Evaluation Of An Alternate Red Colorant For TE Connectivity PIDG Terminal P/N 51863-3

1. INTRODUCTION

1.1 Purpose

Verification testing was performed on the #20 AWG IR TE Connectivity PIDG Terminal P/N 51863-3 in accordance with SAE Specification AS7928, Rev C, to evaluate the potential usage of an alternate red colorant. The samples were separated into Test Sets that were crimped with a TE Connectivity Hand Tool, P/N 59250-B, and a Daniel's Hand Tool, P/N M22520/5-01.

1.2 Scope

The testing was performed at the Harrisburg Electrical Components Laboratory under test number EA20220335T and an outside laboratory at NTS under test report PR 165392, between 10/10/22 and 10/27/22.

1.3 Conclusion

The TE Connectivity PIDG Terminal P/N 51863-3 with the alternate red colorant conformed to the select electrical, mechanical, and environmental requirements of SAE Specification AS7928, Rev C.

1.4 Test Specimens

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

Table 1 – Test Specimens

Test Set	Qty	TE Part Number	Description
1	8	51863-3 Rev AC	Terminal Crimped On 20 AWG AS5086 Wire w/TE Tool
2	8	51863-3 Rev AC	Terminal Crimped On 20 AWG AS5086 Wire w/Daniel's Tool
3	8	51863-3 Rev AC	Terminal Crimped On 20 AWG AS5086 Wire w/TE Tool
4	8	51863-3 Rev AC	Terminal Crimped On 20 AWG AS5086 Wire w/Daniel's Tool
5	2	51863-3 Rev AC	Uncrimped Terminal
6	8	51863-3 Rev AC	Terminal Crimped On 20 AWG AS5086 Wire w/TE Tool
7	8	51863-3 Rev AC	Terminal Crimped On 20 AWG AS5086 Wire w/Daniel's Tool
8	8	51863-3 Rev AC	Terminal Crimped On 20 AWG AS5086 Wire w/TE Tool
9	8	51863-3 Rev AC	Terminal Crimped On 20 AWG AS5086 Wire w/Daniel's Tool
10	10	51863-3 Rev AC	Terminal Crimped On 20 AWG AS5086 Wire w/TE Tool
11	10	51863-3 Rev AC	Terminal Crimped On 20 AWG AS5086Wire w/Daniel's Tool
12	10	51863-3 Rev AC	Uncrimped Terminal
13	10	51863-3 Rev AC	Uncrimped Terminal

1.5 Test Sequence

Table 2 – Test Sequence

TEST OR EXAMINATION	TEST GROUP												
	1	2	3	4	5	6	7	8	9	10	11	12	13
	TEST SEQUENCE (See NOTE)												
Voltage Drop	1, 3	1,3											
Current Cycling	2	2											
Fluid Immersion			1	1									
Dielectric Withstanding Voltage			2	2		2	2	2	2	5	5		
Flammability					1								
Heat Age						1	1						
Low Temperature Crimp								1	1				
Temperature Humidity										1	1		
Measure Insulation										2, 4	2,4	1, 3	1, 3
Axial Load										3	3	2	2

NOTE: *The numbers indicate the sequence in which tests were performed.*

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 Voltage Drop (Initial and Final)

All specimens from Test Sets 1 and 2 met the maximum initial and final voltage drop requirements as specified in SAE Specification AS7928, Rev C. The voltage drop results are shown in Tables 3 through 6 below.

Table 3 – Initial Voltage Drop Test Set 1

Number Of Specimens	Wire Size (AWG)	Test Current (Amps)	Average EWL Millivolts	Minimum Millivolt Drop	Maximum Millivolt Drop	Average Millivolt Drop	Maximum Requirement (Millivolts)	Probe Distance (Inches)
12	20	11	5.04	3.74	5.09	3.47	6.04	0.5625

Table 4 – Final Voltage Drop Test Set 1

Number Of Specimens	Wire Size (AWG)	Test Current (Amps)	Average EWL Millivolts	Minimum Millivolt Drop	Maximum Millivolt Drop	Average Millivolt Drop	Maximum Requirement (Millivolts)	Probe Distance (Inches)
12	20	11	4.99	3.75	5.05	3.61	7.99	0.5625

Table 5 – Initial Voltage Drop Test Set 2

Number Of Specimens	Wire Size (AWG)	Test Current (Amps)	Average EWL Millivolts	Minimum Millivolt Drop	Maximum Millivolt Drop	Average Millivolt Drop	Maximum Requirement (Millivolts)	Probe Distance (Inches)
12	20	11	5.22	3.81	5.88	3.42	6.22	0.5625

Table 6 – Final Voltage Drop Test Set 2

Number Of Specimens	Wire Size (AWG)	Test Current (Amps)	Average EWL Millivolts	Minimum Millivolt Drop	Maximum Millivolt Drop	Average Millivolt Drop	Maximum Requirement (Millivolts)	Probe Distance (Inches)
12	20	11	5.11	3.87	5.57	3.93	8.11	0.5625

2.2 Current Cycling

All specimens passed the final voltage drop requirements after undergoing the current cycling procedure as specified in SAE Specification AS7928, Rev C.

2.3 Fluid Immersion

There was no apparent physical damage or any other evidence that would hinder the electrical performance of the specimens as specified in SAE Specification AS7928, Rev C.

2.4 Dielectric Withstanding Voltage

There were no breakdowns or flashovers of the specimens when tested to 1500 VAC as specified in SAE Specification AS7928, Rev C.

2.5 Flammability

The specimens met the requirement to self-extinguish within 30 seconds after removal from the flame as specified in SAE Specification AS7928, Rev C.

2.6 Heat Age

There was no apparent physical damage that would affect the electrical performance on the specimens after heat age exposure as specified in SAE Specification AS7928, Rev C.

2.7 Low Temperature Crimp

There were no signs of ruptures or cracking that would affect the electrical performance of the specimens as specified in SAE Specification AS7928, Rev C

2.8 Temperature Humidity

There was no apparent physical damage that would affect the electrical and mechanical performance of the crimped specimens as specified in SAE Specification AS7928, Rev C.

2.9 Axial Load

2.9.1 Axial Load (Crimped Samples)

All specimens met the requirements of axial load testing: withstanding the 8-pound minimum axial pull force with the insulation moving less than 1/32 (0.03125”) of an inch as specified in SAE Specification AS7928, Rev C. See Table 7 (Test Set 10 Crimped With TE Hand Tool P/N 59250-B) and Table 8 (Test Set 11 Crimped With Daniel’s Hand Tool P/N M22520/5-01) for the axial load results.

Table 7 – Test Set 10 Axial Load Results

	Maximum Load (lbf)	Insulation Location Initial (in)	Insulation Location Final (in)	Insulation Location (Δ)
Minimum	8.02	0.3594	0.3750	0.0000
Maximum	8.17	0.3750	0.3906	0.0156
Average	8.04	0.3703	0.3813	0.0109
N	10	10	10	10

Table 8 – Test Set 11 Axial Load Results

	Maximum Load (lbf)	Insulation Location Initial (in)	Insulation Location Final (in)	Insulation Location (Δ)
Minimum	8.04	0.3594	0.3594	0.0000
Maximum	8.12	0.3906	0.3906	0.0156
Average	8.07	0.3750	0.3797	0.0047
N	10	10	10	10

2.9.2 Axial Load (Uncrimped Samples)

All specimens met the requirements of axial load testing: withstanding the 8-pound minimum axial pull force with the insulation moving less than 1/32 (0.03125”) of an inch as specified in SAE Specification AS7928, Rev C. See Table 9 (Test Set 12 - Insulation Pull Only) and Table 10 (Test Set 13 - Insulation And Sleeve Pull) for the axial load results.

Table 9 – Test Set 12 Axial Load Results

Specimen	Maximum Load (lbf)	Insulation Location Initial (in)	Insulation Location Final (in)	Insulation Location (Δ)
Minimum	8.02	0.3330	0.3594	0.0000
Maximum	8.03	0.3750	0.3750	0.0264
Average	8.02	0.3510	0.3641	0.0131
N	10	10	10	10

Table 10 – Test Set 13 Axial Test Results

Specimen	Maximum Load (lbf)	Insulation Location Initial (in)	Insulation Location Final (in)	Insulation Location (Δ)
Minimum	8.02	0.3438	0.3594	0.0000
Maximum	8.03	0.3750	0.3750	0.0156
Average	8.02	0.3672	0.3734	0.0063
N	10	10	10	10

3. TEST METHODS

3.1. Voltage Drop

The specimens were tested in accordance with SAE Specification AS7928, Rev C, Requirement Paragraph 3.5.1, and Method Paragraph 4.7.2. Ring terminals on the ends of the wires were attached with hardware to each other to form a continuous chain in which current was applied. Specimens were held with a fixture that allowed them to have free air flow and were elevated approximately 20 inches above a work surface. The test current specified was maintained until the temperature of the conductor stabilized. Measurements were taken by puncturing a point 1/16” from the end of the insulation for the first test point and probing the intersection of the tongue and barrel for the 2nd test point. EWL (Equal Wire Length) readings consisted of measuring a length of wire equal to the probe distance. The average EWL in millivolts plus the maximum allowable difference from Table 2 of SAE AS7982C was the maximum millivolt requirement.

3.2 Current Cycling

The specimens were tested in accordance with SAE Specification AS7928, Rev C, Requirement Paragraph 3.5.2, and Method Paragraph 4.7.3. The specimens, connected in series for the initial voltage drop test, were transferred to a draft-free enclosure. The PIDG ring terminals on the ends of the wires were attached with hardware to each other to form a continuous chain in which current was applied. The Test Set 1 and 2 specimen chain was connected to an automated system. A test current of 13.75 Amperes was applied for a period of 30 minutes followed by a period of 15 minutes with the current off; this was repeated for 50 cycles.

3.3 Fluid Immersion

The specimens were tested in accordance with SAE Specification AS7928, Rev C, Requirement Paragraph 3.5.8, and Method Paragraph 4.7.9.1. Four insulated specimens from each Test Set were immersed into hydraulic fluid at 49±1°C. Four from each Test Set were immersed into aircraft lubricating oil at 49±1°C. After the 20 hours exposure the specimens were taken out of the fluids and left to air-dry for 1 hour, after which any remaining excess fluid was wiped from each specimen.

3.4 Dielectric Withstanding Voltage

The test specimens were tested in accordance with SAE Specification AS7928, Rev C. All specimens were prepared by sealing the PIDG terminal using an insulating wax. Each specimen was tested by submerging the sealed end of the terminal into a 5% salt-water solution to a depth sufficient to cover the crimped area of the barrel and insulating grip. A brass anode was placed in the beaker of salt-water solution to use as one of the connection points for the test potential. A brass fixture was used to connect the end of the terminated wire and used as the second connection point for the test potential. A test potential of 1500 VAC was applied at a rate of 500 volts per second and the maximum leakage current was set to 5 milliamperes. The test potential was held for a period of 60 seconds while monitoring for any breakdowns or flashover.

3.5 Flammability

The two specimens were tested in accordance with SAE Specification AS7928, Rev C, Requirement Paragraph 3.5.10 and Method Paragraph 4.7.11. The samples were preconditioned for 48 hours at 23°C / 50 % Relative Humidity, and then suspended in a draft-free enclosure above a Bunsen burner with a wing-top flame spreader. The tip of a 2-inch gas flame with an inner core one-third its height was applied for 20 seconds to one-half the length of the sample’s insulation.

3.6 Heat Age

The specimens were tested in accordance with SAE Specification AS7928 Rev C, Requirement Paragraph 3.5.9.1, and Method Paragraph 4.7.10.1. The specimens were conditioned in a heat oven at a temperature of 121°C for a period of 120 hours. After exposure they were cooled to 23°C within 1 hour and then subjected to DWV testing.

3.7 Low Temperature Crimp

The specimens were tested in accordance with SAE Specification AS7928, Rev C, Requirement Paragraph 3.5.11 and Method Paragraph 4.7.12. All specimens, along with the crimp tools (TE Hand Tool 59250-B and Daniel's Hand Tool M22520/5-01) and wire, were placed in a chamber at a temperature of -5°C ±1°C for a period of 1 hour. After 1 hour, the chamber was opened, and ten specimens were crimped to 20 AWG wire for each test set. The crimping operation was done inside the chamber while all components were still cold. Upon completion of the crimping, all specimens were subjected to 1 hour exposure at a temperature of -65°C ±1°C. At the completion of the exposure, the specimens were prepared for and subjected to dielectric withstanding testing.

3.8 Temperature Humidity

The specimens were tested in accordance with SAE Specification AS7928, Rev C, and Test Condition B, Method 103, of MIL-STD-202. They were placed in a chamber and subjected to a relative humidity of 90-95% and a temperature of 40 +/- 2°C for 96 hours. After exposure, they were conditioned at room temperature for a period of 1 hour.

3.9 Axial Load

3.9.1 Axial Load (Crimped Samples)

The specimens were tested in accordance with SAE Specification AS7928 Rev C, Requirement Paragraph 3.5.5.2, and Method Paragraph 4.7.6.4. Initial insulation measurements were taken. The PIDG terminal specimen under test was placed in a slotted plate that was held in a goal post fixture that was attached to the movable crosshead of the tensile machine. The wired end of the specimen was held in air jaws that was attached to the base of the tensile machine. An axial force of a minimum of 8 pounds was then exerted at a rate of 0.20 inches per minute on each specimen. Final insulation measurements were then taken.

3.9.2 Axial Load (Uncrimped Samples)

Test Set 12 (Insulation Pull Only)

The specimens were tested in accordance with SAE Specification AS7928 Rev C, Requirement Paragraph 3.5.5.2, and Method Paragraph 4.7.6.3. The uncrimped specimens had four 0.022-inch diameter holes drilled through the insulation overhang and then four piano wires of 0.020-inch diameter were inserted through the drilled holes. Initial insulation measurements were taken. The PIDG terminal under test was then fastened to a fixture held in a vise that was attached to the base of the tensile test machine and the piano wires were then clamped in air-jaws that were attached to the movable crosshead of the tensile machine. An axial force of a minimum of 8 pounds was then exerted at a rate of 0.20 inches per minute on the exposed piano wires. Final insulation measurements were then taken.

Test Set 13 (Insulation and Sleeve Pull)

The specimens were tested in accordance with SAE Specification AS7928 Rev C, Requirement Paragraph 3.5.5.2, and Method Paragraph 4.7.6.3. The uncrimped specimens had four 0.022-inch diameter holes drilled through the insulation overhang and metal sleeve and then four piano wires of 0.020-inch diameter were inserted through the drilled holes. Initial insulation measurements were taken. The PIDG terminal under test was then fastened to a fixture held in a vise that was attached to the base of the tensile test machine and the piano wires were then clamped in air-jaws that were attached to the movable crosshead of the tensile machine. An axial force of a minimum of 8-pounds was then exerted at a rate of 0.20-inches per minute on the exposed piano wires. Final insulation measurements were then taken.