for the size 10 AWG wire, 13 A for the size 14 AWG wire, and 5 A for the size 20 AWG wire. The circuits were allowed to stabilize for 60 minutes before measurements were taken. The overall resistance included 6 inches of wire, pin terminal crimp resistance, bulk resistance of the pin terminal, terminal interface, bulk resistance of the socket terminal, socket terminal crimp resistance, and 6 inches of wire. The resistance of the 12 inches of wire was subtracted out of the final measurements so that the reported data only included the crimps, bulk resistance of the terminals, and the interface.

3.4. Insulation Resistance

Insulation resistance was measured between adjacent contacts. A test voltage of 1000 V DC was applied for 2 minutes, and the resistance was measured.

3.5. Withstanding Voltage

A test voltage of 2100 V DC was applied between the adjacent contacts for 60 seconds and the leakage current was measured. The voltage was increased at a rate of 500 V per second until the test voltage was reached. See Figure 7.

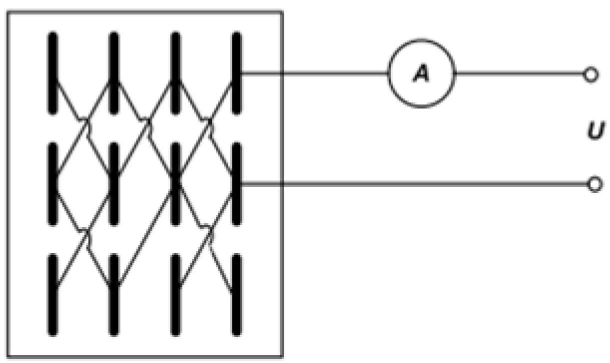

Figure 7. Method of Connecting Leads for Withstanding Voltage

3.6. Random Vibration

Specimens were subjected to a random vibration test, specified by a random vibration spectrum, with excitation frequency bounds of 20 and 2000 Hz. The root-mean-square (RMS) amplitude of the excitation was 5.35 root-mean-square acceleration (GRMS). This was performed for 8 hours in each of 3 mutually perpendicular planes for a total vibration time of 24 hours. Specimens were monitored for discontinuities of 1 ms or greater. See Figure 8. Refer to Figure 9 for the setup.

FREQUENCY (Hz)	POWER SPECTRAL DENSITY (PSD) (g^2/Hz)
20	0.0008088
100	0.02
1000	0.02
2000	0.00502377

Figure 8. Random Vibration Profile

Vibration Base With Wire Bundle Clamped *Vibration Without Wire Bundle*

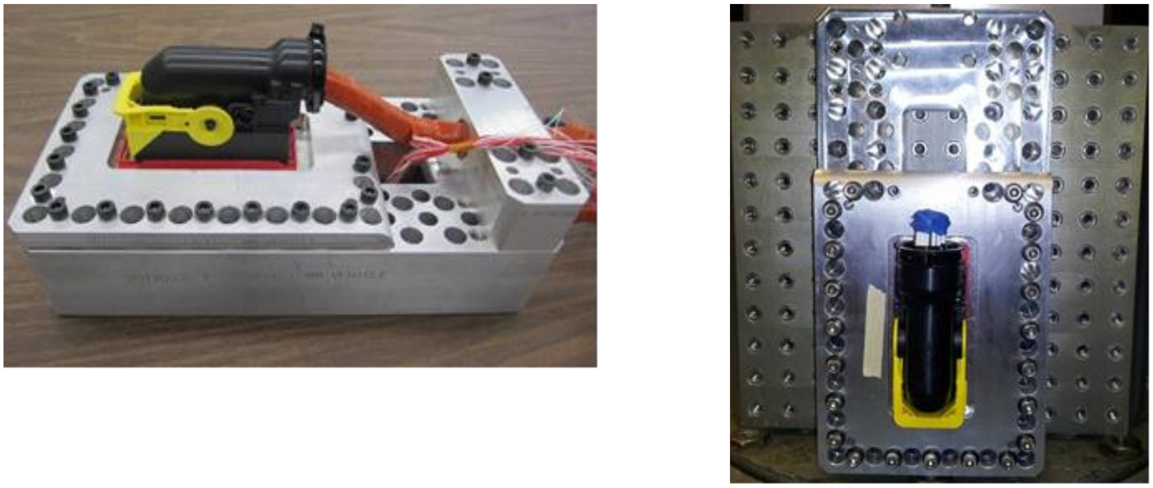

Figure 9. Random Vibration Setup

3.7. Durability

Specimens were manually mated and unmated 50 times.

3.8. Terminal Retention

The plug and cap assemblies were placed in a fixture, which in turn was placed on a fixed table on the base of the Instron testing equipment. Specially designed push pins mounted in a Jacobs Chuck tool holder that was attached to the crosshead of the Instron testing equipment were used to push on the socket and pin terminals, respectively. Terminals were pushed in order of circuit identification starting at circuit 1. Prior to pushing on the terminals, it was ensured that the terminal block was completely bottomed out and that the terminals were completely seated by manually tugging on the wires. See Figure 10 for a depiction of the sample setup.

Plug Assembly *Cap Assembly*

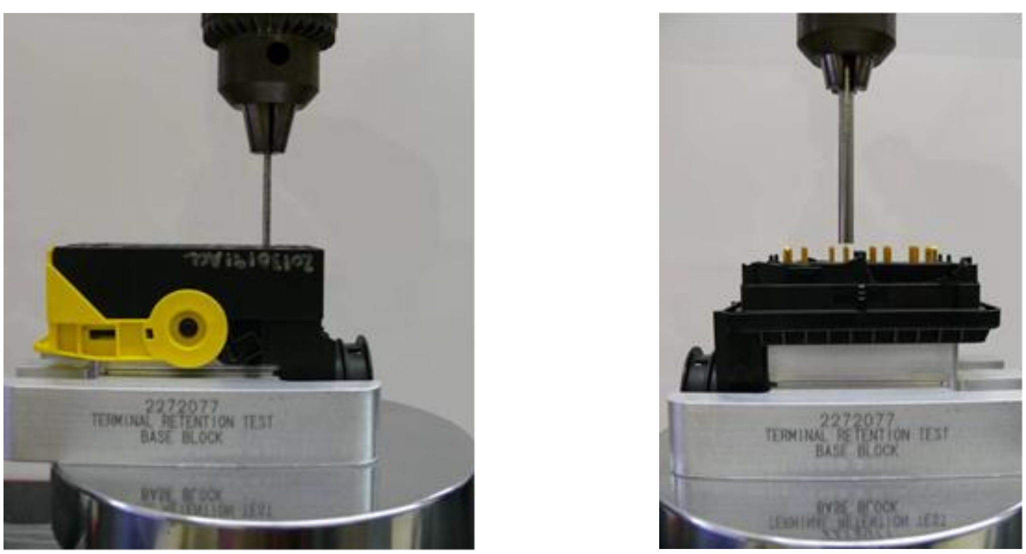

Figure 10. Terminal Retention Setup

Instron is a trademark. Jacobs Chuck is a trademark.

3.9. Mating Forces

To capture the peak mating forces, spacers were used to establish the start and end point for mating force measurements. Spacer 1 was placed onto the cap assembly and the plug assembly and mated by hand until the bottom of the plug assembly came to rest on the top of spacer 1. This established the start point for the mating force measurement. Then, spacer 1 was removed, and spacer 2 was inserted in its place. Spacer 2 established the end point for the mating force measurement. The sample was held by an angle vice that was attached to a free-floating table on the base of the Instron testing equipment. An L-fixture that was mounted in a Jacobs Chuck tool holder, which was attached to the crosshead of the Instron testing equipment, was used to push the lever until the bottom of the plug assembly came to rest on the top of spacer 2. The test speed was 50 mm/min in the compression mode. See Figure 11 for a depiction of the sample setup.

Measurement Start Point *Measurement End Point*

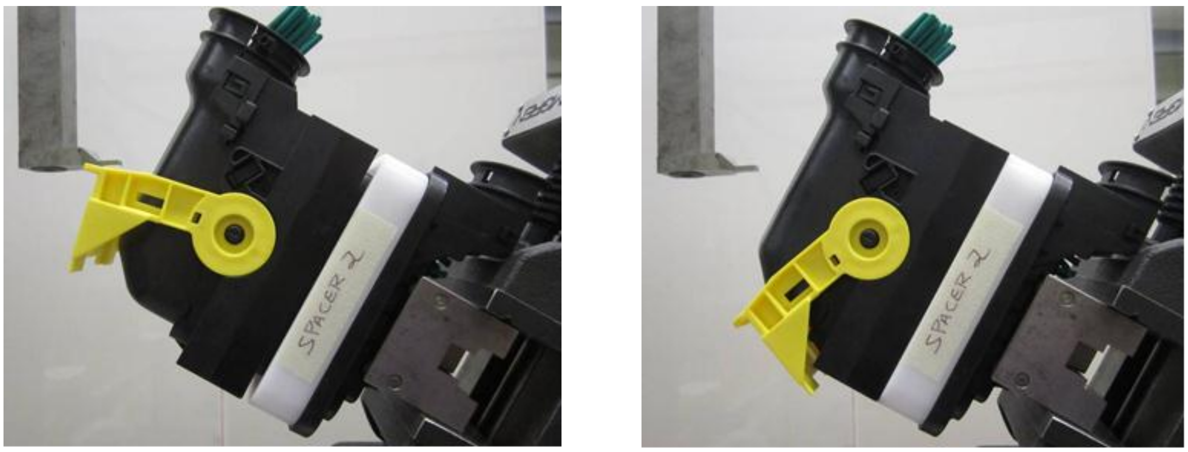

Figure 11. Mating Force Setup

3.10. Un-Mating Forces

The lever on the plug assembly was manually rotated to overcome the closed position detents. The assemblies were held by an angle vice that was attached to a free-floating table on the base of the Instron testing equipment. The L-fixture mounted in the Jacobs Chuck tool holder, which was attached to the crosshead of the Instron testing equipment, was used to the push the lever until the plug assembly was fully un-mated. The test speed was 50 mm/min in the compression mode. See Figure 12 for a depiction of the sample setup.

Measurement Start Point

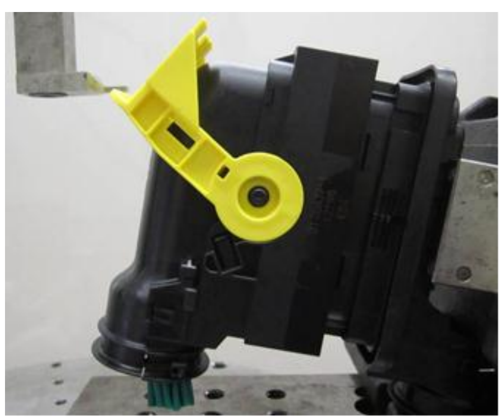

Figure 12. Un-Mating Force Setup

3.11. Maintenance Aging

Terminals were manually extracted and reinserted 10 times at room temperature.

In the mechanical test sequences, test groups 2, 3, and 4 (refer to Figure 2), three random circuits on three samples per group of the plug and cap assemblies were subject to maintenance aging. In the electrical test sequences, test group 5 (refer to Figure 4) random circuits were selected but all circuits were covered across the samples.

3.12. Connector Retention

An axial force of 444 N was applied to the mated connector sample for 30 seconds in an attempt to un-mate/separate the two connector halves. The cap assembly was held in an “L” vise attached to the crosshead of the Instron testing equipment. The plug assembly was held in a tall “L” vise attached to the base of the Instron testing equipment. Each mated connector assembly was tested at 50 mm/min in tensile mode, and the force was held for 30 seconds. See Figure 13 for a depiction of the sample setup.

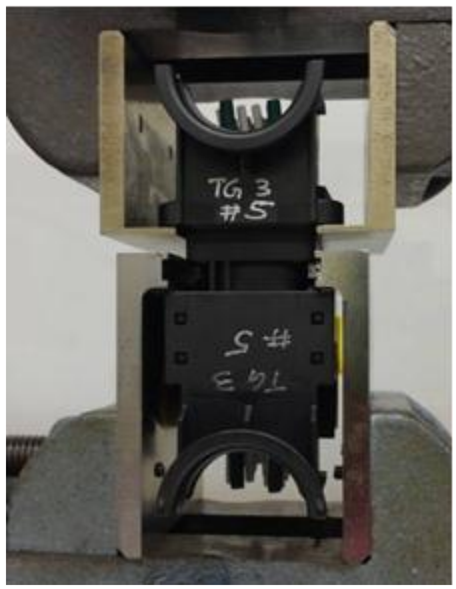

Figure 13. Connector Retention Setup

3.13. Mismating

An axial force of 178 N was applied to the cap assembly rotated 180 degrees from the normal mating position in an attempt to mate it with the plug assembly. The plug assemblies were held in a tall “L” vise attached to the base of the Instron testing equipment. The cap assemblies, which were rotated 180 degrees from normal mating position, were held by an “L” vise mounted to the cross-head on the Instron testing equipment. Each sample was tested at a rate of 50 mm/min in compression mode. See Figure 14 for a depiction of sample setup.

3.14. Thermal Shock

Specimens were subject to 10 cycles between -55° and 125°C with 2-hour dwells at temperature extremes with a 2-minute maximum transition time.

In the environmental sealing test sequences, test groups 2 and 5 (refer to Figure 3) and electrical test sequences, test group 1 (refer to Figure 4), specimens were mounted to a 5-mm aluminum plate using the mounting clip. For all other test groups that had thermal shock as part of the test sequence, specimens were not mounted on the mounting plate.

3.15. Humidity/Temperature Cycling

Specimens were initially conditioned in an oven set at 50°C for 24 hours. The samples were subject to 10 cycles (10 days) between 25° and 65°C at 80% and 100% RH.

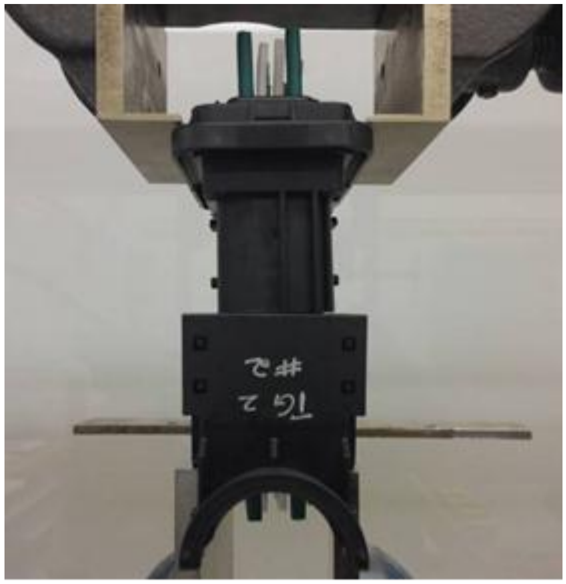

Figure 14. Mismating Test Setup

3.16. Temperature Life

Specimens were exposed to a temperature of 125±3°C for 500 hours.

In the environmental sealing test sequences, test group 4 (refer to Figure 3), specimens were mounted to a 5-mm aluminum plate using the mounting clip. For all other test groups that had temperature life as part of the test sequence, specimens were not mounted on the mounting plate.

3.17. Salt Fog

Specimens were exposed to a fine mist of 5% by weight salt solution for 96 hours at 35±3°C. After exposure, specimens remained mated until after the final electrical measurements were taken. Specimens were then examined for material deterioration, seal integrity, and oxidation of metals.

3.18. Fluid Immersion

No specimen was exposed to more than one chemical. Each specimen was dipped in its designated chemical for 5 minutes, then removed and allowed to air dry for 24 hours. This constituted one cycle. Specimens were exposed to the fluid for a total of five cycles. Chemical levels were monitored daily to compensate for evaporation. Specimens were exposed to the fluids listed in Figure 15.

FLUID	TEMPERATURE (°C)
Motor Oil (30 Weight)	85
Brake Fluid	85
Diesel Fuel	60
50/50 Anti-Freeze Mixture	85
Roundup Original Herbicide	23
Gear Oil (90 Weight)	85
Aqueous Urea	23

Figure 15. Fluids Used for Fluid Immersion Test

Roundup is a trademark.

3.19. Pressure Washing

Specimens were subjected to 375 cycles of spray for 3 seconds of a 6-second period. The source pressure was 7000 kPa gage with a flow rate of 9.46 liters per minute and a temperature of 40°C. The nozzles were located 20 to 30 cm away. No detergent was added to the water.

In the environmental sealing test sequences, test groups 4 and 5 (refer to Figure 3), specimens were mounted onto a sealing fixture. For all other test groups that had pressure washing as part of the test sequence, specimens were not mounted onto the sealing fixture.

3.20. Pressure/Vacuum Leak

Specimens were completely submerged into a container of room temperature salt water solution prepared using tap water and 15 to 16 grams of table salt per liter. The pressure of the regulated pressure source was slowly increased until the gage read the required pressure. Specimens were observed for 15 seconds to verify that there are were no bubbles. The regulated source was then switched from pressure to vacuum and the required vacuum was applied to the samples for 15 seconds. The specimens were then removed from the salt water solution, the excess fluid was shaken off, and all exterior surfaces were carefully dried. Refer to Figure 16 for a depiction of the sample setup.

In the environmental sealing test sequences, test groups 4 and 6 (refer to Figure 3), specimens were mounted onto a sealing fixture and a vent tube was attached to the sealing fixture. For all other test groups that had pressure/vacuum as part of the test sequence, the vent tube was inserted into one empty cavity of the specimen.

Mated Connector Only *Mated Connector Mounted on Sealing Fixture*

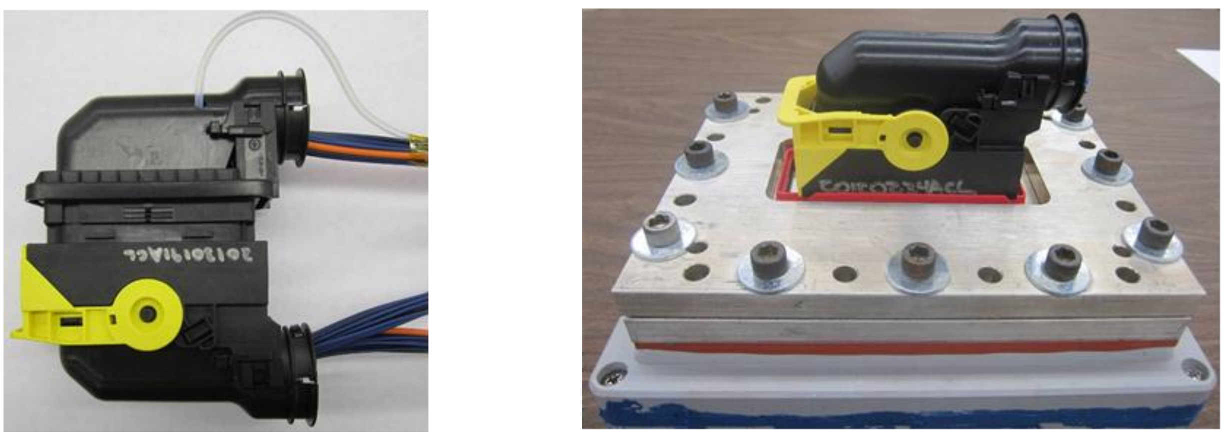

Figure 16. Pressure/Vacuum Leak Setup

3.21. Sealing Pressure

Specimens were placed inside a sealed pressure chamber with one end of a vent tube inserted into one empty cavity of the test specimen and the other end of the vent tube exiting the chamber.
The free end of the vent tube was immersed in a water tank with a beaker on top to trap any bubbles. Pressure of 35 kPa was applied from a dry compressed air source to the chamber and maintained for 30 minutes. Air bubbles were allowed to escape from the connector for the first 15 minutes. After the first 15 minutes, any bubbles that were trapped in the beaker constituted a failure.

3.22. Final Examination of Product

Specimens were visually inspected before and after un-mating connectors for conditions such as torn seals, cracked plastic, evidence of fluid or dust ingress in sealed connector systems, arcing, charring, melting, and any other defect that could affect the performance or serviceability of the product.

4. TEST SEQUENCE-TO-TEST NUMBER CROSS-REFERENCE

TEST SEQUENCE		TEST NUMBER	
Test Sequence	**Test Group**	**Test Number**	**Test Group**
Mechanical (Refer to Figure 2)	1	20130190ACL	1
	2	20130191ACL	2
	3	20130191ACL	3
	4	20130191ACL	4
	5	20130191ACL	5
Environmental Sealing (Refer to Figure 3)	1	20130191ACL	10
		20140234ACL	1A and 1B
	2	20130191ACL	11A and 11B
	3	20130191ACL	12A and 12B
	4	20130107ACL	13
	5	20130107ACL	14
	6	20130191ACL	16
Electrical (Refer to Figure 4)	1	20130191ACL	6
	2	20130107ACL	7
	3	20130107ACL	8
	4	20130107ACL	9
	5	20130191ACL	15