Grounding System

Design and Testing for Critical Facilities
What Is Grounding?

An electrical connection, whether intentional or accidental between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.
Reasons For Grounding

– Personnel **safety** and equipment protection by providing a path to safely dissipate any unwanted charges or potentials.

– Ensure equipment performance and protection

– Satisfy manufacturer’s warranty
Electrical Protection Pyramid®

- RF
- AC Surge
- Telco / Data
- Lightning
- Grounding
Resistance To Earth

\[ 20V \div 0.8 \text{ AMP} \]

25 Ohms
Soil Resistivity Basics
Soil Resistivity

Key Variable in System Design

- Determines grounding system resistance
- Changes from Site to Site
- Dependent on:
  - Soil type
  - Moisture
  - Electrolytes
  - Temperature
## Soil Resistivity Comparison

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Resistivity (ohm-cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Soils</td>
<td>100 - 5,000</td>
</tr>
<tr>
<td>Clay</td>
<td>200 - 10,000</td>
</tr>
<tr>
<td>Sand and Gravel</td>
<td>5,000 - 100,000</td>
</tr>
<tr>
<td>Surface Limestone</td>
<td>10,000 - 1,000,000</td>
</tr>
<tr>
<td>Limestone</td>
<td>500 - 400,000</td>
</tr>
<tr>
<td>Shale</td>
<td>500 - 10,000</td>
</tr>
<tr>
<td>Sandstone</td>
<td>2,000 - 200,000</td>
</tr>
<tr>
<td>Granites, Basalts, etc</td>
<td></td>
</tr>
<tr>
<td>Decomposed Gneisses</td>
<td>5,000 - 50,000</td>
</tr>
<tr>
<td>Slates, etc</td>
<td>1,000 - 10,000</td>
</tr>
</tbody>
</table>
Soil Resistivity Testing
4-Pt. Wenner Method

– Visually Survey Lease Area to Determine Location and Direction For Test
    – Not parallel to buried metallic objects
    – Not parallel overhead power lines
    – Sufficient straight line distance to allow for test
    – **Minimal distance 300 feet**
4-Pt. Wenner Method
### 4-Pt. Wenner Method

<table>
<thead>
<tr>
<th>Probe Spacing (Feet)</th>
<th>Meter Reading (Ohms)</th>
<th>Calculated Resistivity (Ohm-Meter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>52.00</td>
<td>497.90</td>
</tr>
<tr>
<td>10</td>
<td>19.68</td>
<td>370.87</td>
</tr>
<tr>
<td>15</td>
<td>10.16</td>
<td>292.00</td>
</tr>
<tr>
<td>20</td>
<td>6.53</td>
<td>250.10</td>
</tr>
<tr>
<td>30</td>
<td>4.30</td>
<td>247.04</td>
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<tr>
<td>40</td>
<td>10.80</td>
<td>827.28</td>
</tr>
<tr>
<td>60</td>
<td>7.40</td>
<td>850.26</td>
</tr>
<tr>
<td>80</td>
<td>5.58</td>
<td>855.60</td>
</tr>
<tr>
<td>100</td>
<td>4.44</td>
<td>850.26</td>
</tr>
</tbody>
</table>
Typical Grounding Electrode System Resistance Requirements
Typical Resistance Requirements

- NFPA 70 NEC: 25 OHMS or Two Rods
- IEEE Standard 142 & 1100: Equipment Dependent
- Motorola Standard R-56: 10 OHMS (Design Goal)
- Telecommunications: 5 to 10 OHMS
- Emerson DeltaV: 3 OHMS
- Essilor: 3 OHMS
- GE Medical Systems: 2 OHMS
25 Ohm Grounding System

Lightning Strike

18,000A

Potential Rise will be
~450KV at the site
5 Ohm Grounding System

Lightning Strike
18,000A

Potential Rise will be
~90KV at the site
Grounding System
Resistance Testing
Grounding System Testing

- Why Test Grounds?
  - Determine Baseline
  - Validate Construction
  - Confirm Design Spec Satisfied
  - Satisfy Warranty Reqs
  - Ensure Equip Protection & Performance
Testing Methods

• Two Test Methods
  – Fall of Potential (Three Point) Test
  – Clamp-on Test
Fall-of-Potential Method

- C1
- P1
- Ground Rod Under Test
- P2 Auxiliary Voltage Electrode
- 1 ft
- 10% 20% 30% 40% 50% 60% 70% 80% 90%
- Earth
- Remote Current Electrode
- 10 x depth of electrode
Fall of Potential

- Why 10+ Samples?
  - Single Point Could Be Misinterpreted
  - Data Must Be Plotted
    - Visual Plateau
    - Confirms Test Validity
Fall Of Potential Test

Why Invalid?

- #1 Reason
  - Not Isolating System Under Test
    - Meter is a constant amperage meter
    - Part of the current travels through the connection
    - The ground system is part of a parallel network
  - Test is **Invalid** Unless Disconnected
Fall Of Potential Test

Why Invalid?

- #2 Reason
  - Insufficient Probe Spacing
    - Req’d to Avoid the Spheres of Influence
Fall of Potential Test

- Spacing For Current Probe?
  - Single Electrode
    - Minimum 5X Length of Rod
    - Ideal, 10X Length of Rod
      - 10 Foot Rod, 50-100 Feet Away
      - 200 Foot Well, 1000-2000 Feet Away
Clamp-on Ground Resistance Testing

Clamp-on Resistance Testing
Clamp-on Ground Resistance Meter
– Convenient, Quick, Easy
– Does Not Require Disconnecting Equipment
– Measures Current on the Ground

May Read Ground Loops vs. Ground Resistance
Clamp-on Meter Operation

\[ R = \frac{E}{I} \]

2 Control Xformers

??? ohms

Current Flow
Clamp-On Resistance Testing Example

3 Phase Utility Line

Induced Current Flow

Service Meter

Ground Conductor

Current From Other Grounds

Ground Rods

Current From Other Grounds
Invalid Clamp-on Reading

Reading: < 1 Ohm

Invalid

Current Path
Bonding
**Bonding**

Do the words bonding and grounding mean the same thing?

- **Bonding** - The permanent joining of two metallic parts to form an electrically conductive path that ensures electrical continuity and the capacity to safely conduct any current likely to be imposed.

- **Grounding** - An electrical connection, whether intentional or accidental between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.
Why is Bonding More Important Now than Ever Before?

Grounding Processes/Grounding Electrode Systems -V- Technological Advances

- Except for the advent of electrolytic electrodes and different grounding enhancement materials, grounding processes and grounding electrode systems have changes little in the past 100 years.

- Are we using the same technology that our grandparents did?

  - Personal Computers
  - Television
  - Microwave
  - Radar
  - Solar Panels
  - Electronic Points of Sale Systems
  - Electronic Cash Registers
  - Voice Over Internet Protocol

  - Cellular Telephone
  - Ground Positioning Systems
  - Photovoltaic Cells
  - Radio Communications
  - Computer controlled manufacturing
  - Medical Equipment
  - Fiber Optic Voice/Data Transfer
  - Digital Networking
THANK YOU FOR YOUR ATTENTION

BICSI Fall Conference & Exhibition

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