



APPLICATION GUIDE

DECOUPLING ELECTRIC EQUIPMENT GROUNDING SYSTEMS



PROBLEM

Cathodic protection (CP) is most easily achieved when the protected structure is electrically isolated from other structures and from grounding systems. This results in lower current requirements from CP sources, such as rectifiers or galvanic anodes, and generally allows the user to achieve the required voltage criteria for protection against corrosion, per National Association of Corrosion Engineers (NACE) guidelines. However, many cathodically protected structures, such as pipelines and tanks, are inadvertently bonded to other structures and grounding systems, where CP personnel can easily detect that an electrical short exists but can have great difficulty in remediating this connection. Figure 1 shows the typical scenario at a block valve site, where CP is bonded to the grounding system. It is often possible for personnel to specifically identify the bond that shorts the CP system, but they may be unsure of solutions, especially when the short is an electrical grounding conductor that relates to codes and safety.

Even though grounding conductors are identified as the cause of the undesired CP short, these cannot be removed for convenience. Electrical bonding and grounding conductors are needed to conduct AC fault current and prevent over-voltage conditions, and must be left in place. National electrical codes require equipment grounding conductors to be 1) permanent and continuous, 2) rated to handle the anticipated AC fault current from the source, and 3) of low impedance to allow AC fault current to flow, permitting a clearing device (circuit breaker or fuse) to clear the fault. These define what is an “effective ground-fault current path” for safety, per the electrical codes. To remove the offending conductor for convenience on the CP system is to allow an unacceptable shock hazard at the site during any over-voltage condition.

Examples of required electrical grounding codes include the US National Electrical Code, NFPA 70, in section 250.4(A)(5), and the Canadian Electrical code, CSA C22.1, Safety Standard for Electrical Installations, in section 10-500. Other national authorities have similar requirements for safety, describing product requirements, installation materials, and practices.

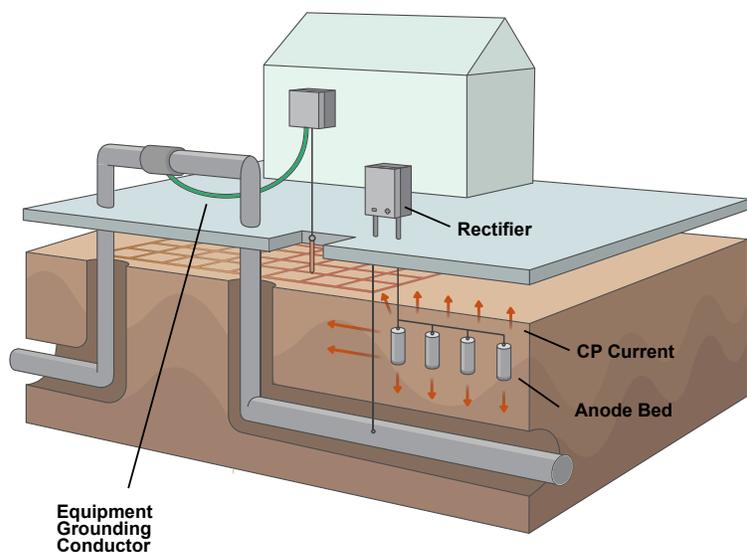


Figure 1: Pipeline electrically shorted to station grounding affects CP

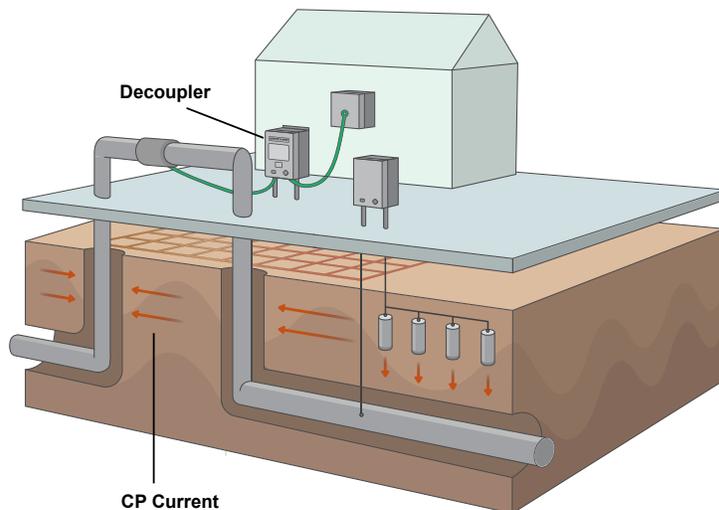


Figure 2: Decoupling blocks CP current in equipment grounding conductor

SOLUTION

While equipment grounding conductors are required, there are solutions that address the conflict with CP. Decoupling devices, or “decouplers,” are solid-state devices that block cathodic protection current but meet safety grounding codes, if the device is independently certified for this use. Decouplers perform a valuable role in making the grounding conductor appear unchanged from an AC current perspective, and allowing all safety functions of the electrical code to be employed, all while blocking CP current. When installed in series in the equipment grounding conductor, CP compliance can be achieved, as well as preserving the needed safety aspects. Figure 2 illustrates how the typical installation locates the decoupler between the electrical equipment on the cathodically protected tank or pipeline and the electrical supply panel that feeds it.



Installation Allowed

Why is a decoupler allowed in an electrical installation, and how does it comply with the electrical codes? If a decoupler has been independently tested and certified as meeting the requirements of an effective ground-fault current path, then it has similar characteristics to the grounding conductor that it has been placed in, and will not compromise that path. While a mechanical switch or a fusible device could never be placed in series in a grounding conductor and meet the code requirements, a certified decoupler can comply. This is explicitly authorized, for example, in US National Electrical Code section 250.6(E) and in Canadian Electrical Code section 10-806(1). For this reason, Dairyland decouplers carry certification marks on the nameplate, traceable to public certification documents showing compliance to the effective ground-fault current path requirements. Decouplers by Dairyland also have additional certifications, such as allowance for use in hazardous locations, which has relevance to this application, as discussed later in this document.

Grounding Conductors versus Neutrals

Certified Dairyland decouplers can be used in series in equipment grounding conductors, which should not be confused with a neutral, which is a grounded conductor. The neutral is a load current-carrying conductor that is grounded at one point in the facility, while a grounding conductor is a non-load current-carrying conductor that performs a safety bonding function. Dairyland decouplers are certified for use in bonding and grounding conductors, not neutrals, and solving any CP short in a facility using a decoupler can be accomplished in the bonding and grounding system, without need for placement in a neutral. Customer confusion about neutrals usually comes from the fact that the neutral that is bonded to the facility grounding system also has a connection to the power utility grounding system at the transformer, and CP current can often be found flowing to the power utility system via the neutral. However, the best solution for simple facilities involves decoupling CP shorts by placement of the decoupler in grounding conductors closer to the point of the bond (near the pipeline or tank). Decoupling an entire facility with CP from the power utility can also be accomplished, when dealing with more complex sites with multiple connections between structures and ground, however that is addressed in other Dairyland documents.

Applicable Installation Sites

As indicated above, certain sites are well suited to decoupling in an equipment grounding conductor, as addressed in this document. These include simple, perhaps small, facilities, where one or several bonds exist between a CP structure and the grounding system. An example of such a facility is a motor-operated block valve site, where possibly only one grounding conductor shorts the pipeline CP to the grounding system. In contrast, a compressor station with dozens of connections to the grounding system is a poor candidate for this approach, as it would require numerous decouplers, with the possibility that a bypass could still exist, rendering the entire attempt

useless. Rather, the best approach for addressing a complex facility can be found in other Dairyland documents, describing how an entire facility, with its CP system, can be DC isolated from the power utility.

Alternative Approaches

Decoupling grounding conductors that affect CP systems can be straightforward and inexpensive, accomplished by a facility electrician. There are other approaches that can accomplish the same end result, however these usually involve greater effort and expense. Some have used electrically isolated joints on either side of a piece of electrical equipment that contains a grounding conductor, to separate that section from the cathodically protected pipeline. If done during the original installation, this can be done inexpensively, however a decoupler should still be used for over-voltage protection of the joint isolation system – an application described in other Dairyland documents. For existing pipelines without such isolation joints, field installation of joints is generally prohibitively expensive and requires a pipeline outage. Decoupling via the grounding conductor therefore becomes much more attractive and requires no pipeline outage.

SPECIFIC INSTALLATION GUIDANCE

There are several typical types of facility construction that provide a continuous metallic path between a cathodically protected structure and a grounding system. The following sections will deal with several common situations, and describe customer-installed arrangements for mitigation of excessive CP current drain.

Warning: This application guide attempts to provide users with additional information for addressing CP problems in facilities via decoupling, but does not cover all electrical requirements, hazards, practices, or other requirements applicable to the sites and installations described herein. The user is responsible for the final application and suitability of the guidance in this document.

Note: Users may be familiar with Dairyland disconnect switches used in series with decouplers, typically associated with AC mitigation applications, which can safely isolate the decoupler. Any such switch may not be used in series with a code-covered grounding conductor, as this would be a violation of code, potentially leaving the grounding system in an “open” state. This loss of the grounding system would result in an unsafe condition during AC fault, lightning, or other over-voltage conditions.

Note on Decoupler Rating and Selection

Selection of a particular Dairyland decoupler model is not covered in this application guide, but guidance can be found on the Dairyland website, via the Applications section as well as the Product Selection Tool. Typically, this application is covered by Dairyland models SSD and PCR, and occasionally the PCRH, but application-specific guidance should be considered in each case.

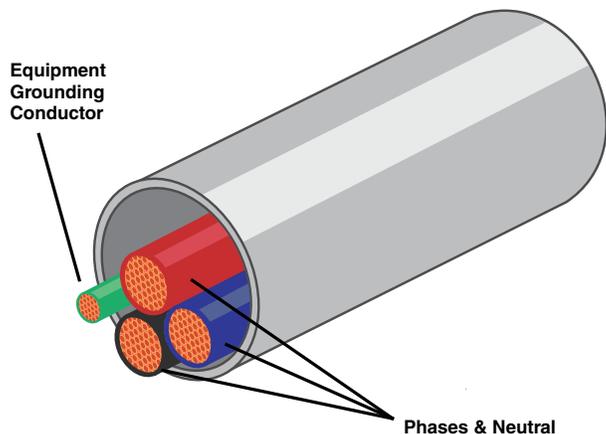


Figure 3: Typical metallic conduit with grounding conductor

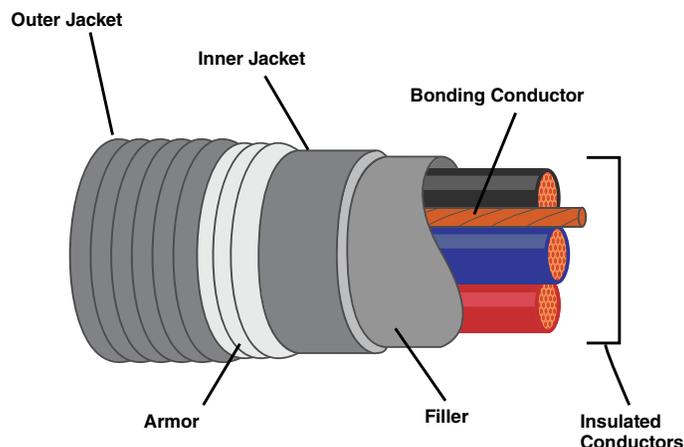


Figure 4: Typical teck (armored) cable construction

Conduit and teck cable:

Continuous metallic conduit can bond electrical equipment on cathodically protected structures to supports and electrical panels, which further bonds to the site grounding system. Likewise, teck cable, which is a bundled cable system with a continuous extruded metallic sheath, bonds between these same connection points. Further, both of these systems have a grounding conductor contained within which also bonds to the same connection points as the conduit and teck sheath. Figures with typical construction are shown below, as well as the typical arrangement for a scenario involving a motor operated valve, with conduit and a grounding conductor that shorts the CP system to the facility grounding system.

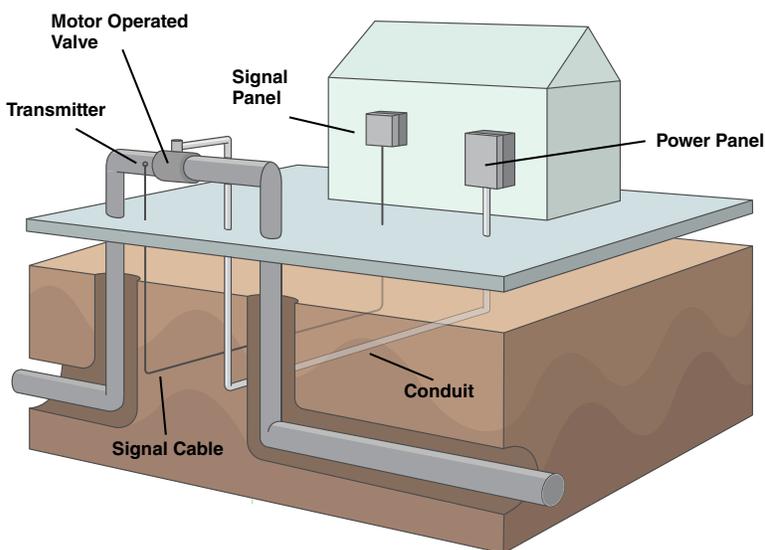


Figure 5: Facility arrangement with AC powered equipment and signal cable

Note that an additional facility feature also commonly bonds between the pipeline and grounding system – a signal cable supporting a transmitter, with a metallic sheath and grounding conductor. If the sheath and ground are bonded at the transmitter to the pipeline, this path has the same effect upon CP as does the motor ground and conduit. Likewise, measurement tubing and other continuous metallic systems can a bypass to the intended isolation. All of these issues are addressed later in this document.

A decoupler, connected in series with the grounding conductor, can block CP current while preserving the AC continuity of the grounding system. This needs to be done at a location where the conduit can also be most easily altered to create an open point. The decoupler will then be connected in series with the grounding conductor, and can also be connected across the open point in the conduit, keeping the system AC continuous. The teck cable sheath is most typically altered at an end of the cable, where it meets a panel or equipment. Options for addressing conduit or teck sheaths with electrical isolation include:

- Installation of a non-conductive enclosure into the conduit (applies to conduit or teck cable)
- Applying an electrically isolated fitting where the conduit/sheath meets the supply panel or the pipeline equipment (applies to conduit or teck cable)
- Replacing a section of the metal conduit with PVC (applies to conduit only)

Each of the above methods addresses the problem of continuous metallic conduit or sheath shorting out the CP system by locating an electrical isolation system at a chosen point along the run. When using a non-conductive enclosure the decoupler is located inside, while the use of an electrically isolated fitting or PVC section must still allow the internal grounding conductor to exit at some point and connect



through the decoupler. For this reason, the decoupler may be located separately from the isolation point. Each of these cases are described in more detail below.

Isolation Point Location Considerations

The conduit or sheath isolation point can be anywhere between the electrical supply panel serving the load and the equipment on the cathodically protected structure. Decisions on where to locate the isolation point should consider the following.

- Access to the conduit or sheath to create a point of isolation – usually at the beginning or end of the run
- The length of conduit or sheath with CP up to the point of isolation, subject to being shorted by inadvertent contact with a grounded object
- Hazardous location zones within the facility, if any
- The number of conduits or sheaths intended to be isolated by a single decoupler. Multiple runs can be decoupled, after consideration of CP systems involved and site layout.

Each of the above points need to be considered during review of every proposed installation in order to avoid excessive effort to test and electrically isolate the conduit or sheath, or to avoid a future bypass of the decoupler.

Access point: Best access to the conduit or sheath typically occurs at the beginning or end of the run on an above grade exposure. Where this metallic system terminates at the panel or cathodically protected equipment, it is easy to install an electrically isolated fitting or alter the system to include a non-metallic enclosure.

Length of run from CP system to the point of isolation: The conduit or sheath is still part of the CP system as it travels back from the cathodically protected structure, up to the point of isolation. If that conduit or sheath segment contacts another grounded object, any decoupling attempt will be already bypassed. Generally, minimizing the conduit length by moving the point of decoupling toward the cathodically protected structure also limits the chance of a bypass. However, this also may affect the hazardous location classification of the isolation point, which is addressed below.

Hazardous locations: The selected decoupler must be rated and certified as meeting the hazardous location criteria of the intended point of isolation. For a Division 2 or Zone 2 site classification, the decoupler must be similarly rated and certified. Likewise, a Division 1 or Zone 1 site requires a decoupler with this rating. An electrical supply panel resides in an ordinary, or non-hazardous, area, while the conduit run may pass through Div 2/Zone 2 and/or a Div 1/Zone 1 areas, requiring an increasing decoupler cost if located in a Div 1/Zone 1 area. Dairyland decouplers rated Div 2/Zone 2 also address ordinary locations.

Number of circuits to decouple: Multiple circuit grounding conductors can be decoupled with a single decoupler, if certain conditions exist. First, consider if the grounding conductors come from CP systems that would be affected

if solidly bonded together at a decoupler. If CP would be affected, then one decoupler should be used for each circuit grounding conductor. Additionally, consider if it is reasonable to wire one decoupler to multiple grounding conductors, or if this effort would require excessive cable length and installation just to avoid the additional cost of a decoupler.

Nonconductive Enclosure with Decoupler

By altering a conduit or teck cable run to install an inline nonconductive enclosure, the conduit can be terminated at the wall of the enclosure, providing the needed isolation. Any phase and neutral conductors carrying load current can pass through the enclosure unaltered, however the grounding conductor should be connected through the decoupler to block CP current. The grounding conductor coming from the cathodically protected structure should be connected to the decoupler negative terminal, while the grounding conductor on the side of the grounding system and electrical panel should be tied to the positive terminal. The conduit or sheath can also be made AC continuous by bonding each where it meets the enclosure wall to the appropriate decoupler terminal (to the same decoupler terminal as the grounding conductor inside that conduit section). See figures 6 and 7.

Dairyland offers nonconductive enclosures to house decouplers for this application, with backplates predrilled for various Dairyland decoupler models. Additional unused backplate area allows for the installation of other customer equipment, such as monitoring devices. See the Dairyland website for various ENCL accessory enclosures.

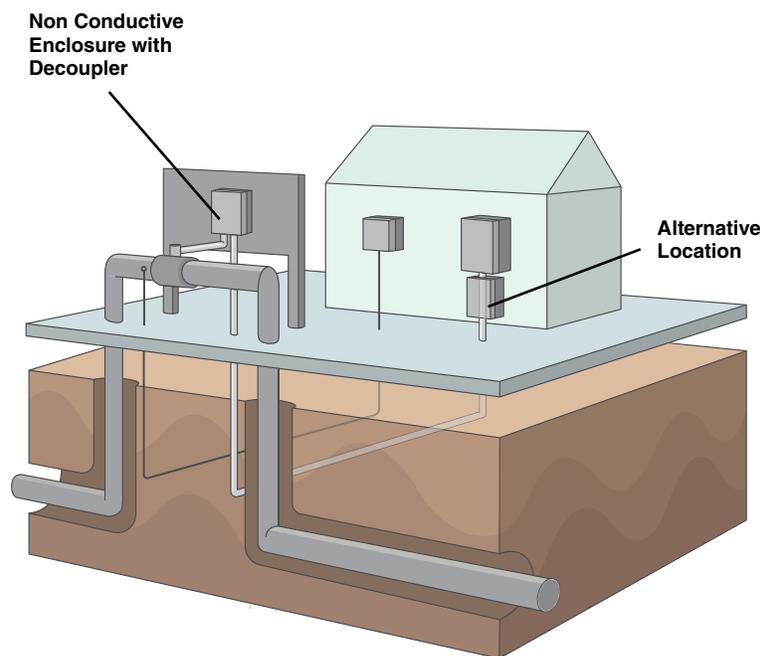
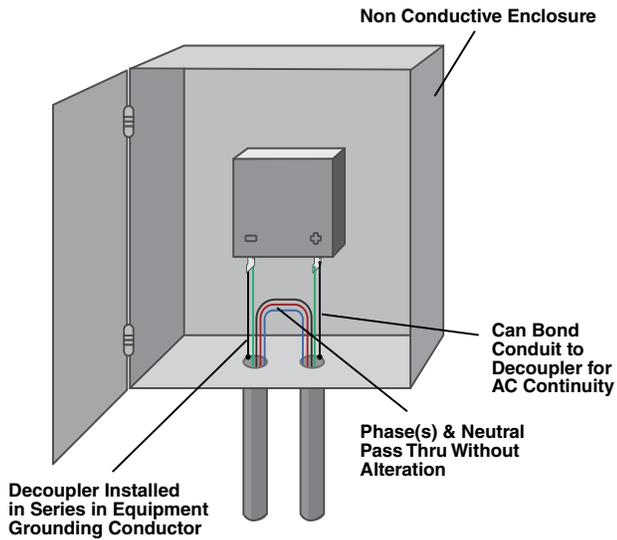


Figure 6: Decoupler in non-conductive enclosure



Equipment Grounding conductor From CP Structure to Decoupler Negative Terminal. Positive Terminal to Supply Panel Grounding Bus.

Figure 7: Decoupler isolating grounding conductor and conduit

Non-metallic conduit and electrically isolated conduit fittings

Another approach for addressing continuous metallic conduit is to replace a segment at one end with a nonconducting conduit material, such as PVC. Electrically isolated conduit fittings can also mate to a panel but provide a nonconducting mount. In either of these cases, the equipment grounding conductor inside of the conduit must first enter an electrical panel, then exit appropriately in order to connect to one decoupler terminal, and finally a new segment of insulated grounding conductor would be added from the other decoupler terminal to the panel grounding bus (if at the panel end) or the equipment grounding point (if at the electrical equipment on the cathodically protected structure). Alternatively, a sealed conduit T fitting can allow the grounding conductor to exit the conduit, connect to the adjacent decoupler, and then continue down the conduit. See figures 8-11.

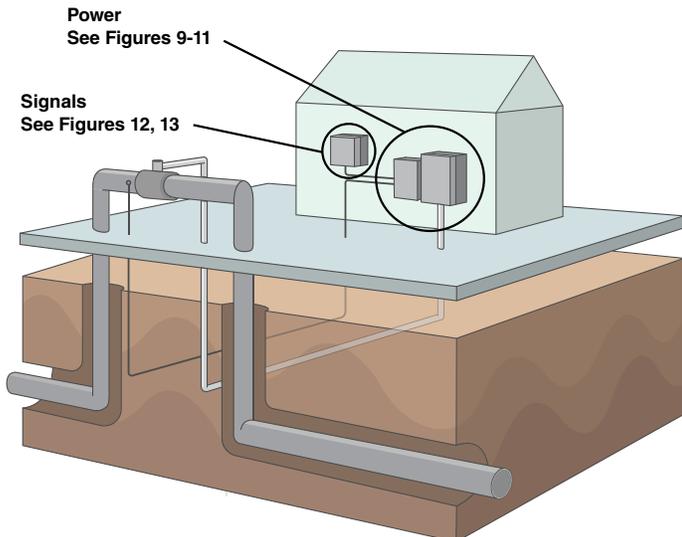


Figure 8: Decoupling details for power and signals

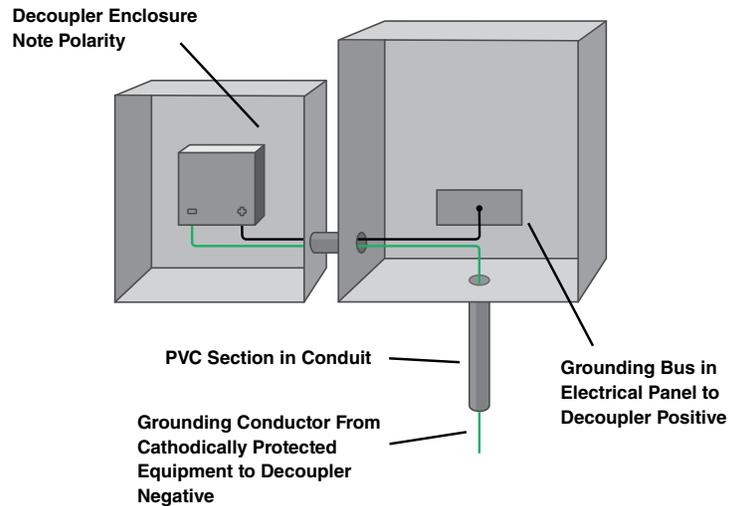


Figure 9: PVC conduit as method of isolation

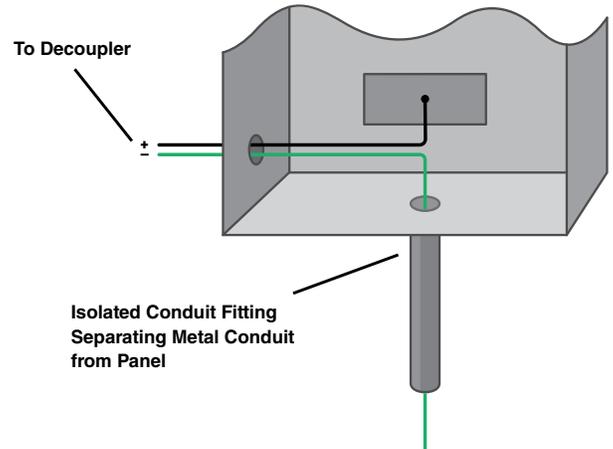


Figure 10: Alternative - Electrically isolated conduit fitting as method of isolation

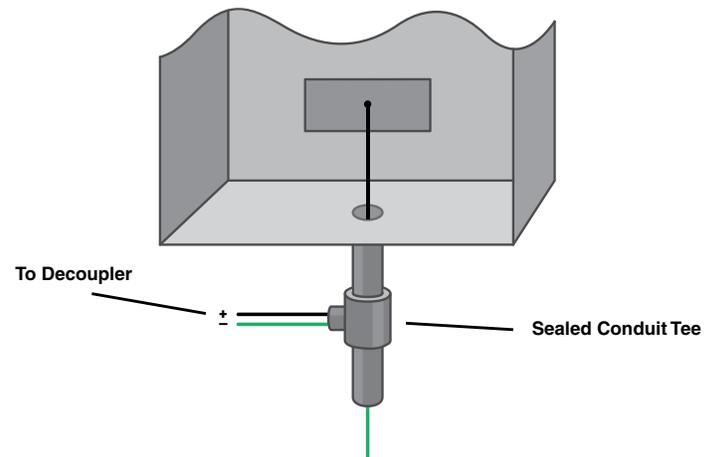


Figure 11: Alternative - Electrically isolated conduit tee as method of isolation



Possible bypasses around the decoupler

Various metallic connections in a facility can bypass a decoupler that has been properly installed in an equipment grounding conductor. Some of these include:

- Signal cable shields and grounding conductors
- Measurement tubing
- Shorted isolators in piping or tubing, or non-isolated piping in contact with grounded objects
- Equipment supports
- Other safety bonds or grounds, such as to nearby structures or grounding grids

Each of these will be addressed briefly, but clearly there are many different arrangements and conditions possible from one facility to the next, and these points should cause the user to more fully examine and test for possible bypasses to the intended isolation.

Signal cable shields and grounds

Transmitters on pipelines and tanks typically have a continuous metallic shield that covers the signal cables, and may have an additional internal grounding conductor as well. These will short the structure to the electrical grounding system, except in the case of a transmitter that has an electrically isolated body. See the drawing of a typical signal cable in Fig 12. The solution for continuous metallic signal cable construction is to create an open point in the shield and/or grounding conductor to block CP current flow, and then protect that open point via a decoupling device. This decoupler may be the same one that is used for electrical equipment grounding conductor, if the two points of isolation can be located near each other, and if the powered equipment and the transmitter are both on the same cathodically protected structure, as in Figure 13. Otherwise, a second decoupler should be used. Practically, the isolation must be at either end of the run in order to extract any internal grounding conductor from the cable bundle. Usually, the AC fault exposure in this connection is very limited, and the lowest AC fault rated Dairyland decoupler can be used, such as the 1.2kA rating. If the decoupler is being used to isolate both an equipment grounding conductor and a signal cable shield, size the decoupler AC fault current rating for the equipment grounding conductor criteria.

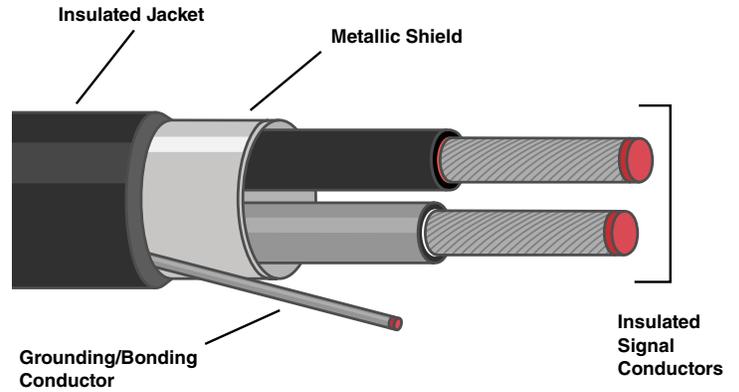


Figure 12: Typical signal cable construction

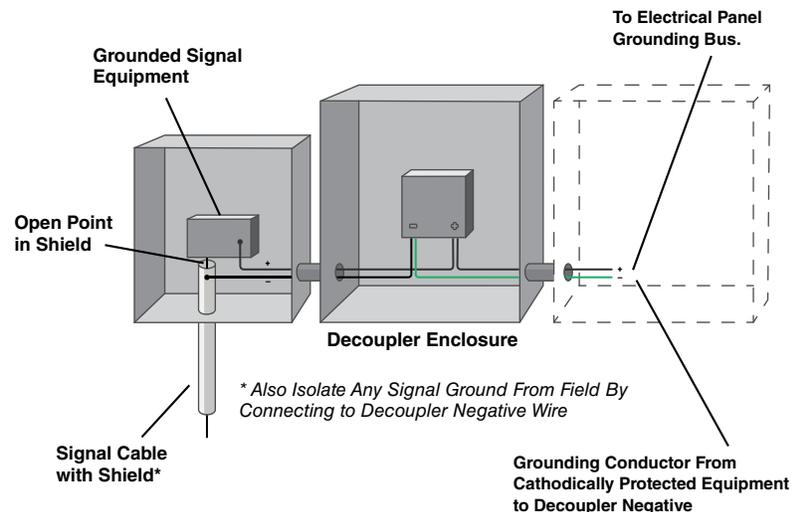


Figure 13: Decoupled signal cable sheath and ground



Measurement tubing

Pipeline pressure measurement or equipment control tubing often bridges between cathodically protected and unprotected structures, affecting CP levels. The solution for such tubing is to install an appropriate electrically isolated fitting or union into the path to isolate CP, as in Fig 14. This may be required in multiple parallel tubing runs, as demonstrated in Fig 15. If all sets of tubing come from the same CP structure, then one decoupler can connect across the isolated fittings, with jumpers across common sides to connect all into the protection scheme. If any existing isolated fittings in tubing are not presently protected, those isolation points should have overvoltage protection via a decoupler in order to prevent arcing and product ignition, as these are often overlooked in overvoltage protection arrangements. Dairyland manufactures tubing clamp kits to allow for attachment to the tubing on either side of the isolated fitting.



Figure 14: Electrically isolated tube fitting as method of isolation



Figure 15: Multiple isolated fittings protected by decoupler

CP POTENTIAL READINGS AND CLEARING ELECTRICAL SHORTS

If cathodic protection readings are unacceptable following decoupling of grounding conductors, there may be various shorts to ground still in existence. These can be challenging to trace, but typical culprits include failed shorted electrical isolation kits (due to previous overvoltage events), piping that has never been isolated properly, pipe supports, and various wired bonds to fences, grounding grids, or other equipment. In each of these cases, testing can typically show CP current flow or electrical continuity, or visual examination may reveal non-isolated points. When the final shorted connection is cleared, CP potentials should immediately improve.

Warning: Any action regarding the clearing of electrical shorts should also closely consider if those points can support voltage during steady-state or abnormal conditions. Such points may require an overvoltage protection device, such as a decoupler, in order to properly reference structures to ground for safety. If steady-state induced AC voltage is present on pipelines, separating metallic connections may result in arcing, which should not be performed in a classified hazardous location. Personnel protection from shock hazards should always be utilized when investigating and testing structures for continuity or isolation. Decouplers provide both AC continuity and DC isolation as well as overvoltage protection, however disconnection from the system may result in an arc and a sudden voltage increase on the structure, if such structure is exposed to induced AC voltage. Users should carefully evaluate facility condition, electrical exposures, and other hazards, and involve appropriate personnel during investigation and remediation.

SUMMARY

Electrical continuity between cathodically protected structures and other unrelated structures or grounding systems can affect cathodic protection, but can usually be addressed by the proper application of isolation techniques and use of decouplers. If questions remain after reviewing the above guidance, please contact Dairyland technical support staff for assistance.