

The Over Voltage Protector (OVP)



INTRODUCTION

The Over-Voltage Protector (OVP) is a solid-state device primarily designed to provide over-voltage protection from lightning and AC fault current in insulated joint applications; however, it also addresses many other cathodic protection applications. It also serves as an effective grounding (or coupling) path whenever the voltage across its terminals attempts to exceed a predetermined value selectable from 1.0 to 4.0 volts.

The OVP is UL and C-UL listed by Underwriters Laboratories for use in hazardous locations: (1) as an over-voltage protective device, (2) as meeting the requirements of an effective grounding path, and (3) for isolation of objectionable DC current from cathodically protected systems to ground. The OVP is packaged in a NEMA 6P rated (comparable to IP68) explosion-proof enclosure suitable for indoor or outdoor, submersible or non-submersible applications.

The OVP functions as an AC and DC isolation device (i.e., it prevents the flow of both DC and AC current) up to a predetermined voltage blocking level and as an effective grounding (or coupling) path when the voltage attempts to exceed this level. The voltage blocking level can be the same or different for each polarity and the voltage blocking choices range from 1.0 volt to 4.0 volts. Blocking voltage refers to the absolute, or peak, voltage that can exist across the device terminals (i.e., $V_{dc} + V_{ac\ Peak}$) while preventing the flow of current. If the voltage attempts to exceed the

voltage blocking level selected, the device immediately begins to clamp (i.e., limit) the voltage by allowing current to readily flow between its two connection points. The OVP should only be used where the steady-state DC voltage plus the peak AC voltage (if any AC voltage is present) is less than the blocking voltage selected; otherwise AC rectification will occur, possibly affecting cathodic protection levels. Where over-voltage protection is required and induced AC voltage is present, it is recommended that the solid-state Polarization Cell Replacement (PCR or PCRH) be used because it can conduct AC current while blocking the flow of DC current. Refer to the PCR and PCRH catalog sections at www.dairyland.com.

APPLICATIONS

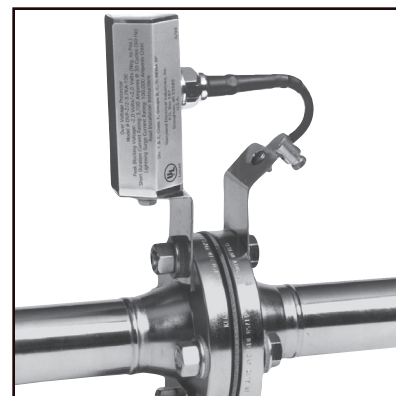
The OVP is designed to perform the following functions, responding to both lightning and AC fault current:

- Provide over-voltage protection (e.g., insulated joints).
- Limit the voltage of cathodically protected equipment with respect to ground (e.g., grounding a motor operated valve).
- Provide AC and DC isolation for voltages below the voltage blocking level selected and an effective grounding (or coupling) path whenever the voltage attempts to exceed the voltage blocking level (e.g., to eliminate objectionable DC current paths).

BACKGROUND

Most cathodically protected pipelines have insulated joints which are installed for various reasons, such as: (1) where pipeline ownership changes, and (2) to segment cathodically protected pipelines from facilities, within which the piping or equipment is normally grounded (e.g., metering stations, power plants, storage tanks, etc.).

The OVP Installed on Insulated Joint



Insulated joints fall into two major categories: field-fabricated insulated joints which are field assembled using insulating materials furnished in a pre-packaged kit, and factory-fabricated monolithic insulated joints which are furnished in a short section of pipe to enable welding the joint into the pipeline.

Of these two types, the most common is the field-fabricated version. Most insulated joint kits do not come with a published voltage withstand capability for the finished joint, primarily due to

the many variables involved in a field assembly, and the fact that they were initially intended to only block DC cathodic protection voltage. Without voltage withstand data for the joint, a user cannot be completely sure that any device selected to provide over-voltage protection would in fact provide the desired protection.

Manufacturers of factory-fabricated insulated joints do publish voltage withstand data and such joints can be ordered to withstand a specified voltage level.

To provide the highest level of over-voltage protection for any application, it is necessary to: (1) utilize a device that clamps the voltage to the lowest allowable level and, (2) install the device with the shortest possible lead length to minimize the voltage created by lead inductance. The OVP was designed to these criteria, thereby providing the highest level of over-voltage protection possible.

Since insulated joints in many pipelines are by definition a "hazardous location" (depending on the material being transported), the OVP is packaged and listed for use in hazardous locations.

PRODUCT CAPABILITY OF THE OVP

The key parameters of the OVP are:

1. The blocking voltage.
2. The DC leakage current for a given blocking voltage.
3. The AC fault current rating.
4. The lightning surge current rating.

Blocking Voltage

At a voltage below the blocking voltage selected, the OVP is an isolating device and prevents the flow of both AC and DC current. At a voltage above the blocking voltage selected, the OVP is a bi-directional conducting device which readily allows current to flow, thereby limiting the voltage.

The blocking voltage choices are des-

igned as "A/B" in the model number structure where "A" is the (-) blocking voltage and "B" is the (+) blocking voltage as measured from the negative terminal (i.e., the exit lead) with respect to the positive terminal (i.e., the enclosure).

Blocking Voltage Ratings

The choices for A/B are:

-A/+B in volts peak

Recommended for most applications:
A/B = -3/+1, -2/+2

Other voltage blocking options, ranging from -2/+1 to -4/+4 volts, are available upon request.

The reasons for symmetrical and asymmetrical choices are best described with an example. If both sides of an insulated 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 may be desirable to select A/B = -2/+2 (symmetrical voltage blocking). In the event that the cathodic protection system is OFF on one side of the joint, the device can block 2.0 Vdc in either direction.

If one side of the insulated joint is cathodically protected and the other side is grounded, then it may be preferable to select the asymmetrical version with A/B = -3/+1 since DC current flow only needs to be blocked in one polarity. Whenever one side of the OVP is referenced to ground, B = +1 should always be selected because this initiates voltage clamping when any positive voltage on the cathodically protected structure attempts to exceed +1.0 volt. In the model number structure the polarity signs are not shown, but the polarity as described above is implied.

DC Leakage Current versus Blocking Voltage

The DC leakage current at the maximum blocking voltage for any OVP model is normally less than 10 milliamperes at

20°C and less than 100 milliamperes at 65°C. With normal cathodic protection voltage across the OVP, the leakage current is well under 1 milliamperes under either temperature condition, a value that is insignificant to a cathodic protection system.

AC Fault Current Rating

There are applications where an over-voltage protective device may be subject to fault current, even though no induced AC voltage is present. For this reason the OVP was designed to have AC fault current carrying capability. The OVP will limit the voltage between its connection points to less than 7 volts AC under the maximum fault current ratings listed in the following table.

AC Fault Current Ratings (Amps AC-RMS Symmetrical)		
Cycles	60 Hz	50 Hz
1	6,500	6,100
3	5,000	4,700
10	4,200	3,900
30	3,700	3,500

Lightning Surge Current Rating

The lightning surge current rating should not be confused with the AC fault current rating. Lightning has a very different waveform, with a faster rise time, a shorter duration, and much less energy than an AC current waveform of the same peak current. Lightning current ratings are established by subjecting the over-voltage protective device to representative lightning current in a high power test laboratory. The waveforms most commonly used are the 8 x 20 microsecond waveform and the 4 x 10 microsecond waveform. The first number represents the time it takes the lightning surge to reach its crest value and the second number represents the time it takes for the current to decrease to 1/2 its crest value.

**Lightning Surge
Current Rating**

Peak Amperes 100,000

(The OVP has also been successfully tested to 75,000 amperes with a 4 x 10 microsecond waveform.)

**Voltage Between OVP
Connection Points Due
to Lightning**

Voltage measurements were taken between the OVP connection points in a high power test laboratory at 50,000 amperes crest rather than at the 100,000 ampere rating because this is the most common lightning surge current rating specified. The clamping voltage (i.e., the maximum voltage that occurred between the two connection points) was primarily due to lead inductance. Therefore, the voltage clamping capability of the OVP is almost entirely dependent on how short the lead can be cut during installation. On most insulated joints, the OVP can, and should be installed with no more than 6" (150 mm) of lead for most effective results.

Following is a summary of the OVP clamping voltage values that can be expected at 50,000 amperes crest based on actual test results.

OVP clamping voltage for a
50kA 8 x 20 microsecond waveform:

≤ 100V with zero lead length (i.e., at
bushing terminal)

≤ 1.25kV with 6" (≈ 150 mm) lead

≤ 1.50kV with 12" (≈ 300 mm) lead

Under field conditions, the actual clamping voltages may be more or less than the above values due to the wide range of lightning surge current magnitudes and wave shapes that can occur.

The primary contributor to clamping voltage is the voltage caused by the very rapid rate of rise of current flowing through leads which inherently have inductance. This voltage is $V = L$

(di/dt) where L is the inductance per unit of lead length in microhenries and di/dt is the rate of change of current in amperes per microsecond. Since di/dt is determined by the characteristics of the lightning strike, the only option to minimize the clamping voltage is to limit the inductance L by keeping the lead length as short as possible during installation. This phenomenon applies to all devices used to limit voltage due to lightning and is relatively independent of lead conductor size.

**OVP FEATURES AND
CHARACTERISTICS****Certifications**

The OVP is Underwriters Laboratories (UL) listed as an over-voltage protective device for use in hazardous locations in accordance with NFPA 70, (U.S. National Electric Code) Articles 500-505 for Class I, Div. 1 and Div. 2, Groups B, C, and D. The OVP is also C-UL listed to the above classifications per Canadian Code C22.2 No. 30-M1986. The listing is valid for ambient temperatures of -45°C to +85°C. The operating temperature code is T6 (85°C). Protection from over-voltage due to lightning complies with the pertinent requirements of ANSI C62.11. The OVP is also UL listed as meeting the requirements of an effective grounding path as defined in NFPA 70 Article 250.2, and as suitable for the isolation of objectionable DC current from cathodically protected systems to ground as defined in Article 250.6(E). Similarly, it is C-UL listed for meeting the effective grounding path requirements of Canadian Electrical Code sections 10-500, 10-806, and CSA C22.2 No. 04-M1982.

For Zone 2 use, the OVP has been given a Type Examination by a Notified Body (UL/Demko) for compliance to ATEX directive 94/9/EC using EN50021. The device is marked II 3 G EEx nA II T6.

Solid-State Design

The OVP uses 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 of the OVP is that if subject to AC fault current or lightning surge current such that failure occurs, failure will occur in the shorted mode. In the shorted mode, the OVP will carry rated fault current or lightning surge current and still provide an effective grounding (or conducting) path.

Field Testing/Maintenance

The OVP can be field tested with an AC/DC multimeter and clamp-on AC ammeter. Testing procedures are included in the installation instructions. The OVP is completely maintenance-free.

Enclosure

The OVP is packaged in an explosion-proof, hexagonal, nickel-plated brass enclosure which is rated NEMA 6P (comparable to IP68) and is suitable for indoor or outdoor use, in submersible and non-submersible applications. See Figure 1 for dimensional data.

Mounting

Several different mounting options are offered. Reference Figures 2 through 4B for mounting details.

Polarity/Electrical Connection

The enclosure is the positive (+) terminal, and a single #4 AWG (≈ 25 mm²) lead, which exits the side of the enclosure through an electrical feed-through bushing, is the negative (-) terminal. It is recommended that the lead always be cut to the shortest possible length during installation to minimize voltage caused by lead inductance.

Number of Operations

The number of times that the OVP can be subject to its rated lightning or AC fault current rating is virtually unlimited, provided the operations are not immediately repetitive.

Energy Requirements

None. The device is totally passive.

Ambient Operating Temperature

-45° C to +85° C

Ordering Information/ Model Number Structure = OVP-A/B-C-D-E

A/B: Blocking Voltage

-A/+B in volts as measured from the negative terminal with respect to the positive terminal.

Recommended for most applications:
A/B = 3/1, 2/2

Other made-to-order options for A/B include 2/1, 4/1, 4/2, 3/3, and 4/4. Longer lead times may apply to these options.

C: Fault Current

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

Standard Rating =
3.7 @ 60 Hz or 3.5 @ 50 Hz

D: Lightning Current

Surge current rating in kA peak (8 x 20 waveform)

Standard Rating = 100

E: Optional Lead Length

Specify lead length in inches or mm only if a longer than standard 12" (\approx 300 mm) lead is required. Standard lead can be cut to a shorter length during installation. The OVP can be installed on most insulated joints with about 6" (\approx 150 mm) of lead.

Example Model Numbers:

OVP-2/2-3.7-100
OVP-3/1-3.5-100-450 mm

Note: If other blocking voltage or mounting options are required, contact DEI.

OVP Mounting Options for Insulated Joint Protection

Mounting options, which include lead terminals, must be ordered separately. See the appropriate figure for details on each option. For other than insulated joint application, select the most appropriate of the following options or contact DEI if a different mounting method is required.

Each mounting option has a terminal choice for the lead connection. Add suffix "B" for a bolted or "C" for a compression connector to mounting option selected. Furnishing the terminals separately enables the lead to be cut to the shortest possible length during installation (to minimize the voltage due to lead inductance). The terminal choices are illustrated in Figure 1.

The compression connector choice will require a tool (user furnished) for compressing in the field. The bolted terminal requires only a 1/2" or adjustable wrench for installation.

Flange Mount using Tapped Holes

See Figure 2. To specify, order "FMTH-3/8-5/16-(B or C)" for English threads or "FMTH-10M-8M-(B or C)" for metric threads. Confirm that field drilling and tapping the structure is acceptable.

When English threads are specified, a 3/8x16 and a 5/16x18 tapped hole is required, each with full threads to a 5/8" depth.

When metric threads are specified, a M10x1.5 and a M8x1.25 tapped hole is required, each with full threads to a 16mm depth.

Flange Mount using Welded Hex Bolts

See Figure 3. To specify, order Mounting Kit "FMWHB-(B or C)". Stainless steel bolts are furnished for welding to the mounting surface as illustrated. Confirm that welding to the structure is acceptable.

Flange Mount using existing Flange Bolts

See Figures 4A and 4B. This kit is furnished with two nickel-plated copper adapter plates which are attached to the OVP and secured to the face of the flange using the existing flange bolts. To order, specify Mounting Kit "FMFB-H-(B or C)" where "H" is the hole diameter required in inches or millimeters. Allow for the insulating sleeve thickness over the bolt, if applicable.

FIGURE 1 OVP Outline Dimensions

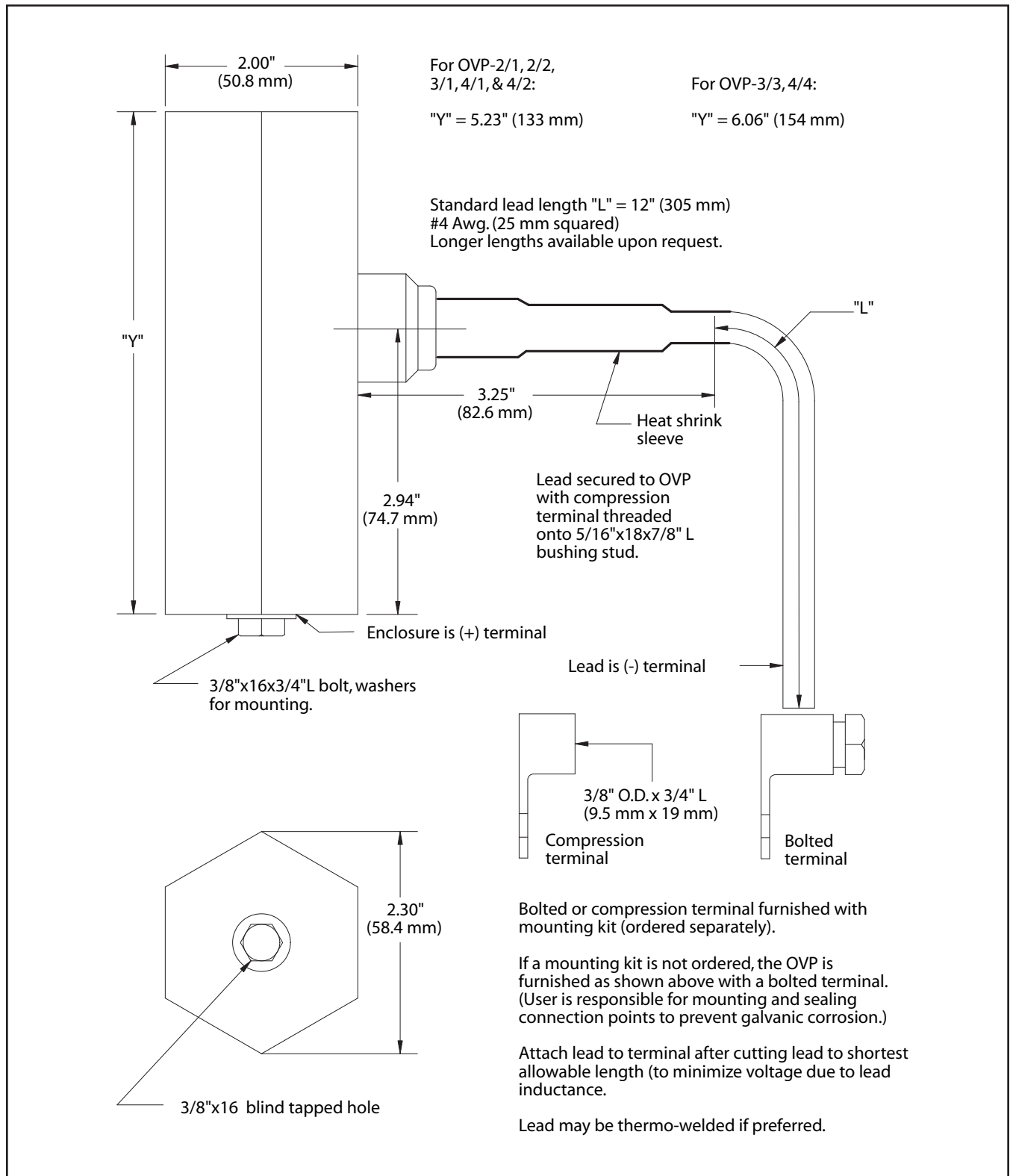
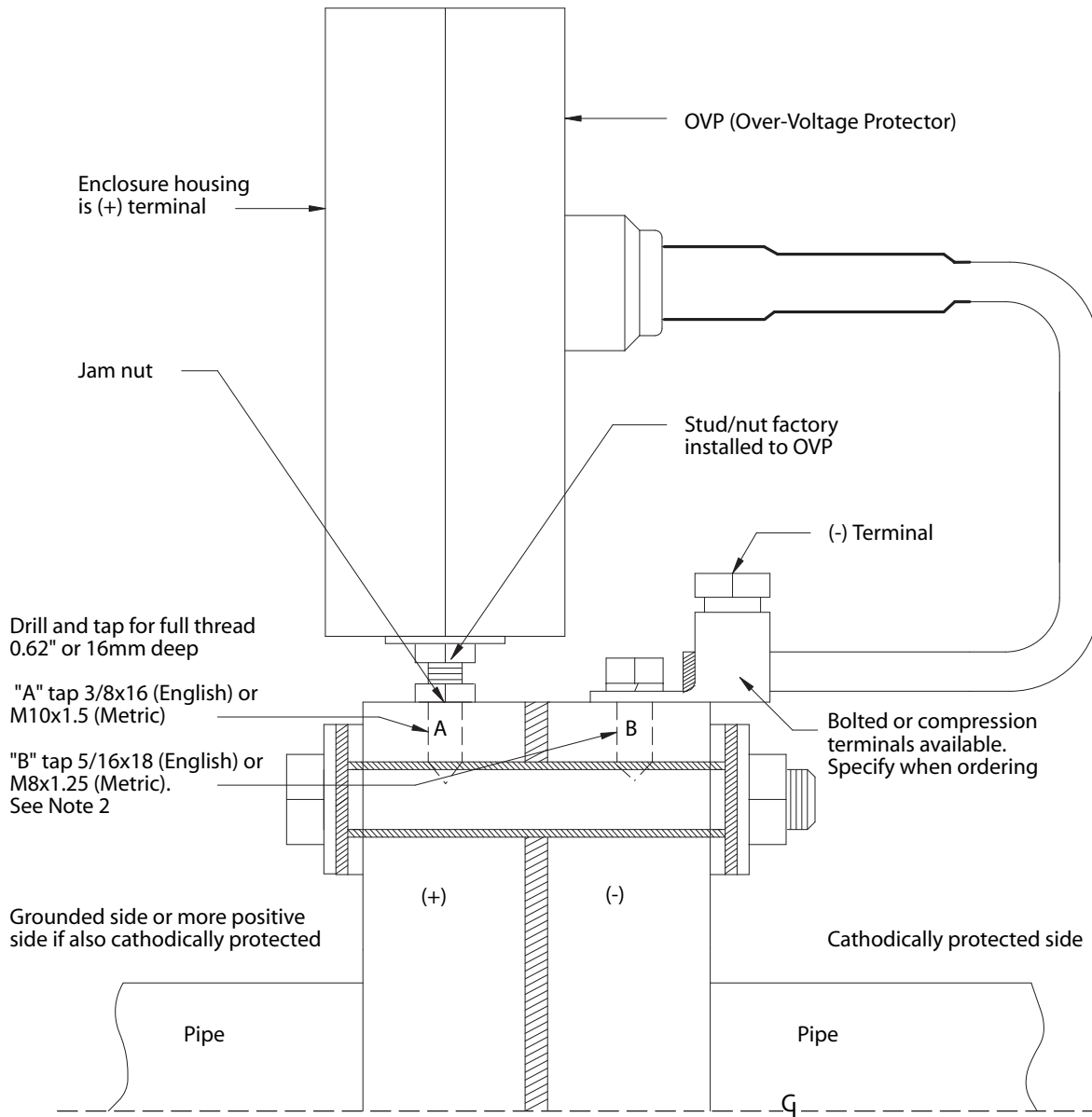
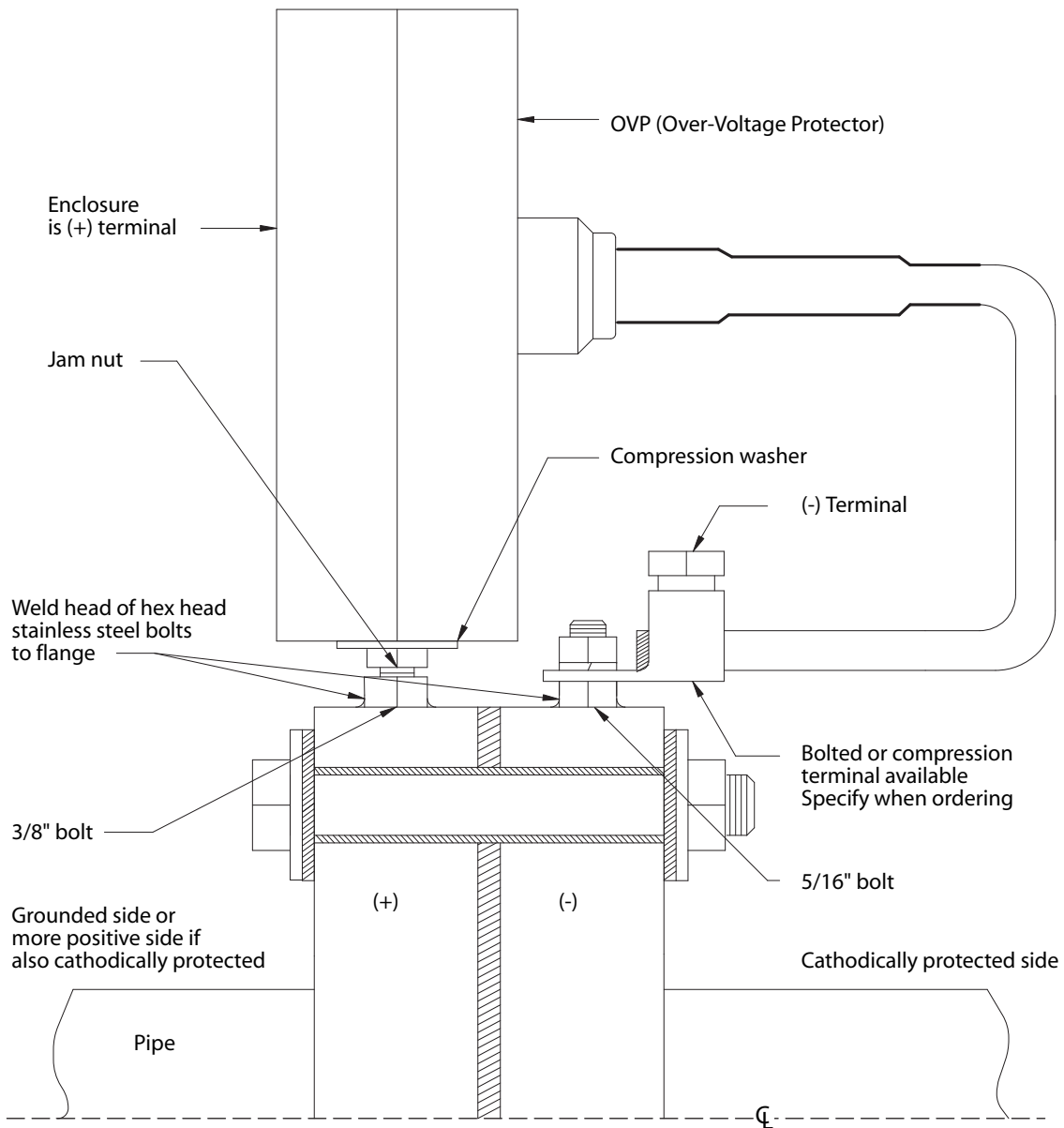


FIGURE 2 Insulated Joint Application – Flange Mount Using Tapped Holes



1. User is responsible to determine if drilling and tapping is acceptable.
2. Mounting Kit FMTH-3/8-5/16 requires English taps, FMTH-M10-M8 metric taps.
If required, off-set bolts to maintain clearance between (+) and (-) connections to flange.
3. Liberally apply lubricant/corrosion inhibitor (furnished) to all threads.
4. Thread OVP into tapped hole, orient as desired, and securely tighten jam nut.
5. Attach (-) terminal to flange with bolt provided and securely tighten.
6. Cut lead to shortest allowable length.
7. Remove lead insulation as appropriate for terminal. Apply corrosion inhibitor to bare strands.
8. Insert bare conductor into terminal and securely tighten terminal bolt (or compress as required if a compression terminal).
9. Cover all connections and attachment points with an appropriate coating/sealing material to prevent galvanic corrosion.

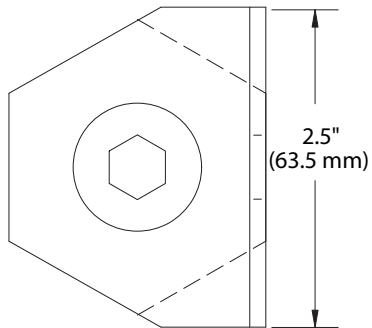
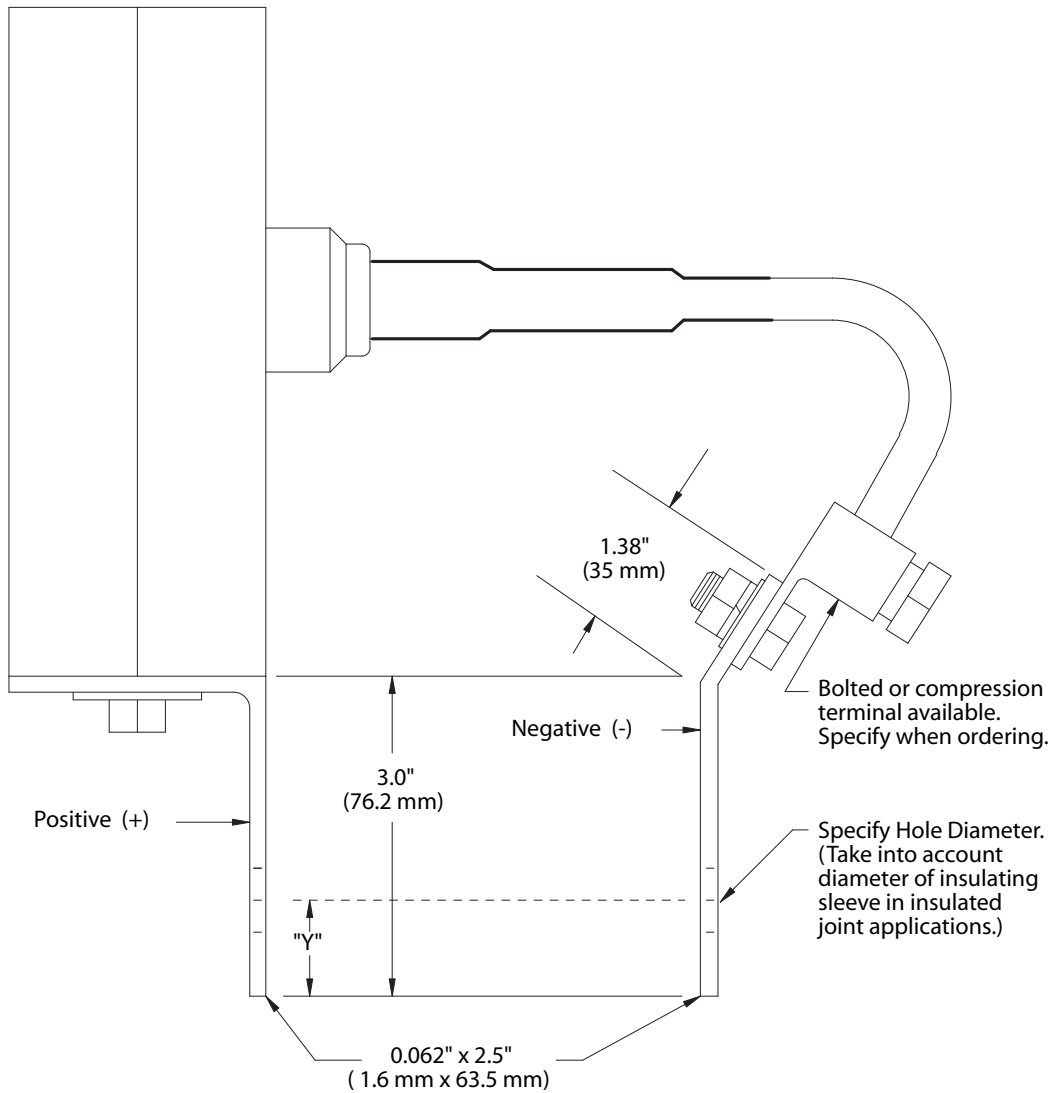
FIGURE 3 Insulated Joint Application – Flange Mount Using Welded Hex Bolts



1. User is responsible to determine if welding to structure is acceptable.
2. Weld head of bolts to flange as shown. For narrow flanges it may be necessary to radially off-set bolts to provide electrical clearance between the OVP housing and the (-) terminal.
3. Liberally apply lubricant/corrosion inhibitor (furnished) to all threads.
4. Thread OVP onto 3/8" stud, orient as desired, and securely tighten jam nut.
5. Attach terminal to 5/16" stud and securely tighten hex nut.
6. Cut flexible lead to shortest allowable length.
7. Remove lead insulation as appropriate for terminal. Apply corrosion inhibitor to bare strands.
8. Insert bare conductor into (-) terminal and securely tighten terminal bolt (or compress as required if a compression terminal).
9. Cover all connections and attachment points with an appropriate coating/sealing material to prevent galvanic corrosion.

FIGURE 4A Insulated Joint Application – Flange Mount Using Existing Flange Bolts

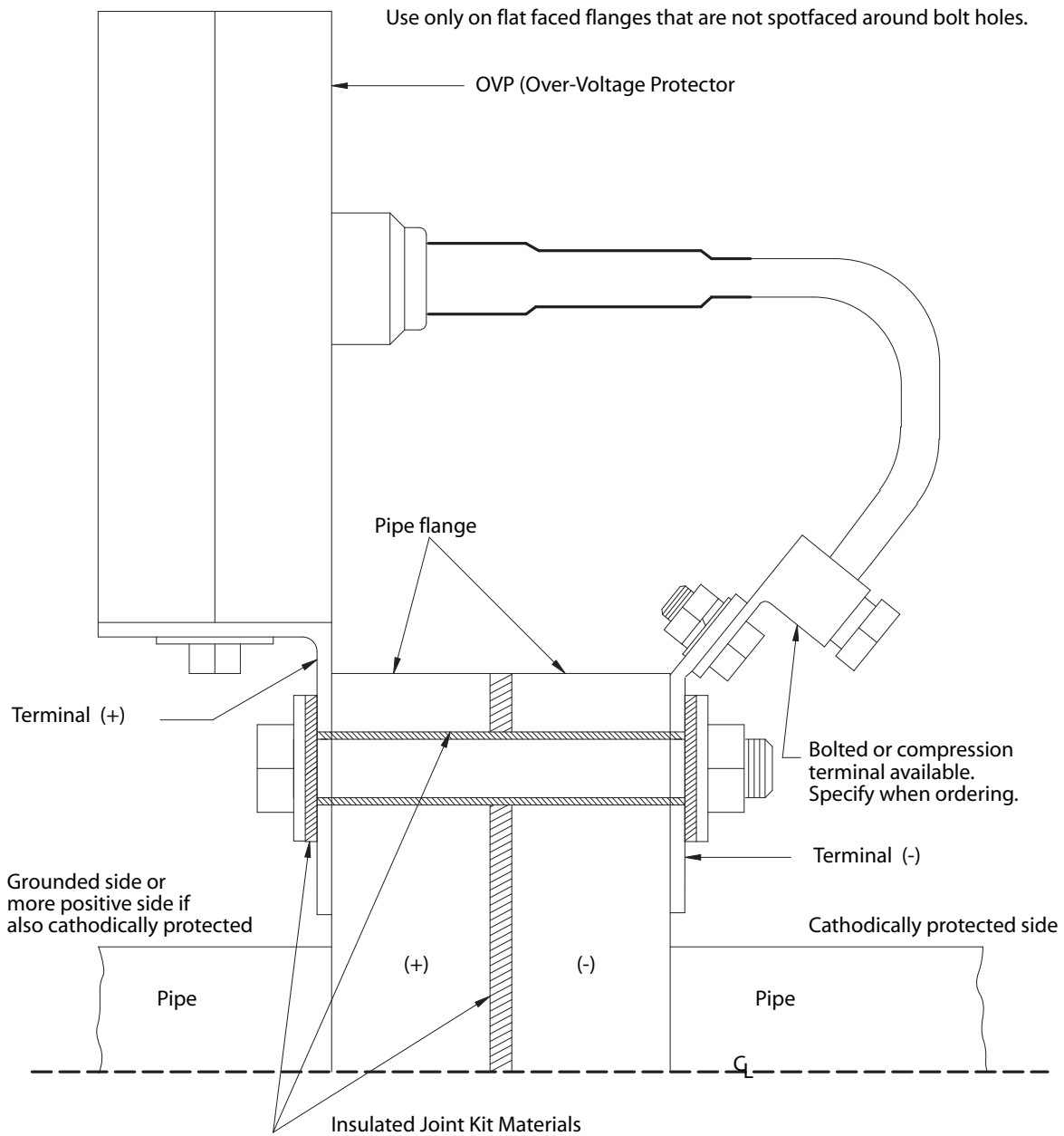
Use only on flat faced flanges that are not spotfaced around bolt holes.



If Hole Diameter is:	Then "Y" is:
1/2" - 7/8" (12 mm - 22 mm)	3/4" (20 mm)
1.0" - 1-1/8" (25 mm - 29 mm)	1.0" (25 mm)
1-1/4" - 1-3/8" (32 mm - 35 mm)	1-1/4" (32 mm)

For other required hole diameters, contact DEI.

FIGURE 4B Insulated Joint Application – Flange Mount Using Existing Flange Bolts



1. Bolt OVP to insulated joint as shown. Flange must be bare metal under terminal plates. Liberally apply corrosion inhibitor (furnished) over entire surface of terminal plates in contact with flange.
2. Confirm that there is no continuity across the insulated joint and confirm that there is continuity between each OVP terminal and its adjacent flange.
3. Cut flexible lead to shortest allowable length.
4. Remove lead insulation as appropriate for terminal. Apply corrosion inhibitor to bare strands.
5. Insert bare conductor into (-) terminal and securely tighten terminal bolt (or compress as required if a compression terminal).
6. Cover all connections and attachment points with an appropriate coating/sealing material to prevent galvanic corrosion.