Effectiveness of Equipotential Bonding Mats for Hydro-excavation

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Fact of equipotential bonding mats

Evolvement of Commercial Bonding Mat

Step 1: The traditional bonding mat is a simplified or practical version of the ideal mat. The key features of such mat are:
- Made of parallel 15-mm wide aluminum bars;
- Height is 15 mm above the ground. Possibility of an individual’s foot contacting the soil/earth below the mat is very small;
- The 35mm earthen lead with heavy duty clamp is for clamping on to switching handles;
- Mat size: 0.8 m × 0.6 m, Mesh size: 0.08 m × 0.015 m

Step 2: The portable bonding mat is a further simplification from traditional bonding mat. Some of the modifications are due to portability considerations but may lack technical justification/support. The features are as follow:
- Made of braided copper conductors with an intersection area of 8 mm²;
- A very thin polyethylene (PE) textile layer on top; no dielectric rating provided;
- Mat size: 1.4 m × 1.4 m, Mesh size: 0.2 m × 0.2 m

Portable bonding mat’s modifications with respect to ideal mat

<table>
<thead>
<tr>
<th>No.</th>
<th>Modification</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Conductive plate is modified into conductive mesh</td>
<td>Equipotential zone is no longer present at every point on the mat.</td>
</tr>
<tr>
<td>2</td>
<td>Polyethylene (PE) fabric layer is used on top of the mesh</td>
<td>This layer may or may not provide added protection depending on its insulation rating, physical condition, and work site conditions.</td>
</tr>
<tr>
<td>3</td>
<td>Braided copper conductors are used to form mesh</td>
<td>1) Fault current carrying capability may be affected, depending on the condition of the copper conductors; 2) The limit on diagonal resistance could be exceeded, depending on the condition of the copper conductors.</td>
</tr>
<tr>
<td>4</td>
<td>The size of the mat is limited</td>
<td>A worker could move a foot off the mat accidentally depending on the mat size and work scenario.</td>
</tr>
</tbody>
</table>

Issues of the portable bonding mat

Issues 1: mat cannot provide an equipotential zone

Open space of the mesh makes the foot contact ground surfaces. When other part of body is energized via the source, a \( V_{touch} \) will occur.

Studied System:
- 25 kV, 8 kA rated fault current
- Upper soil layer (0.1 m deep): typical yard stone contaminated by windblown fines
- Lower soil layer: typical wet underlying clay

Issues 2: textile layer cannot provide insulation

- In vendor’s patents, the sole purpose of the layer is to hold the meshed conductor braids. Insulation capability was not mentioned.
- In user’s guides, vendors have not indicated that the textile material is intended for any insulation or isolation;
- No dielectric ratings or specifications found on the textile material;
- The test standard (ASTM F2715-09) do not contain the verification of the insulation property of the textile.

Issues 3: mat cannot meet the current carrying capability expected in Alberta power distribution systems during a fault due to the low fusing current of its braided copper conductor.

Issues 4: the problems of “design test” and “resistance test” in the test standard specified by the vendor (ASTM F2715-09).

Issues of the portable bonding mat (2)

Potential profile inside a 20 × 20 cm² mesh

Margin of mesh

Center of mesh

Maximum touch potential

<table>
<thead>
<tr>
<th>Mesh size (cm)</th>
<th>Mat resistance ( R_{mat} (\Omega) )</th>
<th>Fault current (A)</th>
<th>Ground potential rise (kV)</th>
<th>Maximum touch potential ( V_{touch} (kV) )</th>
<th>Touch potential Limit (kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>28.8</td>
<td>486.7</td>
<td>14.1</td>
<td>11.3</td>
<td>0.39</td>
</tr>
<tr>
<td>28</td>
<td>25.8</td>
<td>541.4</td>
<td>14.0</td>
<td>10.2</td>
<td>0.39</td>
</tr>
<tr>
<td>20</td>
<td>22.4</td>
<td>618.8</td>
<td>13.9</td>
<td>8.2</td>
<td>0.39</td>
</tr>
<tr>
<td>10</td>
<td>18.6</td>
<td>741.1</td>
<td>13.8</td>
<td>4.6</td>
<td>0.39</td>
</tr>
<tr>
<td>5</td>
<td>16.7</td>
<td>820.9</td>
<td>13.7</td>
<td>2.9</td>
<td>0.39</td>
</tr>
</tbody>
</table>

- The touch potential rise will exceed \( V_{touch} \) limit even for 5 cm mesh size!
- The portable mat cannot provide safe equipotential zone at all.

Design test requires:
When 20 kV kV is applied, \( I_{body} < 5 \text{ mA} \), \( V_{body} < 5 \text{ V} \)
- What is the basis of 8 kV? 
- No specification on \( R_{mat} \).

Conclusion: the results are meaningless

Resistance test requires: diagonal resistance < 1mΩ per foot. This is too strict according to our calculation. This requirement leads to frequent but unnecessary replacement of mats.

Other issues:
- Difficult to inspect: its user guide suggests that a simple visual inspection is enough. However, visual inspection is not possible for edges and corners where braided copper are enclosed inside;
- Hydro-Vac worksites can be messy. The mat complicates work condition;
- Added workload for workers according to Epcor;
- The claim by the vendor that “protection effectiveness when wet” can be improve is unwarranted. Contamination such as snow or water can undermine the safety.

Summary of findings

- The current portable bonding mat cannot provide a safe equipotential zone;
- Some of the functions of mat must be clearly understood by workers;
- The portable bonding mat cannot meet the current carrying capability expected in Alberta. On the other hand, its diagonal resistance request is more stringent than necessary, leading to frequent replacement of mats;
- The vendor’s specifications for testing/checking mats needs significant improvement. The present testing specifications based on ASTM standard lacks sufficient technical support;
- Some technique claims provided by the vendor are incomplete or wrong.