

# Chardon 600V Submersible Low Voltage Connector Design Test Report

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Report Number:

RN-RS3803

Test Start Date:

2020 / 12 / 10

Test Complete Date:

2020 / 12 / 30

“**Note:** The report was made using as sample the code SLVC-J6-500 but however can be applied by similarity the code SLVC-J4-500 and SLVC-J8-500.”

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## 1. Mechanical test - Pullout strength

### Object

To verify the connectors that the parts meet NEMA-C119.1-2011 Pullout strength.

### Testing Samples

Chardon SLVC	SLVC-J6	9 PCS
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### Mating Parts

Test Cable	3.5 mm <sup>2</sup> – Copper
	50 mm <sup>2</sup> – Copper
	240 mm <sup>2</sup> – Copper

### Procedure and Testing Spec

4.2.1 The pullout strength of the connections tested in accordance with clause 6.2.1 shall be equal to or greater than five percent (5%) of the rated conductor strength of the weaker of the conductors being joined, but not less than the values in Table 1 or Table 2 in the standard.

5.2.1 Three (3) samples of each connector-conductor combination shall be subjected to each mechanical test described in 6.2.1.

6.2.1.1 Pullout strength tests shall be performed on the following two (2) conductor combinations for which the connector is designed: 1. the highest rated tensile strength conductor; and 2. the smallest diameter conductor with the highest rated tensile strength.

6.2.1.2 When conducting the tensile strength test, care shall be taken to ensure that all strands of the conductor are loaded simultaneously.

6.2.1.3 The load shall be applied at a cross-head speed not exceeding 20.6 mm per minute per meter (1/4 in. per minute per foot) of the total length of the exposed conductor between jaws.

6.2.1.4 The length of the exposed conductor between each gripping means and each connector shall not be less than 250 mm (10 in.).

6.2.1.5 The pullout strength shall be determined as the maximum load that can be applied to the connector-conductor combination. This load shall be measured to an accuracy of five percent (5%) with instruments calibrated according to ASTM E4. The mode of failure shall be recorded.

### Results

Pullout strength of 3.5 mm<sup>2</sup> cable

Sample number	Pullout strength – 311 N(69 lb)
A1	PASS
A2	PASS
A3	PASS

Pullout strength of 50 mm<sup>2</sup> cable

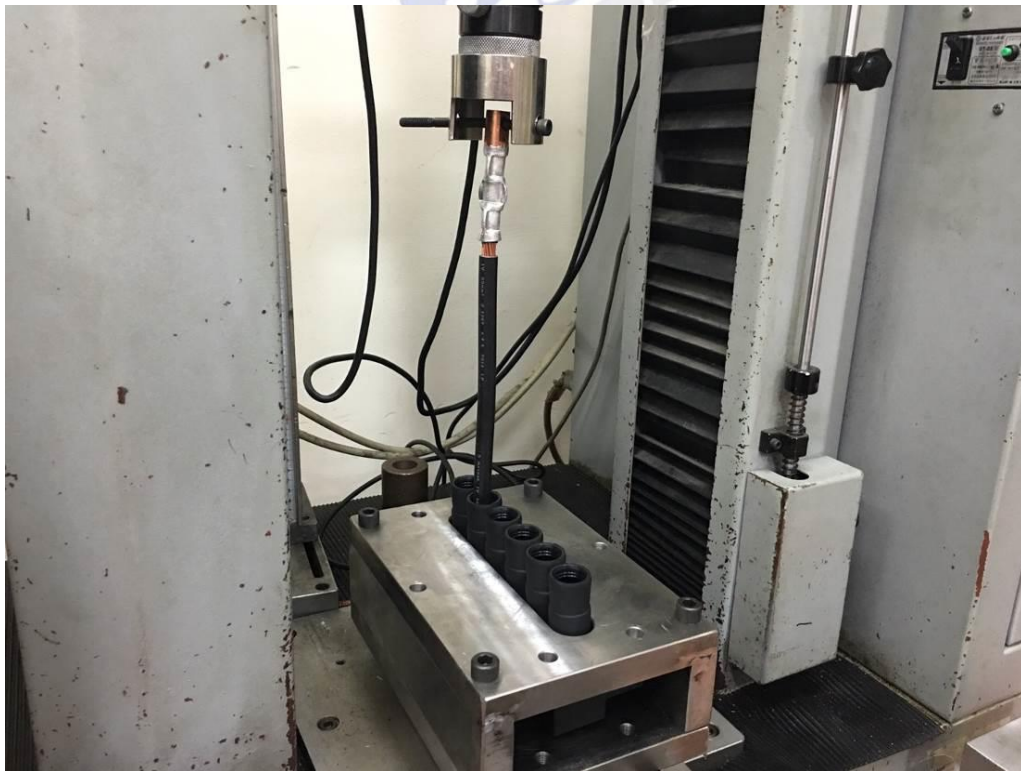
Sample number	Pullout strength – 1060 N(235 lb)
B1	PASS
B2	PASS
B3	PASS

Pullout strength of 240 mm<sup>2</sup> cable

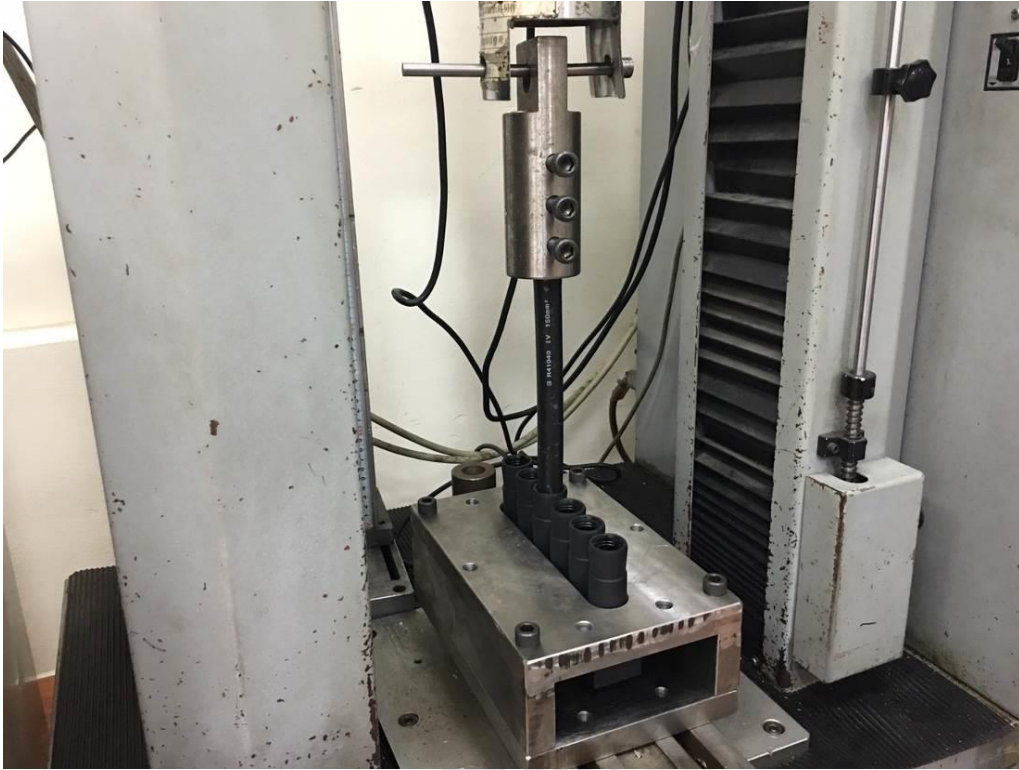
Sample number	Pullout strength – 1800 N(400 lb)
C1	PASS
C2	PASS
C3	PASS



3.5 mm<sup>2</sup> Pullout Strength Test



50 mm<sup>2</sup> Pullout Strength Test



240 mm<sup>2</sup> Pullout Strength Test

CHARDON GROUP

## 2. Mechanical test - Torque strength requirements

### Object

To verify the connectors that the parts meet NEMA-C119.1-2011 Torque strength requirements.

### Testing Samples

Chardon SLVC	SLVC-J6	9 PCS
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### Mating Parts

Test Cable	3.5 mm <sup>2</sup> – Copper 50 mm <sup>2</sup> – Copper 240 mm <sup>2</sup> – Copper
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### Procedure and Testing Spec

4.2.3 A set screw connector shall withstand 120% of the manufacturer's tightening torque applied to the set screw(s) without damage to any component part. Damage is defined as stripping the threads, hex socket or a crack, detected by visual means.

5.2.2 Three (3) samples of each connector-conductor combination shall be subjected to each mechanical test described in 6.2.2.

6.2.2.1 The torque strength of a set screw connector (see 4.2.3) shall be measured using conductors of the largest and smallest diameters for which the connector is designed.

6.2.2.2 Tightening torque values shall be measured using a measuring device that is accurate within  $\pm 6\%$ .



**Results**

Torque strength of 3.5 mm<sup>2</sup> cable

Sample number	Torque strength – 360 in-lbs
A4	PASS
A5	PASS
A6	PASS

Torque strength of 50 mm<sup>2</sup> cable

Sample number	Torque strength –360 in-lbs
B4	PASS
B5	PASS
B6	PASS

Torque strength of 240 mm<sup>2</sup> cable

Sample number	Torque strength –360 in-lbs
C4	PASS
C5	PASS
C6	PASS





Tightening torque values



Torque strength testing

### 3. Mechanical test - Impact test

#### Object

To verify the connectors that the parts meet NEMA-C119.1-2011 Impact test.

#### Testing Samples

Chardon SLVC	SLVC-J6	12 PCS
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#### Mating Parts

Test Cable	3.5 mm <sup>2</sup> – Copper
	50 mm <sup>2</sup> – Copper
	240 mm <sup>2</sup> – Copper

#### Testing Spec

4.2.4 When tested in accordance with clause 6.2.3, a sealed wire connector system intended for direct burial shall withstand the applied voltage of the dielectric withstand test without breakdown.

5.2.3 Twelve (12) samples shall be subjected to the impact test described in 6.2.3.

6.2.3.1 New connector assemblies shall be used for each test sequence.

6.2.3.2 Each connector shall have provision for the connection of at least two conductors.

6.2.3.2.1 The associated insulating and sealing components shall be assembled in accordance with the manufacturer's instructions.

6.2.3.2.2 Connector assemblies shall be prepared with the maximum size wire.

6.2.3.2.2.1 The term "maximum size wire" refers to the maximum wire size for a range-taking connector and refers to the maximum circular mil area for a connector rated for multiple wire combinations.

6.2.3.2.2.2 For a sealed wire connector system having multiple cutoff rings consisting of different sizes, the following rings shall be tested:

1. the largest and the smallest sizes, if the number of cutoff rings consists of four (4) sizes or fewer;
2. the largest, smallest, and one intermediate size, if the number of cutoff rings consists of five (5) sizes; or
3. the largest, smallest, and two (2) intermediate sizes, if the number of cutoff rings consists of more than five (5) sizes.

6.2.3.2.3 The assemblies shall be prepared so that a minimum of 76 mm (3 in.) of conductor extends from the ends of the insulating system.

6.2.3.2.4 Six (6) assemblies shall be oven conditioned at  $113 \pm 5^{\circ}\text{C}$  ( $235 \pm 9^{\circ}\text{F}$ ) for 168 h. The other six (6) assemblies shall be cold conditioned at  $\text{minus } 10 \pm 2^{\circ}\text{C}$  ( $14 \pm 4^{\circ}\text{F}$ ) for 2 h.

6.2.3.2.5 No assembly shall be subjected to more than one (1) impact.

6.2.3.2.6 The assemblies shall be placed on a concrete surface.

6.2.3.2.7 The assemblies that have been cold conditioned shall be subjected to the impact test within 2 min of removal from the cold chamber.

6.2.3.2.8 A steel sphere, 51 mm (2 in.) in diameter and with a mass of 0.54 kg (1.18 lb), shall be dropped onto the assembly from a height of 914 mm (3 ft). Three (3) assemblies subjected to cold conditioning and three (3) assemblies subjected to the heat conditioning shall be impacted on the weakest wall, generally the thinnest wall section. The three (3) remaining assemblies subjected to cold conditioning and the three (3) remaining assemblies subjected to the heat conditioning shall be impacted at the seal where the conductor insulation meets the sealed wire connector system. See Figure 1 for a typical impact test apparatus.

Other dimensions may be used except for those required dimensions in this clause.

6.2.3.2.9 Following the impact test, the connector assemblies shall be immersed to a minimum depth of 305 mm (1 ft) in tap water at  $25 \pm 5^{\circ}\text{C}$  ( $77 \pm 9^{\circ}\text{F}$ ) for 4 h.

6.2.3.2.10 While still immersed, the connector assemblies shall be subjected to the dielectric withstand test as specified in 6.4.1.5.

6.4.1.5 While each connector assembly is immersed in accordance with clause 6.4.1.3, it shall be subjected to a 2.2 kV fifty (50) or sixty (60) Hertz test voltage for one (1) minute, applied between the water and the conductor.

## **Results**

113±5°C / 168h

Sample number	Cable size	Impact test of the 2.2 kV/1 min
A7	3.5 mm <sup>2</sup>	PASS
A8	3.5 mm <sup>2</sup>	PASS
B7	50 mm <sup>2</sup>	PASS
B8	50 mm <sup>2</sup>	PASS
C7	240 mm <sup>2</sup>	PASS
C8	240 mm <sup>2</sup>	PASS

-10±2°C / 2h

Sample number	Cable size	Impact test of the 2.2 kV/1 min
A9	3.5 mm <sup>2</sup>	PASS
A10	3.5 mm <sup>2</sup>	PASS
B9	50 mm <sup>2</sup>	PASS
B10	50 mm <sup>2</sup>	PASS
C9	240 mm <sup>2</sup>	PASS
C10	240 mm <sup>2</sup>	PASS





Oven conditioned at  $113 \pm 5^{\circ}\text{C}$  -I



Oven conditioned at  $113 \pm 5^{\circ}\text{C}$  -II

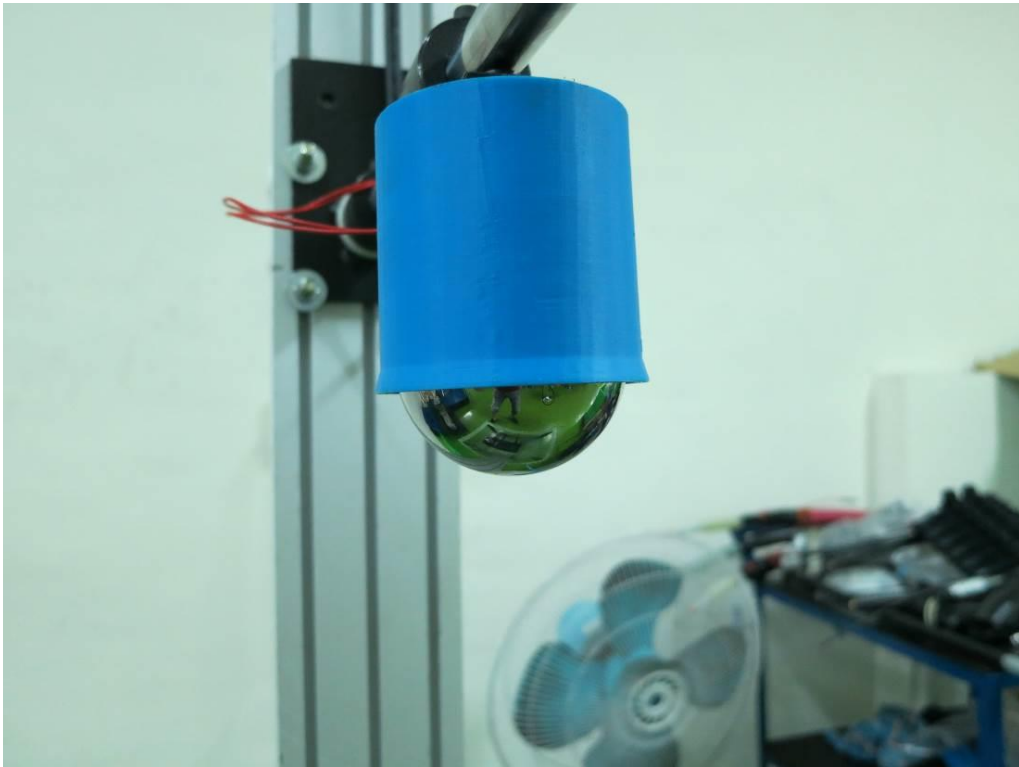




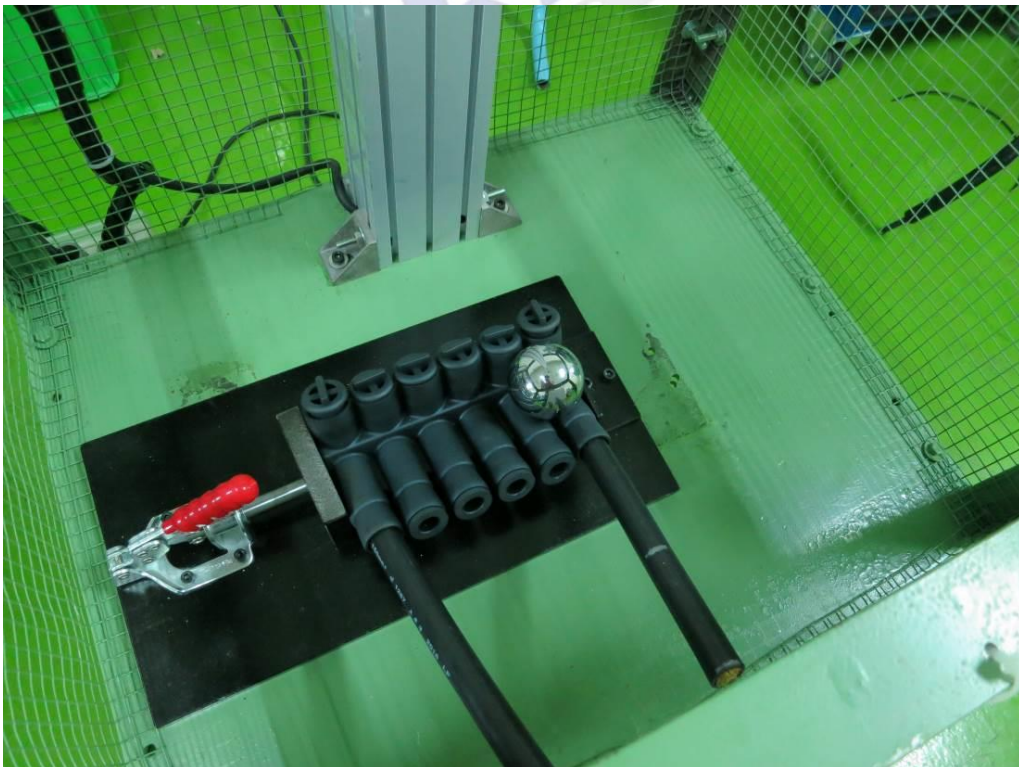
Cold conditioned at minus  $10 \pm 2^{\circ}\text{C}$  -I



Cold conditioned at minus  $10 \pm 2^{\circ}\text{C}$  -II



Impact Testing -I

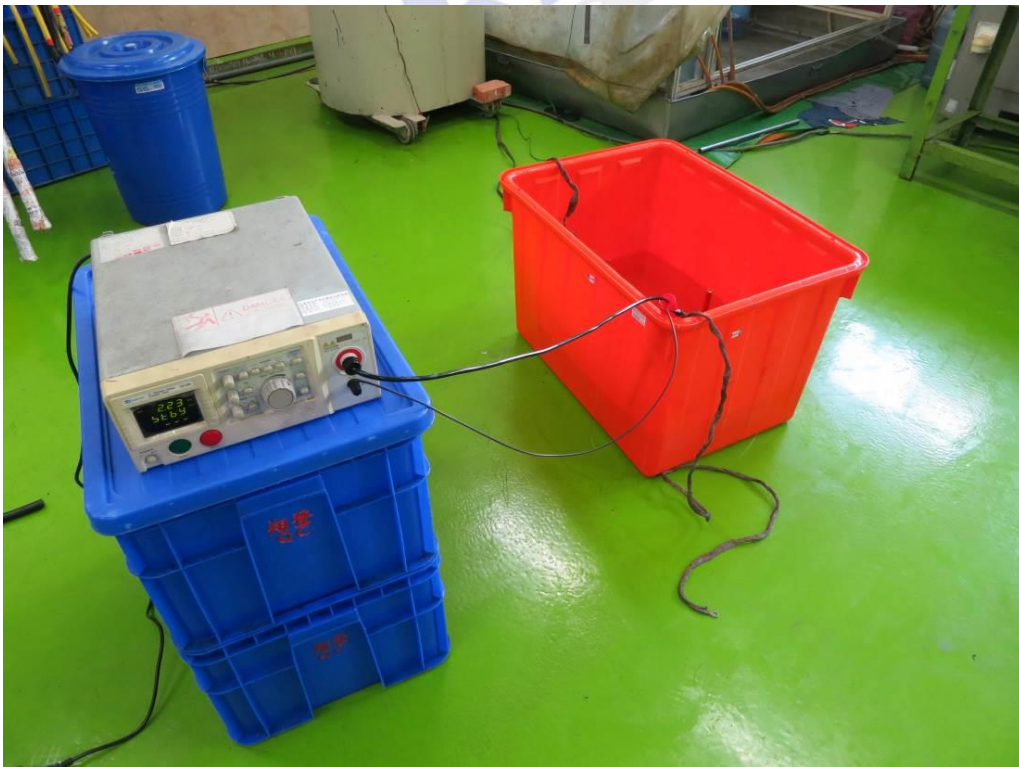


Impact Testing -II

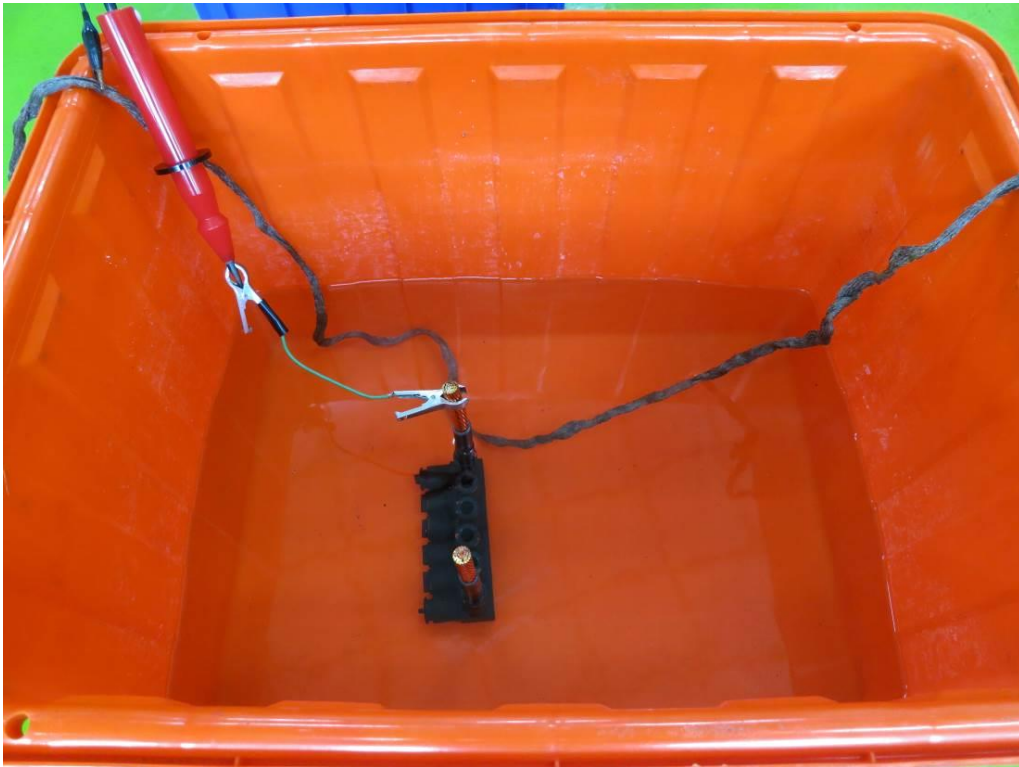




Sample in tap water at  $25 \pm 5^{\circ}\text{C}$  for 4 h



Voltage testing of the 2.2 kV 60Hz / 1min in water -I



Voltage testing of the 2.2 kV 60Hz / 1min in water -II



Voltage testing of the 2.2 kV 60Hz / 1min in water -III

## 4. Electrical tests - Current cycle

### Object

To verify the connectors that the parts meet NEMA-C119.1-2011 Current cycle test.

### Testing Samples

Chardon SLVC	SLVC-J6	12 PCS
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### Mating Parts

Test Cable	3.5 mm <sup>2</sup> – Copper
	50 mm <sup>2</sup> – Copper
	240 mm <sup>2</sup> – Copper

### Testing Spec

4.3.1 Current Cycle Tests shall be conducted in accordance with clause 6.3.1 and shall be of the duration listed in Table 3, depending on the choice of test method: CCST.

4.3.2 Current Cycle Resistance Stability The resistance of the connection tested in accordance with clause 6.3.1 shall be stable. Stability is achieved if any resistance measurement, including allowance for measurement error, does not vary by more than  $\pm 5\%$  from the average of all the measurements at specified intervals during the course of the test.

4.3.2.2 CCST The resistance of the connection tested by the Current Cycle Submersion Test method in accordance with clause 6.3 shall be stable between the tenth (10th) cycle and the completion of the number of current cycles required in Table 3 for the connector class.

4.3.3 Current Cycle Temperature Stability The temperature of the connector when tested in accordance with clause 6.3.1 shall not exceed the temperature of the control conductor.

The temperature difference between the control conductor and the connector shall be stable as determined as follows.

The stability factor "S," shall not exceed  $\pm 10$  for each of the specified connector temperature measurements recorded at the intervals specified in Table 4.

The stability factor S, for each of the specified recorded temperature measurements shall be determined by applying the following equations:

$$S_i = d_i - D$$
$$d_i = (T_{cc} - T_c)$$
$$D = [(d_1 + d_2 + \dots + d_n) / n]$$

4.3.3.2 CCST The temperature of the connector tested by the Current Cycle Submersion Test method shall be stable between the tenth (10th) cycle and the completion of the number of current cycles required in Table 3 for the conductor class being tested.

5.3.1 Four (4) connectors of the same size and type are required for each combination of conductors, as determined by 6.3.1.1.

6.3.1.2.5.2 The control conductor shall be installed on the same horizontal plane as the test connectors. During the current-ON period, no part of the circuit shall be less than 200 mm (7.9 in.) above the surface of the chilled water. At the beginning of the current-OFF period, the connectors and the control conductor shall be submerged to a minimum of 100 mm (3.9 in.) below the water surface.

6.3.1.2.8.2 The current cycle submersion test current shall be adjusted during the current-ON period of the first five (5) cycles to result in a steady-state temperature rise on the control conductor of 100°C (212°F) to 105°C (221°F) over ambient temperature for Class A. This current shall then be used during the remainder of the test current-ON periods, regardless of the temperature of the control conductor.

6.3.1.2.9.1 The current-ON time is determined by reaching and maintaining thermal stability in the connector. Thermal stability is defined as not more than a variation of 2°C (3.6°F) between any two (2) of three (3) readings taken at not less than 10 minute intervals. The length of the current-ON period shall not be less than that listed in Table 9 or Table 10, depending on the size of the control conductor.

6.3.1.2.9.3 Connectors tested by the Current Cycle Submersion Test (CCST) method shall be immersed in still, chilled water (5°C ± 4°C) (41 F ± 7.2 F) within thirty (30) seconds of the start of the current-OFF period. The connectors shall remain immersed in the chilled water for a minimum of fifteen (15) minutes after the temperature of the connector is reduced to the temperature of the water. The connectors shall be removed from the water before they are energized at the beginning of the next current-ON cycle.

The connectors were energized with a current of approximately 700 amps, which raised the temperature of the conductor to approximately 100°C above the ambient temperature. This current was maintained for a minimum of 4 hours to establish stability, before any temperature readings were recorded.



**Table 8**  
**Suggested Initial Test Current to Raise Metric Control Conductor Temperature 100°C**

Aluminum		Copper	
Conductor (mm <sup>2</sup> )	Current (Amperes)	Conductor (mm <sup>2</sup> )	Current (Amperes)
		10	105
16	100	16	145
25	135	25	195
35	170	35	245
50	225	50	330
70	270	70	400
95	345	95	505
120	405	120	600
150	450	150	700
185	550	185	795
240	700	240	970
300	805	300	1100
400	930	400	1300
500	1085	500	1565

## Results

3.5mm<sup>2</sup> Temperature measurement intervals:

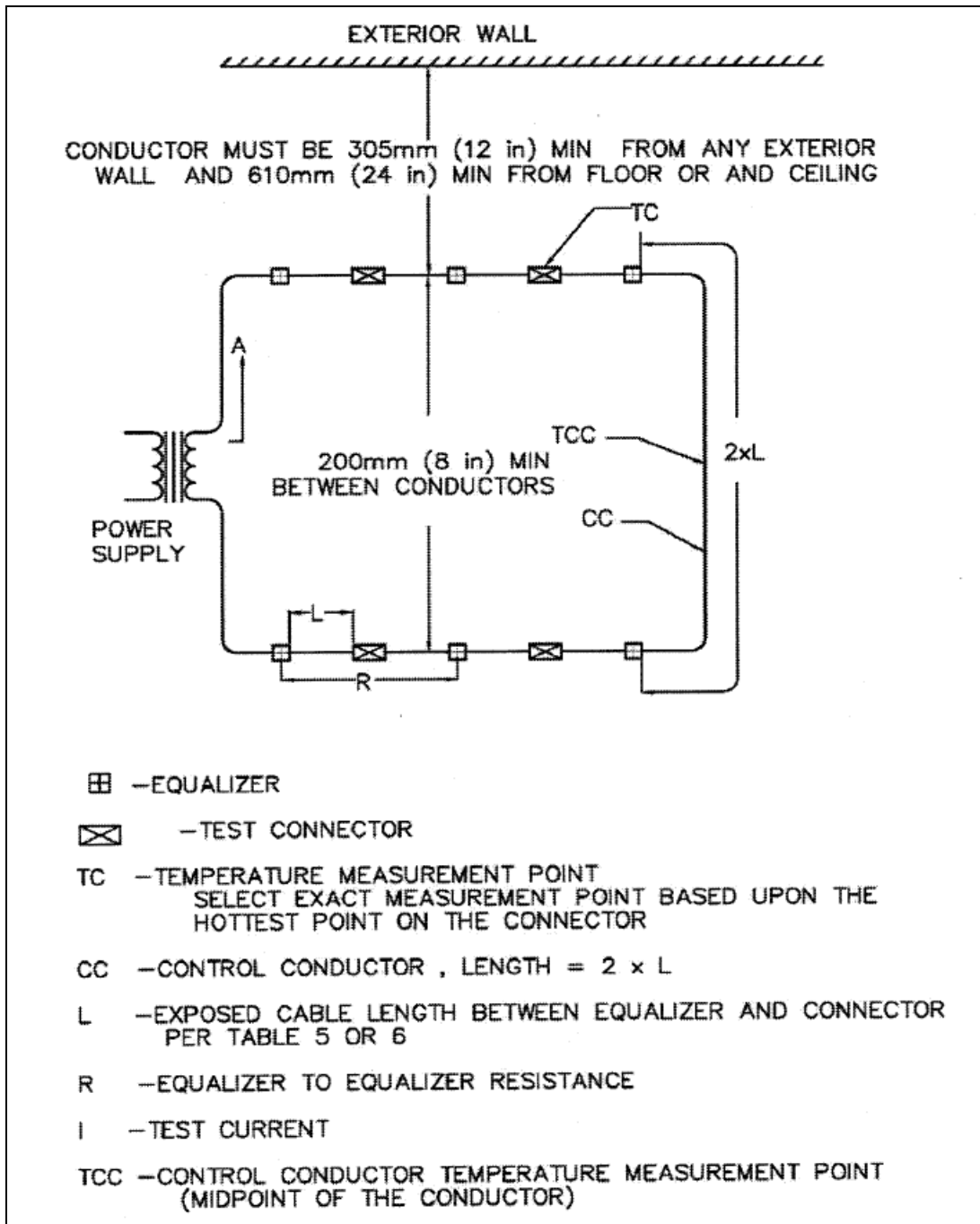
Test cycle (CCST)	Temperature / Stability factor								Cable	Room Temp	Wat Temp
	A11		A12		A13		A14				
6	30.5	-1.5	31.5	-0.6	31.9	-1.2	33.4	-1.1	102.2	27.5	7.8
10	32.6	0.9	32.1	0.3	34.1	1.3	34.2	0.0	101.9	28.4	7.6
20	31.2	-0.9	31.9	-0.3	32.5	-0.7	33.6	-1.0	102.3	28.1	7.2
30	32.8	1.5	32.6	1.2	33.7	1.3	34.6	0.8	101.5	27.9	7.4
40	30.9	-0.1	30.4	-0.7	31.4	-0.7	33.2	-0.3	101.2	27.6	7.9
50	33.4	1.5	33.2	1.2	33.9	0.9	34.1	-0.3	102.1	27.7	8.2
60	32.1	0.7	31.9	0.4	32.6	0.1	34.9	1.0	101.6	28.1	7.7
70	31.7	1.1	31.4	0.7	32.3	0.6	34.5	1.4	100.8	28.6	7.4
80	30.2	-1.0	30.5	-0.8	32.1	-0.2	33.8	0.1	101.4	27.8	7.5
90	30.6	-1.2	30.9	-1.0	31.8	-1.1	33.5	-0.8	102.0	28.8	7.7
100	31.4	-1.1	32.0	-0.6	33.2	-0.4	35.1	0.1	102.7	27.2	8.0

50mm<sup>2</sup> Temperature measurement intervals:

Test cycle (CCST)	Temperature / Stability factor								Cable	Room Temp	Wat Temp
	B11		B12		B13		B14				
6	54.6	2.5	52.2	0.9	53.1	0.9	52.9	6.1	104.1	28.2	8.1
10	58.0	-0.6	55.8	-2.4	58.6	-4.3	58.1	1.2	104.4	28.5	7.4
20	57.7	-0.8	55.0	-2.1	55.9	-2.1	60.1	-1.3	103.9	29.1	6.9
30	58.4	-1.2	55.2	-2.0	57.0	-2.9	60.7	-1.6	104.2	28.8	7.7
40	56.9	-0.2	52.4	0.3	52.5	1.1	58.8	-0.2	103.7	27.6	7.2
50	59.3	-1.9	53.1	0.3	54.2	0.1	60.2	-0.9	104.4	28.5	7.1
60	58.4	-1.3	52.9	0.2	54.1	-0.1	60.4	-1.4	104.1	28.7	8.0
70	57.7	-0.2	52.0	1.5	52.3	2.1	59.9	-0.5	104.5	29.0	6.7
80	55.8	1.5	52.6	0.7	52.9	1.3	58.9	0.3	104.3	29.4	7.5
90	56.5	0.5	52.4	0.6	52.5	1.4	59.3	-0.4	104.0	29.8	7.2
100	55.9	1.7	51.1	2.5	52.3	2.2	61.0	-1.5	104.6	29.1	7.4

240mm<sup>2</sup> Temperature measurement intervals:

Test cycle (CCST)	Temperature / Stability factor								Cable	Room Temp	Wat Temp
	C11		C12		C13		C14				
6	72.5	4.9	74.2	1.4	77.1	2.6	86.3	4.7	100.8	28.1	5.6
10	71.9	5.2	74.7	0.6	76.8	2.6	87.1	3.6	100.5	27.6	5.7
20	76.7	0.8	78.0	-2.3	80.1	-0.3	91.2	-0.1	100.9	27.9	5.4
30	76.6	0.8	76.5	-0.9	79.6	0.1	88.7	2.3	100.8	28.4	5.5
40	78.1	-1.2	78.0	-2.9	81.4	-2.2	90.3	0.2	100.3	28.7	5.9
50	81.8	-2.6	81.6	-4.2	85.1	-3.6	95.1	-2.3	102.6	29.6	5.6
60	80.2	0.3	73.5	5.2	82.8	0.0	93.9	0.2	103.9	28.3	6.0
70	79.4	-2.7	78.1	-3.2	81.8	-2.8	92.1	-1.8	100.1	27.5	5.8
80	79.9	-2.0	71.7	4.4	79.3	0.9	93.7	-2.2	101.3	28.8	6.1
90	80.0	-3.1	71.2	3.9	78.6	0.6	92.7	-2.2	100.3	29.1	5.5
100	77.8	-0.7	77.8	-2.5	77.7	1.7	92.9	-2.2	100.5	29.4	5.7







Current Cycle Test



Current Cycle Test in Progress

## 5. Electrical tests - Thermal performance of insulated system under load

### Object

To verify the connectors that the parts meet NEMA-C119.1-2011 Thermal performance of insulated system under load .

### Testing Samples

Chardon SLVC	SLVC-J6	6 PCS
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### Mating Parts

Test Cable	3.5 mm <sup>2</sup> – Copper
	50 mm <sup>2</sup> – Copper
	240 mm <sup>2</sup> – Copper

### Testing Spec

4.3.4.1 Thermal Stability Connectors shall be thermally stable between the seventy second (72nd) hour and the one hundred twentieth (120th) hour.

4.3.4.2 Determination of Thermal Stability Thermal stability is achieved if the change in connector temperature reading does not differ by more than 2°C (3.6°F) from the change in input conductor temperature.

Thermal stability is achieved when the following equation is satisfied over successive temperature measurements from the 72<sup>nd</sup> hour through the 120<sup>th</sup> hour.

$$ABS (\Delta T_{s,i} - \Delta T_{ic,i}) \leq 2^{\circ}C (3.6^{\circ}F)$$

$\Delta T_{s,i} = T_{s,i+1} - T_{s,i}$  is the change in connector temperature  $T_s$  from time interval  $i$  to  $i+1$

$\Delta T_{ic,i} = T_{ic,i+1} - T_{ic,i}$  is the change in the input conductor temperature  $T_{ic}$  from time interval  $i$  to  $i+1$

4.3.4.3 Connector Temperature The connector temperature shall not exceed the conductor temperature by more than 10°C (18°F) throughout the entire test.

4.3.4.4 The insulation provided as part of the connector system shall show no visible evidence of deterioration upon completion of the test.

5.3.2 A minimum of two (2) insulated connector systems shall be assembled in accordance with the recommendations of the connector manufacturer, on the combination of insulated input and output conductors that represents in number, size, and arrangement the most severe thermal condition for which the connector is designed.

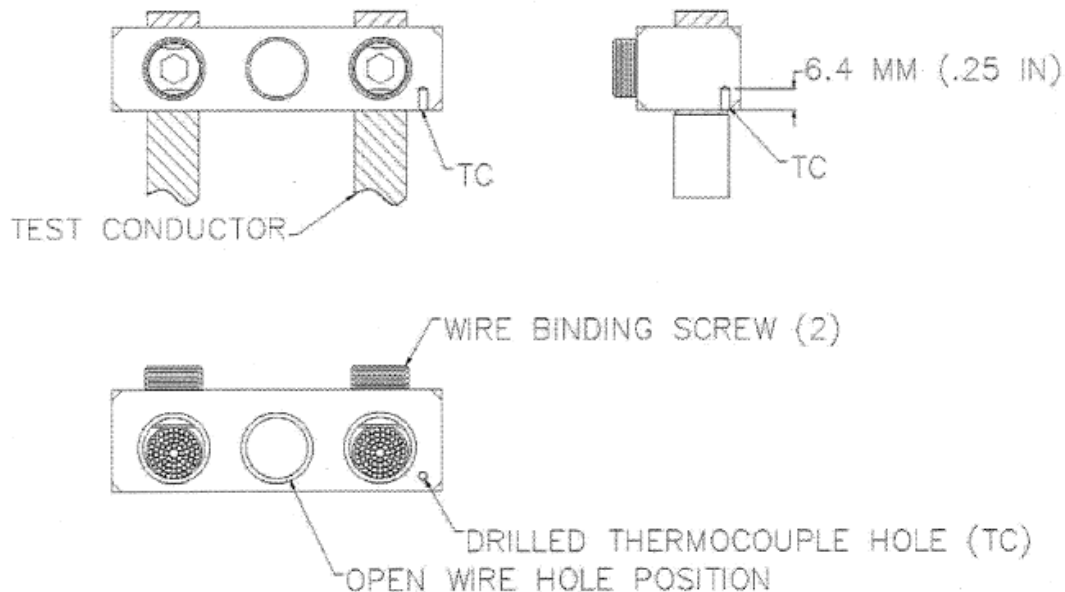
6.3.2.2 Test Conditions This test shall be conducted in a space free of forced air currents or radiated heat striking (directly or indirectly) any portion of the test loop during the current-ON period. The ambient temperature, measured within 610 mm (2 ft) of the test loop at a location that minimizes the effect of thermal convection, shall be held between 15°C (59°F) and 35°C (95°F) . The ambient temperature shall not vary more than  $\pm 5^{\circ}\text{C}$  (9°F) during the entire test.

6.3.2.3 Test Current The input current shall be adjusted to produce  $90^{\circ}\text{C} \pm 5^{\circ}\text{C}$  (194°F  $\pm$  9°F) on the hottest conductor.

6.3.2.4 Test Duration Connectors shall be tested for one hundred twenty (120) hours.

6.3.2.5 Measurements The temperature of the input conductor shall be measured under the conductor insulation at a point 305 mm (12 in.) from the connector. The temperature of the connector shall be measured under the connector insulation in the current path between the input and output where the highest temperature is anticipated.

A suggested location for the thermocouples is shown in Annex C. The temperature measurements shall be recorded a minimum of once every twelve (12) hours (plus or minus two ( $\pm 2$ ) hours) beginning with the seventy-second (72") hour (plus or minus two ( $\pm 2$ ) hours) and continuing through the one hundred twentieth (120th) hour.



A) THERMOCOUPLE LOCATION IS FOR ILLUSTRATION ONLY AND OTHER LOCATIONS ON THE CONNECTOR MAY EXPERIENCE HOTTER TEMPERATURES

B) THIS ILLUSTRATION SHOWS A MECHANICAL CONNECTOR, LOCATIONS ARE SIMILAR FOR A COMPRESSION CONNECTOR

## Results

3.5mm<sup>2</sup> Temperature measurement intervals:

Testing Hours	Temperature / Thermal stability parameters				Cable	Room Temp
	A15		A16			
72	33.9°C	0.34°C	34.6°C	0.36°C	91.8°C	21.7°C
84	33.9°C	0.64°C	34.5°C	0.56°C	90.5°C	21.5°C
96	32.9°C	0.86°C	33.5°C	0.94°C	90.6°C	20.5°C
108	34.1°C	1.04°C	34.8°C	1.06°C	90.0°C	21.6°C
120	32.3°C	1.16°C	33.1°C	1.04°C	90.7°C	20.0°C

50mm<sup>2</sup> Temperature measurement intervals:

Testing Hours	Temperature / Thermal stability parameters				Cable	Room Temp
	B15		B16			
72	64.6°C	0.22°C	63.8°C	0.36°C	91.7°C	21.5°C
84	63.5°C	0.58°C	63.6°C	0.26°C	91.5°C	22.1°C
96	64.0°C	0.58°C	63.9°C	0.46°C	91.1°C	22.3°C
108	64.2°C	0.32°C	64.2°C	0.54°C	90.6°C	21.9°C
120	64.9°C	0.62°C	64.6°C	0.54°C	91.3°C	22.1°C

240mm<sup>2</sup> Temperature measurement intervals:

Testing Hours	Temperature / Thermal stability parameters				Cable	Room Temp
	C15		C16			
72	81.1°C	0.84°C	80.6°C	0.2°C	91.0°C	23.1°C
84	80.0°C	0.04°C	80.0°C	0.1°C	90.7°C	22.5°C
96	79.3°C	1.16°C	80.0°C	0.6°C	91.2°C	21.6°C
108	79.8°C	0.04°C	80.2°C	0.3°C	90.5°C	22.2°C
120	80.4°C	0.24°C	80.5°C	0.2°C	90.9°C	22.7°C





Thermal stability test circuit

CHARDON GROUP

## 6. Electrical tests - Sealing tests

### Object

To verify the connectors that the parts meet NEMA-C119.1-2011 Sealing Tests.

### Testing Samples

Chardon SLVC	SLVC-J6	4 PCS
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### Mating Parts

Test Cable	3.5 mm <sup>2</sup> – Copper 240 mm <sup>2</sup> – Copper
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### Procedure and Testing Spec

4.4.1 Integrity of Seal and Connector Insulation When tested in accordance with clause 6.4, this test determines the connector system's ability to withstand repeated handling during underground installation.

4.4.1.1 Insulation Resistance When tested in accordance with clause 6.4.1.2, No. 2, the connector assemblies shall have an insulation resistance greater than six (6) megohms.

The insulation resistance of the assemblies measured in 6.4.1.4 shall be either: a) greater than ninety percent (90%) of the value measured in 6.4.1.2 No. 2 for resistances less than 1x10<sup>3</sup> megohms; or b) a minimum of 1x10<sup>3</sup> megohms for all other conditions. The latter criterion applies because of the extremely high resistance values and the difficulty in accurately reading analog meters at high resistance levels.

4.4.1.2 Dielectric Withstand The assemblies shall withstand the dielectric withstand tests specified in 6.4.1.2 No. 3 and No. 16 without breakdown.

4.4.1.3 Leakage Current The leakage current of the assemblies shall not exceed 1 milliamperes when tested in accordance with clause 6.4.1.2 No. 17.

4.4.2 Resealability - Optional (Required for Connectors Designated as Resealable Only)  
A connector designated as "Resealable" by the manufacturer shall pass the dielectric withstand requirements of clause 4.4.1.2 when the cable is removed and the port is resealed, without reinsertion of the cable, in accordance with the manufacturer's instructions.

5.4.1 Integrity of Seal and Connector Insulation Two (2) connector assemblies with the largest insulation diameters and two (2) connector assemblies with the smallest insulation diameters shall be tested in accordance with clause 6.4.

5.4.2 Resealability Two (2) connector assemblies that were previously tested with the largest cable size shall be retested in accordance with clause 6.4.1.12.

6.4.1.1 Assemblies for Test Each connector assembly shall be assembled in accordance with the manufacturer's recommendations.

6.4.1.2 Procedural Sequence Each connector assembly shall be subjected to the following in the order in which they are listed:

1. Water immersion for twenty-four (24) hours:

Water Immersion for Twenty-Four (24) Hours All connector assemblies shall be immersed for twenty-four (24) hours in a tank that contains tap water at a temperature of  $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$  ( $77^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ). All parts of the connector assemblies, except leads, shall be at least 305 mm (12 in.) below the surface of the water.

2. Insulation resistance measurement:

Insulation Resistance Measurement While each connector assembly is immersed in accordance with clause 6.4.1.3, the insulation resistance shall be measured by applying a direct-current voltage of 500 volts or 1000 volts for one (1) minute, keeping the length of the immersed conductor constant, and then determining the insulation resistance at the voltage used. The total length of the immersed conductor with each connector assembly shall not exceed 1.83 m (6 ft). The conductor polarity shall be positive.

If the tracking distance from the end of the conductor to the water surface is too short, a guarded circuit (see Annex D) shall be employed.

3. Dielectric withstand test:

Dielectric Withstand Test While each connector assembly is immersed in accordance with clause 6.4.1.3, it shall be subjected to a 2.2 kV fifty (50) or sixty (60) Hertz test voltage for one (1) minute, applied between the water and the conductor.

4. Heat conditioning:

Heat Conditioning Each connector assembly shall be conditioned in an air-circulating oven at  $90^{\circ}\text{C} \pm 5^{\circ}\text{C}$  ( $194^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ) for seventy-two (72) hours. After the conditioning period, the connector assemblies shall be allowed to cool to a room temperature of  $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$  ( $77^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ).

5. Flex:

Flex Each connector assembly shall be subjected to the following:

The insulated conductor shall be securely clamped at a distance from the joint as follows:

- For conductors that are #4 AWG and larger, fifteen (15) times the diameter of the insulated conductor.
- For conductors that are smaller than #4 AWG (16 mm<sup>2</sup>), twenty-five (25) times the diameter of the insulated conductor.



The connectors shall be bent ninety (90) degrees to one side, returned to the starting position, bent ninety (90) degrees in the opposite direction, and returned to the starting position (see Figure 5). Each seal shall be subjected to ten (10) such flexing cycles.

#### 6. Twist:

Twist While clamped in accordance with 6.4.1.7, the connector shall be twisted around the conductor axis fifteen (15) degrees in one direction from the starting position, returned to the starting position, twisted fifteen (15) degrees in the other direction, and returned to the starting position (see Figure 5). Each connector assembly shall be subjected to five (5) such twisting cycles.

Some bending is tolerated to allow both seals on one connector assembly to be twisted simultaneously. After the fifth (5th) twisting cycle, the connector shall be flexed once more to 90 degrees and maintained in that position when returned to the water.

#### 7. Water immersion for twenty-four (24) hours:

Water Immersion for Twenty-Four (24) Hours All connector assemblies shall be immersed for twenty-four (24) hours in a tank that contains tap water at a temperature of  $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$  ( $77^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ). All parts of the connector assemblies, except leads, shall be at least 305 mm (12 in.) below the surface of the water.

#### 8. Insulation resistance measurement:

Insulation Resistance Measurement While each connector assembly is immersed in accordance with clause 6.4.1.3, the insulation resistance shall be measured by applying a direct-current voltage of 500 volts or 1000 volts for one (1) minute, keeping the length of the immersed conductor constant, and then determining the insulation resistance at the voltage used. The total length of the immersed conductor with each connector assembly shall not exceed 1.83 m (6 ft). The conductor polarity shall be positive.

If the tracking distance from the end of the conductor to the water surface is too short, a guarded circuit (see Annex D) shall be employed.

#### 9. Cold conditioning:

Cold Conditioning Each connector assembly shall be exposed for a minimum of four (4) hours in air having a temperature of  $-18^{\circ}\text{C} \pm 5^{\circ}\text{C}$  ( $0^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ). Within five (5) minutes after removal from the cold conditioning, the assemblies shall be tested in accordance with clauses 6.4.1.7 and 6.4.1.8. Both tests shall be completed within the five (5) minute time interval.

#### 10. Flex:

Flex Each connector assembly shall be subjected to the following:

The insulated conductor shall be securely clamped at a distance from the joint as follows:

- For conductors that are #4 AWG and larger, fifteen (15) times the diameter of the insulated conductor.
- For conductors that are smaller than #4 AWG ( $16\text{ mm}^2$ ), twenty-five (25) times the diameter of the insulated conductor.

The connectors shall be bent ninety (90) degrees to one side, returned to the starting position, bent ninety (90) degrees in the opposite direction, and returned to the starting position (see Figure 5). Each seal shall be subjected to ten (10) such flexing cycles.

11. Twist:

Twist While clamped in accordance with 6.4.1.7, the connector shall be twisted around the conductor axis fifteen (15) degrees in one direction from the starting position, returned to the starting position, twisted fifteen (15) degrees in the other direction, and returned to the starting position (see Figure 5). Each connector assembly shall be subjected to five (5) such twisting cycles.

Some bending is tolerated to allow both seals on one connector assembly to be twisted simultaneously. After the fifth (5th) twisting cycle, the connector shall be flexed once more to 90 degrees and maintained in that position when returned to the water.

12. Water immersion for twenty-four (24) hours:

Water Immersion for Twenty-Four (24) Hours All connector assemblies shall be immersed for twenty-four (24) hours in a tank that contains tap water at a temperature of  $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$  ( $77^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ). All parts of the connector assemblies, except leads, shall be at least 305 mm (12 in.) below the surface of the water.

13. Insulation resistance measurement:

Insulation Resistance Measurement While each connector assembly is immersed in accordance with clause 6.4.1.3, the insulation resistance shall be measured by applying a direct-current voltage of 500 volts or 1000 volts for one (1) minute, keeping the length of the immersed conductor constant, and then determining the insulation resistance at the voltage used. The total length of the immersed conductor with each connector assembly shall not exceed 1.83 m (6 ft). The conductor polarity shall be positive.

If the tracking distance from the end of the conductor to the water surface is too short, a guarded circuit (see Annex D) shall be employed.

14. Current cycle and water submersion:

Current Cycle and Water Submersion The connector assembly shall be connected in series with a control cable identical in size and type to that used in the connector assembly and then subjected to the following sequence of operations for fifty (50) cycles:

1. Heating by current in air. The current-ON period shall be one (1) hour using sufficient current to raise the temperature of the conductor of the control cable to  $90^{\circ}\text{C} \pm 5^{\circ}\text{C}$  ( $194^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ).

2. The current shall then be turned off and, within three (3) minutes, the connector shall be submersed in water having a temperature of  $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$  ( $77^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ) for at least one half (1/2) hour.

**15. Insulation resistance measurement:**

Insulation Resistance Measurement While each connector assembly is immersed in accordance with clause 6.4.1.3, the insulation resistance shall be measured by applying a direct-current voltage of 500 volts or 1000 volts for one (1) minute, keeping the length of the immersed conductor constant, and then determining the insulation resistance at the voltage used. The total length of the immersed conductor with each connector assembly shall not exceed 1.83 m (6 ft). The conductor polarity shall be positive.

If the tracking distance from the end of the conductor to the water surface is too short, a guarded circuit (see Annex D) shall be employed.

**16. Dielectric withstand test:**

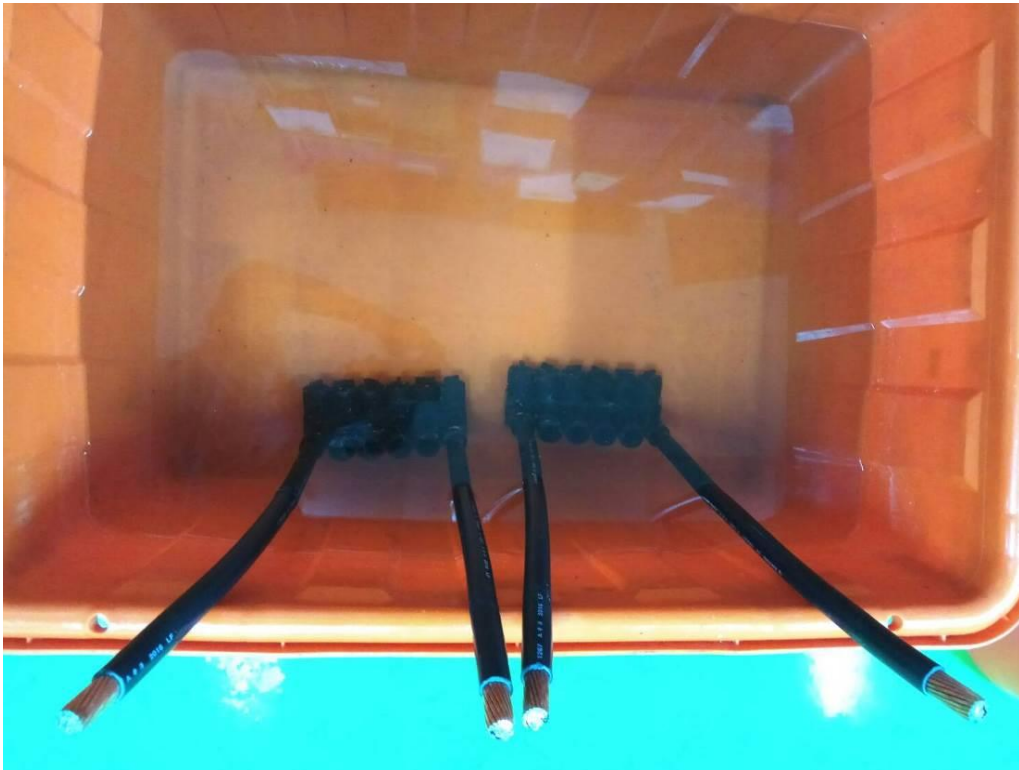
Dielectric Withstand Test While each connector assembly is immersed in accordance with clause 6.4.1.3, it shall be subjected to a 2.2 kV fifty (50) or sixty (60) Hertz test voltage for one (1) minute, applied between the water and the conductor.

**17. Leakage current test:**

Leakage Current Test Following the dielectric withstand test mentioned in 6.4.1.5, and, while still immersed in the water, the connector assemblies are to be subjected to a six hundred (600) volt, fifty (50) or sixty (60) Hertz potential between the water and conductor and the resulting leakage current measured.

## Results

Test Sequence	Test Sample	Cable size & Sample number			
		3.5 mm <sup>2</sup>		240 mm <sup>2</sup>	
		A17	A18	C17	C18
1. Water immersion for twenty-four (24) hours		PASS	PASS	PASS	PASS
2. Insulation resistance measurement		PASS	PASS	PASS	PASS
3. Dielectric withstand test		PASS	PASS	PASS	PASS
4. Heat conditioning		PASS	PASS	PASS	PASS
5. Flex		PASS	PASS	PASS	PASS
6. Twist		PASS	PASS	PASS	PASS
7. Water immersion for twenty-four (24) hours		PASS	PASS	PASS	PASS
8. Insulation resistance measurement		PASS	PASS	PASS	PASS
9. Cold conditioning		PASS	PASS	PASS	PASS
10. Flex		PASS	PASS	PASS	PASS
11. Twist		PASS	PASS	PASS	PASS
12. Water immersion for twenty-four (24) hours		PASS	PASS	PASS	PASS
13. Insulation resistance measurement		PASS	PASS	PASS	PASS
14. Current cycle and water submersion		PASS	PASS	PASS	PASS
15. Insulation resistance measurement		PASS	PASS	PASS	PASS
16. Dielectric withstand test		PASS	PASS	PASS	PASS
17. Leakage current test		PASS	PASS	PASS	PASS



Water immersion for twenty-four (24) hours

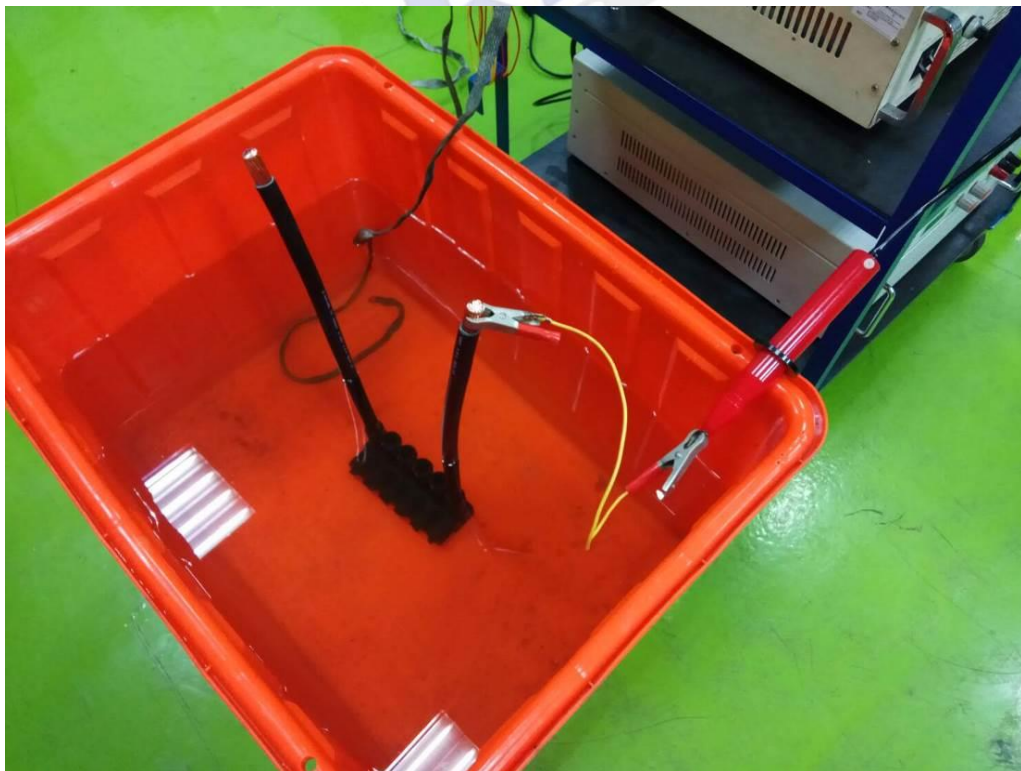


Insulation resistance measurement -I

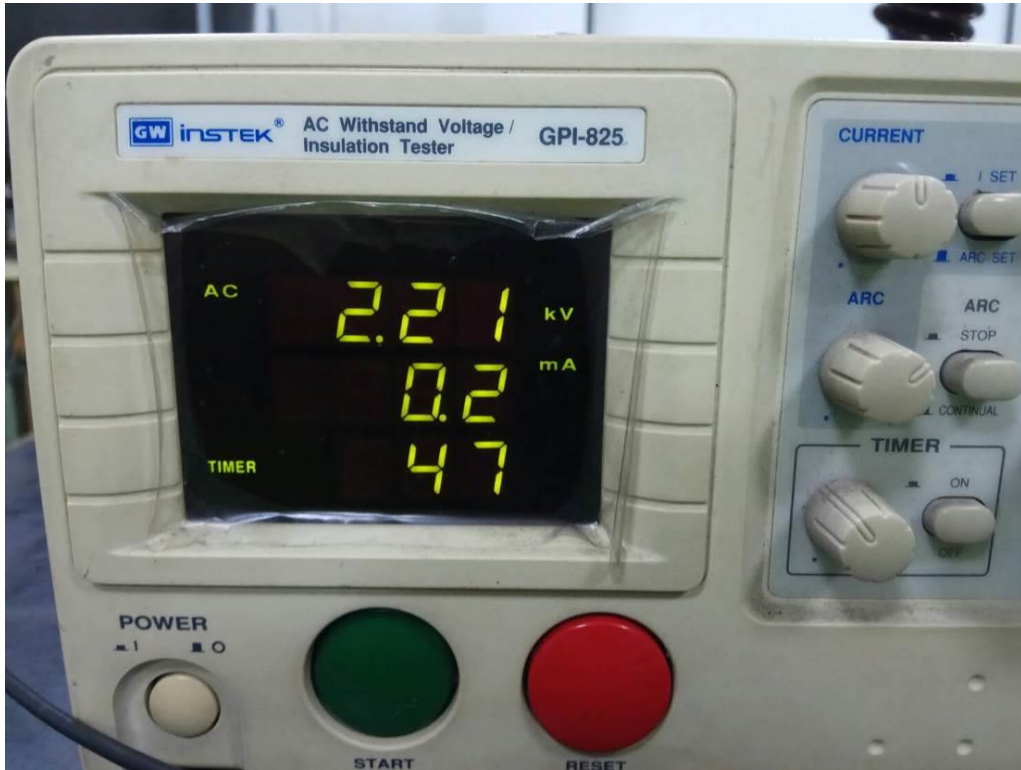




Insulation resistance measurement -II



Dielectric withstand test -I



Dielectric withstand test - II



Heat conditioning - I





Heat conditioning -II



Flex -I



Flex -II



Twist -I



Twist -II



Twist -III





Cold conditioning -I



Cold conditioning -II



Leakage current test -I



Leakage current test -II