



Electric Technologies Panel Meeting

Philadelphia, PA

Low Voltage Quick Connector Evaluation

Status Update

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Approved for public release; distribution is unlimited.

GENERAL DYNAMICS
Bath Iron Works

NATIONAL SHIPBUILDING RESEARCH PROGRAM

Project Mission and Objectives

- Currently, using lugged terminal connectors are traditional methods for electrical connection for shock qualified applications
- Looking for methods and hardware that support expedited installation, while maintaining high reliability
- Ease of use with good electrical characteristics and performance characteristics
- Repeatable if mechanism is engaged several times (i.e., during troubleshooting and activation activities)

Project Participants

- BIW – Lead
- Bollinger Shipyards
- Raytheon
- Laboratory (to be chosen soon)
- Test Specimen Vendors and Distributors
 - WAGO Corp.
 - Tyco Electronics
 - Newark
 - Horizon Solutions
 - Grainger
 - Eaton

Low Voltage Quick Connector Evaluation Project Goals

- Research Available Products: 100% complete
- Evaluate Requirements: 100% complete
- Generate Evaluation Guide: 85% complete
- Evaluate Product Information: 95% complete
- Develop Test Procedure: 95% complete
- Manufacture Demonstrator: 0% complete
- Conduct Testing: 0% complete
- Evaluate Results: 0% complete
- Generate Report and Recommendations

Research Available Products

- Several products were researched and chosen as candidates in four basic configurations
 - Standard lugged terminal (baseline)
 - Screw down wire interface
 - Releasable locking mechanism interface
 - Non releasing locking mechanism interface
- Using terminal blocks, in-line splices

Evaluate Requirements

- Several standards and Mil-Specs were reviewed
- Much of the requirement review based on types of tests that qualify a particular product
- Performance and characteristics testing reviewed
- MIL-C-55243, MIL-DTL-22992, MIL-DTL-24558, MIL-T-16366F, A-A-59125, SAE AS7928

References and Standards for Cable Terminations and Connectors					
Item	Reference	Distribution	Section	Section Language	Remarks
1	MIL-C-55243: Connectors, Plugs, and Receptacles, Electrical, Quick Connect and Disconnect, 12 Contacts, Medium Power (NOTE - Listed as not for new design)	Not listed (A - Public Release)		3.8 Contact retention. Individual contacts shall be capable of withstanding an axial load of 10 pounds minimum uniformly applied at a rate of 1 pound per second. (see 4.7)	Each Contact shall withstand a load of 10 pounds
				3.1 Contact resistance. The voltage drop across mating contact terminals shall not exceed 20 millivolts when a current of 7.5 amperes is applied (see 4.9).	Resistance between two connected terminals will be 2.67mΩ or less
				3.11 Dielectric strength. The connectors shall show no evidence of breakdown when subjected to a potential of 1500 volts rms, 60 cycles per second, for a minimum of one minute (see 4.10).	Adjacent terminals will be able to handle a 1500V difference without arcing
				3.12 Insulation resistance. The insulation resistance shall be not less than 1000 megohms except for unmated connectors following the immersion test when it shall be not less than 100 megohms (see 4.11).	1000MΩ minimum insulation resistance between separate terminals.
				3.19 Pull. Mated connectors shall withstand an axial pull of not less than 40 pounds applied to the shell and 25 pounds applied to the cable. The force shall be applied abruptly (see 4.18)	Mated connectors shall withstand 25lbs applied to the cable.
				3.21 Temperature cycling. At the extreme temperatures during the test specified in paragraph 4.20, the connectors shall be capable of being mated and unmated.	Connectors shall function during Method 102A test condition D of MIL-STD-202
				4.21 Vibration (see 3.22). Mated connectors shall be tested in accordance with Method 201 of Standard MIL-STD-202.	Connectors shall function during vibration test.
2	MIL-DTL-22992: Connectors, Plugs, and Receptacles, Electrical, Waterproof, Quick Disconnect, Heavy Duty Type, General Specification for	Not listed (A - Public Release)		3.7 Contact resistance. When connectors are tested as specified in 4.6.4, the resistance of mated pin and socket contacts shall be such that the potential drop at the test current specified in table I shall not be greater than the values specified.	Contact resistance depends on Contact size. (EX: Size 16, 20A current, 25mV maximum drop, 1,25mΩ. Increases as Contact size increases)
				3.8 Dielectric withstanding voltage. When connectors are tested as specified in 4.6.5, connectors shall be capable of withstanding the applicable voltages shown in table II without flashover or breakdown.	Maximum voltages at sea level range from 1000VAC to 7000VAC based on rating.
				3.11 Contact retention. When contacts are tested as specified in 4.6.8, they shall be capable of withstanding the axial loads shown in table III.	Contact retention depends on size. Withstand axial loads ranging from 10lbs to 35lbs between size 16 and 4/0
				3.13 Insulation resistance. When connectors are tested as specified in 4.6.10, the insulation resistance (prior to conditioning) shall not be less than 5,000 megohms	Insulation resistance minimum of 5000MΩ
				3.17 Cable pull-out. When connectors are tested as specified in 4.6.14, test cables (see 4.4.3) shall not pull-out when the loads given in table V are applied, nor shall slippage exceed .125 inches (3.18 mm)	Cables shall withstand loads from 50-125lbs of force (based on weight of cable) without slipping more than 0.125"
				4.6.6 Thermal shock (temperature cycling). Unmated connectors shall be tested in accordance with test procedure EIA-364-32, condition I, 5 cycles, except that the high temperature shall be 125°C, +3°C - 0°C (see 3.9).	Connectors shall withstand temperatures detailed in EIA-364-33

Generate Evaluation Guide

- Certain criteria for product comparison being considered, including but not limited to
 - Ease of use (design, installation)
 - Reliability
 - Compatibility
 - Commonality
 - Electrical and physical attributes
 - Testing performance
- Chose the ones indicated mainly due to availability, functionality and applicability

Evaluate Product Information

- The previous evaluation guide templates were filled in with vendor data
- This enables a consistent comparison across samples and attributes
- Allows for a down select to build unit demonstrators with sample materials

NSRP ETP Project: Low Voltage Quick Connectors, Vendor and Product Information Evaluation

Item	Name	Model/PN	Product Description	Dimensions			No. Connections	Conductor Size	Rated Voltage	Rated Surge Voltage	Rated Current	Rated SSC	Mounting			Tensile Pull Resistance (Nm)	Mechanism Type	Housing Material	Contact and Mechanism Material	Certification, Qualifications	Fire Rating	Temp Rating C	Interface Type	Remarks
				Length	Width	Height							Metal	Plastic	DIN Rail									
11	Tyco	1-1778301-4	1 Position Fused Terminal Block	0.56	1.06	0.69	3	12-22	400		16													
12	Ideal	Model 3930-1039J	3 Port Push-In Connector	0.78		0.45	3	10-14	600								Polycarbonate							
13	Power First	22EW70	Through Insulation Splice Connector	1.45				12	600		40								UL E62622, CSA 15364		105			
14	3M	72M-187-20NBL	Male Crimp Connector	1	0.65	0.375	2	14-18	32									Tin Plated Copper			90			
15	Cooper Bussmann	BNQ21	Gangable Connector Block	1.45	1.29	1.37	2	8-22	600		40							Tin Plated Aluminum	UL 62622		105			

Develop Test Procedure



- The current list of tests are part of the test procedure, incl. shock, vibration, thermal stress
- Decision on which tests to conduct will be based primarily on estimated costs and value added to decision making processes

Demonstrator Unit Testing							
Order of Test	Test	Standard	Called Out By	Section or Method	Reference	Test Values	Remarks
3	Voltage Drop	Mil-T-16366F		3.4.4		6 - 25mV at rated voltage	- used for 4-30 A units operating at rated current
4	Dielectric Withstand	Mil-Std-202G		301		-2x rated voltage +1000 V for 60 sec -leakage current less than 0.1% rated load	- raise voltage 500 V/sec - Mil-C-55243 uses 1500 V for 60 sec
5	Shock	Mil-Std-202G	Mil-C-55243	207	Mil-Std-901D	- continuity maintained better than 10% of contact resistance value (drop no less than 0.267 mV)	- inspect for damage to mounts, contacts, springs, etc.
6	Vibration	Mil-Std-167-1A	Mil-C-55243			- 6 0.03 in, 0-34 Hz in approx. 6 hrs	- inspect for damage to mounts, contacts, springs, etc.
7	Temperature Cycling	Mil-Std-202G	Mil-C-55243	107 Cond D		- -65 to -5 C 15 min 25 to -5 C 5 min 350 to 0 C 15 min 25 to -5 C 5 min	- inspect for damage, maybe conduct pull test
1, 8	Contact Retention/Pull Resistance	Mil-C-55243			3.8, 3.19	- 10 lbs @ 1lb/min	- 3.19 is for mated connectors (40 lbs)
2	Insulation Resistance	Mil-C-55243			3.12	1000 My	
	Contact Resistance (TDR)	Mil-C-55243			3.10	[20 mV @ 7.5 A ⇒ 2.67 mV	This will be done during shock and vib testing, instrumenting the demonstrator

National Shipbuilder Research Program, Electric Technologies Panel
Low Voltage Quick Connector Project

Demonstrator Test Procedure

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Rev. 1

Submitted by: Greg Stevens, BIV
3/17/14

Testing
The demonstrator unit comprises several different products and is intended to be tested in a manner that will allow for the identification of failure modes and mechanisms. The design utilizes manufacturer recommended mounting arrangements. Cables have been re-terminated using the functionality replicates a single conductor being terminated to a bundle of conductors, which, collectively, are terminated to a cable because loose from the backplane. The laboratory tests and tests will be responsible for restraining the cable under forces on the products being tested. Cables coming loose from the backplane represent a failure, and must be re-terminated, if necessary, before the next test sequence.

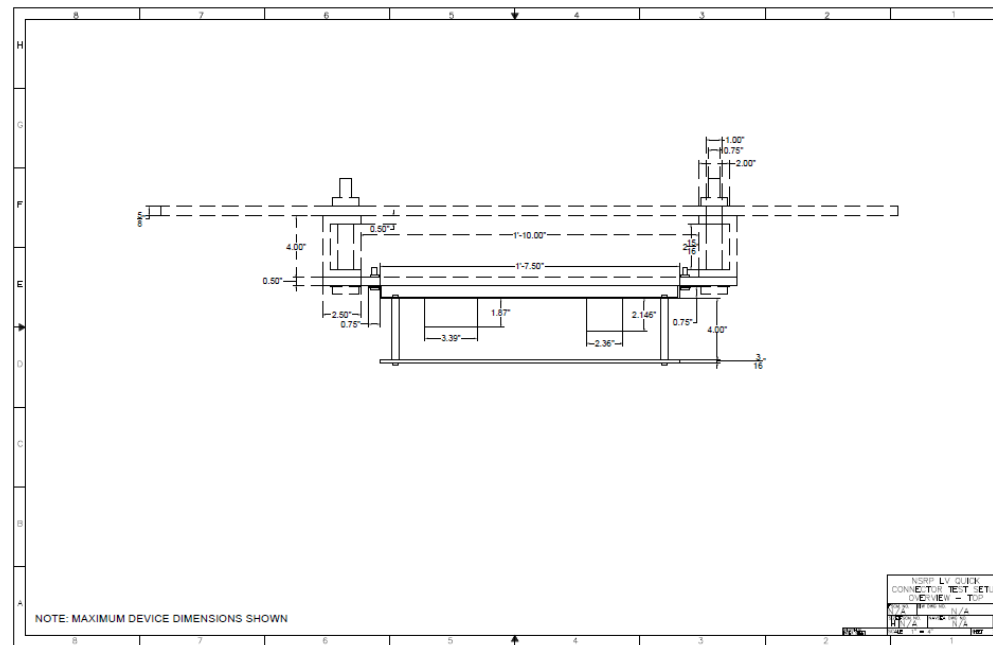
All testing shall be performed in compliance with all local, state and federal safety and environmental regulations.

3 Testing References
 MIL-STD-167-1, Department of Defense Test Method Standard Mechanical Vibrations of Shipboard Equipment (Type I – Environmental and Type II – Intensity Exceeds)
 MIL-S-901D, Military Specification, Shock Tests, H1 (High Impact) Shipboard Machinery, Equipment, and Systems, Requirements for, March 17, 1989.



Design Demonstrator (cont.)

- Plates mounted to test anvil plate at 8 points
- Plexiglass and stand-off units used to maintain safe testing environment when units are instrumented and energized
- Standard shock 901D and vib 167 tests will be done on lightweight machines, 3 dimensions



Design Demonstrator (cont.)

Product list includes terminal blocks and in-line connectors, most mounted on DIN rail

- Wago
- Tyco
- Cooper Bussman
- Ideal
- 3M
- Eaton Cutler Hammer
- Weidmuller
- Rockwell Automation
- Phoenix Contact

DEVICES UNDER TEST AND RELATED EQUIPMENT			
ITEM #	ITEM	DETAILS	QTY
1	Aluminum Plate	0.100 Aluminum, 8052-432, Per GG-A280 RP, 22.8" x 18"	1
2	A-A4912524 28TB-06	BIW CAT # 28283561	1
3	No. 6 screw (1)	(Ø.138" diameter), CRES 316, Self-Locking Nut Required	2
4	A-A4912512 6TB-10	-	1
5	No. 10 screw (1)	(Ø.19" diameter), CRES 316, Self-Locking Nut Required	14
6	1776302-4	Tyco Quick Connecting Terminal Block, Screw-Type	1
7	No. 8 screw (16)	(Ø.125" diameter), CRES 316, Self-Locking Nut Required	2
8	210-196	Wago 35mm DIN Mounting Rail, Aluminum	1
9	352-496 (3) (B)	Wago DIN mounted, Blade Fused Terminal Block, Spring-Type	4
10	352-128 (3) (B)	Wago DIN mounted, Miniature Metric Fused Terminal Block, Spring-Type	4
11	773-164	Wago Push Wire Connector, 4-Conductor Terminal Block	2
12	2002-201 (B)	Wago DIN mounted, through Terminal Block, Cage Clamp Type	4
13	322-415	Wago Lever-Acting Connector	2
14	3930-103H	Ideal Push Wire Connector, 3-Conductor terminal block	2
16	BMU21	Cooper Bussman Gangable Connector Block	4
16	BCF	Cooper Bussman End Mounting Adapter	1
17	No. 8 screw (1)	(Ø.164" diameter), CRES 316, Self-Locking Nut Required	8
18	PCB229-2	Cooper Bussman Series PCB Power Distribution Blocks	1
19	No. 12 screw (1)	(Ø.216" diameter), CRES 316, Self-Locking Nut Required	4
20	PCB-FB-20	Cooper Bussman Series PCB-FB Finger Safe Power Distribution Blocks	3
21	151100000 (3) (B)	Weidmuller DIN mounted, Fuse Terminal Block, Screw Style	4
22	186A03000 (3) (B)	Weidmuller DIN mounted, Fuse Terminal Block, Screw Style	4
23	XBU742623 (3)	Eaton Cutler Hammer DIN mounted terminal block, 4 conductor, screw style	4
24	XBU74748E (3) (B)	Eaton Cutler Hammer DIN mounted fused terminal block, 4 conductor, screw style	4
25	XBP74 (3)	Eaton Cutler Hammer DIN mounted terminal block, 4 conductor, spring style	4
26	XBP74 (3)	Eaton Cutler Hammer DIN mounted terminal block, 4 conductor, insulation Displacement Style	4
27	314-80K	3M Scotchlok Electrical IDC Connector, Moisture Resistant and Flame Retardant	2
28	1482-2 (3)	Rockwell Automation (Alan Bradley) DIN Mounted Terminal Block, Spring Clamp	4
29	1482-3 (3)	Rockwell Automation (Alan Bradley) DIN Mounted Terminal Block, Screw Clamp	4
30	1482-CAM1 (3)	Rockwell Automation (Alan Bradley) DIN Mounted Terminal Block, Open construction	4
31	3003347 (3)	Phoenix Contact UK 2.5 N DIN Mounted Terminal Block, Screw Clamp	4
32	3031076 (3)	Phoenix Contact ST 1.5 DIN Mounted Terminal Block, Spring Cage	4
33	2-1437390-9	Tyco Model 241 Flat Bottom Terminal Block, Spring Screw	4
34	2-1437390-8	Tyco Model 212 Flat Bottom Terminal Block, Tubular Screw	4
35	1646234-1	Tyco Model 925 Flat Bottom Terminal Block, Tubular Screw Clamp	4
36	N/A	Tyco 2" Post Power Plug Bus Bar Unit	1
37	5/16" Bolt (1)	1/2" Diameter bolt, CRES 316, Self-Locking Nut Required	2
38	Fluorogel Sheet	1/8" Thick Fluorogel Sheet, 18.5x18.5"	2
39	740136-AL25 (2)	Orange Ten-Block ISO Standoffs, 4" Long, Ground	8
40	1/4-20 (size screws 54)	1/2" Diameter, CRES 316	16
41	2" Bolt	1/2" Diameter, for grounding, Length between 1" and 2"	2
42	249-117	Wago Screwless DIN rail end stop, 10mm wide	8
43	Aluminum Block	1/2" Wide Aluminum Block	16

NOTES:
 (1) Bolt Lengths to suit. Minimum of 1 thread past bolt must be exposed when tightened. Do not exceed 4" protrusion from the back of the plate.
 (2) 4" long standoff for Plexiglass mounting. Plexiglass for protection during electrical tests, not to be installed during shock or vibration testing. 1" O.D. washers may be used for additional stability at each end of the standoff if necessary.
 (3) Fuses are not supplied with fused terminal blocks.
 (4) 1/4-20 bolts for Plexiglass sheet spacers. Bolt Length Maximum 4" for securing spacers to the plate. Bolts securing Plexiglass to the spacers shall engage a minimum of 2 threads, and may be hand tightened for ease of removal between tests.
 (5) DIN Rail mounted terminal blocks require end plate, usually sold separately, for proper installation, see manufacturers requirements.

NSRP LVL 0118
 CONNECTOR TEST SETUP
 PART LIST
 6/28/2016 11:44
 16/27



Next Steps

- Finish Evaluation Guide to support overall evaluation process
- Construct Demonstrator units
- Perform testing
- Evaluate the testing results
- Generate final report and brief, to include
 - Cursory cost benefit assessment
 - Recommendations
 - Implementation steps/implementation plan

Questions??

Thank you for your support and participation

