Sealed COPALUM* Transitional Butt Splices, Copper and Aluminum Wire

1. INTRODUCTION

1.1. Purpose

Testing was performed on Sealed COPALUM* Transitional Butt Splices to determine their conformance to the requirements of Product Specification 108-11011-3 Revision C.

1.2. Scope

This report covers the electrical, mechanical, and environmental performance of the Sealed COPALUM Transitional Butt Splices. Testing was performed at the Engineering Assurance Product Test Laboratory between 13Sep94 and 27Jul04. The test file numbers for this testing are listed in Figure 1. This documentation is on file at and available from the Engineering Assurance Product Test Laboratory.

Splice Configuration	Test File Number
4 Al to 8 Cu	CTL 3015-036
6 Al to 6 Cu	CTL 3014-011 (Test Group 1) CTL 3014-000-038 (Test Group 2)
4 Al to 4 Cu	CTL 3015-017
1/0 Al to 4 Cu	CTL 3015-031
3/0 Al to 1/0 Cu	CTL 3015-034

Figure 1

1.3. Conclusion

The Sealed COPALUM Transitional Butt Splices, terminated to aluminum and copper wire, listed in paragraph 1.5., conformed to the electrical, mechanical, and environmental performance requirements of Product Specification 108-11011-3 Revision C.

1.4. Product Description

The Sealed COPALUM Transitional Butt Splices are designed especially for solving the inherent problems of terminating both copper and aluminum conductors. These splices, available for terminating and splicing stranded aluminum and stranded copper wire, are made of high conductivity copper and are especially suited for the aerospace industry.

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| Indicates change

1.5. Test Specimens

The test specimens were representative of normal production lots. Specimens identified with the following part numbers were used for test.

Test Group	Quantity	Part Number	Description
1,2	15 each	277164-1	Transitional splice with 8 Cu and 4 Al wire applied with standard pressure crimp
1,2	6 each	277165-1	Extended transitional splice with 4 Cu and 4 Al wire applied with modified crimp die
1	6	55984-1	Transitional splice with 6 Cu and 6 Al wire applied with standard pressure crimp
2	10	55984-1	Transitional splice with 6 Cu and 6 Al wire applied with standard pressure crimp
1,2	15 each	277163-1	Transitional splice with 4 Cu and 1/0 Al wire applied with standard pressure crimp
1,2	15 each	277168-1	Transitional splice with 1/0 Cu and 3/0 Al wire applied with standard pressure crimp

Figure 2

1.6. Environmental Conditions

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

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

1.7. Qualification Test Sequence

Test or Examination	Test Group (a)	
	1	2
	Test Sequence (b)	
Initial examination of product	1	1
Millivolt drop	2,10	2,4
Temperature rise vs current	3,9	
Current cycling		3(c)
Vibration	4	
Crimp tensile	11	
Thermal shock	5	
Humidity-temperature cycling	7	
Temperature life	6	
Salt spray corrosion	8	
Final examination of product	12	5

NOTE

(a) See paragraph 1.5.
(b) Numbers indicate sequence in which tests are performed.
(c) Measurements shall be taken every 10 cycles.

Figure 3

2. SUMMARY OF TESTING

2.1. Initial Examination of Product - Test Groups 1 and 2

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

2.2. Millivolt Drop - Test Groups 1 and 2

All millivolt drop measurements, taken at specified test current, were less than requirements specified in Figure 5.

Test Group	# of Data Points	Condition	Wire Gage (AWG)	Test Current (amperes)	Millivolt Drop			Specified Maximum Millivolts
					Min	Max	Mean	
1 Aluminum	15	Initial	4	73	3.02	3.61	3.20	8.5
		Final			3.78	5.88	4.45	10.6
1 Copper	15	Initial	8	73	4.57	5.06	4.80	8.5
		Final			5.00	5.77	5.36	10.6
2 Aluminum	15	Initial	4	73	3.27	3.59	3.43	8.5
		Final			3.81	4.32	4.08	10.6
2 Copper	15	Initial	8	73	4.75	8.22	5.95	8.5
		Final			5.13	10.47	6.59	10.6
1 Aluminum	6	Initial	6	83	4.20	5.26	4.89	6
		Final			5.37	5.98	5.76	8
1 Copper	6	Initial	6	83	3.40	3.77	3.57	6
		Final			3.24	3.84	3.64	8
2 Aluminum	10	Initial	6	83	4.89	5.48	5.10	6
		Final			5.13	5.81	5.35	8
2 Copper	10	Initial	6	83	2.83	3.41	3.24	6
		Final			2.90	3.43	3.27	8
1 Aluminum	6	Initial	4	108	4.40	4.68	4.53	6
		Final			6.17	7.35	6.63	8
1 Copper	6	Initial	4	108	2.87	3.07	2.98	6
		Final			3.15	3.41	3.26	8
2 Aluminum	6	Initial	4	108	4.70	4.95	4.81	6
		Final			6.38	6.83	6.63	8
2 Copper	6	Initial	4	108	2.77	3.04	2.90	6
		Final			2.73	3.22	2.98	8
1 Aluminum	15	Initial	1/0	135	3.00	3.49	3.16	6
		Final			3.80	4.77	4.27	8
1 Copper	15	Initial	4	135	4.53	4.95	4.70	6
		Final			4.76	5.38	4.98	8
2 Aluminum	15	Initial	1/0	135	2.72	3.56	3.26	6
		Final			3.11	4.89	3.56	8
2 Copper	15	Initial	4	135	4.02	5.30	4.76	6
		Final			4.21	5.42	4.89	8
1 Aluminum	15	Initial	3/0	245	4.90	5.41	5.16	7
		Final			6.09	6.97	6.39	9
1 Copper	15	Initial	1/0	245	4.67	5.07	4.86	7
		Final			4.64	5.15	4.92	9
2 Aluminum	15	Initial	3/0	245	4.62	6.06	5.10	7
		Final			4.99	8.86	5.89	9
2 Copper	15	Initial	1/0	245	3.84	5.48	4.35	7
		Final			4.00	5.86	4.40	9

Figure 4

2.3. Temperature Rise vs Current - Test Group 1

All specimens had a temperature rise of less than 30˚C above the control wire temperature when tested using the test current specified in Figure 5.

Butt Splice Size	"A" Dimension (inches)	Test Current (amperes)	Voltage Drop (millivolts)	
			Maximum Initial	Maximum Final
4 Al to 8 Cu	12	73	8.5 See Note	10.6 See Note
6 Al to 6 Cu	12	83	9.0 See Note	11.0 See Note
4 Al to 4 Cu	24	108	6	8
1/0 Al to 4 Cu	24	135	6	8
3/0 Al to 1/0 Cu	24	245	8.5 See Note	10.5 See Note

NOTE *Maximum voltage drop requirements based on SAE-AS7928 performance requirements.*

Figure 5

2.4. Current Cycling - Test Group 2

No evidence of physical damage was visible as a result of current cycling.

2.5. Vibration - Test Group 1

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

2.6. Crimp Tensile - Test Group 1

All tensile values were greater than specification minimum.

2.7. Thermal Shock - Test Group 1

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

2.8. Humidity-temperature Cycling - Test Group 1

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

2.9. Temperature Life - Test Group 1

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

2.10. Corrosion, Salt Spray - Test Group 1

No evidence of physical damage to the terminals was visible as a result of exposure to a salt spray atmosphere.

2.11. Final Examination of Product - Test Groups 1 and 2

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

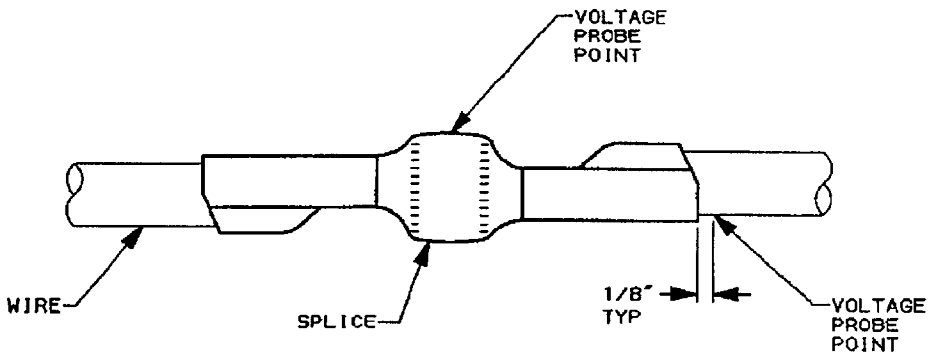
3. TEST METHODS

3.1. Initial Examination of Product

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

3.2. Millivolt Drop

Millivolt drop measurements at specified current were made using a 4 terminal measuring technique at the specified probe points, see Figure 6. See Figure 7 for specified currents for millivolt drop measurements. The specified currents for aluminum wire were also used for copper wire measurements.



Voltage Probe Points for Splices

Figure 6

Wire Size	Test Current
4 Al to 8 Cu	73 amperes
6 Al to 6 Cu	83 amperes
4 Al to 4 Cu	108 amperes
1/0 Al to 4 Cu	135 amperes
3/0 Al to 1/0 Cu	245 Amperes

Figure 7

3.3. Temperature Rise vs Specified Current

Connector and control conductor temperatures were measured, while energized at the specified currents indicated in Figure 7. Thermocouples were attached to the terminals and to the middle of the control conductor to measure their temperatures. When the temperature rise of 3 consecutive readings taken at 5 minute intervals did not differ by more than 1˚C, the temperature measurement was recorded. This temperature was then compared to the control conductor temperature to determine if the requirement of not exceeding 30˚C temperature rise above the control conductor temperature was met.

3.4. Current Cycling

The 4 Al to 4 Cu test specimens were configured into a chain and subjected to 80 current cycles with each cycle being 60 minutes current on followed by 30 minutes current off. The current level was as required to achieve the control conductor temperature requirement listed below. Temperature measurements of samples and the control conductor were taken at the end of the current on cycle, after every 10 cycles. At the end of 60, 70, and 80 current cycles, millivolt drop measurements were taken using the specified current in Figure 7.

Current Cycle Number	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
Control Conductor Temperature ˚C	130	140	150	160	170	180	180	180

NOTE *After completion of this testing, the current cycling test requirement was revised to the 50 cycle test requirement contained in Product Specification 108-11011-3, Revision B.*

All other test specimens were configured into a chain and subjected to 50 current cycles with each cycle being 60 minutes current ON followed by 30 minutes current OFF. The first 40 cycles were performed at the test current specified in Figure 7. The final 10 cycles were at a current level as required to achieve a control conductor temperature of 180˚C. Temperature and millivolt drop measurements were taken at the end of the current cycle after every 10 cycles. Millivolt drop measurements recorded at the test current required to achieve the 180˚C control conductor temperature were not applicable to the specification requirements.

3.5. Vibration, Sinusoidal

Mated specimens were subjected to sinusoidal vibration, having a simple harmonic motion with an amplitude of 0.06 inch, double amplitude, or 15 g's peak, whichever is less. The vibration frequency was varied uniformly between the limits of 10 and 2000 Hz and returned to 10 Hz in 20 minutes. This cycle was performed 12 times in each of 2 planes for a total vibration time of 8 hours.

3.6. Crimp Tensile

An increasing axial force was applied to each specimen, using a tensile/compression device, at a crosshead rate of 1 inch/minute, until the conductor became separated from the specimen.

3.7. Thermal Shock

Specimens were subjected to 5 cycles of thermal shock with each cycle consisting of 60 minute dwells at -55 and 150˚C. The transition between temperatures was less than 1 minute.

3.8. Humidity-temperature Cycling

Specimens were exposed to 10 cycles of humidity-temperature cycling. Each cycle lasted 24 hours and consisted of cycling the temperature between 25 and 65°C twice while maintaining high humidity, see Figure 8.

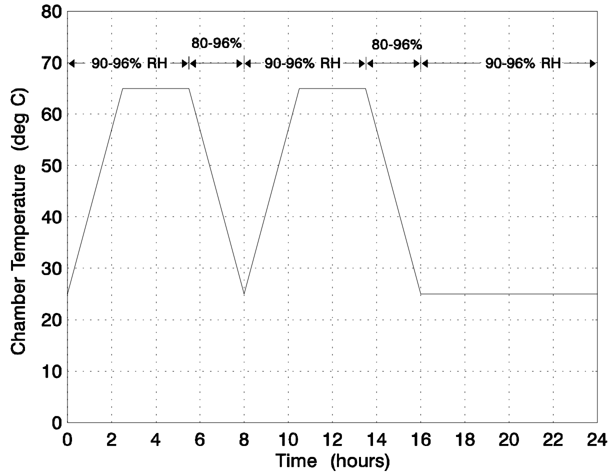


Figure 8
Typical Humidity-Temperature Cycling Profile

3.9. Temperature Life

Specimens were exposed to a temperature of 150˚C for 120 hours.

3.10. Corrosion, Salt Spray

Specimens were subjected to a 5% salt spray environment for 96 hours. The temperature of the box was maintained at 95 +2/-3˚C, and the pH of the salt solution was between 6.5 and 7.2.

3.11. Final Examination of Product

Specimens were visually examined for evidence of physical damage detrimental to product performance.