Healthcare

Isolation Power Systems

Presented by:
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Healthcare Isolation Power Systems

- Theory
- Offer
- Codes & Standards
- FAQs
Isolated Power System Purpose

- To provide ungrounded single-phase power to patient care areas deemed as “Wet Procedure Locations”, so as to:
  - **Reduce electric shock hazard**
    - Limits ground fault current, typically to less than 5 mA
    - Practically eliminates the danger of massive electrical shocks (macro shock) to patients or personnel from ground fault
    - However, does not protect against micro-shock current levels that can affect cardiac patients during ground fault
      - patients with direct electrical pathways to the heart susceptible to ground fault leakage currents of 20 µA - 300 µA
  - **Increased operational safety**
    - Increased electric power reliability by not tripping on ground fault
    - Alarms on ground fault condition
  - **Eliminates arcing on ground faults**
Grounded vs. Isolated (Ungrounded) System

**Grounded System**

- Upstream Source Ground Bus
- Grounding Electrode
- Grounding Conductor
- Panel Ground Bus
- Bonding Jumper
- 120 V
- Grounded Conductor
- White
- Bonding Conductor
- Green
- 0 V

**Isolated (Ungrounded) System**

- Upstream Source Ground Bus
- Grounding Electrode
- Grounding Conductor
- Panel Ground Bus
- Bonding Jumper
- 120 V
- 60 V
- Bonding Conductor
- Green
- Brown
- Orange
Leakage Current

- All energized electrical components – cables, windings, medical devices – have a distributed capacitance to ground – called leakage capacitance
- Cable insulation also has distributed conductance to ground
  - because insulation resistance is not infinite
  - modeled as a parallel resistance to ground
- Sum of capacitive and resistive current to ground known as Leakage Current
- Leakage current increases
  - with length of conductors
  - number of devices connected to the system
Phase-to-Ground Voltages

- Ungrounded 120V distribution system is “weakly” tied to ground through the distributed impedance (capacitive and resistive)
- Impedances are normally balanced – because orange and brown conductor lengths are typically the same.
  - Hence impedance normally provides balanced load per phase
- Causes phase to ground voltages to be balanced at 60V

- Unbalanced Leakage Impedance per Phase
Ground Fault

- Example – brown conductor shorts to ground (bolted fault)
  - leakage impedance of brown conductor shorted out
- Voltage-to-ground of un-faulted phase rises to 120 V
- Leakage impedance of ungrounded phase (orange in this case) determines ground fault current magnitude – 0.24 mA in this example
- Ground fault current is the leakage current of the ungrounded phase

\[
I_F = \frac{120V}{500k\Omega} = 0.24 \text{ mA}
\]
Ground Fault Magnitude vs. Leakage Impedance

- Example – orange conductor shorts to ground
- Ground fault current rises to 0.48 mA in this example, which is the leakage current of the ungrounded phase (brown)
- Magnitude of ground fault current depends on impedance of return path
  - ie. which phase is grounded
- Ground fault current is highest when the fault occurs on the phase with the highest system impedance
- The highest current that would flow if a ground fault were to occur is known as Hazard current
Leakage Current vs. Ground Fault Current

- With no ground fault, leakage current is limited by the sum of the leakage impedance of both phases:

- During ground fault, leakage current rises because it is limited by leakage impedance of one phase only (for a bolted ground fault)
  - Ground fault current magnitude equals the leakage current of the un-faulted phase
Summary - 120V Grounded vs. Ungrounded System

- **Grounded system**
  - Ground fault current is high compared with leakage current
  - Phase to ground voltage is fixed (120 V)
  - Location of system grounding connection is fixed
  - 1-pole branch breakers required

- **Ungrounded system**
  - Ground fault current (single fault) is never greater than the leakage current
  - Phase to ground voltage depends on leakage impedance per phase
  - Since system is grounded only during a ground fault, the location of the grounding connection is unknown and variable
  - 2-pole branch breakers required
## Electric Shock Hazard

### Leakage current

#### In Grounded Systems
- A high fault current can flow
- The fault current is only limited by the body impedance

\[
I_F = \frac{\text{Supply Voltage}}{Z_B + Z_F} \rightarrow \frac{120V}{(1k\Omega + 0\Omega)} = 120mA
\]

#### In Isolated Power Systems (IPS)
- The IPS is a “small” local network with low leakage capacitances.
- The fault current is limited by:
  - \( Z_B \) = body impedance
  - \( Z_{Ce} \) = impedance of the fault loop

\[
I_{Ce} = \frac{\text{Supply Voltage}}{Z_B + Z_{Ce}} \rightarrow \frac{120V}{(1k\Omega + 1500k\Omega)} = 0.08mA
\]
### Operational Safety

<table>
<thead>
<tr>
<th>Fault</th>
<th>Grounded System</th>
</tr>
</thead>
</table>
| A fault current flow is determined by the ground impedance and the fault. | ![Diagram](image)
| • $I_F < I_K$ ($I_K$ typically = 20A) | ▪ Overcurrent Protection Device not trip
|   • Risk of equipment malfunctions | ▪ $I_F > I_K$
| • $I_F > I_K$ | ▪ Overcurrent Protection Device trips
|   • Unexpected interruption of power | |

<table>
<thead>
<tr>
<th>Fault</th>
<th>Isolated Power System (IPS)</th>
</tr>
</thead>
</table>
| In the event of a fault $R_F$ only a very low current $I_{Ce}$ flows | ![Diagram](image)
| ▪ Overcurrent Protection Device does not trip | ▪ In the event of single conductor to ground fault, power is not interrupted
| ▪ Alarm indicated by a Line Isolation Monitor | |
## Operational Safety

<table>
<thead>
<tr>
<th>Fault Condition</th>
<th>Conductors under Fault Condition</th>
<th>GFCI - Class A (Line 2 = Neutral)</th>
<th>Isolated Power System</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fault = I&lt;sub&gt;F&lt;/sub&gt;</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I&lt;sub&gt;F&lt;/sub&gt; &lt; OCPD Rating (Breaker); I&lt;sub&gt;F&lt;/sub&gt; ≥ 6mA</td>
<td>Line 1 to Ground</td>
<td>Power Loss</td>
<td>Alarm</td>
</tr>
<tr>
<td></td>
<td>Line 2 to Ground</td>
<td>*</td>
<td>Alarm</td>
</tr>
<tr>
<td></td>
<td>Line 1 to Line 2 (via Ground)</td>
<td>Power Loss</td>
<td>Alarm</td>
</tr>
<tr>
<td>I&lt;sub&gt;F&lt;/sub&gt; &lt; 6mA; I&lt;sub&gt;F&lt;/sub&gt; ≥ 4mA</td>
<td>Line 1 to Ground</td>
<td>Possible Nuisance Trip</td>
<td>Alarm (5mA)</td>
</tr>
<tr>
<td></td>
<td>Line 2 to Ground</td>
<td>Possible Nuisance Trip</td>
<td>Alarm (5mA)</td>
</tr>
<tr>
<td></td>
<td>Line 1 to Line 2 (via Ground)</td>
<td>Possible Nuisance Trip</td>
<td>Alarm (5mA)</td>
</tr>
</tbody>
</table>

Note: “Class A” GFCI operation occurs when a current imbalance of 4-6 mA is detected
Line Isolation Monitor

- Line Isolation Monitor (LIM)
  - A test instrument designed to continually check the balanced and unbalanced impedance from each line of an isolated circuit to ground and equipped with a built-in test circuit to exercise the alarm without adding to the leakage current hazard.
- Measures how isolated the system is from ground
  - by continually measuring impedance to ground of each phase
- Predicts and displays what the highest ground fault current would be if the line with the highest impedance were to fault to ground
- This predicted current is called the Total Hazard Current
When a ground fault occurs the LIM will sense the new lower impedance to ground.

The LIM will re-calculate the fault current that would flow if the remaining phase (with the highest impedance to ground) were to become grounded:
- LIM predicts the highest fault current for the next ground fault to occur (definition of hazard current)
  - LIM is looking for worst case scenario
  - phase-ground-phase fault limited only by the transformer impedance (bolted faults)
  - Total Hazard Current $\geq 5$ mA

The LIM will display a hazard alarm.

Hence the LIM issues a hazard alarm when either:
- the leakage current becomes excessive
- a ground fault occurs
Summary - Isolated Power System Purpose

- **Protection against Macro Shock**
  - Added protection against electrical shock hazards resulting from the systems high impedance (capacitive/resistive) return path

- **Continuity of Supply**
  - Power will remain during a single ground fault condition (ie. L1 or L2 connected to Ground)

- **Advanced Warning of Faulty Equipment**
  - Provide a warning when the insulation integrity of medical devices connected to the Isolated Power System are compromised
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- Theory
- Offer
- Codes & Standards
- FAQs
Isolation Transformer

- **Performance**
  - comply with UL-1047 requirements
  - electrostatic ground shield
  - over sized for heat dissipation
  - high quality non-aging electrical grade grain-oriented silicon steel

- **Ratings**
  - 3kVA – 25kVA
    - 5kVA and 10kVA are most common
    - recommended **NOT** to exceed 10kVA for transformers providing 120 volt power.
    - > 10kVA recommended only for loads requiring 208 or 240 volts such as portable lasers

- **Mounting options**
  - in the IPS enclosure (most common)
  - remotely from the IPS enclosure
    - retrofit applications
    - adds leakage (requires extensive planning to ensure compliance)
Line Isolation Monitor

Key Features

- **Automatic operating voltage selection**
  - reduces repairs and technical calls, increases customer satisfaction
- **Automatic self test with data logging**
  - reduces time required to perform periodic testing
- **Communication - BMS interfacing**
  - centralized monitoring of LIM installations – improves predictive maintenance
- **EDS function**
  - reduces time required to locate fault(s)
- **Plain text menu interface**
  - makes setting easier and makes alarms clearer
- **General electrical system measurements**
  - helps determine root cause of fault
Isolated Power Panels – Types

- **IP - Operating Room**
  - Most common

- **IP - ICU**
  - Like OR panel, but includes receptacles and/or ground jacks on front panel

- **IX - Dual (Duplex) Panel**
  - Two operating room panels in one enclosure
  - Requires two feeders

- **ID - Dual Output Voltage Panel**
  - Single feeder with 120 V secondary, and 208 V or 240 V secondary

- **IP - Controlled Power Panel**
  - 208 or 240 V secondary, usually to feed laser equipment
  - Controlled by PLC so that a limited number or circuits are active at a time.
Isolated Power Panels – Types

- **IP - Operating Room**
  - most common
  - 3, 5, 7½, 10 kVA
  - 6” or 8” deep
  - 43” tall x 24” wide
  - Up to 16 circuits (SQD, Eaton, GE)
    - recommended not to exceed 12

- **IP - ICU**
  - Like above except:
    - includes receptacles and/or ground jacks on front panel
    - 48” tall x 24” wide
Isolated Power Panels – Types

- **IX – Dual (Duplex) System Panel**
  - Two systems in a common enclosure
  - Requires independent feeder per system
  - 3, 5, 7½, 10 kVA
  - 8” deep
  - 71” tall x 34” wide
  - Up to 16 circuits per system (SQD, Eaton, GE)
    - recommended not to exceed 12
(IX) - Dual (Duplex) System Panel

**CONDUIT ENTRANCE TOP**

**PLAN**

- 8.0 in (204 mm)
- 36.0 in (915 mm)

**SYSTEM "A"**

**SYSTEM "B"**

**FRONT VIEW**

- 34.0 in (863 mm)
- 1.0 in (26 mm)

**SIDE VIEW**

- 73.0 in (1865 mm)
- 71.0 in (1804 mm)

**NOTE:**

- See Detail "A"
Isolated Power Panels – Types

- **ID – Dual Output Voltage Panel**
  - provides both 120V and 208V or 240V power
  - single feeder
  - 10, 15, 20, 25kVA
  - 12” or 14” deep
  - 51” tall x 34” wide
    - 56”x34” available includes receptacles and/or ground jacks on front panel
  - Up to 16 circuits (SQD, Eaton, GE)
    - recommended not to exceed 12
(ID) - Dual Output Voltage Panel

CONDUIT ENTRANCES TOP AND BOTTOM

PLAN

Low Voltage Section

High Voltage Section

TOTAL PANEL WEIGHT: 630 LBS. (287 Kg)
Isolated Power Panels – Types

- **IP – Controlled Power Panel**
  - provides multiple ORs with 208V or 240V power
  - 15 or 25kVA
  - Up to 12 circuits
  - maximum of 6 circuits simultaneously active
    - recommended not to exceed 4
  - PLC limits the number of simultaneously “active” circuits
  - circuit selection is operated via laser receptacle module (door contact) located in OR

- **XRM – Laser Receptacle Module**
  - Receptacle, Remote Indicator, & PLC input (door) contact
  - Optional “IN-USE” indicator
## Remote Indicating Devices

### MK2000 Series

- LED display for long life
- Mounts to standard electrical box
- Includes “Mute” button
- Optional:
  - “Push to Test” Button
  - Transformer Overload Indication
  - Numeric THC / Transformer Load Value
- Easy to clean rugged stainless steel and Lexan front foil design

<table>
<thead>
<tr>
<th>Model</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>MK2000-G1</td>
<td><img src="MK2000-2G2" alt="MK2000-G1" /></td>
</tr>
<tr>
<td>MK2000P-G1</td>
<td><img src="MK2000-2G2" alt="MK2000P-G1" /></td>
</tr>
<tr>
<td>MK2000-2G2</td>
<td><img src="MK2000-2G2" alt="MK2000-2G2" /></td>
</tr>
<tr>
<td>MK2000CBM-G2</td>
<td><img src="MK2000-2G2" alt="MK2000CBM-G2" /></td>
</tr>
</tbody>
</table>
## Remote Alarm Stations

<table>
<thead>
<tr>
<th>Model</th>
<th>Features</th>
</tr>
</thead>
</table>
| **RAS** | - Stainless Steel Face Plate  
|         | - Custom arrangements per application                                    |
| **MK2430** | - Indication of operating and alarm messages  
|         | - Text display with backlit LCD (4 x 20 / 3 lines)  
|         | - 200 freely programmable text messages  
|         | - Alarm history with real-time clock to save 250 messages               |
| **MK800** | - Indication of operating and alarm messages  
|         | - Text display with backlit LCD (4 x 20 / 3 lines)  
|         | - 1000 freely programmable text messages  
|         | - Alarm history with real-time clock to save 1000 messages              |
Ground/Power Module

Red or ivory duplex receptacle: 20 A, hospital grade

Ground jack: 30 A, twist-to-lock
Stainless steel faceplate

18 lugs for #14–#6 AWG
1 terminal block for #12–1/0 AWG

Stainless steel faceplate
Isolated Power System - Basic
Isolated Power System - Options

- Mains load monitoring
Isolated Power System - Options

- Mains load monitoring
- Branch circuit ground fault location
Fault location in practice

Insulation Fault
R=20kOhm
EDS:off-auto-
Adr2 k3 5.2 mA
Isolated Power System - options

- Mains load monitoring
- Branch circuit load monitoring
- Branch circuit ground fault location
Isolated Power System - options

- Screw-less flush mounted with bezel frame and surface mounted enclosures.
- Closed foil surface allowing easy integration of third-party systems:
  - Operating Room Table Controls
  - Operating Room Light Controls
  - Humidity / Temperature Controls
  - Medical gases
  - Intercom systems
  - Control (Laser) Panel Circuit Selection
Isolated Power System - options
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Codes & Standards

- **Applicable Codes**
  - NFPA 70:2014 - National Electrical Code, Article 517
    - minimum requirements for the installation of various electrical system
  - NFPA 99:2012 - Health Care Facilities Code
    - minimum requirements for the performance of various system

- **Always check with your local Authority Having Jurisdiction (AHJ).**
  - Local codes such as North Carolina Department of Health and Human Services (NCDHHS) and Agency for Health Care Administration (AHCA) as well as the City of Chicago have more stringent requirements for the installation & performance of Isolated Power Systems.
Chapter 3 - Definitions
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- 3.2 NFPA Official Definitions
- 3.3 General Definitions
- 3.4 BICSI Definitions

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- 4.2 Risk Assessment
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- 6.2 Nature of Hazards
- 6.3 Electrical System
- 6.4 Essential Electrical System Requirements — Type 1
- 6.5 Essential Electrical System Requirements — Type 2
- 6.6 Essential Electrical System Requirements — Type 3
Chapter 6 - Electrical Systems

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6.3.2 Distribution

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  6.3.2.2.1 Regular Voltage Wiring Requirements
  6.3.2.2.2 Grounding Requirements
  6.3.2.2.3* Grounding Interconnects
  6.3.2.2.4 Protection Against Ground Faults
  6.3.2.2.5 Low-Voltage Wiring
  6.3.2.2.6 Receptacles
  6.3.2.2.7 Special Grounding
  6.3.2.2.8 Wet Procedure Locations
  6.3.2.2.9 Isolated Power
  6.3.2.2.10 Essential Electrical Systems (EES)
  6.3.2.2.11 Battery-Powered Lighting Units

6.3.2.3 Laboratories

6.3.2.4 Other Non-patient Areas

6.3.2.5 Ground-Fault Protection

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6.3.3.1 Grounding Systems in Patient Care Rooms
  6.3.3.1.1* Grounding System Testing
  6.3.3.1.2 Reference Point
  6.3.3.1.3* Voltage Measurements
  6.3.3.1.4* Impedance Measurements
  6.3.3.1.5 Test Equipment
  6.3.3.1.6 Criteria for Acceptability for New Construction

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6.3.3.3 Isolated Power Systems

6.3.3.4 Ground-Fault Protection Testing

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6.3.4.1 Maintenance and Testing of Electrical System

6.3.4.2 Record Keeping
  6.3.4.2.1* General
  6.3.4.2.2 Isolated Power System (Where Installed)
NFPA 99 - Wet Procedure Locations

- **Wet Procedure Locations**
  - area in a patient care room where a procedure is performed that is normally subject to wet conditions while patients are present, including standing fluids on the floor or drenching of the work area, either of which condition is intimate to the patient or staff

- Wet procedure locations shall be provided with special protection against electric shock.
  - Isolated Power System or Class A GFCI Receptacles
    - GFCI can only be used if loss of power can be tolerated

- **Operating rooms shall be considered to be a wet procedure location, unless a risk assessment conducted by the health care governing body determines otherwise.**
  - risk assessment should include all relevant parties
    - clinicians, biomedical engineering staff, and facility safety engineering staff
The wording in the NFPA 99:1999, allowed for “blanket policies” without the requirement of a formalized analysis or risk assessment.

- **Similarities:**
  - Individual facilities are still free to determine whether Wet Procedures will be performed in a particular Operating Room.

- **Differences:**
  - All Operating Rooms are deemed Wet Procedure locations by default.
  - If believed to be a “Non-Wet Procedure” location; hospital governing body must complete a formal risk assessment to show evidence that “Wet Procedures” will not be performed in the particular OR(s).
NFPA 70 - Patient Care Area(s)

**NFPA-99 (2012)**
All Operating Rooms are Wet Procedure Locations. Facility must perform a risk assessment to prove an OR as dry.

**NEC Article 517-2**
Determine type of Patient Care Area

- General Care Area
- Critical Care

**NEC Article 517-20**
Can tolerate power outage during ground fault?

- YES
- NO

**Wet Procedure Location**

- YES
- NO

**Grounded Power with GFCI**

- YES
- NO

**Isolated Power System (IPS)**

- Grounded Power no extra protection required
NFPA 99 - Electrical Systems

- **Grounding System**
  - effectiveness is determined by voltage and impedance measurements
  - **Voltage**
    - measurements made under no-fault conditions between a reference point (ground bus in IPP) and exposed fixed electrical equipment with conductive surfaces in a patient care vicinity.
    - acceptable for new construction ≤ 20mV
  - **Impedance**
    - measurements made between the reference point and the grounding contact of 10 percent of all receptacles within the patient care vicinity
    - acceptable for new construction ≤ 0.1Ω
NFPA 99 - Electrical Systems

- **Receptacle Testing**
  - non-hospital grade -> yearly testing
  - hospital grade - after initial installation, replacement, or servicing of the device
    - physical integrity confirmed by visual inspection
    - ground continuity
    - correct polarity
    - retention force of grounding blade (not less than 115g)

- **GFCIs**
  - when installed, each level shall be performance-tested to ensure compliance
    - manufactures recommend monthly testing
NFPA 99 - Electrical Systems

- Isolated Power Systems
  - Impedance of Isolated Wiring
    - impedance to ground of either conductor of an isolated system shall exceed 200kΩ
  - LIM Testing
    - after installation, and prior to being placed in service
    - after any repair or renovation to the electrical distribution system
      - by successively grounding each line of the energized distribution system through a resistor whose value is $200 \times V$ (ohms), where $V$ equals measured line voltage
    - 24kΩ for 120V system ($200 \times 120V = 24,000\Omega$)
      - by actuating the LIM test switch
        - monthly for analog LIMs
        - yearly for digital LIMs with automated self-test and self-calibration capabilities
  - Permanent records shall be kept of the results
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Designing – Isolated Power System

- **Overcurrent Protection & Switches**
  - Branch circuit breakers to be 2-pole, since both conductors are current carrying
  - Hardwired fixed equipment should be connected with 2-pole switches
    - boom brake & motor, film viewers, etc.

- **Isolated Conductors**
  - Dielectric constant of 3.5 or less is recommended (XHHW, XHHW-2)
  - Identification of conductors; insulation shall be:
    - Orange with a distinctive colored stripe other than white, green, or gray
      - Terminated on Receptacle “Neutral” terminal
    - Brown with a distinctive colored stripe other than white, green, or gray
      - Terminated on Receptacle “HOT” terminal
  - Keep length of conductors to a minimum.
    - Longer runs = higher leakage

- **Conduit**
  - Use nonflexible metal conduit
  - ¾" conduit minimum - not more the 2 circuits (6-conductors) per ¾" conduit.
  - Use 1" conduit with 3 or 4 circuits, but do not use larger than 1”.
Designing – Isolated Power System (cont.)

- **Wire splices**
  - Minimize as much as possible
  - If splices are necessary, use compression splices in lieu of wire nuts.

- **Wire Pulling Compound**
  - NEVER use wire pulling compounds.

- **Devices per Circuit**
  - Recommended to limit circuits to two duplex receptacles (4 receptacles)
    - The LIM is looking for a worse case scenario.
    - Adding receptacles to a circuit for additional equipment can cause additional leakages

- **Use “Hospital Grade” devices only**
  - Do not use GFCI, Surge Protection Power Taps or Isolated Ground devices
    - Any device that has a relationship with an equipment ground to operate properly, will not operate properly on an IPS
# Recommended Total Conductor Length

## Table 30.1
Maximum allowable panel leakage

<table>
<thead>
<tr>
<th>Maximum panel rating, kVA</th>
<th>Maximum panel leakage current, µA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>120</td>
</tr>
<tr>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>10</td>
<td>50 (highlighted)</td>
</tr>
<tr>
<td>25</td>
<td>70</td>
</tr>
<tr>
<td>Wall modular units</td>
<td>100</td>
</tr>
</tbody>
</table>

## Table 30.2
Maximum allowable transformer leakage

<table>
<thead>
<tr>
<th>Maximum transformer rating, kVA</th>
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</tr>
<tr>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>25</td>
<td>35</td>
</tr>
</tbody>
</table>
Recommended Total Conductor Length

- Limit total length of RW90 XLPE, AWG #12 cable to 480 ft

Rationale:
- Minimum impedance to ground ≥ 200 kΩ at commissioning
- Therefore at 120 V, maximum allowable system hazard current is 600 μA
  - $600 \text{ μA} = \frac{120 \text{ V}}{200 \text{ kΩ}}$
- 75 μA leakage = interior (50 μA) & transformer (25 μA)
  - leaves 525 μA for conductors
- Leakage current XLPE cable is 1 μA/ft in metallic conduit, as per IEEE 602-2007
  - Use conservative value of 1.1 μA/ft
- Therefore, recommended maximum 480 ft to keep system hazard current below 600 μA
Isolated Power Systems – Final Notes

- Total length of branch circuit conductors should be limited to 480 ft.
- Limit the number of circuits per panel to 12
  - $480\text{ft} ÷ 12\text{ circuits} = 40\text{ft/circuit}$
- Wire pulling lubricants that increase the dielectric constant of cables must not be used
  - Higher dielectric constant means higher leakage capacitance
- Isolated panels (120V) should not be rated higher than 10 kVA
  - use (2) systems if more load is required
- Field lighting should never be connected to the IPS