

Connector Theory update and threats to connection quality from the outside

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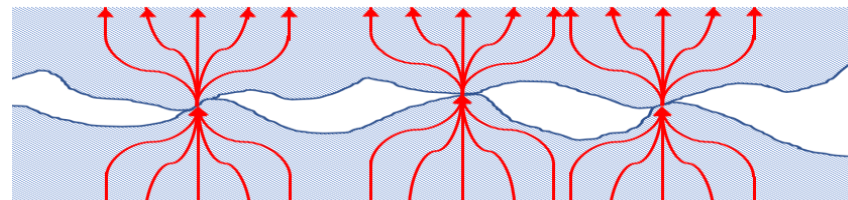
Connector Theory Update

- The Fifth Edition of the Connector Theory And Application was published in December of 2018 with Updates by Ron Lai. It is available at our company resources page.
- Key updates included renewed recognition of the effect of external corrosives on connection quality and longevity, some of that addressed in a paper in 2019.
- You have seen an earlier paper that discusses the challenges and options for bonding to Coated surfaces which was also included in the update.
- In Network protection any connection failures (open circuit or high resistance) force faults and electrical noise to find alternate paths to ground (safety hazard) or to your electronic circuits.
- For power circuits the long term low impedance in the ground fault return path is critical to proper circuit interrupting device operation. One bad connection can increase that impedance to a value making that operation impossible.

We'll discuss some connection facts as reminders and some new threats to your connection quality to consider.

Electrical Considerations – what has not changed.....

- A-Spots (asperities points of physical contact) carry current between substrate of the conductor and connector
- Any connection other than a weld relies on these small contact points to be established at installation and remain stable for the life of the connection. So what's new?



Microscopic depiction of A-Spots

Outside variables in installation practices and requirements are proliferating.....and A spots are under threat

- Change proposals with the NESC could lower the minimum requirements for ground electrodes.
- The importance of installation torque for mechanical fastener connectors.
- UL Classified installation tools.

Covered in the NESC updates, but worth an additional warning from the connection view.

- One variable all connector designs must address is conductor dimensions and the other is material properties.
- NESC Change Proposal **CP5287** would make this a open field for diameters and coating for ground rods. The new wording would be:
- Driven rods may be sectional; the total length shall be not less than 2.45 m (8 ft) and the diameter shall be not less than 12.7 mm (0.5 in). No longer any differentiation by diameter and rod materials or coatings.
- What will the NESC users' supply chain pressure be to move to a 12.7mm iron rod? The new minimum.
 - The facility or operations engineers will have to prove their site soil does not cause undue corrosion to justify ground rods they have had no corrosion issues with for decades.
 - The incredible shrinking diameters of Trade Sized rods will also creep back into the market which had largely been eliminated, making connection quality difficult to control.

Installation torque and clamping pressure is critical.

- 2017 National Electrical Code 110D. New torque requirement.

- Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the connector manufacturer, a calibrated torque tool shall be used to achieve the indicated torque value, unless the manufacturer has provided installation instructions for an alternative method of achieving the required torque

- 2020 National Electrical Code 110D. Revised significantly

- Tightening torque values for terminal connections shall be as indicated on equipment or in installation instructions provided by the connector manufacturer. An approved means shall be used to achieve the indicated torque value.

- Informational Note No. 1: Examples of approved means of achieving the indicated torque values include torque tools or devices **such as shear bolts** or breakaway style devices with visual indicators that demonstrate that the proper torque has been applied.

- Informational Note No. 2: The equipment manufacturer can be contacted if numeric torque values are not indicated on the equipment or if the installation instructions are not available. Informative Annex I of UL Standard 486A-486B, *Standard for Safety-Wire Connectors*, provides torque values in the absence of connector manufacturer's recommendations.

- Informational Note No. 3: Additional information for torquing threaded connections and terminations can be found in Section 8.11 of **NFPA 70B-2016, Recommended Practice for Electrical Equipment Maintenance**.

- In the absence of connector or equipment manufacturer's recommended torque values, Table I.1, Table I.2, and Table I.3 may be used to correctly tighten screw-type connections for power and lighting circuits*. Control and signal circuits may require different torque values, and the connector manufacturer should be contacted for guidance.

- *For proper termination of conductors, it is very important that field connections be properly tightened. In the absence of manufacturer's instructions on the equipment, the torque values given in these tables are recommended. Because it is normal for some relaxation to occur in service, checking torque values sometime after installation is not a reliable means of determining the values of torque applied at installation.



Enforcement of torque requirements

- Blind Trust
- Live / Visual Inspection
- Affidavit Submittal
- Photo / Video Submittal
- NFPA 70B Recommendations:
 - Low-Resistance Ohmmeter Test Comparison
 - 90% Calibrated Torque Test
 - Thermographic Survey – not applicable for bonding/grounding

What is a UL Classified (UL Only) Tool vs. a UL Listed Connection? Why should you care?

- The UL Listed categories for compression connectors fall within : UL 486A-486B Category: ZMVV Wire Connectors, ZMOW Wire Connector Adapters, UL 310 Category: RFWV Electrical Quick-connect Terminals, UL 467 Category: KDER Grounding and Bonding Equipment **ATIS-0600029.2019 first requirement in 5.1, all connectors must be UL listed.**

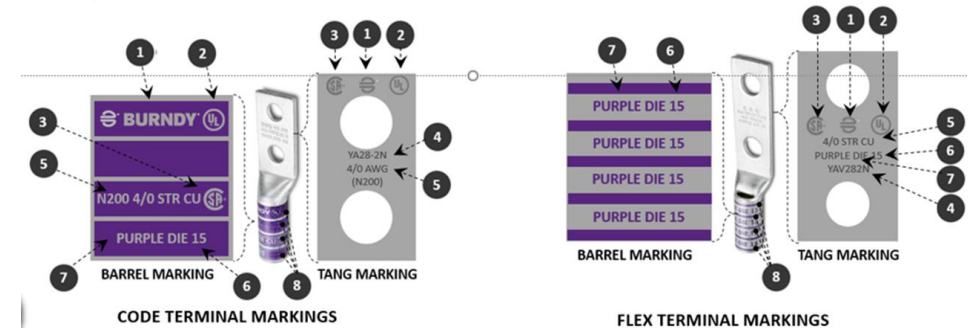
All connector companies “list” their connectors using recommended tools

- The UL Listing for the product(s) must include the following requirements:

- Identified **UL Category** (wire connector, grounding and bonding, etc.)
- Identified **Wire**: Material, Type, Construction, Size
- Identified **manufacturer Specific Part Number/Family of Product**
- Identified **Die Set** (if applicable)
- Identified **Installation Tooling**
- Identified **Installation Procedure**

- UL requires product to be installed using the prescribed **connector** manufacturer’s installation instructions.

- After certifying a product, by testing the contact or connection, UL authorizes the manufacturer to apply a registered certification mark to the product. In a connector company's case, the “product” is the connector. This UL mark signifies that company qualified the product in accordance to the applicable above-mentioned category or categories testing requirements.*



What is UL Classified Crimping Tooling?

- UL Classification Program ZMLS –(UL1976) CRIMP TOOLS CERTIFIED FOR USE WITH SPECIFIED WIRE CONNECTORS. This category covers crimp tools suitable for use with specific certified Grounding and Bonding Equipment (KDER), Electrical Quick-connect Terminals (RFWV), Wire Connectors and Soldering Lugs (ZMVV) and Wire-connector Adapters (ZMOW) in accordance with the Certification Mark and a compatibility list provided with the tool.
- Crimp tool manufacturers CANNOT obtain a UL Listing on other connector manufacturers' product. Those UL files are tied to the connector manufacturer. UL Classified tools are added by UL to those files without involvement of the connector company in any way.
- Key issue: Classified Crimp tool for use with A Connector Manufacturer's UL Listed product(s) must state the following instructions by the crimp Tool manufacturer:
 - Identified **UL Category** (wire connector, grounding and bonding, etc.), Identified **Wire**: Material, Type, Construction, Size, Identified **Specific Catalog Number of Product**, Identified **Crimp Tool Manufacturer's Die Set** (if applicable), Identified **Crimp Tool Manufacturer's Specified Tool(s)**, Identified **Crimp Tool Manufacturer's Installation Procedure**,
- ***The Classification Mark of UL identified by the crimp tool manufacturer in their documentation requires an installer to follow the guidelines as the installation instructions that were used to Classify the tool with the UL Listed products. UL Classification Mark is earned by testing the contact or connection.***

Does the type of cable matter to a connection?

Copper Code B (Concentric, Compressed, Compact) or C					Aluminum B (Concentric, Compressed, Compact)					Flex Wire Sizes & Class					Flex Wire Sizes & Class					Flex Wire Sizes & Class					Flex Wire Sizes & Class				
	BURNDY	GREENLEE	MILWAUKEE	DEWALT		BURNDY	GREENLEE	MILWAUKEE	DEWALT		BURNDY	GREENLEE	MILWAUKEE	DEWALT		BURNDY	GREENLEE	MILWAUKEE	DEWALT		BURNDY	GREENLEE	MILWAUKEE	DEWALT		BURNDY	GREENLEE	MILWAUKEE	DEWALT
8 AWG	Y	Y	Y	Y	8 AWG	Y	Y	Y	Y	#8 FLEX G	Y	N	N	N	#3 FLEX G	Y	N	N	N	2/0 FLEX G	Y	N	N	N	300 FLEX G	Y	N	N	N
6 AWG	Y	Y	Y	Y	6 AWG	Y	Y	Y	Y	#8 FLEX H	Y	N	N	N	#3 FLEX H	Y	N	N	N	2/0 FLEX H	Y	N	N	N	300 FLEX H	Y	N	N	N
4 AWG	Y	Y	Y	Y	4 AWG	Y	Y	Y	Y	#8 FLEX I	Y	N	N	N	#3 FLEX I	Y	N	N	N	2/0 FLEX I	Y	N	N	N	300 FLEX I	Y	N	N	N
2 AWG	Y	Y	Y	Y	2 AWG	Y	Y	Y	Y	#8 FLEX K	Y	N	N	N	#3 FLEX K	Y	N	N	N	2/0 FLEX K	Y	N	N	N	300 FLEX K	Y	N	N	N
1 AWG	Y	Y	Y	Y	1 AWG	Y	Y	Y	Y	#8 FLEX M	Y	N	N	N	#3 FLEX M	Y	N	N	N	2/0 FLEX M	Y	N	N	N	300 FLEX M	Y	N	N	N
1/0 AWG	Y	Y	Y	Y	1/0 AWG	Y	Y	Y	Y	#8 FLEX DLO	Y	N	N	N	#3 FLEX DLO	Y	N	N	N	2/0 FLEX DLO	Y	N	N	N	313 DLO	Y	N	N	N
2/0 AWG	Y	Y	Y	Y	2/0 AWG	Y	Y	Y	Y	#6 FLEX G	Y	N	N	N	#2 FLEX G	Y	N	N	N	3/0 FLEX G	Y	N	N	N	350 FLEX G	Y	N	N	N
3/0 AWG	Y	Y	Y	Y	3/0 AWG	Y	Y	Y	Y	#6 FLEX H	Y	N	N	N	#2 FLEX H	Y	N	N	N	3/0 FLEX H	Y	N	N	N	350 FLEX H	Y	N	N	N
4/0 AWG	Y	Y	Y	Y	4/0 AWG	Y	Y	Y	Y	#6 FLEX I	Y	N	N	N	#2 FLEX I	Y	N	N	N	3/0 FLEX I	Y	N	N	N	350 FLEX I	Y	N	N	N
250 KCMIL	Y	Y	Y	Y	250 KCMIL	Y	Y	Y	Y	#6 FLEX K	Y	N	N	N	#2 FLEX K	Y	N	N	N	3/0 FLEX K	Y	N	N	N	350 FLEX K	Y	N	N	N
300 KCMIL	Y	Y	Y	Y	300 KCMIL	Y	Y	Y	Y	#6 FLEX M	Y	N	N	N	#2 FLEX M	Y	N	N	N	3/0 FLEX M	Y	N	N	N	350 FLEX M	Y	N	N	N
350 KCMIL	Y	Y	Y	Y	350 KCMIL	Y	Y	Y	Y	#6 FLEX DLO	Y	N	N	N	#2 FLEX DLO	Y	N	N	N	3/0 FLEX DLO	Y	N	N	N	373 DLO	Y	N	N	N
400 KCMIL	Y	Y	Y	Y	400 KCMIL	Y	Y	Y	Y	#5 FLEX G	Y	N	N	N	#1 FLEX G	Y	N	N	N	4/0 FLEX G	Y	N	N	N	500 FLEX G	Y	N	N	N
500 KCMIL	Y	Y	Y	Y	500 KCMIL	Y	Y	Y	Y	#5 FLEX H	Y	N	N	N	#1 FLEX H	Y	N	N	N	4/0 FLEX H	Y	N	N	N	500 FLEX H	Y	N	N	N
500 KCMIL	Y	Y	Y	Y	500 KCMIL	Y	Y	Y	Y	#5 FLEX I	Y	N	N	N	#1 FLEX I	Y	N	N	N	4/0 FLEX I	Y	N	N	N	500 FLEX I	Y	N	N	N
750 KCMIL	Y	Y	Y	Y	750 KCMIL	Y	Y	Y	Y	#5 FLEX K	Y	N	N	N	#1 FLEX K	Y	N	N	N	4/0 FLEX K	Y	N	N	N	500 FLEX K	Y	N	N	N
										#5 FLEX M	Y	N	N	N	#1 FLEX M	Y	N	N	N	4/0 FLEX M	Y	N	N	N	500 FLEX M	Y	N	N	N
										#5 FLEX DLO	Y	N	N	N	#1 FLEX DLO	Y	N	N	N	4/0 FLEX DLO	Y	N	N	N	444 DLO	Y	N	N	N
										#4 FLEX G	Y	N	N	N	1/0 FLEX G	Y	N	N	N	250 FLEX G	Y	N	N	N	535 DLO	Y	N	N	N
										#4 FLEX H	Y	N	N	N	1/0 FLEX H	Y	N	N	N	250 FLEX H	Y	N	N	N	550 FLEX G	Y	N	N	N
										#4 FLEX I	Y	N	N	N	1/0 FLEX I	Y	N	N	N	250 FLEX I	Y	N	N	N	550 FLEX H	Y	N	N	N
										#4 FLEX K	Y	N	N	N	1/0 FLEX K	Y	N	N	N	250 FLEX K	Y	N	N	N	550 FLEX I	Y	N	N	N
										#4 FLEX M	Y	N	N	N	1/0 FLEX M	Y	N	N	N	250 FLEX M	Y	N	N	N	650 FLEX G	Y	N	N	N
										#4 FLEX DLO	Y	N	N	N	1/0 FLEX DLO	Y	N	N	N	262 DLO	Y	N	N	N	646 DLO	Y	N	N	N
																								750 FLEX G	Y	N	N	N	
																								750 FLEX H	Y	N	N	N	
																								777 DLO	Y	N	N	N	

- **12-ton Tool Scope:**
 - Burndy = UL Listed with 100% of the Wire Classes shown
 - Classified tools ONLY UL Classified with copper and aluminum code wire as illustrated in the table.

Does the connector type/application matter?

Type	Family Description	Burdny UL Listing		UL Classified Tools	
		UL 486A-B	UL 467	UL 486A-B	UL 467
Terminal	YA- Copper Code Wire Terminals	Yes	Yes	Yes	No
Terminal	YA-A Aluminum Code Wire Terminals	Yes	NA	Yes	No
Terminal	YA-A Aluminum Copper Clad Wire Terminals	Yes	NA	No	No
Terminal	YA-FX, YAZ-FX, YAZV-FX, YA-LB, YAG-FX, Copper Flexible Wire Terminals	Yes	NA	No	No
Splice	YS- Copper Code Wire Splices	Yes	Yes	Yes	No
Splice	YS-A Aluminum Code Wire Splices	Yes	NA	Yes	No
Splice	YS-A Aluminum Copper Clad Wire Splices	Yes	NA	No	No
Splice	YS-FXB, YS-LB Copper Flexible Wire Splices	Yes	NA	No	No
Splice	YS-AT High Voltage Aluminum Copper Code Splice	Yes	NA	No	No
Splice	YSCM- Parallel Splice Copper Wire	Yes	Yes	No	No
Terminal	YA-E Copper Code E-Line Terminals	Yes	NA	No	No
Terminal	YA-A-E Aluminum Code E-Line Terminals	Yes	NA	No	No
Splice Reducer	YSR- Copper Code Splice Reducers	Yes	Yes	No	No
Splice Reducer	YSR- Copper Flex Splice Reducers	Yes	Yes	No	No
Splice Reducer	YRB- Aluminum Splice Reducer	Yes	NA	No	No
C-Tap	Copper Code Wire C-Taps	Yes	Yes	No	No
C-Tap	Copper Flexible Wire C-Taps	Yes	NA	No	No
H-Tap	Copper Code Wire H-Taps	Yes	Yes	No	No
H-Tap	Copper Flexible Wire H-Taps	Yes	NA	No	No
Pin Adaptor	YEV- Copper Code Wire Pin Adaptor	Yes	NA	No	No
Pin Adaptor	YEV-FX Copper Flexible Wire Pin Adaptor	Yes	NA	No	No
Pin Adaptor	AYP-/AYPO- Aluminum / Copper Code Wire Pin Adaptors	Yes	NA	No	No
Pin Adaptor	AYP-/AYPO- Copper Flexible Wire Pin Adaptors	Yes	NA	No	No
Grounding	HYGROUND™ (Terminals, Splices, Taps)	NA	Yes	No	No

Do the installation instructions matter?

The most obvious conflict is that all UL Classified Tool manufacturers recommend the same number of crimps on a short barrel lug or splice as they do long barrel? So why specify long barrel connectors with double the A spots from all UL listed connector companies?

Connector Selection (NOT for use with flex, navy or welding wire)

Tool Range: 8 AWG to 750 kcmil

When used with KC12-type dies, this tool is cUL and UL classified for use with the following connector brands:

CONNECTOR TYPE	BARREL TYPE	ANDERSON	BLACKBURN®	BURNDY	ILSCO	PANDUIT	T&B	PENN-UNION	NUMBER OF CRIMPS*
Copper Splices	Short	VHSS	CSP	YS-L	CT	SCSS SCS	54504 to 54523-TB	BCU	8 AWG to 250 kcmil: 1 crimp 300 to 750 kcmil: 2 crimps
	Long	VHS	CU	YS	CTL	SCL SCH	54804 to 54823	BBCU	
Copper Lugs	Short	VHCS	CTL-2/CTL	YA-2LN/ YA-L/YA-2L; YA/YA-L-TC/ YA-L-2TC	CSW CRA/CRB CRC	LCAS LCA LCD LCAN	54104 to 54123-TB; 54204 to 54223	BLU	
	Long	VHCL	CTL-L/LCN	YA/YAZ YA-2N/YA-2TC YAZ-2N/YAZ-2TC	CLN, CLW CRA-L/CRB-L CRA-2/CRB-2L CRC-2L	LCB LCC	54930BE to 54923BE; 54850BE to 54880BE	BBLU	



Is this a good connection?



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Session 1: *Grounding & Bonding*
Practical Solutions
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BURNDY® C & I Medium and Large Compression

Type YA-2N, YA-2TC, YA-4N (Continued)

INSTALLATION TOOL AND DIE INFORMATION

Catalog Number	Installation Tooling					Die Index	
	Dieless (# of crimps)	Mech.		Hydraulic			Color Code
		MD6, OUR840, MD7-34R	BCT500, Y500CT	Y35, Y39, 750 Series, 46 Series*			
YA312TC4E2	Y544 (1)	WG1VT (4)	WG1VT (4)	U31RT (4)	Red	18 or 324	
YA312TC38	Y / PAT81KFT (3)		WG1RT (4)	L294RT (4)			
YA312N							
YA322TC38	Y544 (1)	WG2VT (4)	WG2VT (4)	U33RT (4)	Blue	19 or 470	
YA322N	Y / PAT81KFT (3)		WG3RT (4)	U304RT (4)			
YA332N		WG3VT (4)	WG3RT (4)	U35RT	Grey	325 or 538	
YA342TC4E2	Y544 (1)	WG4VT (4)	WG4RT (4)	U34RT (4)	Brown	20 or 299	
YA342N	Y / PAT81KFT (4)						
YA352N				U35RT (4)	Yellow	21	
YA362TC38				U36RT (4)			
YA362N				U324RT (4)	Green	22 or 472	
YA392NT38							
YA392TC38	Y544 (1)			U39RT (4)	Black	34	
YA392N	Y / PAT81KFT (4)			•P39RT (4)			
YA392ENNT							
YA402N				•P40RT (4)	Orange	25	
YA442TC38				•P44RT (4)	White	27	
YA442N				•P44RT (4)	White	27	
YA452N				•P45RT (6)	Yellow	29	
YA462N				•P46RT (6)	Green	31	
YA472N					Grey	33	
YA482N					Brown	34	

* Use PUADP-1 adapter with U dies in 46 Series tooling
 ** P-RT die sets for use in 46 Series only, PUADP-1 adapter not required
 *** Y122CMR tool #10-#2 AWG Wire Only
 ****The MWP conductor sizes listed are the recommendations for Class 2 conductor
 ▲ See tooling section of this catalog for complete tool and die listings

Compression Connectors

Tool and Die Index for Short Barrel — Types CTL, CTL-2 and GSP

CONDUCTOR SIZE	BLACKBURN® TOOLS				BURNDY® TOOLS				TAP TOOLS				AMERICAN TOOLS			
	MECH. PER CRIMP	MECH. PER CRIMP	HYD. PER CRIMP	HYD. PER CRIMP	MECH. PER CRIMP	MECH. PER CRIMP	HYD. PER CRIMP	HYD. PER CRIMP	MECH. PER CRIMP	MECH. PER CRIMP	HYD. PER CRIMP	HYD. PER CRIMP	MECH. PER CRIMP	MECH. PER CRIMP	HYD. PER CRIMP	HYD. PER CRIMP
6 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
4 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
2 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
1 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
1/0 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
2/0 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
3/0 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
4/0 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
250 MCM	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
300 MCM	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
350 MCM	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
400 MCM	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
500 MCM	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
750 MCM	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
1000 MCM	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1

Tool and Die Index for Long Barrel — Types CTL-L, LCN and CU

CONDUCTOR SIZE	BLACKBURN® TOOLS				BURNDY® TOOLS				TAP TOOLS				AMERICAN TOOLS			
	MECH. PER CRIMP	MECH. PER CRIMP	HYD. PER CRIMP	HYD. PER CRIMP	MECH. PER CRIMP	MECH. PER CRIMP	HYD. PER CRIMP	HYD. PER CRIMP	MECH. PER CRIMP	MECH. PER CRIMP	HYD. PER CRIMP	HYD. PER CRIMP	MECH. PER CRIMP	MECH. PER CRIMP	HYD. PER CRIMP	HYD. PER CRIMP
6 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
4 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
2 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
1 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
1/0 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
2/0 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
3/0 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
4/0 AWG	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
250 MCM	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
300 MCM	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
350 MCM	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
400 MCM	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
500 MCM	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
750 MCM	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1
1000 MCM	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1	1/4	3	1	1

***The MWP conductor sizes listed are the recommendations for Class 2 conductor
 ▲ See tooling section of this catalog for complete tool and die listings

Connectors & Grounding — Blackburn® Compression Connectors

Do the installation instructions matter?

- Per UL: The Classification Mark of UL identified by the crimp tool manufacturer in their documentation requires an installer to follow the guidelines of the installation instructions that were used to Classify the tool.
- Also Per UL an installer must follow the Connector Manufacturer's installation instructions to obtain a UL listed connection.
- They do not match.....**that's a problem** with the NEC compliance and inspectors, and for the building owner and the contractor. Who owns that connection?

What are the real risks with UL Classified tools?

- If the tools and dies are not recommended in the connector manufacturers' instructions, it **voids the warranty** from the connector manufacturer.
- If the specific part number is covered by the tool supplier's UL Classification it may be UL486 A/B listed but that is all today.
 - **Class B Stranding only** today, no flex conductors are covered.
 - **Special Aluminum Stranding not covered** today. – No compact conductors.
 - **Only standard lugs and splices.** No H Taps, C taps and custom connector types.
- **No UL467 for Grounding or Bonding** is covered under any UL Classification tool suppliers.
- What project can a contractor complete with these UL Classification limitations and one of those tools and be in compliance with the NEC, NESC or your specifications?

Conclusion

- Proper connector installation is both system and safety critical for Grounding and Bonding connections and post installation maintenance/inspection is difficult as many of these connections are inaccessible after installation.
- Several factors are growing in frequency that can and do effect your grounding and power systems connection quality for mechanical and compression connections and with rods welds will be in play.
- If you cannot control what is done at installation outside your facility footprint, other's problems may become yours.
- Control the variables in your connection installations so that you have the performance from those connections you expect.



Questions?



Additional detail available in Connector Theory at the Resources Section of www.Burndy.com