Ship-based Isolation to Prevent Galvanic Corrosion on Ships

Application Note 7A

Introduction

Whenever a marine vessel is connected to AC shore power, a galvanic circuit, which can cause corrosion of the vessel and its drive system components, is established. Anytime there is a direct bond between dissimilar metals in an electrolyte, a galvanic corrosion cell is established. In this application, the direct bond is the grounding conductor in the ship-to-shore power cable, the electrolyte is earth and water, and the metals in the marina and marina electrical grounding system are normally different than the metals in a boat.

A simple way to eliminate this corrosion-causing circuit is to install a decoupling device in series with the safety grounding conductor in the ship-to-shore power circuit. This can be done one of two ways. A decoupling device can be installed by the marina or port operator on the shore side of the circuit or it can be installed on the vessel by the owner. Either installation location will prevent the flow of corrosion-causing galvanic current while retaining the safety features of the grounding conductor, provided an appropriately rated and certified decoupling device is used. This application note deals specifically with preventive measures that can be taken by the marina or port operator. (For information on actions that can be taken by the ship owner, refer to the section on marine applications on DEI's web site or contact DEI.)

When a decoupler is used in the safety grounding conductor of electrical equipment, it must meet certain code requirements. In the U.S., the applicable code is the National Electrical Code (NFPA 70). The most important code sections are 250.2 which defines the requirement for "an effective [AC] grounding path," and 250.6(E), which allows the use of a certified decoupling device for "blocking the flow of objectionable DC current." Section 250.6(E) is a new section in the code beginning with the 1999 edition. For Canada, the products must be certified as meeting the "effective grounding path requirements" per Canadian codes, CSA Standard C22.2 No. 0.4-M1996 using Canadian Electric Code Part 1, Section 10-500 as a guide. Other countries have similar codes.

A key requirement of Section 250.2 is that if a decoupler fails, it must fail as a "short circuit." In the short circuit mode it must still be capable of meeting all published current ratings. If this requirement is not met, it is not "an effective grounding path." DEI products recommended for this application meet and exceed this criterion. That is, when the DEI decoupler recommended for this application is tested to current levels that will cause failure, the product will fail in the short circuit mode and be capable of carrying current well in excess of every current rating (i.e., steady-state current, fault current, and lightning current). On a related note, decouplers that are installed on a vessel must meet requirements which are defined in American Boat and Yacht Council (ABYC) Standard A-28. The ABYC standard does not require or reference the sections of NFPA 70 that should also apply to assure safety grounding under all foreseeable conditions.

Typical Application

A typical installation for installing a decoupling device on the shore side of a ship-to-shore AC power circuit is schematically illustrated in Figure 1 for a single-phase service. Similar criteria apply to other types of single-phase service or three-phase services that utilize a safety grounding conductor.Product

The product recommended for this application is DEI's solid-state Polarization Cell Replacement (PCR). This product is so named because it was originally developed to replace liquid-filled polarization cells, products previously used by others for DC isolation/AC grounding in limited applications. The major limitations of these predecessor products is that they could not be certified as meeting the requirements of an effective grounding path due to their "fail open" failure mode and the need for routine maintenance. The PCR is a certified, maintenance-free device used extensively in the corrosion protection industry where it is often necessary to provide simultaneous DC isolation and AC coupling (or grounding).

DC Blocking Voltage Rating

For this application, either the standard PCR with an asymmetrical blocking voltage rating of -3/+1 volt or the optional symmetrical PCR with a blocking voltage of -/+2 volts is acceptable.

Steady-State AC Current Rating

Under normal operating conditions, the grounding conductor does not carry any steady-state AC current; therefore, the standard steady-state current rating of 45 amperes (60Hz) or 40 amperes (50Hz) is recommended.

AC Fault Current Rating

The primary rating to be selected is the AC fault current rating. The product fault current rating must encompass the available fault current for its time duration. The fault current of interest is the fault current available to flow in the safety grounding conductor of vessel-to-shore power circuit through the decoupling device. The fault current rating required can be determined by one of the following methods.

1. The preferred method is to select a fault current rating based on the circuit breaker clearing curve, for the circuit of interest. Select a product rating in which the product fault current capability for a given time exceeds the current/time clearing curve for the breaker. Contact DEI if you would like assistance with this method.

   First, determine the "Secondary Full Load Current" (I_{FL}) for the transformer using one of the following formulas, depending whether the transformer is single-phase of three-phase.

   (I_{FL}) = Single-phase kVA / kV Secondary
   (For a single-phase service)
   or
   I_{FL} = Three-phase kVA / =3 kV Secondary
   (For a three-phase service)

   (Note: “kV Secondary” is the phase-to-phase voltage expressed in kV)

   Second, determine the available AC Fault Current ($I_{AC\ FAULT\ CURRENT}$) at the transformer terminals as follows:

   $I_{AC\ FAULT}$ = [I_{FL} / % Transformer Impedance] x 100

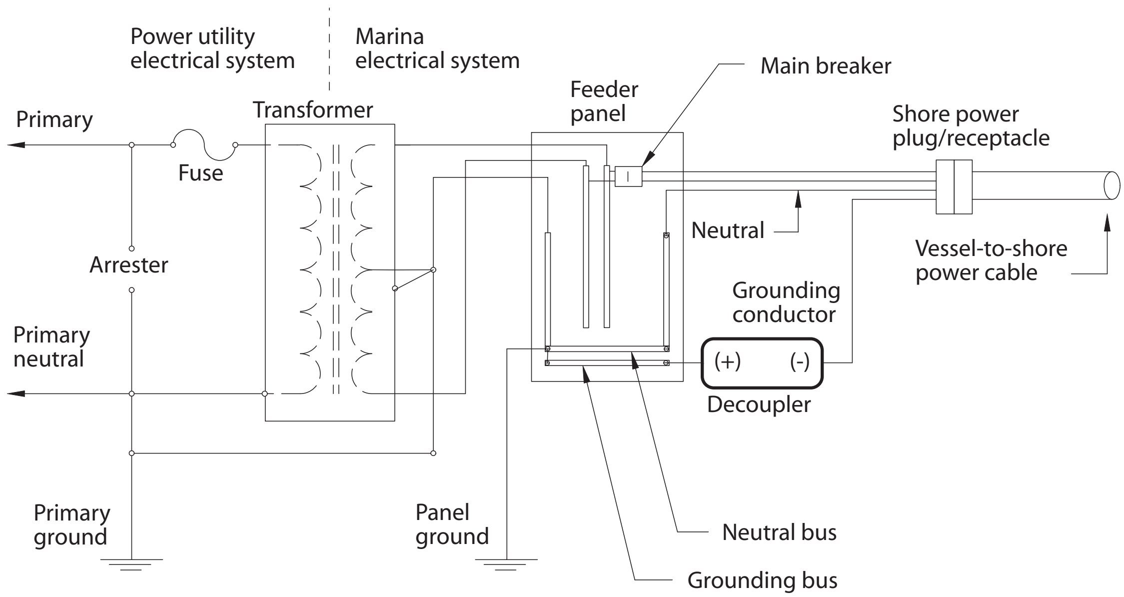
   If the clearing time of the secondary breaker can be determined for the magnitude of fault current calculated above, use that time (converted to cycles) to select a product fault current rating that exceeds the available fault current for the time duration that it can flow. (Refer to the PCR catalog section in the DEI catalog where fault current ratings are published for each model number at 1, 3, 10, and 30 cycles.) Lacking breaker clearing information, assume that most faults will be cleared within 3 to 6 cycles.

2. A second method is to select a product fault current rating that equals or exceeds that fault current carrying capability of the wiring to the electrical load. First, determine the grounding conductor size and material type. Second, look up the fault current ampacity. For copper conductors, this information is shown in Figures 2 and 3 in NACE Standard RP0177-2000. Third, select a product rating that meets or exceeds the conductor ampacity.

3. The most conservative approach is to determine the maximum fault current that is available at the transformer terminals. This method will assure an adequate fault current rating for the decoupling device even if a phase-to-ground fault occurs in the vessel-to-shore power circuit near the shore-based transformer. All information required to calculate the maximum available fault current is on the transformer nameplate.

Refer to the PCR section in the DEI catalog to select the specific product model number and any options or accessories that may be desired.

FIGURE 1 **Representative On-Shore Installation of a Decoupling Device in the Grounding Conductor of a Vessel-to-Shore AC Power Circuit**



Notes:

1. Decoupler: A DC isolation/AC coupling device. Recommended: PCR models by DEI. UL listed per NFPA 70, Article 250.2, 250.6(E).
2. Do not install the decoupler in series with the secondary neutral.
3. Observe polarity marks when installing the decoupler. (Not applicable if the symmetrical voltage blocking rating is selected.)
4. There can not be any bond between the neutral conductor and the grounding conductor on the vessel or at any receptacle because this would by-pass the decoupler.
5. One decoupling device per vessel is recommended, (to prevent bonding the vessels to each other through the grounding conductors, which would establish a vessel-to-vessel galvanic corrosion cell.) However, this will depend on whether this feeder panel serves multiple vessels and if the decoupler can be located at a pedestal or junction box so that the vessel of interest is isolated from all other grounds/vessels.
6. Similar installation procedures apply to other single-phase and three-phase services that utilize a safety grounding conductor.
7. If there is any question as to proper installation procedures, contact DEI for assistance.

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