



Ontario Hydro

TECHNOLOGIES

SUBSTATION GROUNDING CONNECTORS IEEE STD 837-1989 TEST SERIES

Report No C-95-EST-193-P

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ABSTRACT

A comparative evaluation of three fundamentally different designs of direct burial electrical grounding connectors was performed under contract for Erico® Inc. of Solon Ohio. These tests were performed in accordance with the method and procedures specified in IEEE Std. 837-1989, "*IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding*". The test results indicate that exothermically welded connections appear to be more consistent and uniform in their performance following the series of tests. In the samples tested, some of the bolted and compression connectors have unexplained failures or increase in resistance. It was also observed that bolted and compression connectors appear to be more susceptible to deterioration in a corrosive environment than welded connections. Although these test results show failures of individual connector samples, it does not imply that the connectors fundamental design concept is flawed. It does however indicate that some of these connector/conductor combinations did not meet the IEEE Std 837-1989 series of tests.

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Attn: Mr. K. Switzer

**SUBSTATION GROUNDING CONNECTORS
IEEE STD 837-1989 TEST SERIES**

INTRODUCTION

A comparative evaluation of three fundamentally different designs from four manufacturers of direct burial, electrical grounding connectors was performed under contract for Erico Inc in accordance with the method and procedures indicated in IEEE Std. 837-1989. The three designs evaluated were bolted wedge, exothermically welded (Cadweld®) and die compression type connections. The performance of each design type was evaluated on 4/0 to 4/0, 19 strands, medium hard drawn copper conductor and on 4/0 to 3/4" copper clad, steel core ground rod.

One hundred and sixty connectors (twenty of each connector/conductor combination) were included in the test program.

- ◆ Exothermically welded connection, (Cadweld # XAC2Q2Q) for 4/0 to 4/0
- ◆ Exothermically welded connection, (Cadweld # GTC182Q) for 4/0 to 3/4" rod
- ◆ Bolted wedge type connectors, (AMP Wrench-lok # 81228-1) for 4/0 to 4/0
- ◆ Bolted wedge type connectors, (AMP Wrench-lok # 81229-1) for 4/0 to 3/4" rod
- ◆ Die compression type connectors, (Burndy # YGL29C29) for 4/0 to 4/0
- ◆ Die compression type connectors, (Burndy # YGLR29C34) for 4/0 to 3/4" rod
- ◆ Die compression type connectors, (T&B # GG40250-40250) for 4/0 to 4/0
- ◆ Die compression type connectors, (T&B # GG500-40250) for 4/0 to 3/4" rod

The connectors were tested in accordance with the IEEE Std. 837-1989, "*IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding*". Additional tests were performed at higher than specified levels in certain sections. This was to provide information on the connectors' ability to surpass the performance requirements of IEEE Std. 837-1989.

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TEST SUMMARY

The different tests are described by category and identified as indicated in IEEE Std 837.

- ◆ Individual test group mechanical - Mechanical Pullout, Section 7.2
- ◆ Individual test group electromagnetic - Electromagnetic Force, Section 7.3
- ◆ Sequential test groups-acidic - Current-Temperature Cycling, Section 8
- Freeze-Thaw, Section 9
- Corrosion-nitric acid, Section 10.2
- Fault Current, Section 11

- ◆ Sequential test groups-alkaline - Current-Temperature cycling, Section 8
- Freeze-thaw, Section 9
- Corrosion-salt spray, Section 10.3
- Fault current, Section 11

For each of the above-mentioned test groups, a different connector set (consisting of four connectors) was assembled from each manufacturer. An additional set was prepared for the Electromagnetic force test for the test at higher levels. The connector sets were coded as indicated in Table 1.

Table 1
Connector Set Identification

Test	Conductors	AMP 81228-1	BURNDY YGL29C29	CADWELD XAC2Q2Q	T&B GG40250-40250
Mechanical-pullout	4/0-4/0	1A	1B	1C	1T
Electromagnetic force	4/0-4/0	3A	3B	3C	3T
Electromagnetic force	4/0-4/0	4A	4B	4C	4T
Alkaline Test group	4/0-4/0	7A	7B	7C	7T
Acidic Test group	4/0-4/0	9A	9B	9C	9T
	Conductors	81229-1	YGLR28C34	GTC182Q	GG500-40250
Mechanical-pullout	4/0-ROD	2A	2B	2C	2T
Electromagnetic force	4/0-ROD	5A	5B	5C	5T
Electromagnetic force	4/0-ROD	6A	6B	6C	6T
Alkaline Test group	4/0-ROD	8 A	8B	8C	8T
Acidic Test group	4/0-ROD	10 A	10B	10C	10T

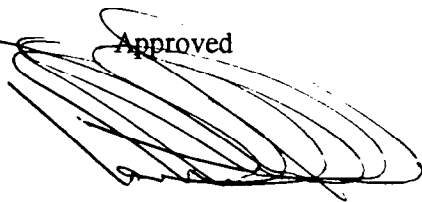
CONCLUSION

Based on the test results obtained and documented in this report, the following observations and comments are based on the test criteria in IEEE Std 837-1989. The test results in Table 9 do not include the results obtained on the EMF tests performed at levels above IEEE Std 837-1989. It must also be noted that some of these products are multi-range conductors, the tests and results obtained on a single conductor size may not be sufficient to fully assess the performance of the connector. In accordance with IEEE Std 837-1989, multi-range connectors must be evaluated with the minimum and maximum conductor sizes as specified.

Table 9: Summary of Comparative Evaluation

Connector	Mechanical-Pullout	Electromagnetic Force	Acid Test Series	Alkaline Test Series
AMP Wrench-Lok #81228-1 4/0 to 4/0	Pass	Slip on 3 connectors, ¼ in. No significant change in resistance	Four connectors with resistance increase over 150%	One connector fail during current-temperature cycling. Fusing of conductor at one connector. Other connectors with resistance increase over 150%
AMP Wrench-Lok #81229-1 4/0 to 3/4" rod.	One rod pull out below 1000 lbs.	Pass No significant change in resistance	Pass	Three connectors with resistance increase over 150%
Burndy #YGL29C29 4/0 to 4/0	Pass	Pass No significant change in resistance	Pass	Four connectors with resistance increase over 150%
Burndy #YGLR29C34 4/0 to 3/4" rod	Pass	Slip on 3 connectors Increase in resistance over 50% in 2 connectors	Two connectors with resistance increase over 150%	Three connectors with resistance increase over 150%
Cadweld #XAC2Q2Q 4/0 to 4/0	Pass	Pass No significant change in resistance	Pass	Pass
Cadweld #GTC182Q 4/0 to 3/4" rod	Pass	Pass No significant change in resistance	Pass	Pass
Thomas & Betts #GG40250-40250 4/0 to 4/0	Pass	Pass No significant change in resistance	Four connectors with resistance increase over 150%	Fusing of conductor at one connector. Other connectors with resistance increase over 150%
Thomas & Betts #GG500-40250 4/0 to 3/4" rod	Four rods pull out below 1000 lbs	Slip on 3 connectors. Complete pull-out on one. Other connector having resistance increase of 54%	One connector with resistance increase over 150%	Four connectors with resistance increase over 150%

Approved



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