Understanding Voltage Threshold Ratings of Decouplers and Over-Voltage Protectors

Threshold voltage rating function
Decouplers and over-voltage protectors are extensively used on cathodically protected structures such as pipelines and must provide dc isolation in order for the CP system to work effectively, yet must provide over-voltage protection for abnormal conditions.

For convenience, the term “decoupler” will be used throughout this article to represent the operation of both types of devices. The device’s threshold represents the dc voltage that the device is rated to block, in either polarity. DC voltage above the device’s blocking threshold, for a given polarity, will put the unit into conduction. The device will begin to pass all current as it performs its protective function of clamping voltage.

After the voltage decreases below the decoupler’s threshold rating, the decoupler will resume blocking dc as designed. The clamping of voltages across the decoupler can also occur from an ac fault or a lightning event. This clamping of the ac and dc voltage can occur numerous times without damage, due to the design of solid state decouplers, as long as the events are within the current ratings of the device.

The threshold rating is the voltage difference between the decoupler’s two connection terminals. The applied dc voltage can be directly measured between the terminals and should be less than the device threshold voltage rating, for a given polarity. Also, it can be obtained by subtracting the pipe-to-soil reading from each side of where the decoupler will be attached across the connection terminals.

Threshold voltage ratings for these bi-directional devices can be the same (symmetrical) or different (asymmetrical) in each polarity. Typical thresholds are in the range of 1 to 3V. The most common symmetrical threshold is -2V/+2V, while a typical asymmetrical threshold is -3V/+1V.

The operation of a decoupler with a specific threshold voltage will be explained, but first we must address the most typical connection arrangements for decouplers.

Examples of terminal connections
- Across an isolation flange (with CP present on one or both sides)
- Between electrical equipment on a CP system and a separate grounding system
- Between a pipeline and an AC mitigation system
- Isolating a grounding system at the electrical service panel
- Isolating a station grounding system with CP from the electrical power company’s grounding grid

Examples of Decoupler Model Numbers with Threshold Ratings

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Threshold Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSD-2/2-3.7-100-R</td>
<td>-2/+2 volts</td>
</tr>
<tr>
<td>SSD-3/1-3.7-100-R</td>
<td>-3/+1 volt</td>
</tr>
<tr>
<td>PCR-5KA</td>
<td>-3/+1 volt</td>
</tr>
<tr>
<td>PCR-5KA-S</td>
<td>-2/+2 volts (S equals a symmetrical threshold rating of -2/+2)</td>
</tr>
</tbody>
</table>

Other optional PCR ratings available are -4/+1 and -6/+1.

Device operation with a given threshold rating
The decoupler negative terminal should be connected to the more negative structure — typically the cathodically protected structure — and the positive terminal to the more positive system, often a grounding system (not cathodically protected). With this arrangement, the structure connected to the negative terminal will be limited to a voltage value equal to the stated negative threshold relative to the positive terminal/structure. Likewise,
the same negative structure cannot rise in voltage above the positive threshold, relative to the positive structure. This keeps one structure close in voltage to the other structure, regardless of which was affected by an over-voltage condition.

**Selection Scenarios**

**Scenario 1:**

Both sides of an isolation flange are protected by CP. The P/S (pipe-to-soil voltage) ON reading for the pipeline side is -1.35 volts. The station side of the flange ON reading is -1.05 volts. The voltage difference is -0.300 volt. Typically, a symmetrical device is used for the situation where CP is present on either side of an isolation joint, to allow for either side to be higher or lower in voltage, since both are active CP systems.

Therefore, with a -0.300-volt difference, the threshold of the decoupler is not exceeded with a -2/+2-volt threshold. The recommendation is to select an SSD or a PCR with a threshold rating of -2/+2 volts.

Graphically, the threshold voltage for a -2/+2V device appears below.

**Scenario 2:**

The cathodically protected side of isolation flange P/S ON reading is -2.45 volts. The grounded copper side of the flange on reading is -0.340 volt. The voltage difference is -2.11 volts. Therefore, the -2.11 volt difference exceeds the threshold of the decoupler with a -2/+2-volt threshold. See the graph below for the excessive leakage current that would result if -2.11V were applied to a decoupler with -2/+2V threshold.

DC voltage between decoupler terminals -2.11V which is beyond the -2/+2 threshold rating, resulting in excessive current flow.

= DC voltage between decoupler terminals

\[ V_1 - V_2 \]

= Functions as an open switch

V₁ = Pipe 1 = (-2.45 V)
V₂ = Pipe 2 = (-0.340 V)
\(-2.45 - (-0.340) = -2.11\)

Recommendation: select an SSD or a PCR with a threshold rating of -3/+1 volt. See the graph below for the new, acceptable result if a -3/+1V device were used instead of a -2/+2V unit.

= DC voltage between decoupler terminals

\[ V_1 - V_2 \]

= Functions as a closed switch

V₁ = Pipe 1 = (-2.45 V)
V₂ = Pipe 2 = (-0.340 V)
\(-2.45 - (-0.340) = -2.11\)

www.dairyland.com
Scenario 3:

Electrically separating an AC mitigation system from a pipeline. The pipeline P/S ON reading is -2.25 volts. The copper mitigation system reading is -0.350 volt. The voltage difference is -1.90 volts. Therefore a -1.90 volts difference is close to exceeding the threshold of a decoupler with a -2/+2-volt threshold.

Recommendation: select an SSD or a PCR with a threshold rating of -3/+1 volt. See the graph below for the new, acceptable result if a -3V/+1V device were used instead of a -2/+2V unit.

Option: select an SSD or a PCR with a threshold rating of -3/+1 volt

= DC voltage between decoupler’s terminal

Dairyland Decoupler and OVP Threshold ratings

- SSD (Solid State Decoupler) available in the following threshold ratings: -2/+2 and -3/+1 standard version
- PCR (Polarization Cell Replacement) available in the following threshold ratings: -3/+1 standard version, and -2/+2, -4/+1, and -6/+1 optional versions
- PCRH (Polarization Cell Replacement for Div 1/Zone 1 hazardous locations) available in the following threshold ratings: -3/+1 standard version, and -2/+2 optional version
- OVP (Over-Voltage Protector, for Div 1/Zone 1 hazardous locations) available in -2/+2 and -3/+1 standard versions, and -4/+1 and -4/+4 optional versions
- OVP2 (Over-Voltage Protector) available in -2/+2 and -3/+1 standard versions

Rule of Thumb for Proper Threshold Selection

- In most situations where both terminal connection points are cathodically protected, a threshold rating of -2/+2 will be an acceptable choice. If one side has a higher than normal CP reading, then a -3/+1 or higher value should be selected.
- When isolation is present and only one side of isolator is receiving cathodic protection, then a threshold of -3/+1 is usually the correct choice.
- In most AC mitigation projects, a threshold rating of -3/+1 will
• In the case of isolating electrical equipment on a CP system from a copper grounding system a threshold rating of -3/+1 is common, since copper is notably shifted on the galvanic series of metals compared to most protected structure potentials.

• When decoupling an entire facility with CP from a power utility grounding grid, the expected potential difference between two grounding systems is often fairly small, and within the rating of -2/+2, however a -3/+1 threshold is always a safe choice.

**Connection summary:** connect the more negative structure to the device negative terminal, and the more positive (less negative) structure to the positive terminal

If selecting the proper threshold rating is in question, please contact Dairyland's technical support at: techsupport@dairyland.com