



Comparative Analysis of Lug Types and Installation Practices for Outdoor Telecom Grounding



Choosing the Right Connector

Connector Selection

- Select a connector that is designed for the application.
 - Proper **wire size / wire range**
 - Correct **listing or certification requirements** (e.g. UL 486 A-B vs. UL 467)
 - Designed to interface with the mounting surface (e.g. flat bar vs round pipe)
 - Proper **connector materials, plating & hardware** (high copper content, tin plating, SS or silicon bronze hardware)



Bare copper connector designed for flat surface installed incorrectly on a round steel pipe



Fully tin-plated connector designed to be used on round pipe

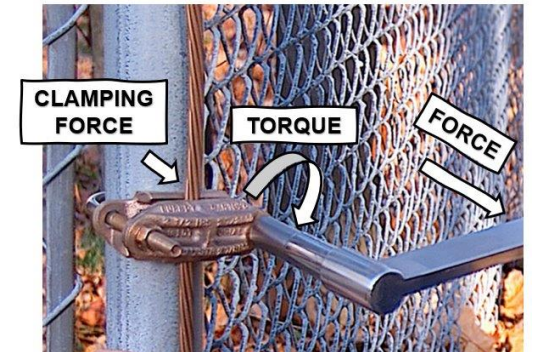
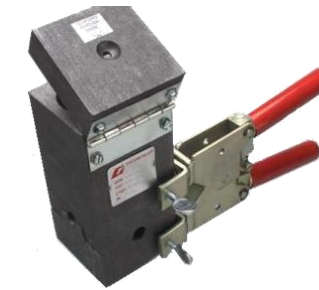
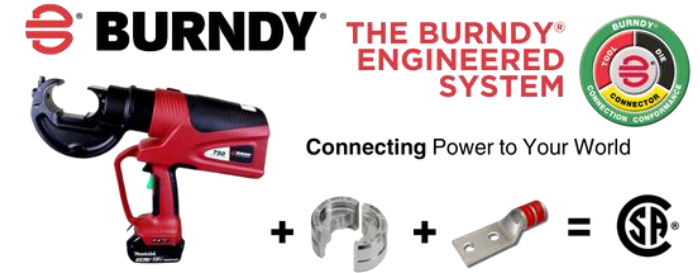
Connector Installation

Install per the manufacturer's recommendations

- **Compression** - Tool, Die, No. of crimps
- **Exothermic** - Cleaning & dry mold, proper shot and conductor size
- **Mechanical** - Installation Torque

Minimize corrosion opportunities that can be controlled

- **Cleaning** conductor and connection surface
- **Avoid dissimilar metals** when possible
- Use **proper oxide inhibitor** on conductor, connector and mounting surface
- Use **corrosion resistant hardware** (SS or Silicon Bronze)



Preferred Connection Methods (Telecom)

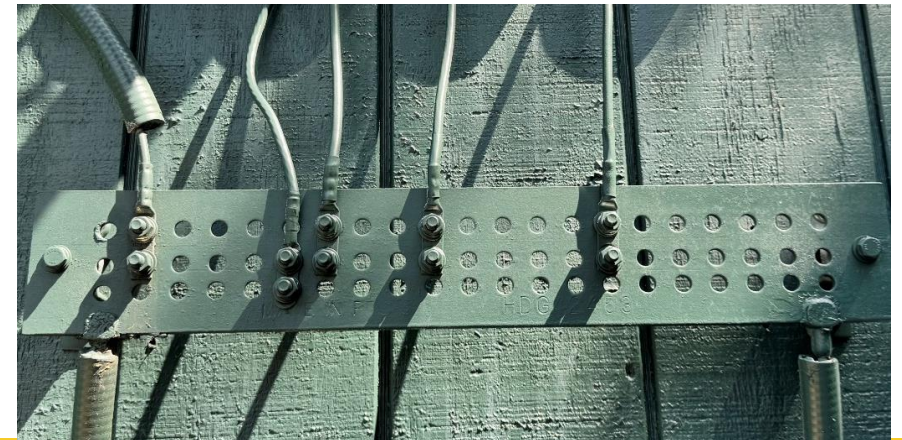
Compression / 2 – hole long barrel lugs

- Irreversible
- Inability to rotate which can cause hardware to loosen
- Larger contact surface when compared to a single hole lug
- Ability to utilize more crimps (Lower resistance & higher mechanical strength)



Exothermic

- Molecular bond between the two conductors
- Strong, low resistance connections when done properly
- Highly corrosion resistant as there is no ability for water or air to enter the connection



Lug Selection Considerations

Inspection Window

- 👍 **Visual inspection** of the wire ensuring **full wire insertion**
- 👎 Creates an area for **moisture and other contaminants** to enter the connection



Two - Hole

- 👍 **Unable to rotate** preventing hardware from Loosening
- 👍 **Large contact surface** with additional clamping force

No Inspection Window

- 👍 **Less vulnerable to moisture and contamination**
- 👎 **No ability to visually inspect wire** before or after crimping



Single - Hole

- 👍 Can fit in a more **confined space**
- 👎 Potential for **hardware to loosen** over time from lug rotating



Lug Testing & Comparative Analysis

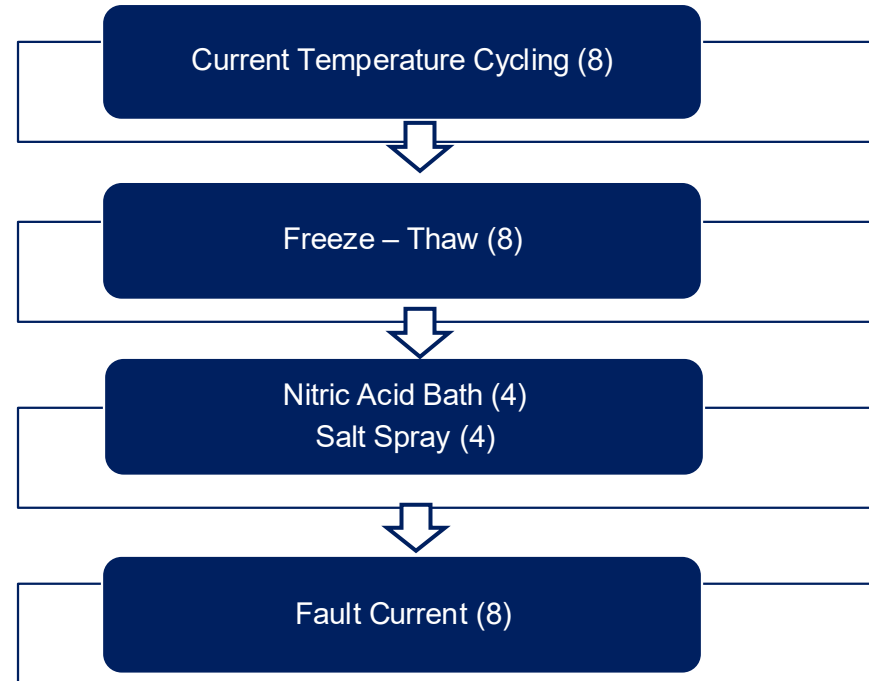


Testing Overview

IEEE- 837 Sequential Testing

- Standard for qualifying **permanent**, fault-current-carrying **grounding connections in substations**.
- **8 total samples** of each connection type
 - ✓ 4 samples **acid sequence**
 - ✓ 4 samples **salt spray sequence**
- **Resistance measurements** taken after each test

Test Sequence



*Fault Current Test omitted due to time constraints



IEEE-837 Sequential Test Details

Current Temperature Cycling

- Heated to 350C for one hour and returned to ambient.
- 25 cycles total

Freeze – Thaw

- Connections submerged in water
- -10°C (2 hours) → 20°C (2 hours)
- 10 cycle

Nitric Acid Bath

- Connections submerged in nitric acid bath.
- Connections removed after control wire has lost 20% of its mass

Salt Spray

- 500-hour salt spray test per ASTM B117

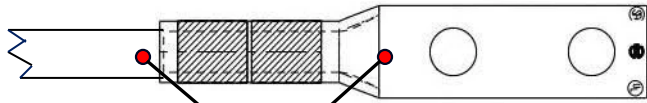
Test Group Overview

CONNECTOR	CONDUCTOR	SAMPLES	CONFIGURATION NOTES
YA2C2TC38	#2 SOL	8	No inspection hole
YAZ2C2TC38	#2 SOL	8	Inspection hole
YA2C2TC38	#2 SOL	8	No inspection hole — 1/2 insertion
YA2C2TC38	#2 SOL	8	No inspection hole with penetrox
YAZ2C2TC38	#2 SOL	8	Inspection hole with penetrox

* All connections crimped with PAT750 (15-Ton) with U2CRT Die



Test Results Cont.



Resistance reading locations

Avg. Initial Resistance ($\mu\Omega$ - Micro-Ohm)



Models

DLRO100EB

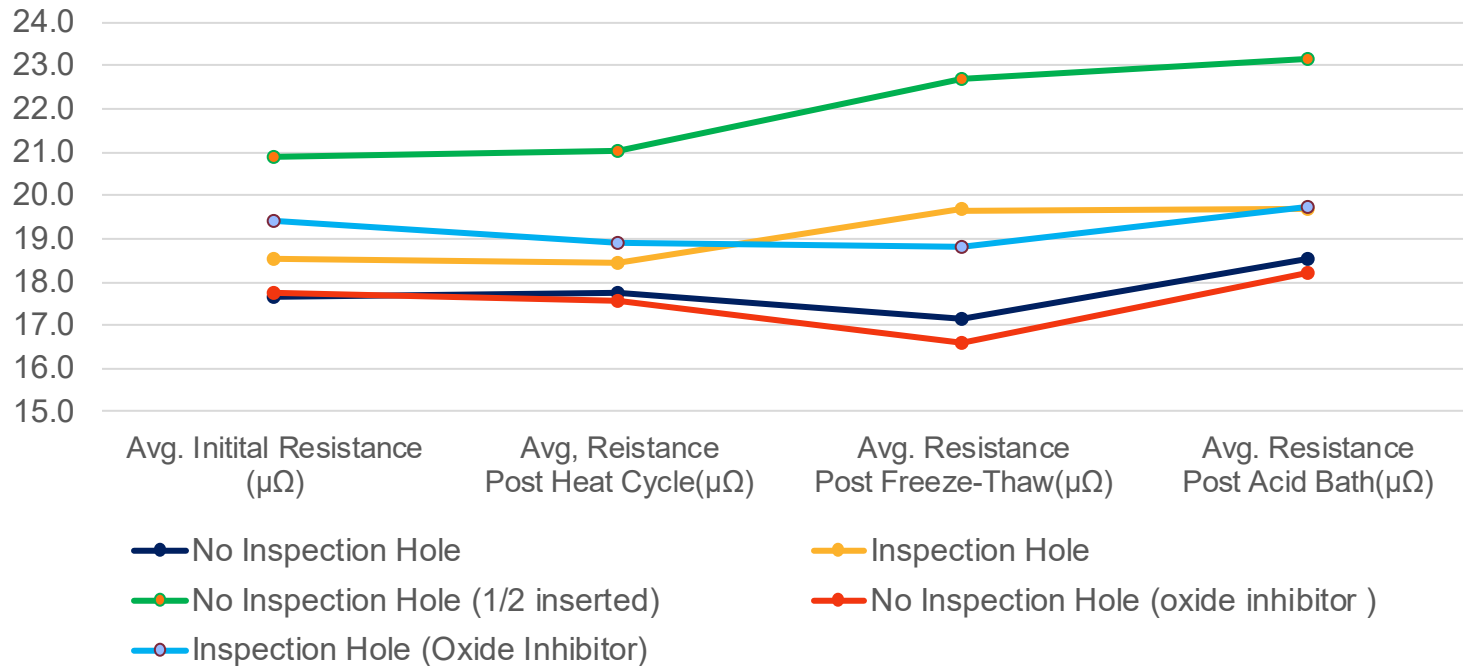
- Configurable tests
- Manual, Auto, and Continuous Modes



Test Group	Initial Resistance	Relative STD. Deviation
No Inspection hole	17.7 $\mu\Omega$	4%
Inspection hole	18.6 $\mu\Omega$	3%
No inspection hole w/ 1/2 insertion	20.9 $\mu\Omega$	4%
No Inspection hole with penetrox	17.7 $\mu\Omega$	4%
Inspection hole with penetrox	19.4 $\mu\Omega$	2%

Test Results Cont.

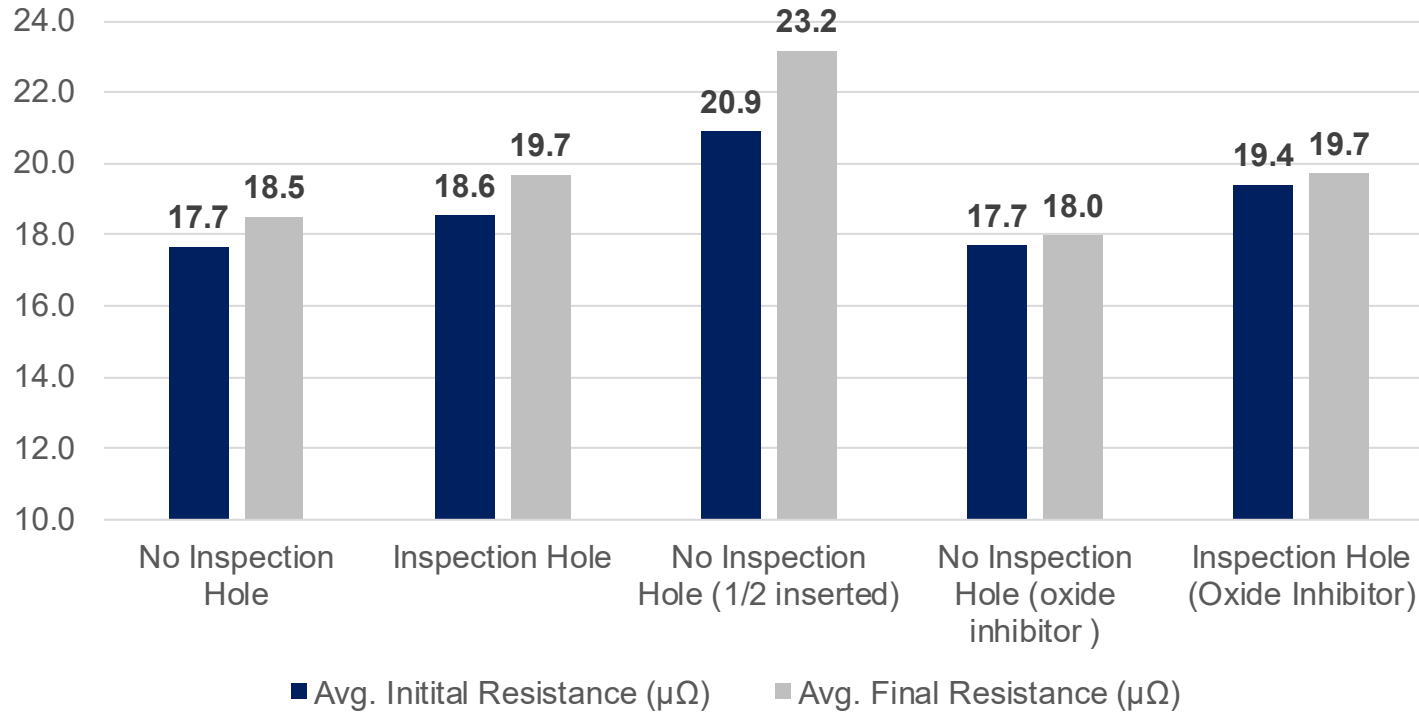
Avg. Resistance Throughout Acid Sequence (Micro-Ohms)



- All samples had very low resistance readings
- Freeze –thaw cycle has a greater effect on inspection hole samples
 - ✓ Using an oxide inhibitor limits resistance increase
- Not having full conductor insertion provides the least stable connection

Test Results Cont.

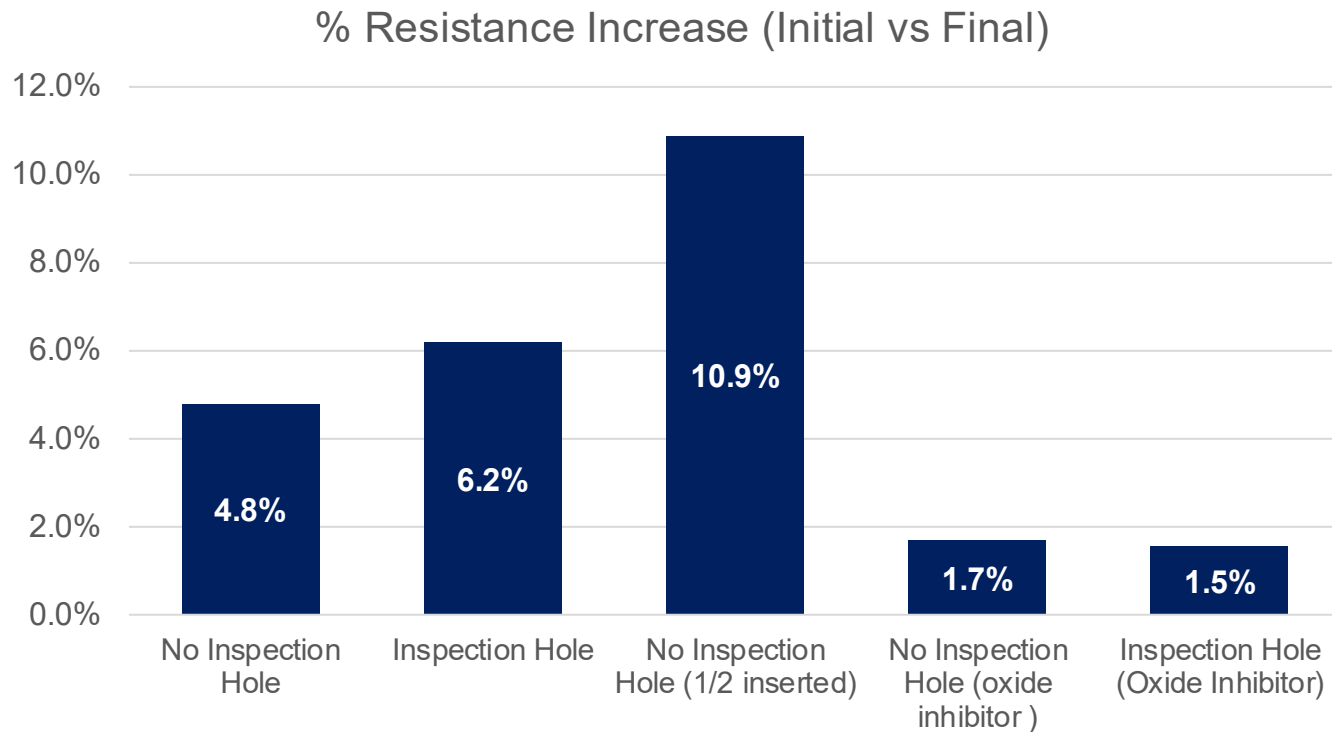
Initial vs Final Avg. Resistance (Micro-Ohm)



Test Results Cont.



Test Results Cont.



- ✓ Ensuring conductor is fully inserted into lug barrel is crucial
- ✓ Inspection hole has a larger increase in resistance when compared to no inspection hole
- ✓ Using oxide inhibitor eliminates concern around inspection hole



Summary

- ✓ Select the **proper connector** for the application
- ✓ Follow **manufactures recommendations** and installation instructions
- ✓ Using a **12-ton crimp tool** provides very **consistent & reliable connections**
- ✓ Ensuring **conductor is fully inserted** is critical.
- ✓ Lugs with Inspection holes are adequate for outdoor use
- ✓ When making lug connections outdoors it is important to use an **oxide inhibitor**.

Expanding This Research

- Performing testing using different tools & dies
 - ✓ 12-ton crimp tool → 6-ton crimp tool → Ratcheting hand crimp tool
- Compare conductor types
 - ✓ Stranded conductor (7 or 19 strand)
 - ✓ Tin-plated
- Exploring the lug pad connection
 - ✓ Hardware material
 - ✓ Hardware torque
 - ✓ Mounting surface materials



THANK YOU!

Please reach out if you have questions regarding the testing or future testing.

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