The Solid-State Polarization Cell Replacement

PCRH: For Class I, Div.1 Locations

INTRODUCTION

The Polarization Cell Replacement for hazardous locations (PCRH) is a solid-state device commonly used in conjunction with cathodically protected structures. This product and its counterpart, the PCR, are an ideal replacement for electrochemical polarization cells because the solid-state design eliminates the maintenance requirements and the potentially hazardous electrolytes associated with polarization cells. Furthermore, the operating parameters offer a number of distinct advantages. Because the device has a higher DC blocking voltage, one device can often replace two or more polarization cells. The product is easy to apply because its operating parameters are precisely defined.

This product is available in two different versions to most economically accommodate the two different hazardous location listings which are available. In many applications, these products are used in a hazardous location; hence, the reason for hazardous location listings.

PCRH
(Leads Optional)

All model numbers with a PCRH prefix are listed for Class I, Division 1, Groups C and D hazardous locations. For more information on the PCR device for Class I, Div. 2 and non-hazardous locations, please see the seperate PCR literature.

These products prevent the flow of DC current when the absolute voltage (i.e., the DC plus peak AC voltage) across the terminals is between -3.0 volts and + 1.0 volt while simultaneously providing a grounding (or coupling) path for steady-state AC current, if AC current is present. A symmetrical version, which blocks +/-2.0 volts is available as an option. Custom versions with other voltage blocking levels will be considered upon request. These products also provide over-voltage protection to both lightning and AC fault current.

TYPICAL APPLICATIONS

- Over-Voltage Protection of Insulated Joints
- Mitigation of Induced AC Voltage
- Blocking Stray DC Voltage
- AC Grounding and DC Isolation of Cathodically Protected Electrical Equipment (such as Motor-Operated Valves)
- DC Isolation of Cathodically Protected Equipment from Power Utility Grounding Systems
- Over-Voltage Protection of Equipment from AC Faults, Lightning, and Switching Transients

RATING INFORMATION REQUIRED

The following information is required for each application in order to select the appropriate product rating.

1) The AC fault current available to flow through the device under a fault condition. (This will often be less than the total fault current available).

2) The steady-state AC current available to flow through the device while blocking the flow of DC current.

3) The DC blocking voltage required.

4) The hazardous location listing required for the planned installation location. If a Class I, Division 1 location applies, select a PCRH model. If not applicable, or if a Class I, Division 2 location applies, select a PCR model instead.

5) The environmental rating of the enclosure.

Items (1) and (2) on previous page will not apply in all applications.

ELECTRICAL RATINGS

AC FAULT CURRENT RATINGS

Three different fault current ratings are offered at 60 Hz and 50 Hz with the following current-time relationship:

AC Fault Current Ratings (Amps AC-RMS Symmetrical				
60 Hz Cycles	PCRH 3.7KA	5KA	10KA	15KA
1	6,500	8,800	20,000	35,000
3	5,000	6,800	15,000	27,000
10	4,200	5,700	12,000	21,000
30	3,700	5,000	10,000	15,000
50 Hz Cycles	**PCRH 3.5KA**	**9KA**	**14KA**	
1	6,100	8,800	19,000	33,000
3	4,700	6,800	14,000	25,000
10	3,900	5,700	11,000	20,000
30	3,500	5,000	9,000	14,000

Understanding 60 Hz Fault Current

To select the correct fault current rating, it is necessary to know how much AC fault current is available to flow through the PCRH in the event of an AC fault.

Faults from the Primary (Power Utility) System

If the PCRH is used to mitigate AC voltage on a pipeline that is in the same corridor as an electrical transmission line, the PCRH could be subject to AC fault current from the transmission line in the event of a line-to-ground fault. For safety, the PCRH allows all current to pass immediately to ground with minimal voltage drop across the terminals (i.e., less than 10 volts under maximum rated fault current). When the fault condition has cleared, the PCRH returns to its normal operating mode, which passes low level steady-state AC current (if present) while blocking the flow of DC current. Another example is when the PCRH is installed across an insulated joint to provide over-voltage protection from lightning and AC faults. In this case, the product protects the joint by passing all AC current through the PCRH around the insulating joint while limiting the voltage across the joint insulation. After the fault or lightning event, the device automatically returns to its normal mode of blocking the flow of DC current.

Faults from the Secondary (User) System

For example, consider a PCRH used to provide AC grounding and DC isolation for an item of electrical equipment that is an integral part of a cathodically protected pipeline (e.g., a motor- operated valve). If the equipment has an electrical short-circuit, the PCRH allows all current to flow through itself to ground, thus grounding the fault. The amount of available secondary fault current can be calculated from the data on the transformer nameplate (kVA rating, the % transformer impedance, and the transformer secondary voltage) using the information in the next section.

How to Determine Fault Current Available for a Specific Application

- If the potential fault current is from the primary (power utility) system, call the local power utility and request the phase-to-ground fault current magnitude and duration (i.e., number of cycles of current) at the specific locations of interest.
- If the potential fault current is from the secondary (user) system:

Step 1: determine the "secondary full load current" of the transformer providing power by using the appropriate following formula:

$$\text{Secondary Full Load Current} = \frac{\text{1 Phase Transfomer kVA}}{\text{kV Secondary}}$$

OR

$$\text{Secondary Full Load Current} = \frac{\text{3 Phase Transfomer kVA}}{\sqrt{3}\ \text{kV Secondary}}$$

Step 2: Determine the "worst-case" fault current using the following formula.

$$\text{Available Fault Current} = \frac{\text{Secondary Full Load Current}}{\text{\% Transformer Impedance}} \times 100$$

(This gives the fault current available directly at the transformer terminals, which is the worst case scenario. Fault current decreases rapidly with distance from the transformer.)

Select a PCRH fault current rating that encompasses the fault current available. Also see the DEI website for more sizing options.

STEADY-STATE AC CURRENT RATINGS

This rating represents the maximum steady-state AC current that is allowed to flow through the device while still blocking the flow of DC current.

The table represents maximum values. As the DC voltage approaches the maximum blocking voltage rating selected, the allowable steady-state AC current is reduced as shown in Figure 1.

Steady-State Current Ratings (Amps AC-RMS Symmetrical)	
Ambient Temp	**50/60 Hz 45A**
20°C	50A
65°C	40A

There are a number of applications where a PCRH may be required to block DC while simultaneously carrying steady-state AC current. For example, when a pipeline is in the same corridor as an electrical transmission line, steady-state AC voltage is often induced on the pipeline. The PCRH can mitigate this voltage by providing a low AC impedance path to ground while simultaneously preventing the flow of DC current.

The steady-state AC impedance of the PCRH at 60 Hz is 9.8 milliohms, and at 50 Hz, the comparable impedance is 11.9 milliohms. Under an AC fault or lightning current condition, these impedances momentarily become virtually zero.

Determining Steady-State Current Rating

To determine the steady-state AC current rating it is necessary to determine how much steady-state AC current is available to flow through the PCRH. If this cannot be determined by analytical means, it can be measured as follows. Connect a solid jumper (i.e. short circuit) between the two points to which the PCRH will be connected and measure the steady-state AC current with a clamp-on AC ammeter. For greatest accuracy, measure during a known electrical system load (on the electrical transmission system) and then ratio the results to the expected peak electrical system load. The local power utility can provide known system load and its ratio to peak system load. Select a steady-state rating that is above the maximum steady-state current to be expected for the forseeable future.

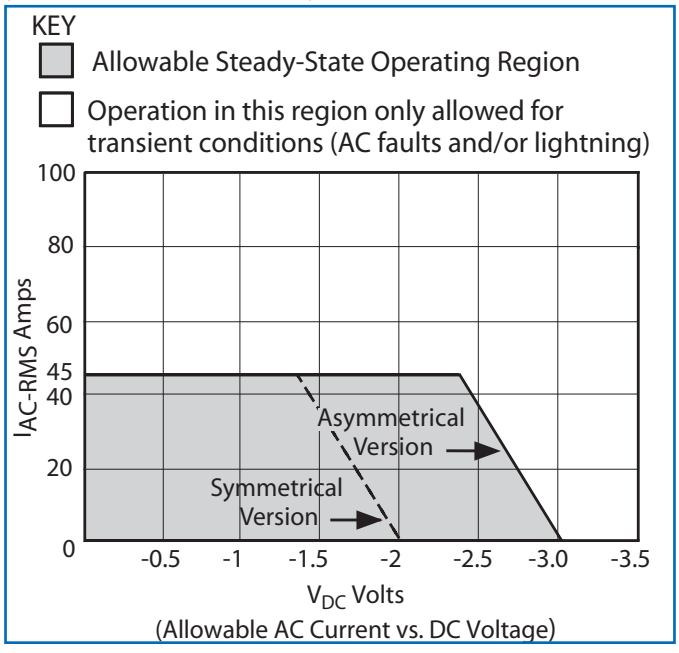
DC BLOCKING VOLTAGE RATING

The standard, and most commonly specified, PCRH model has an asymmetrical voltage blocking rating of -3.0 volts to +1.0 volt. Either model can also be furnished with a symmetrical voltage blocking rating of +/- 2.0 volts. Other voltage blocking ratings will be considered upon request.

The reasons for symmetrical and asymmetrical choices are best described with an example. If the PCRH is used to provide over-voltage protection for an insulated joint and both sides of the joint are cathodically protected, the DC voltage across the joint will be the difference in voltage between the two cathodic protection systems, normally near zero volts. For this application it is desirable to select the symmetrical +/- 2.0 volt blocking rating. In the event that the cathodic protection system is OFF on one side of the joint, the device can block 2.0 V_{DC} in either direction.

If one side of the insulated joint is cathodically protected and the other side is grounded, then it is preferable to select the asymmetrical version which blocks from -3.0 volts to +1.0 volt since DC current flow only needs to be blocked in one polarity. Whenever one side is referenced to ground, the asymmetrical version is suggested because this initiates voltage clamping when any positive voltage on the cathodically protected structure attempts to exceed +1.0 volt.

FIGURE 1 PCRH Operating Characteristics @ 43°C (Standard 45A @ 50/60 Hz)



The DC leakage current of any model is well under 1.0 milliampere under typical operating conditions where the DC voltage is in the 0.85 to 1.25 V range, even when the temperature is up to 65ºC. See Figure 2.

LIGHTNING SURGE CURRENT RATING

All models have the same lightning surge current rating which is shown in the following table.

Lightning Surge Current Rating For all models	
Peak Amperes	**100,000**

Note: 8 x 20 microsecond waveform

When providing over-voltage protection from lightning, the PCRH should always be installed with the shortest possible lead length to minimize clamping voltage.

The peak voltage directly across the voltage-clamping elements within the device is less than 250 volts at rated lightning surge current; however, the voltage developed between the lead connection points will be greater due to the effect of lead inductance. Leads can develop from 1 to 3 kV per foot (approx. 3 to 10 kV/meter) when subject to lightning current. This is the reason that leads should be kept as short as possible.

FEATURES AND CHARACTERISTICS

Certifications

Underwriters Laboratories (UL) has listed the PCRH as meeting the criteria for "an effective grounding path" as defined in Section 250.2 and 250.4(A)(5) of the 2005 edition of the U.S. National Electrical Code (NFPA 70), thereby enabling its use as an AC grounding device.

The PCRH is also listed by UL as meeting:

- The requirements of a DC isolating/ AC coupling device suitable for the isolation of objectionable DC current from cathodically protected systems to ground as defined in the 2005 edition of the NFPA 70 Article 250.6(E).
- An over-voltage protective device, having been tested to the applicable requirements of ANSI C62.11.

The PCRH is listed by Underwriters Laboratories (UL) for use in hazardous locations in accordance with NFPA 70 (U.S. National Electric Code), Articles 500-505 for Class I, Division 1, Groups C, and D. (Optional: Groups B, C and D are available in a non-raintight enclosure.) The applicable UL standard to which the PCRH is listed is UL 1203 which deals with explosion proof products to meet Class I, Division 1 requirements. The listing is valid for ambient temperatures from -45ºC to +65ºC. The operating temperature code is T5 (100ºC). Refer to NFPA 70 for comparable zone listings if required.

The PCRH is also C-UL listed to the above classifications per Canadian code C22.2 No. 30-M1986.

Solid-State Design

Both the PCRH and its counterpart, the PCR use proven solid-state components which have an instantaneous response with respect to voltage, thereby initiating voltage clamping immediately when the voltage attempts to exceed the blocking level selected.

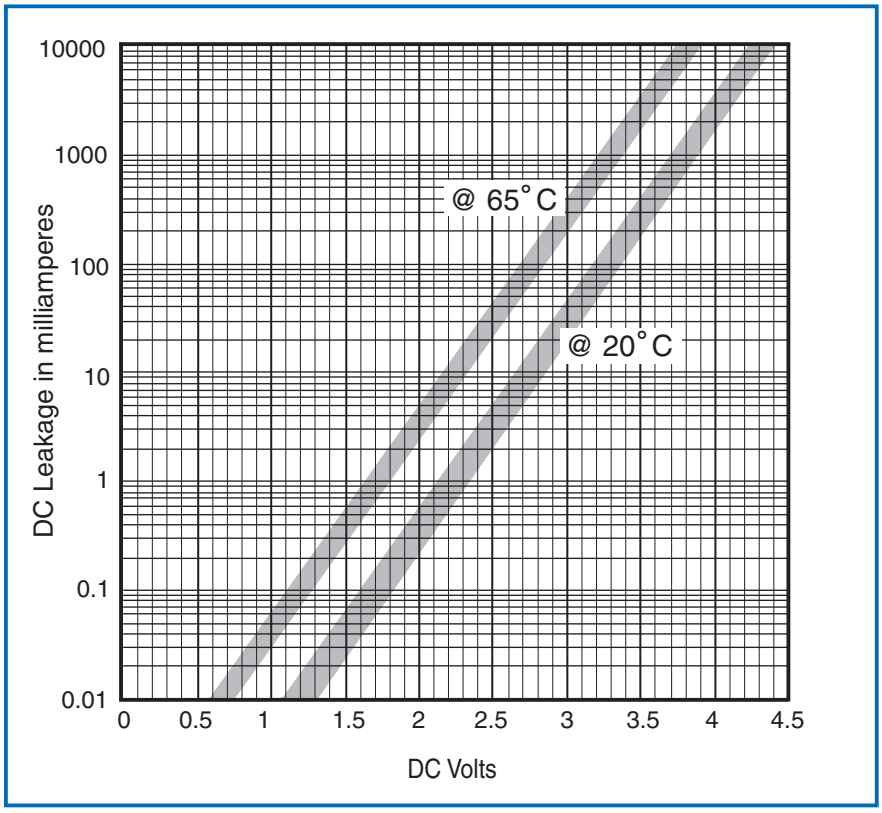
Fail-Safe

An important safety feature is that if subject to AC fault current or lightning surge current in excess of rating such that failure occurs, failure will occur in the shorted mode. In the shorted mode, the unit can carry greater than rated fault current or lightning surge current and still provide an effective grounding (or conducting) path.

Enclosure

All PCRH enclosures are explosion proof and are made of cast aluminum. The standard enclosure is NEMA 4 (comparable to IP66). This enclosure is listed for Groups C and D by UL in the U.S., and for Groups B, C and D by UL in Canada. The positive terminal is bonded internally to the metallic enclosure.

FIGURE 2 DC Voltage vs. DC Leakage Current (Standard Asymmetrical PCR/PCRH)



Mounting

All PCRH versions have a 3/16" (4.8 mm) thick aluminum back-plate which can be mounted to a flat surface with two 1/2" (12 mm) bolts, user furnished. All models are also furnished with appropriate holes in the back plate, suitable for U-bolt mounting to a 2" pipe (2.375" or 60.3 mm outer diameter). See the accessories section for more information on the Pipe Mounting Kit.

It is always recommended that the product be mounted so that the total lead length to the connection points is kept as short as possible so as to minimize the voltage developed due to lead inductance. (Refer to section on lightning current ratings.) Because of the internal bond between the enclosure and positive terminal, mount the PCRH on a structure not in contact with the cathodically protected structure.

Packaged Weight / Unit

The PCRH-3.7KA (60 Hz) or PCRH-3.5KA (50 Hz) and the PCRH-10KA (60 Hz) or PCRH-9KA (50 Hz) models weigh about 30 lbs. (13.6 kg). The PCRH-15KA (60 Hz) or PCRH-14KA (50Hz) model weighs about 39 lbs. (17.7 kg). These weights are exclusive of packaging, leads, or other accessories that may be ordered and packaged with the product.

Polarity / Electrical Connections

Polarity marks (+) and (-) are provided above the lead connection points to aid in proper installation. Connect the (-) to the structure with CP and the (+) to the grounded, or more positive, system. Lead connections are made to bush-

ings which have a 1/2" x 13 diameter threaded stud that is 0.875" long. It is suggested that the PCRH be purchased with factory furnished leads and connectors to simplify field installation. The lead length is user-specified when ordering. Two lead connection options are offered. Leads can be either axial connected to the bushing studs (preferred, and only possible with components furnished by DEI) or angle connected (90º or 45º) using commercially available connectors with a hole that accommodates a 1/2" (12 mm) bolt.

Terminals, pre-connected to adapter plates, are also available to facilitate mounting across insulated joints or to similar bolted connection points. See Figure 5.

Size

Refer to the following figures for dimensional data for each product. Figures: 7A, 7B.

Ambient Temperature

-45º C to +65º C

Number of Operations

Virtually unlimited under maximum ratings, provided the operations are not immediately repetitive.

Energy Requirements:

None. The devices are totally passive.

Model Number Structure

Model # = PCRH-A-B-C

A: Fault Current

Symmetrical AC-RMS fault current rating at 30 cycles in kA.

(See previous rating table for capability at 1, 3, and 10 cycles.)

60Hz	50Hz
3.7KA	**3.5KA**
5KA	**5KA**
10KA	**9KA**
15KA	**14KA**

B: Asymmetrical vs. symmetrical voltage blocking

Omit B if the standard asymmetrical voltage blocking level of -3.0 volts to +1.0 volt is acceptable. If a PCRH with a symmetrical voltage blocking level of -2.0 volts to +2.0 volts is desired, then specify **"S"** in this model position.

Examples:

PCRH-3.7KA
(Asymmetrical blocking)

PCRH-3.5KA-S
(Symmetrical blocking)

C: Enclosure: Group Rating

Specify **"CD"** for the standard PCRH which is furnished in a raintight enclosure rated NEMA 4 (equivalent to IP66) and rated for Groups C and D. Note: This same enclosure is listed for Groups B, C, and D by UL in Canada. For other enclosure/group rating combinations, contact DEI.

Examples:

PCRH-3.7KA-CD
(Asymmetrical blocking, Groups C and D)

PCRH-3.5KA-S-CD
(Symmetrical blocking, Groups C and D)

Accessories

If desired, order the following seperately:

Lead Options

When leads are not furnished with the PCRH, the user must make provision to connect the leads to a 1/2" x 13 diameter threaded stud that is 0.875" long (≈ 25 mm dia. x 22 mm long). The stud is furnished with two hex brass jam nuts per stud. User furnished leads can only be installed with a right-angle or 45° angle connection using commercially available one-hole connectors. Factory furnished, axial-connected leads are suggested for most applications.

The PCRH can be furnished with extra flexible, insulated 2/0 AWG (≈ 70 mm²) stranded copper leads either for axial connection (recommended) or for right angle connection to the 1/2" (≈ 12 mm) diameter bushing studs as illustrated in Figure 3. When axial-connected leads are furnished, a length of heat-shrink sleeve is provided to completely insulate the lead-to-bushing connection.

If Axial-Connected Leads are desired, specify **ACL-"L," where L is the desired length.**

If Right-Angle Connected Leads are desired, specify **RACL-"L," where L is the desired length.**

Specify the units for length "L" (e.g., inches, mm, etc.).

Each PCRH requires two leads. If only one length is specified, both leads will be furnished to the same length. Axial-connected leads will be factory connected to the bushing stud and insulated for lead lengths up to about 15 ft. (4.6 m). (Always minimize lead length to provide the best over-voltage protection.) Longer leads will be packaged separately. If axial-connected leads of different lengths, but less than 15 ft. (4.6 m) are specified, advise which length goes to the positive and negative terminals, in which case they will be factory attached to the PCRH bushing studs and insulated.

Lead Adapter Plate Options

If the PCR leads are to be bolted to their connecting points in the field, such as across an insulated joint, a 1/8" (3.2 mm) thick, nickel plated copper adapter plate can be furnished to simplify making this connection. The adapter plate has a factory-assembled bolted-type cable lead connector that accepts 2/0 to 4/0 AWG (70 to 120 mm²) conductor with a mounting hole size specified by the user. Reference Figure 4 for Adapter Plate details.

If Adapter Plates are desired, specify

model **AP- "D"** where **"D"** is the bolt diameter in inches or mm. The resulting hole diameter in the adaptor plate will allow sufficient clearance for the outer diameter of the insulating sleeve over the flange bolts. Ideally, the insulating sleeve over the bolt, and the bolt to which the adapter plates are attached, should be 1/4" (6.4 mm) longer than the other sleeves/bolts to account for the thickness of two adapter plates. Most manufacturers of insulated joint kits can provide one different length bolt and insulating sleeve in an insulation kit upon request.

Pipe Mounting Options

Any PCRH can be mounted using a Pipe Mounting Kit which includes U-bolts, a 2" diameter pipe, 48" (1219 mm) long, a 4-bolt threaded pipe flange base suitable for mounting to a field fabricated concrete foundation, and four 5/8" x 12" (≈ 16 mm x 305 mm) galvanized anchor bolts, each with two nuts. Complete Pipe Mounting Kits can be ordered with any PCRH model by specifying PMK2-48.

Pedestal Mounting Options

A light green 36" fiberglass pedestal is available for enclosing the PCRH and all cable connections. When the PCRH is used in applications where both cable lead connections come from below ground level (e.g., AC voltage mitigation applications) or where it is desired to provide a second level of protection around the standard PCRH enclosure, the Pedestal Mounting Option can be ordered as an accessory. All mounting hardware required to mount the PCRH in the pedestal will be packaged with the PCRH. The channel bracket, normally furnished with a PCRH, will be omitted.

See Figure 6 for Pedestal details. The height of the standard pedestal is 36". To order, specify **Pedestal-36"** plus the desired PCR model.

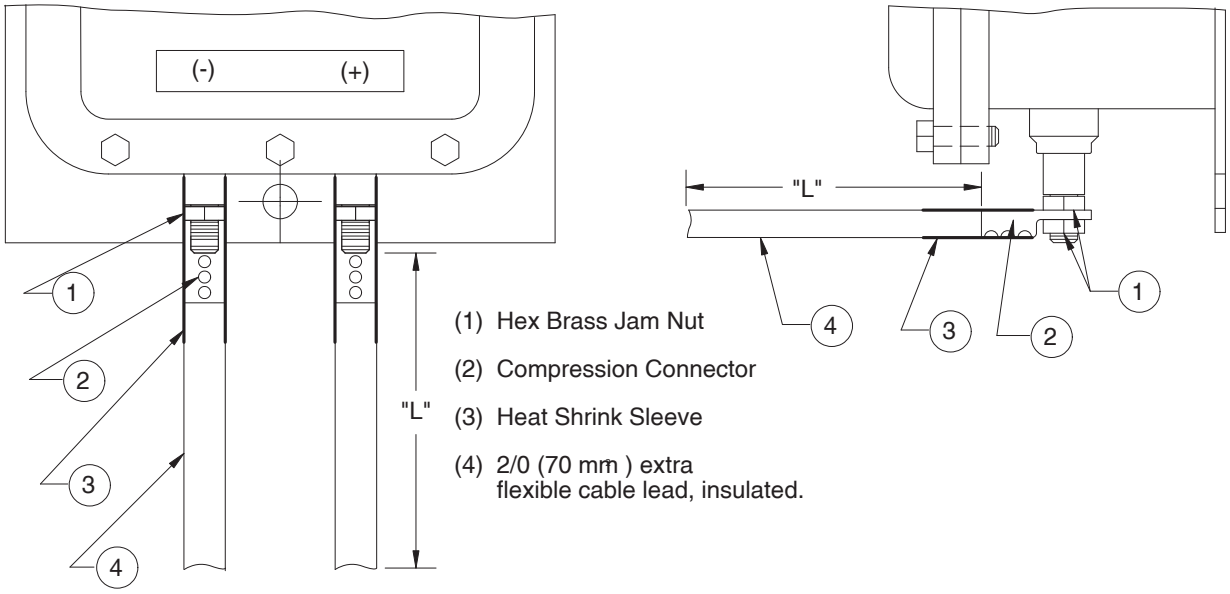
Example:

Pedestal-36"

FIGURE 3 Cable Lead Option – PCRH

Axial Connected Leads
To order, specify the value and the units for "L" in the following part number:
ACL-"L"

Right Angle Connected Leads
To order, specify the value and the units for "L" in the following part number:
RACL-"L"



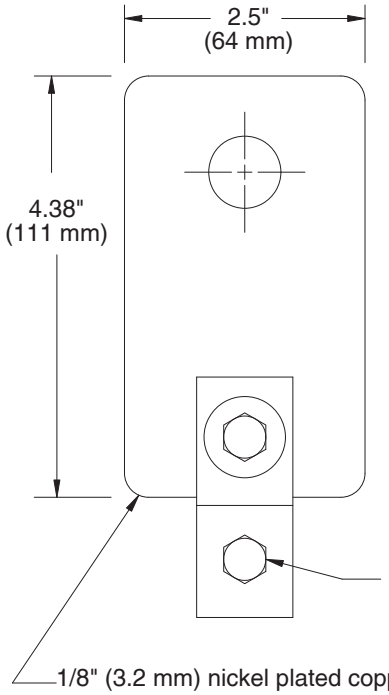
(1) Hex Brass Jam Nut

(2) Compression Connector

(3) Heat Shrink Sleeve

(4) 2/0 (70 mm) extra flexible cable lead, insulated.

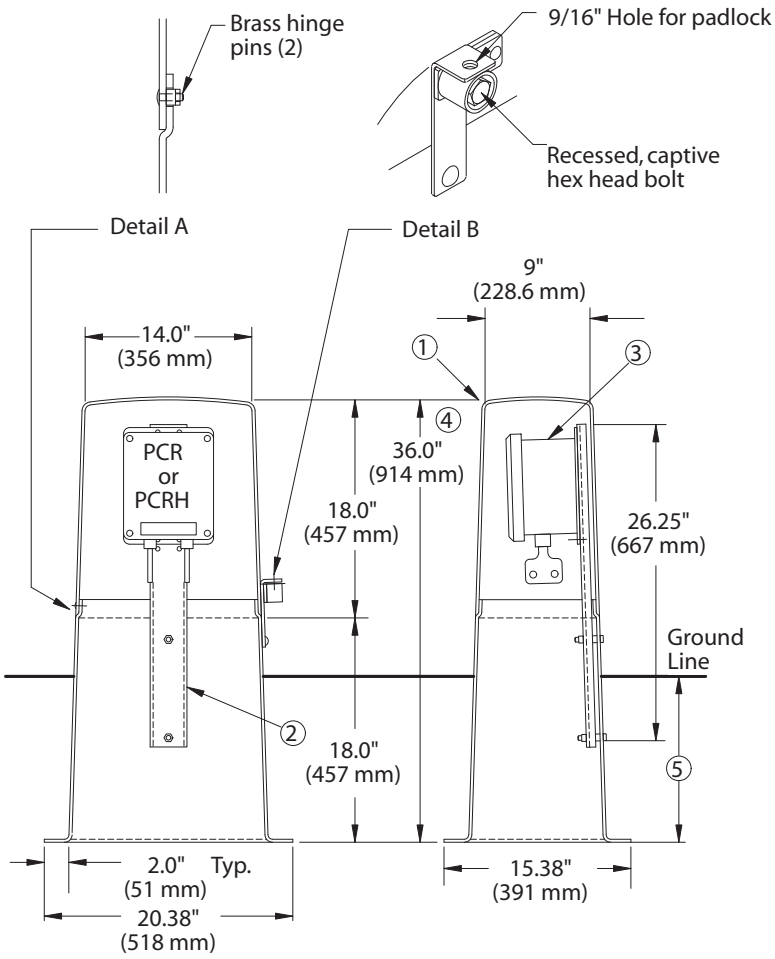
FIGURE 4 Adapter Plates – PCR or PCRH



To order Adapter Plate, specify bolt diameter "D" in inches or mm in the following part number: AP-"D". Hole diameter will be determined from the bolt diameter.

Bolted connection accommodates 2/0 to 4/0 AWG. (70 to 120 mm) copper conductor. Other size terminals and adapter plates will be considered upon request.

FIGURE 6 **Pedestal Mounted PCR or PCRH**



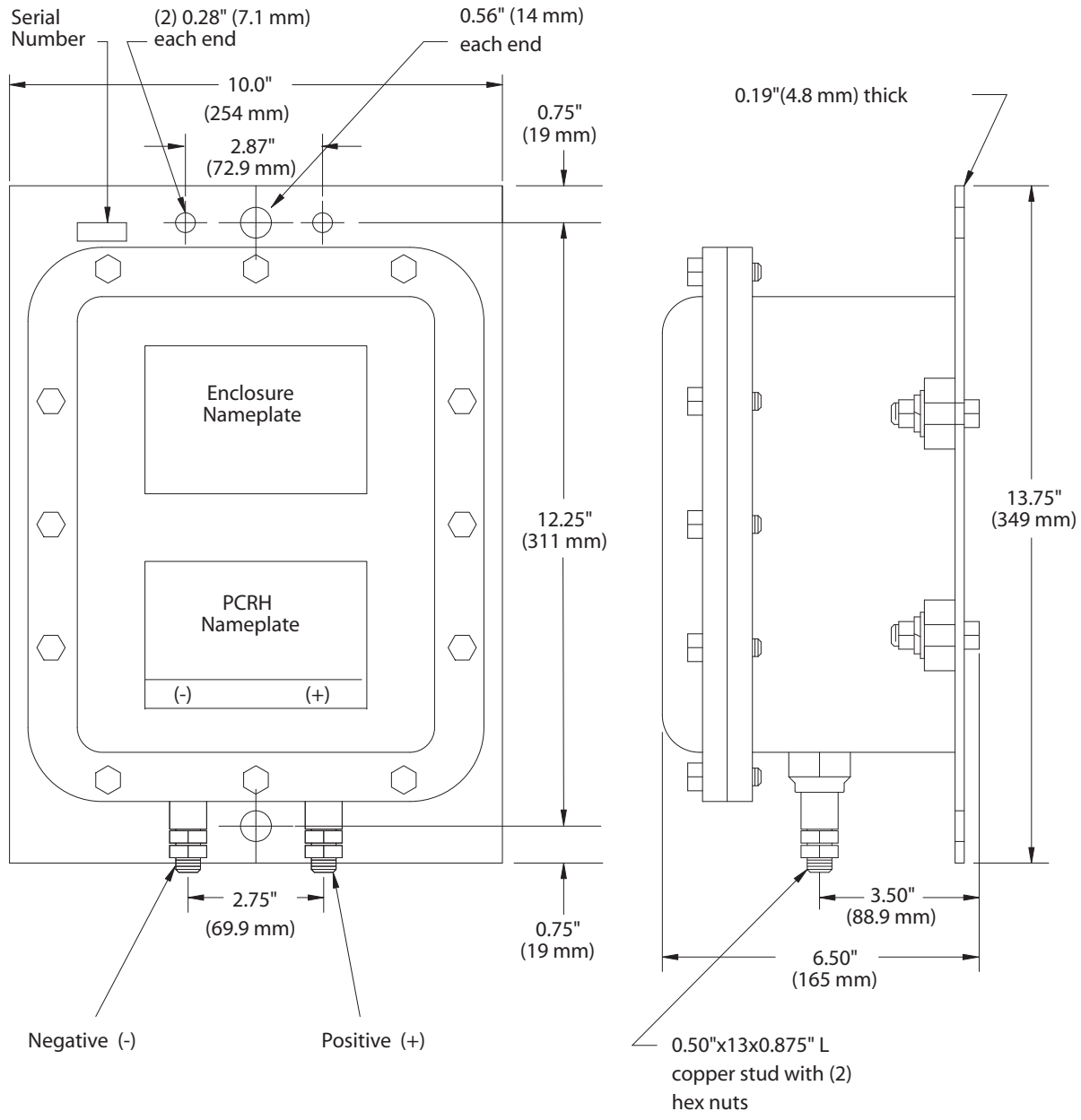
Model #: Pedestal - 36"

1. Fiberglass pedestal, light green.
2. Stainless steel mounting channel.
3. Solid-State Polarization Cell Replacement - Ordered separately.
4. Standard 36" size shown.
5. Typical burial depth: 8" to 12" (200 mm to 300 mm)

Notes:

- Nominal fiberglass thickness 3/16" (4.8 mm)
- Exterior UV stabilized gelcoat 14 Mil (0.36 mm) thick.
- Fire retardant. Does not support combustion.
- Stainless steel hardware.

FIGURE 7A **PCRH Outline Dimensions**

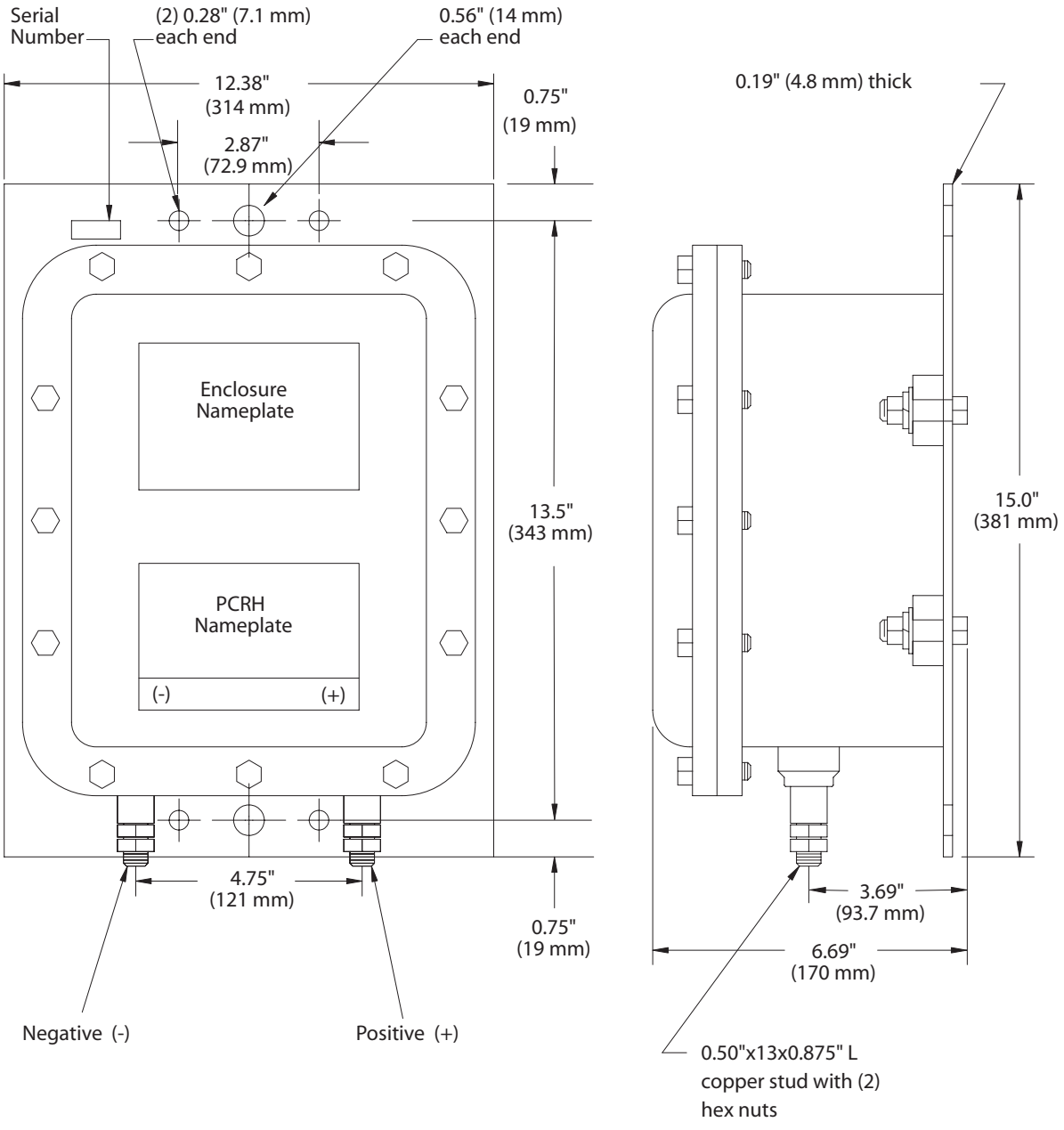


Applies to Models:

PCRH-3.7KA & PCRH-10KA @ 60 Hz

PCRH-3.5KA & PCRH-9KA @ 50 Hz

FIGURE 7B **PCRH Outline Dimensions**



Applies to Models:

PCRH-15KA @ 60 Hz

PCRH-14KA @ 50 Hz