

# ELECTRIC UTILITY APPLICATION AND REFERENCE GUIDE





## **Power Generation** 3

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## **Substation Earthing/Grounding Lightning Protection** 4 – 5

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## **Power Transmission and Distribution** 6 – 7

---

## **Accessories for Electrical Utility Applications** 8 – 9

---

## **Design Assistance** 10

---

## **Earth/Ground Test Equipment** 10

---

## **Applicable Standards** 11

---

## **Facility Electrical Protection**

Pentair offers a full range of facility electrical protection products designed to protect power utility facilities worldwide. Pentair's product offerings include ERICO grounding and bonding accessories, surge and lightning protection products and CADWELD welded electrical connections.

## **Earthing/Grounding and Bonding**

Pentair offers an extensive line of ERICO grounding and bonding products, which includes ground rods, theft deterrent conductors, mechanical clamps, compression and threaded couplers, chemical ground rods, Ground Enhancement Material (GEM), inspection wells, grounding plates, prefabricated ground mesh and ground test instruments.

## **CADWELD Welded Electrical Connections**

CADWELD welded electrical connections are used to connect the grounding and bonding conductors to the ground electrode system, including ground rod electrodes, building steel and rebar. CADWELD connections provide a permanent, low-resistance connection needed to create a long-lasting, reliable bonding network with long service life. CADWELD connections will not deteriorate or loosen with time and are made with affordable, lightweight and portable equipment.

## **Surge Protection**

Surge protection products are designed to help protect against damaging electrical surges on power and communications lines caused by lightning and other switching events. With the increasing focus on system reliability and the Smart Grid initiatives underway in many countries, surge protection is more critical than ever based on the amount of electronics control and monitoring systems on the power grid today.

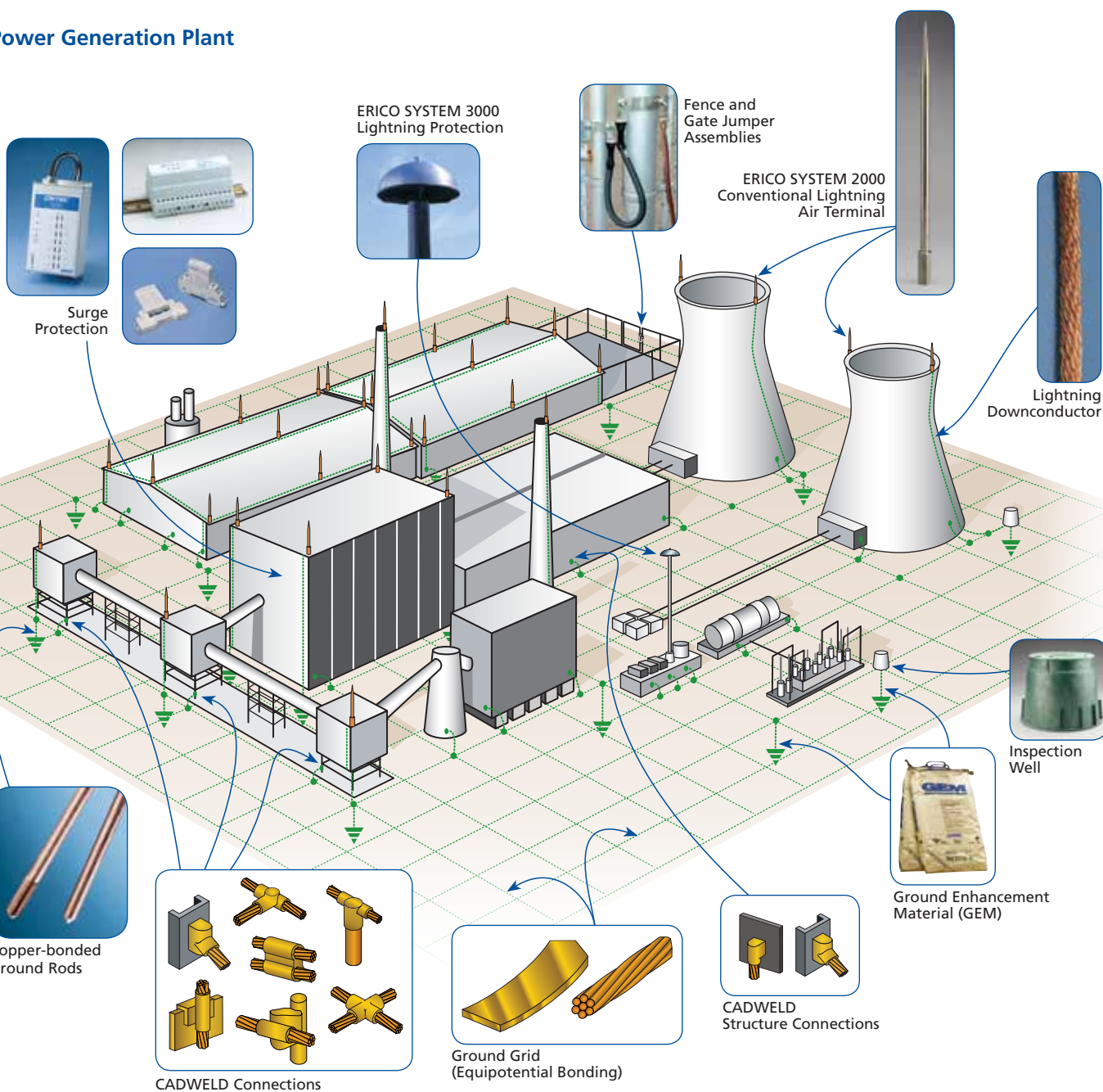
## **Lightning Protection Systems**

Direct and indirect lightning strikes can pose many risks to businesses, including damaging buildings and critical equipment. ERICO lightning protection products offer a variety of solutions to help protect valuable equipment and personnel and to help prevent service disruption and downtime.

## Power Generation Facilities

Traditional power generation facilities have either been coal-fired, gas-fired, nuclear, diesel or hydro-powered. Modern alternative power generation facilities can include geothermal, bio-gas, wind or solar. ERICO brand of lightning protection systems have been used to provide lightning protection to the whole host of facilities in a unique manner. ERICO grounding and bonding solutions can provide a complete system for the grounding and bonding of any of these facilities.

### Power Generation Plant



# Substation Earthing/Grounding and Lightning Protection

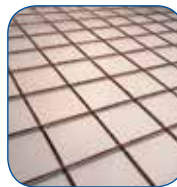
## Substation Earthing/Grounding and Lightning Protection

The conceptual design of a ground grid at a substation is summarized by the points below and depicted on pages 4 and 5.

- A continuous loop conductor should surround the perimeter to enclose as much area as practical. Under Standard IEEE® 80, this loop conductor is placed 3 ft (or 1 meter) outside the fence line. This measure helps to avoid high current concentration and high gradients both in the grid area and near the projecting cable ends. Enclosing more area also reduces the resistance of the grounding grid.
- Within the substation, conductors are typically laid in a parallel grid and, where practical, along the structures or rows of equipment to provide for short ground connections.
- A typical grid system for a substation may include bare copper conductors buried 18" (0.5 m) below grade, spaced 9 ft to 21 ft (3 m to 7 m) apart, in a grid pattern. At cross-connections, the conductors would be securely bonded together. Ground rods may be at the grid corners and at junction points along the perimeter.
- This grid system would be extended over the entire substation switchyard and beyond the fence line.



Surge Protection



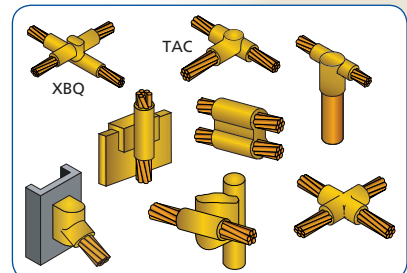
Prefabricated Wire Mesh



Copper-bonded Rods



Ground Enhancement Material (GEM)

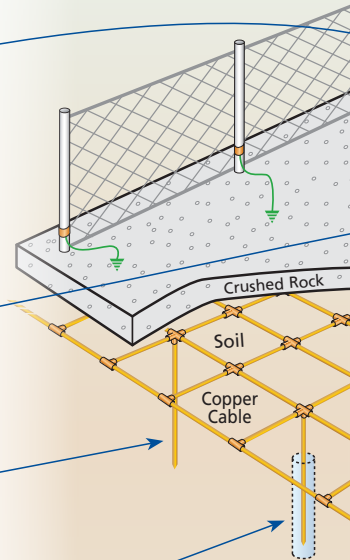


CADWELD Connections

## Earth/Ground Rods

Pentair offers a range of ground rods to suit the needs and preferences of the utilities. The most common of these are copper-bonded steel rods, due to their versatility in varied soil conditions and compatibility with various common metals used underground. The copper-bonded ground rod has an electrolytic coating of copper deposited over a layer of nickel. This process helps ensure a long-lasting molecular bond between the copper layer and the steel core. Pentair recommends ERICO brand of copper-bonded ground rods because the copper coating will not slip or tear when driven, nor will it crack if the rod is bent. The tough, carbon steel core has good characteristics for deep driving. Copper-bonded ground rods have a high resistance to corrosion and provide a low-resistance path to ground.

It is important to note that certain soils and landfill areas may not be compatible with copper. In these situations, stainless steel is a better choice. The ERICO brand of copper-bonded ground rods comply with UL® 467, BS:7430 & EN50164, Standards.



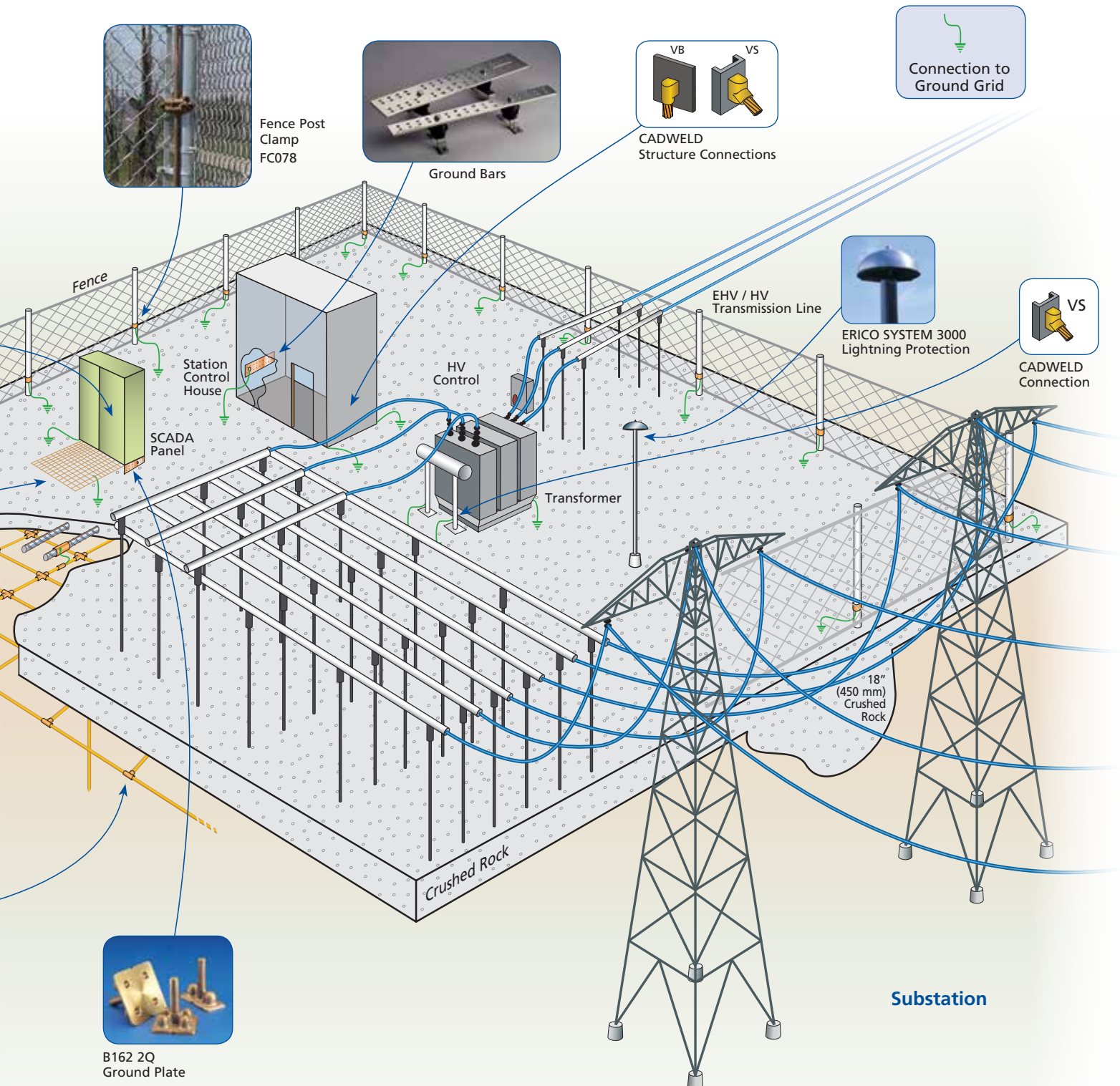


# Substation Earthing/Grounding and Lightning Protection

## Surge Protection for SCADA-controlled Equipment

Electronic equipment operating within a substation environment is particularly subject to electrical disturbances such as switching, electrical noise, ground potential rise and occasional induced or direct lightning impulse. Surge protection is an extremely cost-effective investment for electronic substation equipment, because:

- Each site's operation is critical to the quality supply of electrical power
- Downtime costs are significant



## Power Transmission and Distribution

The grounding of facilities associated with the distribution of power is sometimes not given the same level of thought and design scrutiny as is given to the substations. Pentair has a complete range of products that address this need.

## Earthing/Grounding Connections

Grounding connections are vital to the proper operation and integrity of the electrical system. Pentair offers a range of mechanical connections, including clamps, jumpers, fence connections, U-Bolts and other clamps. Pentair recommends the CADWELD welded electrical connection for making these connections. The principle technology consists of bringing together a welding material and ignition agent in a graphite mold. The reduction of copper oxide by aluminum produces molten copper and aluminum oxide slag at extremely high temperatures. The shape of the mold, its dimensions and the size of welding material are all dependent on the items to be welded. This results in a molecular bond that exceeds the life of the conductor.

## Ground Enhancement Material (GEM)

GEM is a superior conductive material that improves grounding effectiveness, especially in areas of poor conductivity (rocky ground, areas of moisture variation, sandy soils). GEM can dramatically lower earth resistance and impedance measures. Typically, it has resistivity in a range from 12-18 Ohm cms (20 times lower than bentonite clay). Once in its set form, it maintains constant resistance for the life of the system. GEM performs in all soil conditions, even during dry spells and it does not dissolve, decompose or leach out with time.

## Theft Deterrent Cables

Pentair offers several solutions for areas where traditional copper cables are prone to theft.

Theft deterrent composite cable is a bare concentric stranded conductor that consists of peripheral galvanized steel stranding, which protects and conceals the internal copper strands. This conductor is ideal for exposed electrical distribution grounding leads where copper theft may occur. The conductor is difficult to cut with hand tools, and the outer steel stranding is magnetic, which further deters thieves looking for copper.

Pentair has a range of copper-coated steel conductors that are also used for this application. Copper-coated steel conductors can either take the form of a traditional cable with stranding or they can be preformed ground rods that have a hardened steel center. These preformed rods can connect directly to steel structure being earthed with no need for copper cables.

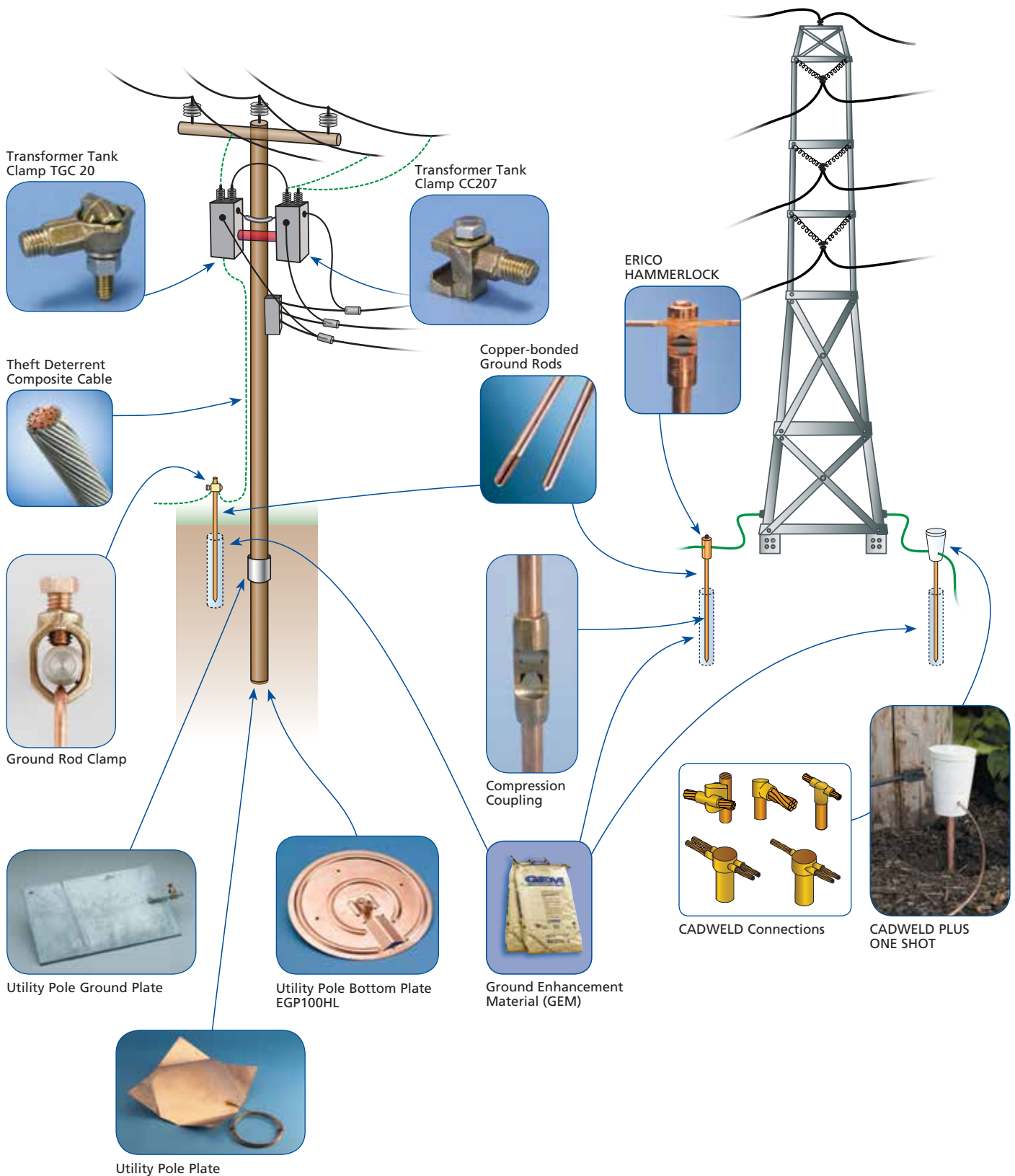
CADWELD is the most suitable connection method for all these specialized conductors.

## Surge Protection for Transmission and Distribution

Electronic equipment operating at remote system monitoring locations on distribution lines are susceptible to ground potential rises and induced or direct lightning impulses on the network. Surge protection is an extremely cost-effective investment for such equipment as this equipment is most needed during times of local storm activity. Therefore protection that is robust against high level surge activity, and protection that is immune to voltage fluctuation on the network is critical.

## Distribution Pole

## Transmission Tower



# Accessories for Electrical Utility Applications

Along with our main systems and components for the utility industry, Pentair offers a wide range of accessories to assist in grounding, bonding and lightning protection needs.

## Ground Rods and Ground Rod Couplers



Complete range of earth/ground rods, and couplers, including copper bonded rods of various size and specification. For complete range and details please visit [www.erico.pentair.com](http://www.erico.pentair.com).

## CADWELD



Complete range of CADWELD applications for permanent connections from wire to rod, or wire to wire, etc. For complete range and details please visit [www.erico.pentair.com](http://www.erico.pentair.com).

## CADWELD ONE SHOT



Complete range of CADWELD ONE SHOT applications for permanent connections from wire to rod, or wire to wire. For complete range and details please visit [www.erico.pentair.com](http://www.erico.pentair.com).

## Ground Rod Clamps



SP Series



CP Series



HDC Series

Part No.	Rod Diameter (in)	Conductor Range (AWG)
HDC58*	5/8	8 solid - 1/0 stranded
HDC58R*	5/8	8 solid - 1/0 stranded
HDC34	3/4	8 solid - 1/0 stranded
HDC34SP	3/4	8 solid - 3/0 stranded
CP58	5/8	10 solid - 2 stranded
CP34	3/4	10 solid - 1/0 stranded
SP58	1/2, 5/8	10 solid - 2 stranded
SP58B916**	1/2, 5/9	11 solid - 2 stranded

\* HDC58 threads are 1/2" - 13 UNC. HDC58R threads are 7/16" - 14 UNC.

\*\* SP58B916 bolt head is 9/16"

## ERICO HAMMERLOCK



Part No.	Rod Ø	Conductor Range: Imperial / Metric
EHL58G2G	5/8	1/0 - 2/0 str (50.0 to 70.0 mm² str)
EHL58G1V	5/8	4 - 2 str (22.0 to 35.0 mm² str)
EHL58G1K	5/8	6 - 4 sol (10.0 to 16.0 mm² str)
EHL34G1V	3/4	4 - 2 str (22.0 to 35.0 mm² str)
EHL34SG1V	3/4	4 - 2 str (22.0 to 35.0 mm² str)
EHL34G1K	3/4	6 - 4 sol (10.0 to 16.0 mm² str)
EHL34SG1K	3/4	6 - 4 sol (10.0 to 16.0 mm² str)
Dual-Hole (2 Conductors)		
EHL58G1K1K	5/8	6 - 4 sol (10.0 to 16.0 mm² str)

## Utility Grounding Bars



EGB Series

Various material, coating and configurations – contact Pentair for your specific needs.

## Ground Enhancement Material (GEM)



GEM25A



GEM25ABKT

GEM25A: 25 lb (11.36 kg) bag of GEM

GEM25ABKT: 25 lb (11.36 kg) bucket of GEM

Technical support is available to help estimate the quantity of GEM needed for any installation – contact Pentair for your specific needs.

## Theft Deterrent Cable



CCL04A

Part No.	Description
CC5A04	Theft deterrent composite cable, 7 strand, 0.330" outside diameter, 250' reel
CC5A05	Theft deterrent composite cable, 19 strand, 0.334" outside diameter, 250' reel
CC5A12	Theft deterrent composite cable, 157 strand, 0.572" outside diameter, 200' reel
CCL04A	Aluminum composite cable clip for theft deterrent composite cable

A range of MTO copper-bonded, pre-formed or coiled steel conductors is available.



# Accessories for Electrical Utility Applications

## Inspection wells



Part No.	Description
PIT05	Polymer inspection well 12" X 12" X 8.5" deep
PIT03	Polymer inspection well 6" X 8.5" X 8.5" deep
T416A	Polymer inspection well 14" X 23" X 18" deep
T416B	High density polyethylene inspection well 10" round X 10" deep
T416C	High density polyethylene inspection well 14" round X 18" deep
T416D	Polymer inspection well 13" X 13" X 12" deep
T416E	Polymer inspection well 13" X 13" X 18" deep
T416F	Polymer inspection well 13" X 13" X 26" deep

## Transformer Tank and Vice Clamps



Part No.	Conductor Range (AWG)	Stud Thread Size
TGC2/0	10 solid - 2/0 stranded	1/2" - 13
CC207	6 solid - 1/0 stranded	
VC62	6 solid - 2 stranded	
VC220	2 solid - 2/0 stranded	

## Ground Plates



Part No.	Description
B1612Q	4-hole, 4/0 concentric
B1613Q	4-hole, 500 concentric
B1622Q	2-hole, 4/0 concentric
B1642Q	4-hole, 4/0 concentric
B1643Q	4-hole, 500 concentric

## Ground Plate Electrodes



Part No.	Description
UGP719	Utility ground plate 7.5" X 19.25"
UGP738	Utility ground plate 7.5" X 38.5"
EGGP	Galvanized steel ground plate, without connector
EGGPC	Galvanized steel ground plate, with HDC58R connector
EGP100	Copper utility pole bottom plate with cable lug
EGP100HL	Copper utility pole bottom plate with ERICO HAMMERLOCK connector

## Split Bolts



ESB Series

Visit [www.erico.pentair.com](http://www.erico.pentair.com) for a complete range of copper or tinned copper split bolts.

## Fence Post Clamps



Part No.	Pipe Size (Imperial)	Conductor Range (AWG)	Pipe Size (Metric)	Conductor Range (Metric)
FC073	1-1/2"	4 Sol - 2/0 Str	40.0 mm	16.0 mm <sup>2</sup> Str - 70.0 mm <sup>2</sup> Str
FC074	1-1/2"	2 Sol - 250 MCM Str	40.0 mm	50.0 mm <sup>2</sup> Str - 120.0 mm <sup>2</sup> Str
FC075	2"	4 Sol - 2/0 Str	50.0 mm	16.0 mm <sup>2</sup> Str - 70.0 mm <sup>2</sup> Str
FC076	2"	2 Sol - 250 MCM Str	50.0 mm	50.0 mm <sup>2</sup> Str - 120.0 mm <sup>2</sup> Str
FC078	2-1/2"	4 Sol - 250 MCM Str	65.0 mm	16.0 mm <sup>2</sup> Str - 120.0 mm <sup>2</sup> Str
FC079	3"	4 Sol - 2/0 Str	80.0 mm	16.0 mm <sup>2</sup> Str - 70.0 mm <sup>2</sup> Str
FC080	3"	2 Sol - 250 MCM Str	80.0 mm	50.0 mm <sup>2</sup> Str - 120.0 mm <sup>2</sup> Str
FC082	3-1/2"	4 Sol - 2/0 Str	90.0 mm	16.0 mm <sup>2</sup> Str - 120.0 mm <sup>2</sup> Str

## Rebar Clamps

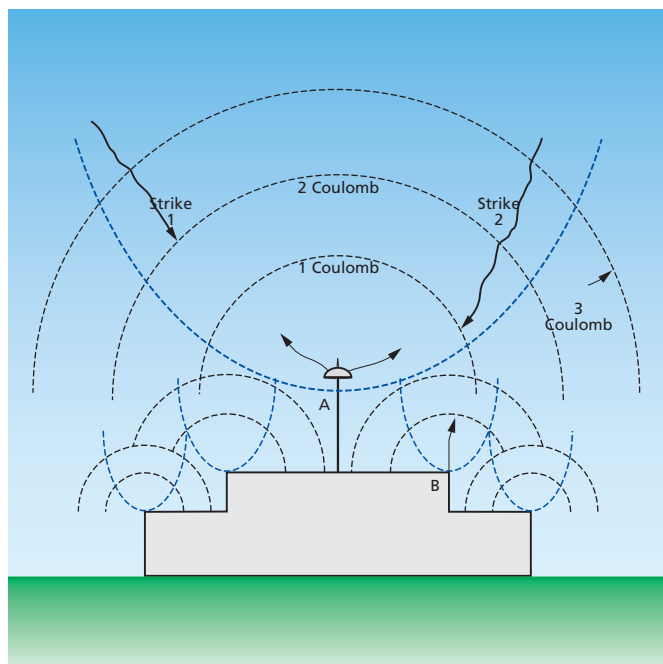


EK Series RC Series

Part No.	Conductor Range (AWG)	Conductor Range (Metric)	Rebar Size (imperial)	Rebar Size (Metric)
EK16	8 solid - 2/0 stranded	10 - 70 mm <sup>2</sup>	#3 - #6	8 - 18 mm
EK17	8 solid - 4/0 stranded	10 - 100 mm <sup>2</sup>	#6 - #11	18 - 36 mm
RC70	8 solid - 2/0 stranded	10 - 70 mm <sup>2</sup>	#3 - #6	8 - 18 mm
RC100	8 solid - 4/0 stranded	10 - 100 mm <sup>2</sup>	#6 - #11	18 - 36 mm

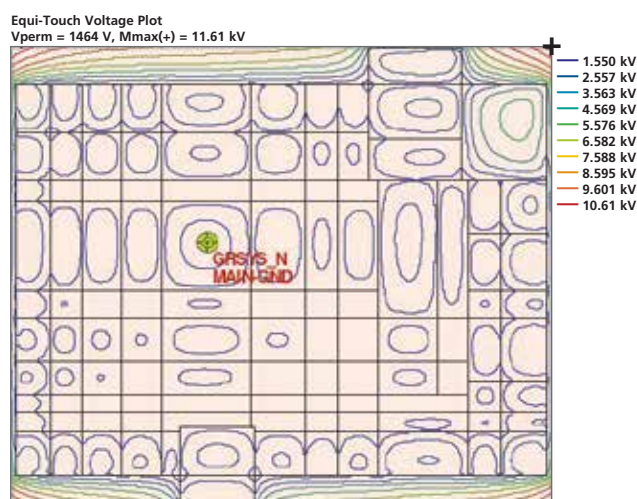
# Design Assistance

Pentair provides a high level of application engineering and design assistance to the users of its products. This team carries out modeling of a lightning protection system using modern software tools that use complex algorithms to model lightning strikes in a more accurate way than traditional methods.



**Lightning Protection Modelling**

Pentair offers a set of drawings of details using our products that can be used in the customers' construction documentation. Software is available for public use that will assist with the selection of CADWELD connections and the design of grounding systems using GEM.



**Computer Analysis of Substation Earthing/Grounding**

## Earth/Ground Test Equipment

To complete the range of grounding products, Pentair offers modern ground testing equipment that is suitable for performing soil resistivity measurements, step-and-touch voltage measurements, ground resistance measurements and stakeless clamp-on ground testing.



**Earth/Ground Testers**

# Applicable Standards for Design of Earthing/Grounding Systems

## USA, Australia, Asia

The IEEE® earthing/grounding and lightning protection standards in the U.S. are used quite commonly around the world, especially in Asia and Australia.

The IEEE 80 Standard for Safety in AC Substation Grounding is the most common document used to assist with the design of a system. Many countries have guides written either by power utilities, industry associations or standards to complement IEEE standards. The IEEE 80 Standard requires connections that are used in substations to pass all the tests stipulated in IEEE 837 as verified by independent reports.

CADWELD welded connections have been shown to pass all of the tests sequences in IEEE 837 in comprehensive tests carried out by independent test labs. In the same set of experiments, it was demonstrated that mechanical connectors that are sometimes used in substation applications do not pass the tests outlined in Standard IEEE 837.

Other standards that are relevant to grounding and lightning protection include the IEEE 81- IEEE Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Ground System and IEEE Std 998 Guide for Direct Lightning Strike Shielding of Substations.

The UL® SPEC 467 Grounding and Bonding Equipment provides a comprehensive compliance and testing method to ensure long and reliable life of an earth/ground rod.

## Europe

Most major power utilities in Europe have their own internal standards and regulations for the grounding of substations and the designer should refer to them for guidance. Additionally, the IEEE 80 Standard (as well as the standards related to it) is also widely used since it provides a fully integrated approach to the design of an efficient earthing system. The IEC® 60479-1 Standard contains formula for the calculation of step-and-touch potentials but does not cover all the resistivity and system resistance aspects or fault current-related calculations covered in IEEE 80.

The EN62305-3 Standard regarding lightning protection of buildings gives directions about earthing/grounding of lightning protection systems, as well as some simple rules regarding step-and-touch potentials, which have to be used with care when applied to power utility installations.

The BSEN50164-2:2002, Requirements for Conductors and Earth Electrodes, is a standard used as a reference for testing of ground rods.

## Latin America

In Mexico, the utility [COMISIÓN FEDERAL DE ELECTRICIDAD (CFE)] uses IEEE 80 and IEEE 837 (rev 2002) standards in its project specifications. For ground rods, the utility also has its own specification, the 56100-16 rev 2008. The rods must be issued by LAPEM (CFE Laboratory) during routine tests, which verifies compliance with the CFE Specification 56100-16.

In regard to lightning protection, Mexico uses the Standard ANCE NMX-J-549-ANCE-2005 Protection Against Lightning – Specifications, Materials and Methods of Measurement. The Mexican law also establishes that all government entities must use the Mexican standards (called Norma Mexicana or NMX) or the official ones (Norma Oficial Mexicana or the NOM), so ERICO is an active member of the Mexican standardization committee (Asociación de Normalización y Certificación A.C. or ANCE) to participate in the NOM or NMX reviews or development of new standards.

In the rest of Latin America, the utilities adopt the US Standard (NFPA®, IEEE, NEMA®, TIA®/EIA®) and write local standards or local electrical codes based in these. Frequently, they will make minor modifications.

## Brazil

Brazil uses international standards, such as IEC, and for products they base their requirements on European specifications.

The voltage that is used in Brazil is low-voltage 127 V, medium-voltage distribution 13.8 kV, 25 kV and 36 kV and high-voltage transmission 138 kV, 230 kV.



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