CANADA'S OIL & NATURAL GAS PRODUCERS

Guide

Electrical Installations for Impressed Current Cathodic Protection Systems

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The Canadian Association of Petroleum Producers (CAPP) represents companies, large and small, that explore for, develop and produce natural gas and oil throughout Canada. CAPP's member companies produce about 80 per cent of Canada's natural gas and oil. CAPP's associate members provide a wide range of services that support the upstream oil and natural gas industry. Together CAPP's members and associate members are an important part of a national industry with revenues from oil and natural gas production of about $101 billion a year. CAPP's mission, on behalf of the Canadian upstream oil and natural gas industry, is to advocate for and enable economic competitiveness and safe, environmentally and socially responsible performance.

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Overview

Impressed current cathodic protection systems are a technique for controlling the corrosion of a metal surface by making that surface the cathode of an electrochemical cell. Impressed current cathodic protection systems are in widespread use at thousands of oil and natural gas surface production facilities, and serve to prevent failure of piping and other facilities that may lead to uncontrolled release of products, resulting in safety hazards and environmental contamination.

This guide is intended to help those designing, installing, inspecting, or maintaining impressed current cathodic protection systems to meet minimum regulatory requirements; and it also simultaneously benefits worker safety and reliability of the system. It outlines, from an electrical perspective, design and installation criteria related to impressed current cathodic protection systems, including:

- codes and standards related to cathodic protection work
- worker qualification
- equipment certification
- connection and splicing methods
- installations
- warning signs
- documentation
- electrical inspections.

Although mandatory language is used in this guideline, this guideline as a whole is non-mandatory in nature and is not a regulatory document. The adoption and enforcement of a practice or specification (or parts of it) is for the specific company or organization to determine in light of its own particular operations. However, the user should note that many of the elements of this guideline are also regulatory requirements. Therefore, if a user wishes to deviate from parts of this document, the user must be aware of the relevant minimum regulatory requirements. In addition, use of this guide is not a substitute for knowledge of regulatory requirements and each company and organization is responsible for its own regulatory compliance.

This guideline has been developed by a joint industry committee with representatives from Canadian Association of Petroleum Producers (CAPP) member companies, the cathodic protection services industry, cathodic protection rectifier manufacturers, and corrosion specialists and electrical technical staff from user companies.

The guide has been developed for Alberta. Consideration may be given for other jurisdictions at a later time.

Changes Found In This Edition

This edition of the CAPP *Electrical Installations for Impressed Current Cathodic Protection Systems Guide* includes the following updates and revisions relative to the first published guideline from 2008:

- Updates on applicable codes and standards, including an updated reference list. A reference to CSA Z462 Workplace Electrical Safety has been added.
- Updated information on worker qualifications applicable to cathodic protection impressed current equipment and systems, including incorporation of content reflecting the Cathodic Protection Technician designated occupation in Alberta. The Trades Scope Diagram in Appendix A has also been updated and clarified to reflect the current regulatory requirements.
- Addition of liquid flexible conduit/frost loop connections, capacitive discharge stud welding (CDSW) connections, and pipe saddle connections as recognized connection methods to protected structures.
- Expanded section on Canadian Electrical Code installation requirements including use of cable tray, use of pipe-supported cables, use of liquid tight flexible conduit, use of junction boxes, and conductor termination requirements.

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1 Purpose

This guide is intended to set minimum electrical safety requirements for impressed current cathodic protection system installations. This guide also identifies work responsibilities and/or restrictions.

2 Scope

The scope of this cathodic protection guide includes aspects of:

- Electrical design
- Installation
- Maintenance.

2.1 Exclusions

The following subjects are excluded from the scope of this guide:

2.1.1 Design of Cathodic Protection Systems

The general design of cathodic protection systems is excluded from the scope of this guide, for example:

- Any details with respect to cathodic protection current requirements
- Anode location
- Anode type
- Impressed current control techniques
- Planning which structures to protect and where electrical insulation is required
- Galvanic cathodic protection systems.

2.1.2 Work Procedures for Pipes and Vessels

Work procedures for working on pipes, flanges or fittings where cathodic circuits might be connected or interrupted are excluded from the scope of this guide, for example:

- Use of bonding jumpers and mats
- Use of hot work permits.

3 Codes and Standards

Codes and standards related to the electrical installation aspects of cathodic protection systems include (but are not limited to) those listed below.

Always refer to the latest edition or version, and/or the one in force per regulation.

3.1 Canadian Electrical Code

The objective of the *Canadian Electrical Code (Part 1)*[1] is to establish safety standards for the installation and maintenance of electrical equipment. Consideration has been given to the prevention of fire and shock hazards, as well as proper maintenance and operation. Its requirements apply for all oil and natural gas facilities' electrical installations, all non-distribution or non-transmission electrical utility electrical installations, and all natural gas distribution utilities' electrical installations in the province.

The entire *Canadian Electrical Code* applies to all electrical installations. Within the *Canadian Electrical Code* there are specific sections commonly referenced for cathodic protection installations (e.g., Section 80 - Cathodic Protection). Some other examples include:

- Section 4 covers ampacities,
- Section 10 covers grounding and bonding,
- Section 12 covers wiring methods, and
- Section 18 covers hazardous locations.

In addition to the Canadian Electrical Code, various provinces have additional requirements and modifications in force in their jurisdictions. For example, in Alberta, a system of Standata is used, which provides information on additional requirements.

3.1.1 Section 80 – Cathodic Protection

Section 80 applies to the installation of impressed current cathodic protection systems and is supplemental to, or amendatory of, other *Canadian Electrical Code* sections. Installations must meet the requirements of this section. Some of the specific requirements of this section are discussed in more detail in this document.

3.2 Code for Electrical Installations at Oil and Gas Facilities

The *Code for Electrical Installations at Oil and Gas Facilities*[2] recognizes the area classification drawings of a professional engineer for a specific facility. In the absence of engineered area classification drawings, this code establishes the minimum hazardous area classification requirements for any oil and natural gas facility. When planning and installing cathodic protection systems, the installed equipment must be either rated for the hazardous location, or installed outside of the hazardous location. Installing outside of the hazardous location is always preferred, but when it comes to connections to protected structures (i.e., pipes, vessels, tanks, etc.) this may not be possible.

3.3 Occupational Health and Safety Code

The *Alberta Occupational Health and Safety Code*[3] addresses worker safety in a comprehensive manner. It has content pertaining to general worksite safety and procedures which govern all oilfield work. Some examples of where this code applies to the installation and servicing of cathodic protection systems include:

- Workers having proper training, qualification, and experience
- Lockout and tag procedures
- Hot work procedures and work in hazardous locations
- Working alone requirements
- Working in the vicinity of power lines.

3.4 CSA Z462 Workplace Electrical Safety

CSA Z462[4] covers workplace electrical safety requirements for work on energized electrical equipment. It applies to all electrical trades as well as Cathodic Protection Technicians. It introduces requirements and concepts in the area of worker training, personal protective equipment, electrical work permits, incident energy levels, shock approach boundaries, and electrical safe work procedures. It is intended to help employers develop and establish electrical safety programs for their workers. Those programs, in turn, would dictate specific electrical safe work requirements to be used on the jobsite by personnel working on impressed current cathodic protection equipment and systems.

3.5 Electrical Safety: A Program Development Guideline (Energy Safety Canada)

Electrical Safety: A Program Development Guideline[5] provides additional guidance to employers on how to develop an electrical safety program in support of meeting the requirements in CSA Z462.

3.6 CSA Z662 Oil and Natural Gas Pipeline Systems

CSA Z662 covers design, construction, operation and maintenance of oil and natural gas industry pipeline systems. This standard has requirements for corrosion control, including electrical interference.

3.7 Canadian Gas Association Recommended Practice OCC-1

Canadian Gas Association Recommended Practice OCC-1 "Control of External Corrosion on Buried or Submerged Metallic Piping Systems"[6] applies to the control of external corrosion on buried or submerged metallic piping systems. This document is referenced in CSA Z662 above. It is the responsibility of each company to provide procedures that will satisfy all regulations, as well as the company's own unique requirements, to ensure effective, safe, and proactive corrosion control.

3.8 NACE SP0169 Control of External Corrosion on Underground or Submerged Metallic Piping Systems

This document contains a section on installation requirements (Section 8). Many of those requirements are also covered in more depth in this guideline within the context of the *Canadian Electrical Code* and other oil and natural gas industry cathodic protection practices. The *NACE SP0169*[7] document also covers design, operations, maintenance, and documentation issues which are outside of the scope of this guideline.

3.9 Corporate Standards

Some upstream oil and natural gas companies may have their own engineering standards outlining cathodic protection installation details and maintenance procedures. Companies that have accreditations in the electrical discipline may also have specific variances permitting deviations from the *Canadian Electrical Code*.

4 Worker Qualifications and Equipment Certification

4.1 Alberta

In Alberta, there are various requirements for worker qualification with respect to cathodic protection systems, rectifiers, and other equipment. This information can be provided by regulatory bodies such as Alberta Apprenticeship and Industry Training (for example, covering cathodic protection technicians and electricians), Energy Safety Canada, and other industry associations. In other jurisdictions, consult your local regulatory bodies and industry associations.

For example, electrical work on cathodic protection systems falls under the *Electrician Trade Regulation*.[8] This regulation is put in place under the *Apprenticeship and Industry Training Act*.[9] The *Electrician Trade Regulation* restricts electrical work to certified electricians. Cathodic protection technicians, under the *Cathodic Protection Technician Exception Regulation*,[10] and the *Cathodic Protection Technician Occupation Regulation*[11] have a specific designated occupation in Alberta allowing them to perform work tasks within their permitted scope of work, some of which overlaps with the electricians' scope in the cathodic protection area. Refer to the above references for further details.

The rationales for these various regulations are related to personnel safety (shock), indirect safety issues (e.g. excessive heat, fire), knowledge of electrical principles, and good workmanship.

See Appendix A for a scope definition diagram for various worker roles.

In Alberta, engineering practice is governed by the *Engineering, Geological, and Geophysical Professions Act*.[12]

4.2 Other Provinces

Other provinces have similar acts in place governing "electrical work" and "engineering."

4.3 Equipment Certification

Equipment and/or components used in the electrical circuit(s) of cathodic protection systems must be certified to Canadian standards by an accredited certification body. The accredited certification bodies (such as the Canadian Standards Association, Underwriter's Laboratories, Entela, etc.) are, in turn, accredited by the Standards Council of Canada. Equipment which is certified to Canadian standards is often referred to as "CSA Approved" or "CSA Certified," but the equipment can also be certified by one of these other accredited certification bodies, and that certification is also recognized. Information on approved certification organizations, and the recognized markings on equipment, is available from Alberta Municipal Affairs. For the purposes of this document, the terms “certified” or “approved” are used, and refer to equipment that is certified by an accredited certification body to Canadian standards.

Exceptions to the certification requirements are possible for equipment types for which Canadian certification test standards are not available. Examples in the cathodic protection trade where these exceptions are needed include standalone variable and fixed resistors (which may only have a “component” certification); or engineered connections to structures. This document identifies when engineering involvement for the design of a piece of equipment is required.

5 General Technical Requirements for Connections to Structures

5.1 Conductor Cross-Sectional Area

Rated rectifier current capacity and mechanical strength requirements will govern the minimum required wire cross-section. The ampacity of the selected copper wire cross-section will determine the minimum current rating of all components used in the current path.

Canadian Electrical Code Table D5 “Strandings for building wires and cables” may be used for cross-sectional area conversions from American Wire Gauge (AWG) to mm^2.

5.2 Resistivity

Resistivity is a property related to the electrical resistance of a material and is independent of the geometry of the specimen. It is, however, sensitive to the temperature and composition of the material. Using resistivity, the resistance for a wire of given material, length, cross-sectional area, and at a given temperature, can be computed using the formula below:[13]

Equation 5-1 Wire resistance calculation

$R = \rho\, l / A$

where

R = resistance in ohms

ρ = resistivity in ohm-metres

l = length in metres, and

A = cross-sectional area in square-metres

5.2.1 Copper

The resistivity of pure copper is $1.678 \times 10^{-8}\ \Omega{*}m$ at $20^{o}C$.[13]

5.2.2 Carbon Steel

Some carbon steels have approximately 10 times the resistivity of copper, depending upon the alloy and temperature. Therefore, for the same length of steel or copper conductor, the cross-section of any carbon steel component or structure in the current path has to be at least 10 times the cross-section of the copper conductor to have similar resistance, and thus produce comparable I^2R (heating) losses, and comparable operating temperatures. This guide uses this “ten-times rule-of-thumb” for sizing carbon steel connections to structures.

If smaller carbon steel cross-sections are to be used, then further engineering analysis will be required, which is outside of the scope of this guide.

5.2.3 Stainless Steel

Stainless steel has approximately 44 times the resistivity of copper. Therefore, the cross-section of any stainless-steel construction piece in the current path has to be at least 44 times that of the copper wire used in the installation.

If smaller stainless-steel cross-sections are to be used, then further engineering analysis will be required, which is outside of the scope of this guide.

5.3 Contact Surfaces

All electrical connections require good metal-to-metal contact (i.e. paint-, rust-, and grease-free; with buff surfaces). For atmospheric connections, consideration should be given to protecting the completed metallic connection in corrosive environments (e.g.: salt, H_2S, condensation, etc.) through the use of anti-corrosion products such as paint or special coverings.

5.4 Frost Heave and Thermal Expansion

Frost heave and thermal expansion may cause the cathodic protection wiring, conduits, and the protected structure to move relative to one another. Sufficient slack in the wire will prevent separation of the wire from the structure. For example, the wire can be coiled in a flexible loop in the air (this is also known as a “pigtail”) as shown below.

Figure 5-1 Example of a Protective Bracket with Frost Loop and Servit Post™ [1]

[1] Registered Trademark of Burndy LLP

In locations subject to extreme temperature changes, provision should be made for expansion and contraction in long runs of rigid conduit by using approved expansion joints.

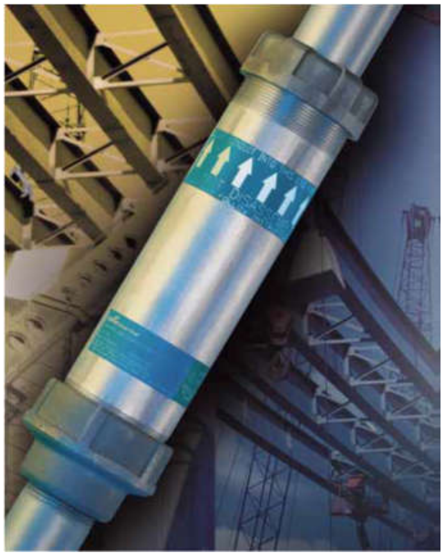


Figure 5-2 Conduit expansion joint

6 Connection Methods

6.1 General

Visible open wire connections are preferred over “hidden” connections. Visible connections allow visual inspections for solid contact, corrosion, or frost heave damage.

All cathodic protection wires above grade have to be mechanically protected and/or protected by location.

6.2 Carbon Steel Bracket with Servit Post™

6.2.1 Construction

Various designs incorporating a Servit Post™ can be used, but some of the main features include:

- Servit Post™ (certified); see Figure 6-1 and Figure 6-2
- Pigtail wire in air to allow frost heave movement; see Figure 6-2
- Bracket to protect wire; see Figure 6-2
- Anti-corrosion paint application to prevent atmospheric corrosion.

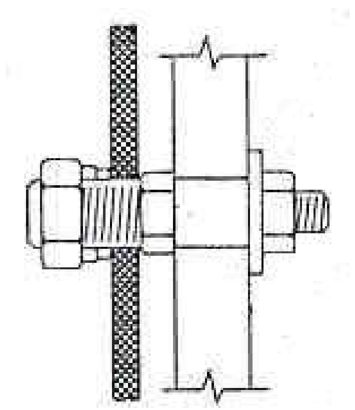


Figure 6-1 Example of a Servit Post™ Connection Cross Section

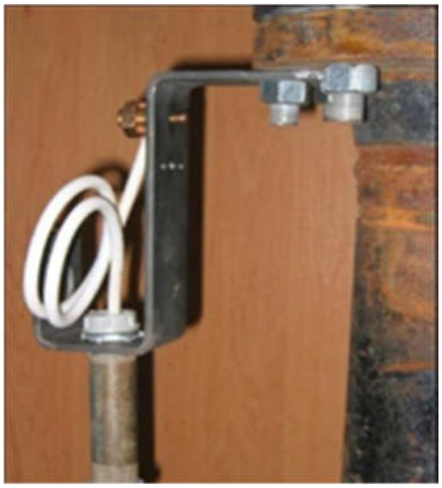


Figure 6-2 Example of a Protective Bracket with Frost Loop, Servit Post™ and Frost Loop (a.k.a. pigtail)

6.2.2 Engineering

Engineering is not required if the carbon steel bracket's cross-section is at least 10 times that of the copper wire.

6.2.3 Applications

These carbon steel brackets may be considered in the following locations, provided that these locations do not expose the connectors and conductors to mechanical damage:

- Wellheads
- Tanks (welded or bolted)
- Vessels (at the shoe or other appropriate point)
- Pipes
- Buildings and structures.

6.3 Pipe Connections – Ground Clamp

6.3.1 Construction

Off-the-shelf certified ground clamps, for example a Burndy® GAR clamp. See Figure 6-3.

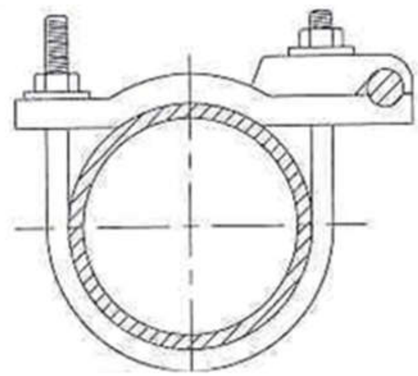


Figure 6-3 Example of a Certified Ground Clamp Connection

6.3.2 Engineering

Engineering is not required when used within the approved current rating of the wire and clamp.

6.3.3 Applications

Certified ground clamp connections are suitable for:

- Connection directly to uncoated, cleaned pipe
- Underground installations with reapplied coating, equivalent to the pipeline coating, covering the entire connection and clamp.

6.4 Exothermic Connections

6.4.1 Construction

Exothermic bonding, see Figure 6-4. Exothermic bonding uses special charges which are ignited and use oxidation reactions to produce heat and fuse the conductor to the steel structure. Charges are premeasured and designed for use with steel. The final bonded connection is covered with protective caps and/or coatings.

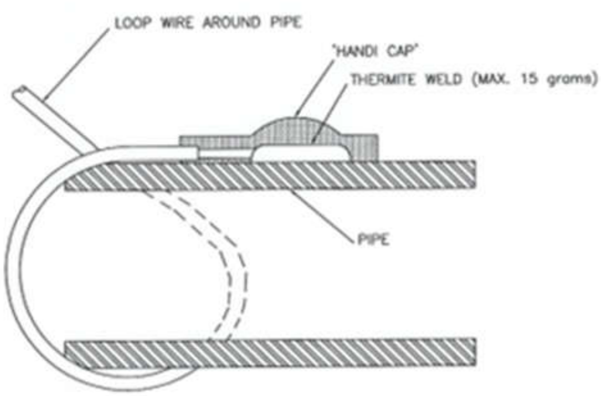


Figure 6-4 Example of a Exothermic Weld Connection

6.4.2 Engineering

No engineering is required, but there are potential metallurgical concerns, e.g. hardness in sour service. Charge sizes and wire sizes should follow industry and operating company recommended practices and standards. Charge sizes are normally limited to no more than 15 grams, sometimes necessitating splitting conductors down to smaller sizes and making more connections. Also, safe work procedures must be applied when making the connection.

6.4.3 Applications

Prior to exothermic connections being made, it is recommended that an assessment be performed to determine the suitability of the proposed connection location. Examples of possible tests or checks which could be used, depending upon the situation, include magnetic particle testing, ultrasonic thickness testing, verification of metallurgy, review of pipeline history and condition, visual inspections, etc.

Exothermic connections are only suitable for:

- Connection directly to uncoated, cleaned, steel structures
- Underground installations with reapplied coating, equivalent to the pipeline coating, covering the entire connection.

6.5 Capacitive Discharge Stud Welding (CDSW) Connections

6.5.1 Construction

The CDSW technique is based primarily upon electric-arc silver soldering. It uses a specially designed portable capacitive discharge tool to solder a pin to the structure. See Figures 6-5 and 6-6.

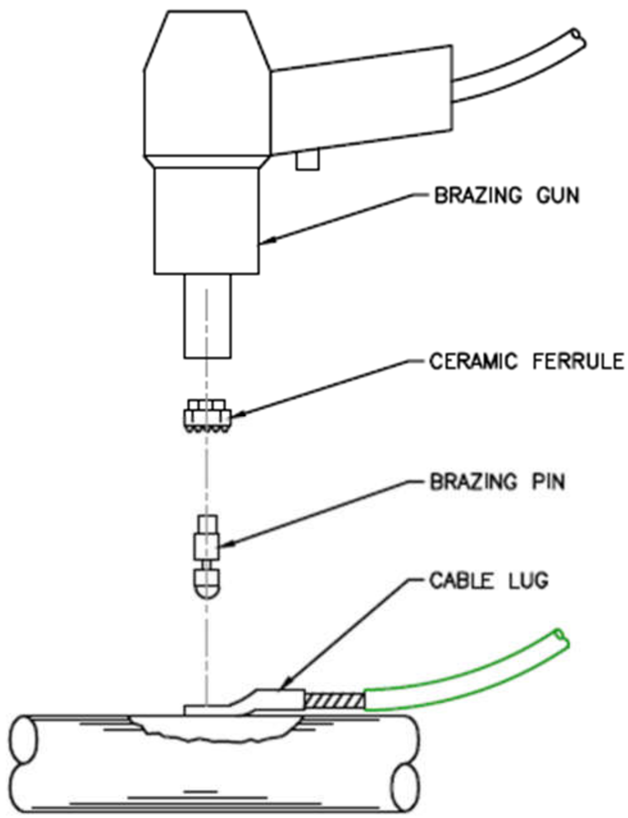


Figure 6-5 Capacitive Discharge Stud Welding System.

Figure 6-6 Example of a Final Capacitive Discharge Stud Welded Connection.

6.5.2 Engineering

No electrical engineering is required. Pin, stud, and wire sizes should follow industry and operating company recommended practices or standards. Also, safe work procedures must be applied when making the connection.

6.5.3 Applications

CDSW connections are only suitable for:

- Connection directly to uncoated, cleaned, metallic structures
- Underground or above ground installations with reapplied coating, equivalent to the pipeline coating, covering the entire connection.

6.6 "LB" Fitting and Plate Connection

6.6.1 Construction

The flat plate bracket is not a certified component, so the design should be engineered. The "LB" fitting is only for external mechanical protection of the wire. See Figure 6-7. A disadvantage of this design is that the wire connection is not readily visible.

Note: the use of the "LB" fitting does not make this device certified for the hazardous area it is used in. In any event, certification is not available for this type of connection.

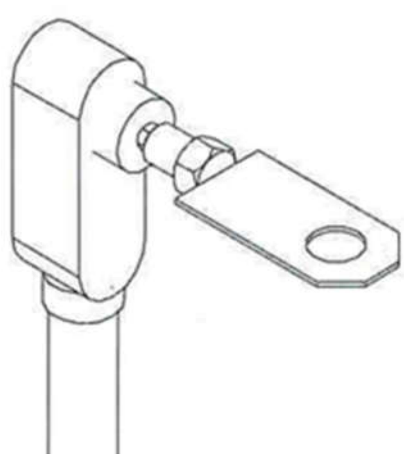


Figure 6-7 Example of an LB Fitting and Plate Connection

6.6.2 Engineering

Engineering is required, including a check for I^2R losses and adequate ampacity.

6.6.3 Applications

"LB" fitting and plate connections are suitable for connection to:

- Wellheads
- Tanks (welded or bolted)
- Vessels (at the shoe or other appropriate point)
- Pipes
- Buildings and structures.

6.7 Pipe Connections – U-Clamp

6.7.1 Construction

There are other cost-effective, but non-certified mechanical connection devices available, such as U-clamps and U-bolt clamps.

6.7.2 Engineering

Engineering is required, including a check for I^2R losses and adequate ampacity:

- Since the clamps are built as mechanical fastening devices, their contact surface and current carrying capabilities are not tested or approved,
- The engineering review has to ensure adequate contact surface and ampacity.

6.7.3 Applications

U-clamps should be used for temporary installations only, as they may be subject to loosening over time. In all cases, administrative or other controls should be used to ensure that the temporary installation does not become permanent.

U-clamps are suitable for:

- Connection directly to uncoated, cleaned, metallic structures
- Underground or above ground installations with reapplied coating, equivalent to the pipeline coating, covering the entire connection.

6.8 Pipe Saddle Connections

6.8.1 Construction

For an example of a saddle connection to pipe, see Figure 6-8. Saddle connections allow cathodic protection connections to be made to the saddle rather than directly to the protected pipeline. Saddle connections use specially engineered saddles which have a curvature that matches the curvature of the pipe being protected. Electrical contact and mechanical connection between the saddle and the protected pipe is made through electro-conductive epoxies. Banding or other means are used to augment mechanical connection between the saddle and the pipe, especially before the epoxy has cured. Special procedures are required for these installations.

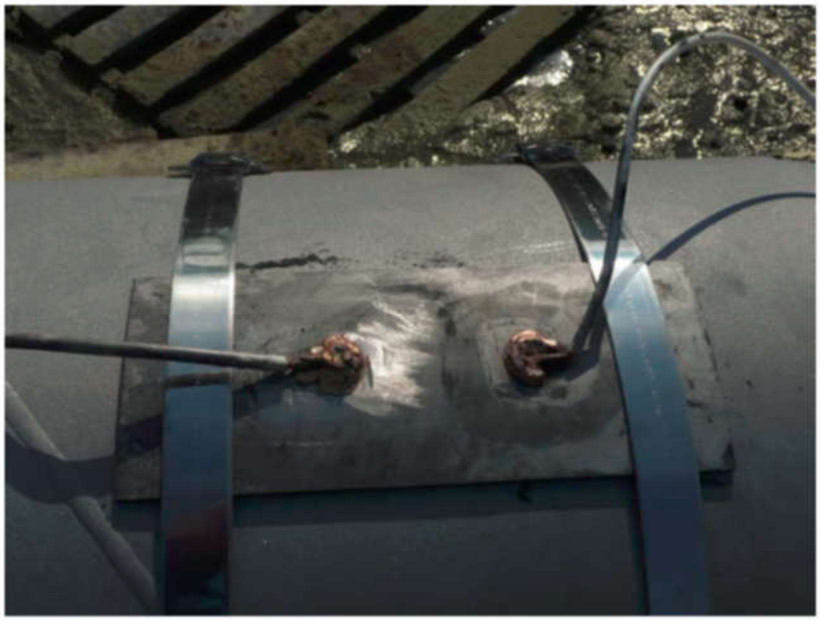


Figure 6-8 Example of a Saddle Connection to a Pipeline

6.8.2 Engineering

Saddle connections are engineered for the specific application.

Engineering considerations include:

- Using proper electro-conductive epoxy product to ensure proper electrical conductivity,
- Adherence to manufacturer's instructions for applying the epoxy (e.g.: applying the epoxy at proper temperatures), and
- Obtaining proper bond strength from the epoxy and the banding.

6.8.3 Applications

Saddle connections are used when the pipeline owner is concerned about damage to the pipe wall from exothermic connections. Consult with the client to determine whether saddles are needed.

Saddle connections are suitable for:

- Connection directly to uncoated, cleaned, pipe surfaces
- Underground or above ground installations with re-applied coating, equivalent to the pipeline coating, covering the entire connection.

7 Splicing and Terminations

7.1 Splicing

See Figure 7-1 for an example of a taped splice (other types are available as well). Examples include split bolt or high-pressure compression fittings. Splices should:

- If located underground, be suitable for direct burial,
- If used for above grade installations, be contained in a suitable junction box,
- Have equivalent, or superior, integrity relative to the original un-spliced conductor,
- Be assembled and installed per manufacturer's instructions.

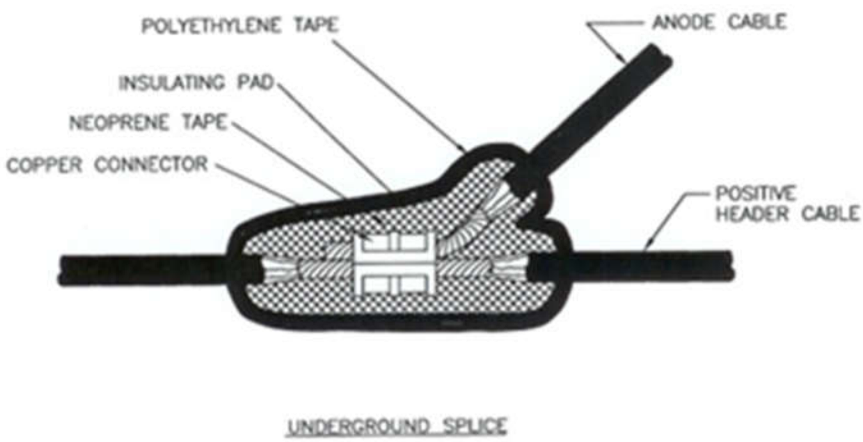


Figure 7-1 Example of a Splice Connection

7.2 Terminations

Terminations (other than underground connections to structures) should be:

- Accessible
- Suitable for the location they are installed in
- Mechanically reliable and secure.

Note: There are no additional requirements beyond these for terminations in *Canadian Electrical Code* defined Class I Zone 2 or Class I Division 2 locations.

8 Current Controllers

Current controllers are adjustable resistors (rheostats) or fixed resistors used to control current going to a particular protected structure. Contacts within rheostats can cause sparks as the resistance value is adjusted. Also, all resistors will produce heat as current passes through them. Both sparking and heat production are a concern in hazardous locations, so current controllers must be located outside of hazardous locations, or be properly rated for the location.

9 Using Insulating Devices

The potential exists in cathodic protection systems to have cathodic protection currents taking multiple paths through facilities, some of which may be through conductors intended for bonding electrical or instrumentation equipment, or through grounding conductors or systems. Where these currents lead to concerns, for example draining of cathodic protection currents, arcing or sparking in hazardous locations (which could lead to a fire or explosion), or mis-operation of devices, then these concerns should be investigated and resolved.

Additionally, the *Canadian Electrical Code Section 10-200 – Current over grounding and bonding conductors* discusses “objectionable current flows” in grounding and bonding conductors.

Some possible scenarios and solutions are:

- Do not inadvertently bypass electrical insulation devices (for example, insulating flange kits and/or dielectric unions). Refer to Section 10.2 for guidance regarding warning signs.
- Be aware of forgotten tools, jumpers, damaged or removed electrical insulation devices, thermal insulation cladding, glycol or electric heat tracing, electrical grounding systems, instrumentation lines, and any other potential parallel path.
- Other bypasses may occur due to wellhead instrumentation, conductive fluids in the pipelines, etc. In those situations, contact the client representative and your engineering support for a more detailed assessment. Long line insulating devices can be considered for the conductive fluid situation.
- Flange shielding (for example taping or other non-conductive external shielding) can be considered in specific situations.
- When objectionable currents are found in bond wires leading to instruments mounted on cathodically protected structures, non-metallic boxes, and/or electrical insulation (on the mechanical connection between the instrument enclosure and the cathodically protected structure) can be considered.

10 Installation

10.1 Installation and Wiring

Electrical installation and wiring should comply with the *Canadian Electrical Code Part 1 C22.1.* The following sections provide additional guidance specific to common cathodic protection installation concerns. This is not an exhaustive list.

10.1.1 Tray Supported Cathodic Protection Cables

Supporting cathodic protection cables in cable tray (new or existing) is acceptable subject to the following requirements:

- Owner approval,
- Meets applicable sections of Section 12 of CEC Part I,
- Proper segregation from high voltage cables when they are present,
- Adhere to any conductor spacing or cable tray loading requirements per CEC Part I and tray manufacturer's instructions,
- Any new tray installations or extensions will be installed per tray manufacturer's instructions, proper engineering design practices, and company specifications. This includes supports for the tray, and bonding of the tray.

10.1.2 Pipe Supported Cathodic Protection Cables

Supporting cathodic protection cables on pipe is acceptable subject to the following requirements:

- Owner approval,
- A recommended maximum of two cables can be supported on one pipe,
- The cable is supported at maximum 1.5 m intervals with proper support clamps, or other support attachments, to ensure a secure connection that does not damage the cable, pipe, or pipe insulation,
- Support at no more than 300 mm from every box or fitting,
- Ensure the cathodic protection cable is protected by location or other means,
- Ensure the cathodic protection cable does not interfere with valves, fittings, or other removable or serviceable components mounted on the pipe structure.

10.1.3 Liquid Tight Flexible Conduit

Liquid tight flexible conduit is acceptable for attaching to protected structures subject to the following requirements:

- Meets applicable sections of Section 12 of CEC Part I
- May be used in non-hazardous or Class I Zone 2 or Class I Division 2 locations only
- Company specifications and standards.

10.1.4 Junction Boxes

Junction boxes are acceptable for cathodic protection wiring distribution and protection subject to the following requirements:

- All applicable CEC Part I Sections, including Section 10 for bonding and grounding, Section 12 for wiring methods, Section 18 for hazardous locations, etc.,
- Specifically, for volume fill considerations, see CEC Part I Section 12-3034,
- All cable connectors should be approved and installed per manufacturer's instructions,
- All junction boxes should be properly mounted on secure structures,
- Proper junction box bonding should be installed,
- All junction boxes should be protected by location or other means (especially near traffic areas),
- All junction boxes should be labeled with proper identification labels, which also match the drawings,
- All junction boxes should be rated for the environment and conditions they are located in,
- Company specifications and standards.

10.1.5 Terminating Conductors

Multiple conductors can be terminated using one connector, subject to the following requirements:

- The connector must be rated for multiple conductors,
- If the connector is not rated for multiple conductors, then only one conductor can be installed in that connector.

In addition, the following requirements should be met:

- The conductors must be within the size limitations of the connector,

- The connector should be rated for the conductor material,
- The connector bolts should be properly torqued (if applicable),
- Manufacturer's instructions should be followed.

10.2 Burial Depth

Codes, standards, and factors to be considered:

10.2.1 Canadian Electrical Code Requirements

The *Canadian Electrical Code* has burial depth requirements in two sections:

Section 12-012 (Table 53)

This rule is intended mainly for power cables where a significant shock, spark, or arc flash hazard can exist.

For un-armoured cables less than 750 V:

- 900 mm burial below vehicular traffic
- 600 mm burial below non-vehicular traffic.

Section 80-002

For DC cables for cathodic protection:

- Burial not less than 450 mm if unprotected
- Burial not less than 200 mm if in raceway or mechanically protected (see Section 10.4 for methods of mechanical protection).

Follow Section 80-002, when no variance for burial depth is in place (see Section 10.2.4)

10.2.2 Alberta Energy Regulator

The Alberta Energy Regulator administers the Alberta *Pipeline Act*[14] and regulations which has requirements governing ground disturbance activities:

- Procedures are required at depths of more than 300 mm
- Companies may have more stringent rules.

10.2.3 Agricultural Activities

Local plowing activities may require deeper burial depth than required in the *Canadian Electrical Code*.

10.2.4 Variances

Corporations accredited under the Alberta *Safety Codes Act*[15] may opt for a *Canadian Electrical Code* variance allowing burial depth of less than *Canadian*

Electrical Code requirements. Example: Some variances currently allow for a ground-grid wire depth of typically 300 mm. Since cathodic protection DC wiring is low voltage, this variance could be extended to include cathodic protection wiring as well.

10.2.5 Warning Tape

Per the *Canadian Electrical Code* rule 12-012, warning tape should be installed 150 mm above the cathodic protection cable. Where the burial depth of the cable is less than 300 mm, the warning tape should be installed approximately halfway between the cable and grade level.

10.3 Wire Protection – Ground Emergence

10.3.1 Mechanical Protection

All wires and cables should be suitably protected when they emerge from the ground. Accepted wire protection methods include:

- Conduit sleeve (metal or PVC) for risers
- Protection by location.

The *Canadian Electrical Code* rule 80-0002 (3) provides requirements for sealing of conduits. Note that these requirements apply only to conduit installations where flammable vapours can migrate from a hazardous location (example: gasoline dispensing equipment) to another location with a different classification (for example, a non-hazardous location). In this rule, it is assumed that conduit is run all the way between the hazardous and non-hazardous locations. When only a conduit sleeve riser is used, a seal is not required since migration to a non-hazardous location is not possible, as the conduit does not run all the way back to the non-hazardous location. The conduit sleeve riser is only intended to protect the vertical section of conductor, and extends into the ground only far enough to ensure conductor protection and adequate support.

10.4 Wire Protection – Underground Wiring

Where required by the *Canadian Electrical Code* or otherwise required, accepted wire protection methods for directly buried wires include:

- Conduit (metal or PVC)
- Planking installed above the cable
- Concrete above the cable.

10.5 Wire Protection – Long Cable Runs

As a good practice, underground cable warning signs should be placed every 300 m, or as appropriate, depending upon site requirements.

10.6 Wire Identification

The following techniques are used to ensure proper identification of cables and conductors:

- Anode conductors are black
- Conductors for protected structures are any colour except black; they are often white
- Tags should be permanent and legible
- Conduit, cable, and conductor tags should be used at each termination point. These should be referenced in drawings so that circuits/conductors can be identified.

11 Warning Signs

11.1 Cathodic Protection Warning Signs

Refer to *Canadian Electrical Code* Section 80 for further details about warning sign requirements, for example, warning signs are required:

- For cathodically protected structures
- Anode bed locations
- On disconnect means
- At the entrances to tanks or vessels with impressed current cathodic protection systems protecting internal components of the tank or vessel.

In addition, it is recommended that warning signs be installed to identify cathodic protection cable routings.

11.2 Electrical Insulation Device Warning Signs

Warning signs should be installed where electrical insulation devices are not immediately visible. In all other cases, it is recommended that warning signs be installed near the locations of electrical insulation devices.

12 Documentation

12.1 General Requirements for Drawings

Both the *Canadian Electrical Code* Rule 80-014 and *CSA Z662 Oil and Gas Pipeline Systems* Clause 9 “Corrosion Control” specify requirements for cathodic protection drawings.

When applicable, the cathodic protection service provider and owner’s electrical representative need to communicate in order to make provision for cathodic protection installation design in the site electrical drawings.

A management of change process should be in place to update drawings and related documentation over the life of the facility.

12.2 Cathodic Protection System Drawings

As-built drawings should be retained for each impressed current cathodic protection installation. These drawings should show details and location of components of the cathodic protection system with respect to the protected structure(s) and to major physical landmarks. In particular, the following information should be contained on the drawings:

<u>AC Wiring and Installation Requirements</u>

- Power source – voltage, load centre and circuit assignment, breaker size or fuse rating
- Location of rectifier and external disconnect
- Cable size, type of insulation and routing information
- Grounding and bonding requirements
- Installation details for equipment.

<u>Cathodic Protection System Wiring and Installation Requirements</u>

- Specifications and drawings for rectifier and related equipment (e.g.: thermo-electric generators, remote monitoring units, etc.)
- Size, type and routing of positive and negative cables from power source
- Location of cathodic protection panels (junction boxes, test stations and other termination points)
- Anode details including anode size, weight, and material specifications; installation methods; installation depths and backfill material
- Locations and details of connections to structures
- Locations and details of electrical insulation devices

- Locations and details of all other equipment such as current control stations
- Right-of-way information (when applicable).

12.3 Area Classification

The site hazardous area classification drawing should be referenced when planning the location of cathodic protection equipment and the layout of cathodic protection installations.

Cathodic protection equipment should be installed outside of hazardous areas unless it is rated for the hazardous location. Equipment that does not produce arcs or sparks may be suitable for installation in a Class I Zone 2 or Class I Div. 2 area. Heat producing connections or equipment (for example, resistance wire) are not acceptable in a Class I Zone 2 or Class I Div. 2 area. Terminations and connections are generally acceptable in Class I Zone 2 or Class I Div. 2 areas.

12.4 Rectifier Schematics, Manuals, and Operating Settings

Documentation covering rectifier schematics, manuals and settings should be stored in a suitable location. This documentation should be:

- Accurate
- In good condition, and
- Legible.

13 Electrical Inspection

13.1 General

All cathodic protection installations are governed by *Canadian Electrical Code* requirements and are subject to government regulated code compliance inspections.

13.2 Accredited Corporations

Accredited corporations have their own electrical Safety Codes Officers inspecting the electrical aspects of cathodic protection installations for *Canadian Electrical Code* compliance.

13.3 Non-Accredited Corporations and Other Non-Accredited Entities

Non-accredited corporations and other non-accredited entities should adhere to the requirements of the jurisdiction having authority. Typically, in Alberta this means the installer is required to obtain a permit from the local municipality or county. In other provinces, a permit will be obtained from the inspection authority (e.g. SaskPower Inspections in Saskatchewan).

14 References

[1] *C22.1, Canadian Electrical Code, Part I*; Canadian Standards Association, Mississauga, Ontario, Canada; www.shopcsa.ca

[2] *Code for Electrical Installations at Oil and Gas Facilities*; Safety Codes Council of Alberta; Edmonton, Alberta, Canada; www.safetycodes.ab.ca

[3] *Occupational Health and Safety Code*; Government of Alberta - Human Resources and Employment; Edmonton, Alberta, Canada; www.qp.gov.ab.ca

[4] *CSA Standard CAN/CSA-Z662, Oil and Gas Pipeline Systems*; Canadian Standards Association, Mississauga, Ontario, Canada; www.shopcsa.ca

[5] *Electrical Safety: A Program Development Guideline*; June 2014; Calgary, Alberta, Canada; www.enform.ca

[6] Corrosion Control Subcommittee; 2005; *Canadian Gas Association Recommended Practice OCC-1-2005 Control of External Corrosion on Buried or Submerged Metallic Piping Systems*; Canadian Gas Association; Ottawa, Ontario, Canada; info@cga.ca

[7] *NACE Standard FP0169: Control of External Corrosion on Underground or Submerged Metallic Pipeline Systems*; National Association of Corrosion Engineers (NACE International); Houston, Texas, USA; www.nace.org

[8] *Alberta Regulation 274/20: Electrician Trade Regulation;* Government of Alberta - Advanced Education and Technology; Edmonton, Alberta, Canada; www.qp.gov.ab.ca

[9] *RSA 2000 cA-42 June 12, 2013: Apprenticeship and Industry Training Act;* Government of Alberta - Advanced Education and Technology; Edmonton, Alberta, Canada; www.qp.gov.ab.ca

[10] Apprenticeship and Industry Training Act; Cathodic Protection Technician Occupation Regulation 17/2013; Government of Alberta - Advanced Education and Technology; Edmonton, Alberta, Canada; www.qp.gov.ab.ca

[11] Apprenticeship and Industry Training Act; Cathodic Protection Technician Exemption Regulation 16/2013; Government of Alberta - Advanced Education and Technology; Edmonton, Alberta, Canada; www.qp.gov.ab.ca

[12] Chapter E-11.1, Revised Statutes of Alberta; *The Engineering, Geological, and Geophysical Professions Act;* Government of Alberta; Edmonton, Alberta, Canada; www.qp.gov.ab.ca

[13] Dorf, Richard C.; 1993; *The Electrical Engineering Handbook*; CRC Press, Boca Raton, Florida, USA; pp. 5-6, 2527.

[14] Chapter P-15, Revised Statutes of Alberta; *Pipeline Act;* Government of Alberta; Edmonton, Alberta, Canada; www.qp.gov.ab.ca

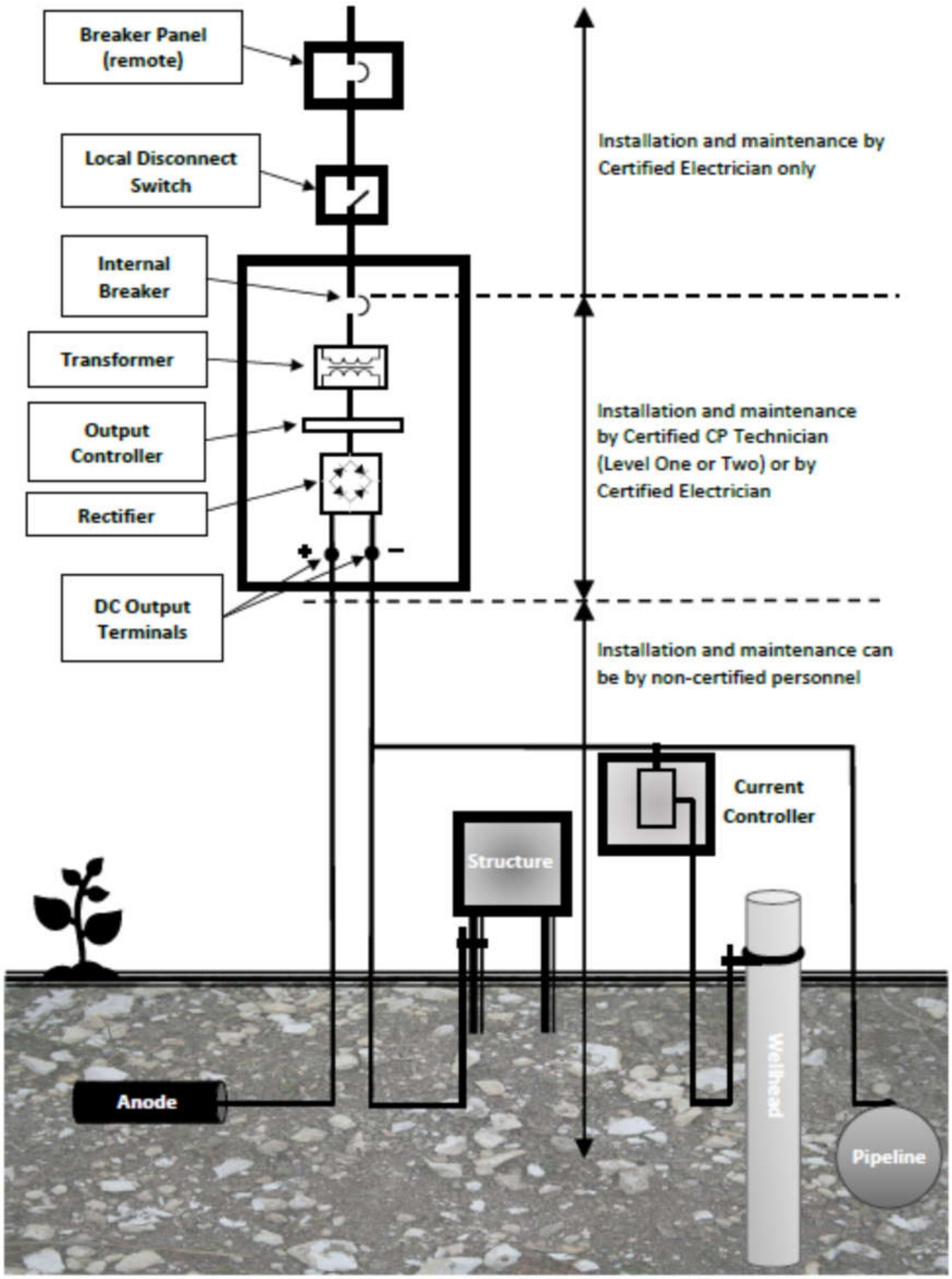
[15] Chapter S-1, Revised Statutes of Alberta; *Safety Codes Act;* Government of Alberta; Edmonton, Alberta, Canada; www.qp.gov.ab.ca

Appendix A. Work Responsibilities or Restrictions for Cathodic Protection Systems from a Trade Perspective

A.1. Trades Scope Diagram

The following diagram delineates the boundaries between Electricians', Cathodic Protection Technicians', and other workers' scopes of work. It is provided for convenient reference only – please consult the specific regulations for exact requirements.

- Note 1: Per the *Electrician Trade Regulation*, an electrician can work on the DC side of the rectifier system, and beyond the DC terminals on the output side of the rectifier, but it is recommended that electricians only do this with cathodic protection industry cathodic protection equipment and trades practices training.
- Note 2: Workers who are not Electricians or Cathodic Protection Technicians can work on output DC circuits external to the rectifier enclosure, but only if they have industry recognized training.


Breaker Panel (remote)
Local Disconnect Switch
Internal Breaker
Transformer
Output Controller
Rectifier
DC Output Terminals
+
−
Installation and maintenance by Certified Electrician only
Installation and maintenance by Certified CP Technician (Level One or Two) or by Certified Electrician
Installation and maintenance can be by non-certified personnel
Current Controller
Structure
Anode
Wellhead
Pipeline