Improving safety
Through arc resistant switchgear and arc reducing components
Automation & Power World 2011
April 18-21, 2011 in Orlando, Florida
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April 18-21, 2011 in Orlando, Florida

- Save the date for this “must attend” event!
- April 18-21, 2011
- Orlando World Center Marriott, Florida
- Over 400 hours of educational training
  - Business forum
  - Customer case studies
  - Hands-on training
  - Panel discussions
  - Technical workshops
- Earn PDHs and CEUs
- Technology & Solution Center
  - Over 70,000 sq. ft. of exhibits
- Network with your peers
- www.abb.com/a&pworld
Educational workshops
Automation & Power World offers over 400 hours of educational workshops specifically designed to make engineers, maintenance and management more valuable to their companies.

Technology & Solution Center
Over 1 ½ acres (70,000 ft²) of with nearly 100 tons of electrical gear and 100’s of experts ready to answer any of your questions and share the future of Automation & Power Solutions.

Connect with Peers
With over 4,000 of your peers in attendance, this is a powerful opportunity to network and learn from the industry. In addition, over 45 customers will be sharing their own case studies.
Educational workshops developed for all audiences
Just a few examples

- The coming wave of process safety system migration
- Implementing an alarm management strategy for a 100,000 I/O system - Case study
- Replacement and retrofit of large motors: Challenges and solutions
- Dynamic studies for large scale renewable energy integration at a Texas CREZ - Case study
- Secure commissioning of your process plant - Case study
- New arc flash mitigation technologies and techniques for a safer working environment
- Robotics 101
- A better approach to non-revenue water loss
- Electric vehicles: Are they real this time?
- Why is SIL more important than architecture?
Past attendees input

“I am impressed with the different parts of the program, the workshops and also the exhibit set-up... there is a lot of information to pick up.”
Duane Souers, Georgia Pacific

“It’s a great opportunity to get a lot of exposure to people and products in one week.”
Pardeep Gill, Alcoa

“It is well worth the time given the opportunities to: learn from industry experts, network with peers in the same industry, learn about emerging technologies, and build excellent supplier relationships.”
Sanjin Osmancevic, National Grid
Jerry Earl – Product Manager
Medium-voltage
metal-clad switchgear

ABB – Lake Mary, FL
Introduction

Today’s topics

- Arc flash characteristics
- Causes of arc flash incidents
- Current standards and how they apply
- Safety techniques
- Arc flash mitigation techniques
  - Space and distance
  - Arc-resistant switchgear
  - Relays to mitigate arc flash hazard
What is an arc flash?

- The result of a rapid release of energy due to an arcing fault between phases, neutral or a ground.
  - An arc arises when at least part of the current passes through a dielectric, usually air
  - Maximum peak power up to 40 MW
  - Arc temperature up to five times the surface temperature of the sun (20,000°C)
  - Light intensity more than 2000 times that of normal office light
  - Volumetric expansion approximately 40,000+ - 1

Temperature of the sun surface is about 5000°C.
Arcing incidents happen When?

Without operator, 25%

With operator working in the switchgear, 65%

With operator in front of a closed door, 10%
Hazards of an arc flash

- We all know about the heat that is generated but what are the other hazards besides the fire ball?
  - Shrapnel – push buttons, lights and relays make great projectiles
  - Pressure waves – generate extremely violent forces on the human body
  - Hot gases – frequently the cause of death is not the burns on the body but the hot gases that are inhaled and burn the lungs
  - Toxic fumes – long term health risks
  - Molten metal – as the copper vaporizes and melts, droplets can splatter and burn through most current PPE
Common causes of arc faults in switchgear

- Human error
  - Accidental touch
  - Dropping or misplacement of tools & other parts
  - Improper installation practices
  - Wrong tools used selected
- Mechanical failures
  - Voids in insulation and insulation breakdown
  - Breaker failures in contacts, springs, stabs, etc.
  - Loose connections and bolts
  - Warping due to shifts in floor, aging connectors, etc.
- Intrusion
  - Snakes, mice, rats, raccoons, bees, etc.
- Environmental issues
  - Dust, contamination, moisture
Arc flash danger statistics

- Currently, OSHA lumps arc flash incidents in with electrical incidents.
- A recent survey showed that 5-10 people per day go to burn centers due to arc flash incidents – that does not include those going to local and regional hospitals
  - That is 2000-3500 people a year in the US!
  - With the high mortality rate of burn injuries, this can translate to hundreds of deaths a year
- IEEE did a study with a large utility and over the last 53 years, they have had 1 major arc flash incident every 18 months.
Arc-resistant standards
Evolution of arc-resistant switchgear standards

- Interest in Europe – uninsulated bus was common
- Annex AA to IEC 298 was approved in 1981
- EEMAC G14-1 was published in 1987 in Canada
  - Type A – arc-resistant construction at the front only
  - Type B – arc-resistant construction at the front, back, and sides
  - Type C – arc-resistant construction at the front, back, and sides, and between compartments
- IEEE C37.20.7-2007 includes
  - Type 1 – similar to EEMAC Type A above
  - Type 2 – similar to EEMAC Type B above
  - Annex A addresses suffixes “B” and “C”
    - Type 1C – Type 1, but also with arc-resistance designs or features between adjacent compartments
    - Type 2B – Type 2 with LV instrument compartment door open – relay and maintenance personnel survive
    - Type 2C - Type 2 with arc-resistance features between adjacent compartments – switchgear survives with minimum damage
    - Type 2BC – The ultimate in protection – combines types 2B and 2C
Arc-resistant standards
Industry recognition of arc flash hazards

Arc-resistant standards
Current requirements and how they apply

  - Safe practices to prevent electrical shock or burns must be implemented
  - Mandates that exposed workers must be qualified
  - Requires provisions for the appropriate personnel protective equipment (PPE)
  - Details steps to comply with the OSHA requirements
    - Worker training
    - Appropriate safe tools
    - Safety program
    - Arc flash PPE ratings
    - Equipment warning labels
The new NFPA 70E – 2009, Table 130.7 (C) (9)
Arc-resistant switchgear type 1 or 2

- Applies to clearing times of <0.5 sec with a perspective fault current not to exceed the arc-resistant rating of the equipment

<table>
<thead>
<tr>
<th>Category</th>
<th>Hazard/Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insertion or removal of CBs from cubicles</td>
<td>4</td>
</tr>
<tr>
<td>CB operation with enclosure door closed</td>
<td>0</td>
</tr>
<tr>
<td>doors open</td>
<td></td>
</tr>
<tr>
<td>Insertion of removal of CBs from cubicles</td>
<td>0</td>
</tr>
<tr>
<td>doors closed</td>
<td></td>
</tr>
<tr>
<td>Insertion or removal of ground and test device</td>
<td>0</td>
</tr>
<tr>
<td>with door closed</td>
<td></td>
</tr>
<tr>
<td>Insertion or removal (racking) of voltage</td>
<td>0</td>
</tr>
<tr>
<td>transformers on or off the bus, door closed</td>
<td></td>
</tr>
<tr>
<td>Work on control circuits with energized electrical</td>
<td>2</td>
</tr>
<tr>
<td>conductors and circuit parts 120V, exposed</td>
<td></td>
</tr>
</tbody>
</table>
Safety measures you can take

- Principle factors to determine arc flash hazard:
  - Available short circuit current
  - Duration of the arc (clearing time)
  - Distance from arc to personnel
  - Arc gap

- Actions you can take to minimize hazards (in order of preference):
  - Elimination
  - Substitution
  - Engineering controls
  - Work practices
  - Personal protective equipment
  - Training and communication
Work practices

- Safe distances from electrical switchgear
  - flash boundary can be established
- Warning labels and correct PPE per NFPA 70E
- Operating procedures
  - Work on de-energized switchgear
  - Safety tools & equipment
  - Training of personnel
## Arc flash introduction

### Mitigation techniques

<table>
<thead>
<tr>
<th>Move the people away from the equipment</th>
<th>Redirecting energy away from workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Remote racking mechanisms for breakers</td>
<td>• Arc-resistant switchgear</td>
</tr>
<tr>
<td>• Automatic secondary disconnects on breakers</td>
<td>• Type 2 – Arc-resistant construction at front, back and sides of equipment</td>
</tr>
<tr>
<td>• Relays &amp; meters moved to separate panels</td>
<td>• Type 2BC – Arc-resistant construction from compartment to compartment and isolation of the instrument compartment</td>
</tr>
<tr>
<td>• Eliminate need for maintenance</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduce the clearing time of the breakers</th>
<th>Use of fast acting fuses</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Maintenance mode switch with all breakers having instantaneous over-current trips active</td>
<td>• Not a practical solution today due to cost and size constraints in most applications</td>
</tr>
<tr>
<td>• Differential relays to detect internal faults</td>
<td>• Viable solution when separating parallel gear to reduce total available fault</td>
</tr>
<tr>
<td>• Light detection relays for extremely fast detection times</td>
<td></td>
</tr>
</tbody>
</table>
Improving safety via distance

- Many equipment failures occur during breaker open, close or racking operations
  - Use remote racking devices where possible
  - Use extension poles where possible
  - Have automatic secondary disconnects to avoid opening breaker door
  - Use of arc-resistant switchgear allows closed door racking
- Most maintenance activities involve relays and relay testing.
  - Remove relays from switchgear and install on remote racks
Significantly reduced maintenance needs

- Monitoring connections
  - Use of **infra-red windows** reduces requirements for entering equipment and lowers worker exposure
- Eliminate need for most breaker maintenance
  - **Magnetic actuated breakers** have fewer moving parts
  - Magnetic actuated breakers don’t require annual maintenance like spring-stored energy devices
  - Longer life due to fewer moving parts leads to fewer failure points, lower spare parts inventory. Less frequent replacements and maintenance lowers worker exposure
AMVAC circuit breaker

- Operating mechanism rated for 100,000 operations
  - 10 times ANSI requirement
- Interrupter assemblies rated for 30,000 full load operations
- Virtually maintenance free (minor lubrication needed)
- Only seven moving parts
  - 90% less parts
- Permanent magnet for holding force and latch
- Dual capacitors store energy
- Full operation for up to 90 seconds after loss of control power
- Interchangeable with ADVAC
Redirecting energy from the workers
Characteristics of arc-resistant switchgear

- Enhanced safety for personnel and equipment
  - Flap/vent system to relieve pressure
  - Patented collection chamber
  - Gases are safely expelled out the roof
- More than 25 years experience in arc-resistant switchgear
- Design allows for flexibility in configurations and promotes superior safety performance
- Reduces damage to adjacent equipment, thus reducing down time
Characteristics of arc-resistant switchgear

- Robust construction to direct gases to exhaust chambers
- Vent flaps designed to open under pressure and safely expel gases
- Special ventilation
  - Under normal conditions, open to allow air to flow
  - Under arc fault conditions, slams shut to prevent exit of gases
- Double wall construction with 3/16” air gap is very effective in resisting burn through
- Closed door racking and operation of circuit breakers, PTs, CPT fuses
Arc-resistant switchgear
Pressure relief

Characteristics of arc-resistant switchgear designs

Typical pressure vs. time relationship for switchgear internal arc fault
Characteristics of Arc-resistant switchgear designs

- Vertical clearance above switchgear is required to allow for plenum.
- Plenum is used to exhaust arc gases outside the building.

Roof-mounted plenum vents exhaust gases outside the building.

Separate low voltage control compartment modules are critical to ensuring the integrity of the control bus under arc fault conditions.

Two-high circuit breaker configuration.

Exhaust plenum mounted on roof of two-high switchgear in PDC building.
Customer adoption of arc-resistant switchgear

- Arc-Resistant Switchgear introduced to US Market
- Market Share reaches 10% in 2003
- >50% of Market will have converted to Arc-Resistant Switchgear in 2010!
Arc flash mitigation relays

- **Advantages:**
  - Fastest acting system (<2.5 ms)
  - Can be retrofitted into existing systems
  - Does not impact existing relaying scheme
  - Uses light and current for system reliability
  - Lower cost than bus differential scheme
  - Covers all compartments in the switchgear

- **Disadvantages:**
  - Takes an outage to install in existing gear
  - Fiber optic sensors installation procedures
The REA features

- REA 101 arc protection relay
- Fast trip time (< 2.5 ms)
- Unique fiber optic sensor technology with self supervision
- Current supervision for secure and reliable arc detection
- Easy to configure via front mounted dip switches
- Suitable for existing LV / MV switchgear installations or new applications
- Minimize potential risk of injury or death while increasing reliability
- Includes standard 12 year warranty
Target applications and methods with the REA

- New equipment
  - Utilities
  - Industrial
  - Power plants
- Existing installations
  - Medium voltage switchgear
    - Vacuum
    - Air magnetic
  - Low voltage motor control centers
Effect of arc flash protection on incident energy

### Incident Energy Comparisons

<table>
<thead>
<tr>
<th>REA101</th>
<th>Incident Energy (cal/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.09</td>
</tr>
<tr>
<td>10</td>
<td>1.08</td>
</tr>
<tr>
<td>20</td>
<td>2.25</td>
</tr>
<tr>
<td>30</td>
<td>3.46</td>
</tr>
<tr>
<td>40</td>
<td>4.69</td>
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<tr>
<td>50</td>
<td>5.95</td>
</tr>
<tr>
<td>60</td>
<td>7.22</td>
</tr>
<tr>
<td>70</td>
<td>8.51</td>
</tr>
<tr>
<td>80</td>
<td>9.80</td>
</tr>
<tr>
<td>90</td>
<td>11.11</td>
</tr>
<tr>
<td>100</td>
<td>12.43</td>
</tr>
</tbody>
</table>

Select Equipment Type
- Switchgear
- Panelboard or MCC (<1000V)

Select Grounding Method
- Ungrounded or High Resistance Grounded System
- Grounded Systems

Voltage (kV) 13.8
Arc-resistant switchgear & the REA together

- Arc-resistant SafeGear is like a seatbelt - It offers the most complete personnel and equipment protection for your switchgear when the unit is in normal operation
- The REA is designed to complement SafeGear and works when the equipment is opened and energized for maintenance, testing or service
- The REA is like an airbag – It does not eliminate the need for PPE but it does reduce the energy and in many cases, may reduce the PPE required. Do your own arc flash calculation and see the results!
Workshop Statistics
Over 400 hours of training

- ~45 customer presented case studies
- 87 sessions in the Technology and Solution Center
- 11 hours of panel discussions consisting of customers, industry experts and ABB executives
- Nearly 50 hours of hands on technical training
## ABB Automation & Power World Registration options

<table>
<thead>
<tr>
<th></th>
<th>Full Conference</th>
<th>Courtesy Registration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to ABB product developers and application experts in the 70,000 ft(^2) (over 1.5 acre) Technology &amp; Solution Center</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td>Access to a series of complimentary and educational workshops.</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td>Free Lunch and Tuesday Evening Reception</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td>Access to over 300 additional educational workshops – Including ARC Analysts presentations</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td>Up to $1,500 off a future ABB purchase*</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td>Complimentary ARC report valued at $2,500!*</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td>Evening Events (Monday and Wednesday)</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>$300 per day or $800 for all three days.</td>
<td><strong>Free!</strong></td>
</tr>
</tbody>
</table>

* See [www.abb.com/a&pworld](http://www.abb.com/a&pworld) for more details.
1. Become more valuable, choose from over 400 educational workshops and hands-on training sessions
2. Connect with thousands of peers and industry experts from 40 countries
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