Personnel Protection GFCI for Industrial Systems
The Hazard – Electrocution

- **5th leading cause of death** from 1980 to 1992
  - 7% of all work fatalities (411 deaths per year)  
  Source: NIOSH

- **3 killed every 4 days** from 1992 to 2010
  - 5% of all work fatalities (270 deaths per year)  
  Source: BLS

- **Over 1000 people** die each year  
  Source: National Safety Council

- **51% of all reported electrical-related incidents are fatalities** in Ontario from 2001 to 2010  
  Source: 2010 Ontario Electrical Safety Report

- **17 other injuries** (non-fatal shock and burns) for every electrocution  
  Source: Ontario Ministry of Labour
The Hazard – Implications ($$$

- **$160.4 billion** was the cost of US workplace injuries in 2006*

- **Over $30 million** per incident in fines, medical, litigation, lost business, and equipment costs*

- **Over $19 billion** is the total annual cost of occupational injuries to the Canadian economy**

- **$7.67 billion** benefits paid to Canadian workers for time-loss injuries or fatalities in 2008**

*Source: National Safety Council  
**Source: Human Resources and Skills Development Canada
Electrical Fatalities – US

Electrical Fatalities by Industry Group as a Pct. of Total Electrical Fatalities, 2003-2010

- Construction, 52%
- Professional and business services, 13%
- Trade, transportation, and utilities, 11%
- Natural resources and mining, 9%
- Manufacturing, 8%
- All other industry groups, 6%


Source: Electrical Safety Foundation International
Electrical Fatalities – Canada (ON Only)

Occupational Electrocution by Type of Work 2000 to 2009

- Repair and maintenance 58.3%
- Construction 26.7%
- Disassembling 1.7%
- Farming 5.0%
- Other 1.7%
- Utility 1.7%
- Moving 1.7%
- Production 1.7%
- Packing 1.7%

Source: 2009 Ontario Electrical Safety Report
Types of Electrical Injuries*

- **Electrical Shock**
  - reflex response possibly involving trauma
  - involves burns, abnormal heart rhythm and unconsciousness

- **Electrocution**
  - occurs when electrical current passes over or through a worker’s body resulting in a fatality

*Source: Prevention Strategies for Electrical Hazards © 2008 National Safety Council*
Types of Electrical Injuries*

- **Fall**
  - Electric shock may cause muscles to contract causing lose of balance
  - Explosion from an electrical incident can also cause a fall

- **Burn**
  - Most common non-fatal injury
  - Internal (electric shock)
  - External (arc flash)

*Source: Prevention Strategies for Electrical Hazards © 2008 National Safety Council*
How Shock Occurs?*

- **Direct Contact**
  - Touching wires in an energized circuit
  - Touching one wire of an energized circuit and a path to the ground

- **Indirect Contact**
  - Touching metallic part that has become “hot” by contact with an energized conductor due to an insulation fault

*Source: Prevention Strategies for Electrical Hazards © 2008 National Safety Council
Effect of Electric Shock

- Disagreeable sensation
- Involuntary muscular contraction
- Burns
- Ventricular fibrillation
  - Most serious cardiac rhythm disturbance
  - The Lower chambers quiver and the heart can't pump any blood, causing cardiac arrest*
  - AC current flow through the body generates periodic excitation

*Source: American Heart Association
Severity of Shock*

- The path of current through the body
- The amount of current flowing through the body
- The length of time the body is in the circuit

LOW VOLTAGE DOES NOT IMPLY LOW HAZARD!

*Source: Prevention Strategies for Electrical Hazards © 2008 National Safety Council
Basic Current Pathways

1. TOUCH POTENTIAL (hand/hand path)
2. STEP POTENTIAL (foot/foot path)
3. TOUCH/STEP POTENTIAL (hand/foot path)
Amount of Current

Image courtesy of Pass & Seymour
Effect of AC Current on Human Beings

Source: Std. IEC 60479-1
The Solution – Personnel Protection

- Ground Fault Circuit Interrupter (GFCI)
  - Fast-acting circuit breaker
  - Very low pick-up current (6 mA)

- Types of GFCI
  - Permanently-connected
  - Portable

- Mandated by NEC & CEC
- Defined by UL 943 & C22.2 No. 144.1–06
GFCI – Theory of Operation

1. Current travels through body
2. CT picks up current imbalance
3. Sensor detects current imbalance and opens circuit
   Fault is cleared and personnel are protected
GFCI – Facts

- Since mandated by NEC in 1973*:
  - 50% reduction in residential electrocutions has been accredited to GFCIs
  - 280 lives could be have been save each year, had each household equipped with GFCIs

*Source: Electrical Safety Foundation International
Personnel Protection – The Gap

- UL 943 Class A GFCI:
  - 150 V line-to-ground max. (240 V systems)
  - 6 mA trip level (too low for industrial equipment)
  - Load-ground is not monitored

- Only appropriate for residential applications

- UL identified the need for new GFCI classes appropriate for industrial applications

**INDUSTRIAL PERSONNEL PROTECTION IS STILL LACKING**
UL 943C – Special Purpose GFCIs

- Dec. 2000: Request for Submittal
- May 2009: Revised Draft “Outline of Investigation”
- Jan. 2011: Subject 943C “Outline of Investigation”
- Nov. 2012: UL 943C “Outline of Investigation”
UL 943C – Special Purpose GFCIs Usage

- Line-to-ground voltage is greater than 150 volts (i.e. 480 V & 600 V systems) and equipment grounding or double insulation is required by the National Electrical Code, ANSI/NFPA 70

- Line-to-ground voltage is 150 volts or less (i.e. 208 V & 240 V) and equipment grounding or double-insulation is provided, but the use of a Class-A GFCI is not practical.
UL943C – GFCI Classes

Line Voltage

Over 240 V

Over 480 V

Voltage ≤ 150 V

Oversized ground

Class A

Class C

Class D

Class E

Notes:
1. May be provided but NOT required
2. Equipment grounding or double insulation is required by the NEC Sections 250-110 (6) & 250-114 (2)
3. Across the body during a fault
4. Low-impedance grounding path is required. Therefore, oversized equipment grounding conductor shall be provided
5. High speed tripping is required
UL 943C Trip Curve – Class C & Class D GFCIs
The SB6000 Series – Industrial Shock-Block*

- First & only UL 943C listed GFCI
- 208-600 V, 100 A
- Trip Level Options
  - Fixed 20 mA GFCI
  - Selectable 6, 10, 20, and 30 mA EGFPD
- Packaging Options
  - Enclosed model mounts like an electrical cabinet
  - Open-chassis model for mounting inside existing cabinets or OEM equipment

*Patent pending
The SB6000 Series – UL 943C Listed?

- Reliable performance
  - 85%, 100%, and 110% of the rated voltage
  - Full-load & no-load
  - 20 mA & 500 Ω ground faults
  - -35°C (-31°F) to +66°C (+151°F)

- Leakage-current return path

- SCC rating of at least 5,000 A
  - ISB was tested at 50,000 A

- Environment Considerations
  - Humidity conditioning, ultraviolet, corrosion, & dust
  - RF immunity
The SB6000 Series – GFCI

**Open-Chassis Model**

**Enclosed Model**
The SB6000 Series – EGFPD

Open-Chassis Model

Enclosed Model
The SB6000 Series – Connection Diagram

Circuit Breaker

SB6100 Industrial Shock-Block Open-Chassis Model

SB6100 Industrial Shock-Block Enclosed Model

M M
The SB6000 Series – Operator Interface (SB-OPI)

- Power (PWR) and Operation (EN)
- Ground Leakage Percentage
- Fault (FLT)
- Input Connection (INP)
- Load Ground Connection (GC)
- Test & Reset
The SB6000 Series – Load-ground Monitor

- Zener diode installed on the load equipment
- Pilot wire from SB6100 to termination
- DC signal from SB6100 (over a pilot wire) to the termination, then load’s chassis and back to the source through ground
- If monitored circuits opens, or the ground-check conductor shorts to ground, the supply will be de-energized
The SB6000 Series – Termination Device

1N5339B

SE-TA6A

SE-TA6A-WL

SE-TA6-SM

SE-TA6ASF
# The SB6000 Series – Features and Benefits

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>BENEFITS</th>
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<tbody>
<tr>
<td>UL 943 inverse time trip curve</td>
<td>Reduces the probability of nuisance tripping</td>
</tr>
<tr>
<td>UL 943C fixed trip level (GFCI 20 mA)</td>
<td>GFCI protection for systems with leakage current higher than the standard 6 mA required by UL 943 Class A</td>
</tr>
<tr>
<td>Selectable trip levels (EGFPD)</td>
<td>Help reduce nuisance tripping by providing adjustable trip levels in systems with leakage current higher than the standard 6 mA required by UL 943 Class A</td>
</tr>
<tr>
<td>UL 943C ground monitor/interrupt</td>
<td>Trips if continuity of the load ground is lost</td>
</tr>
<tr>
<td>Undervoltage, brownout, chatter detection</td>
<td>Prolong the internal contactor lifetime</td>
</tr>
<tr>
<td>3 x Class T, 600 V incoming fuses</td>
<td>Provides overcurrent protection for the internal contactor</td>
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Applications – Ground-monitor*

• Stud gun machine
• Move around the shop floor
• Welding outlets all around the shop

• 6-ft cable with a 60 A welding plug
• 200-ft cable to stud gun machine

*Courtesy of Liberty Fuel Mines, NA Coal Corporation
Applications – Ground-monitor*

*Courtesy of Liberty Fuel Mines, NA Coal Corporation
Applications – Concrete Cutter*

- Wet environment
- High leakage-current
- Personnel protection needed

*Courtesy of Interstate Brick
Applications – Manufacturing/Processing

- Food & Beverage
- Mixers
- Heaters
- Fans
- Tile/concrete cutters
- Conveyors & Hoists
- Elevators & Escalators
Applications – Manufacturing/Processing

- Paint booths
- Pressure washers
- Submersible pumps
- Arc welders
- Portable lighting
- Motors
- Compressors
Applications – Entertainment

- Aquariums
- Fountains
- Swimming pools
- Amusement parks
- Water slides
- Golf courses
- Fairs
- Zoos
Applications – Municipal/Institutional

- Water treatment plants
- Generating stations
- Airports
- Subways
- Train & Bus stations
- Hotels & Restaurants
- Resorts
- Convention centers
- Marinas
A True Story*

One hot summer morning, a 23 year old apprentice construction worker had just started his shift when he felt a tingling sensation in his hand while using an electric power drill. The young man took the drill to the air conditioned construction trailer where the 59-year old project manager worked. The project manager plugged the drill into a wall socket, but did not feel any tingling.

*Source: Prevention Strategies for Electrical Hazards © 2008 National Safety Council
A True Story*

Assuming the young man was trying to get out of his assigned tasks, he told the young worker either to use the drill to complete his job assignments or to punch out and go home. The young man was angry and returned to his work area. The apprentice spent the next ninety minutes working on various tasks. He then returned to the assignment requiring the use of the drill.

*Source: Prevention Strategies for Electrical Hazards © 2008 National Safety Council
A True Story*

He plugged in the drill, knelt down on one knee and began to drive a screw into a board. Coworkers saw the employee on the floor convulsing. A co-worker was able to knock the extension cord from the source and power to the drill was cut. The apprentice suffered a cardiac episode before an emergency crew arrived. Efforts to revive the young man were unsuccessful.

*Source: Prevention Strategies for Electrical Hazards © 2008 National Safety Council
A Shock-free Workplace!