Switchgear and Circuit Breakers Failures and Case Studies

UE Systems 2015 Reliable Asset Conference June 4th
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180 years of expertise

Mutuality

Single focus
  – commercial property
FM Global-Engineering

- ~1,800 engineers
- 148 countries
- Loss Prevention Solutions
  - Consistent
  - Practical and cost effective
  - Scientific proven
Switchgear and Circuit Breaker Failure

What can happen?

Switchgear/circuit breakers fail to operate with severe consequences
Switchgear and Circuit Breaker Failure

What can happen -

![Image of damaged switchgear and circuit breaker]
Switchgear and Circuit Breaker Failure

What can happen -
Switchgear and Circuit Breaker Failure

What can happen – worst case
Switchgear and Circuit Breaker Failure

Beyond the loss of the CBs and Switchgear

– Ignition source
– Catastrophic failure of controlled equipment
– Business Interruption
Switchgear and Circuit Breaker Failure

FM experience

- Business interruption
- Equipment Damage
- Fire following
Risk Factors

- Environment
- Operating conditions
- Age/history
- Maintenance
- Operator training

Operator training, contingency plan, safety device
Contingency Plan – What to ask yourself.

- Is a needed spare on hand and ready to install
  - Critical equipment
  - Long lead time
  - Obsolete
- Is re-configuring the electrical system possible
- Is redundant equipment installed
  - double-ended substation
- Has an alternative supply been identified
  - Rental diesel engine-driven generator units
Safety Device
Preventive Maintenance Program

Electrical protection - a system of many components

- Instrument
- Relay
- Control wire
- Trip coil
- Battery
- Etc.
### Preventive Maintenance Program Examples

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Flooded Lead Acid</th>
<th>Flooded Ni-Cd</th>
<th>Sealed Lead Acid (VRLA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly</td>
<td>Check and record charger voltage and current, electrolyte levels and for evidence of corrosion and leaks,…</td>
<td>Check and record charger voltage and current, electrolyte levels,…</td>
<td>Check and record charger voltage and current, ambient temperature, and for evidence of corrosion, leaks, overheating …</td>
</tr>
<tr>
<td>Quarterly</td>
<td>Check the specific gravity for lead-antimony batteries*, and the temperature of 10% of the cells…</td>
<td>Check the pilot cell electrolyte temperature</td>
<td>Check the internal ohmic values and negative terminal temperature of 10% of the cells…</td>
</tr>
<tr>
<td>Annually</td>
<td>Check the specific gravity of all the cells for lead-antinomy batteries as well as all inter-cell resistances …</td>
<td>check all inter-cell resistances …</td>
<td>Check the inter-cell resistance and the amount of AC ripple in the charger waveform, charger alarm accuracy…</td>
</tr>
</tbody>
</table>
Preventive Maintenance Program Examples

2.1.3.4.2 Perform a capacity test (also called performance test or discharge test) every 5 years for flooded lead acid and flooded Ni-Cd batteries, and every 2 years for sealed lead acid (VRLA) batteries.

Sources:

*DS 5-19: Switchgear and Circuit Breakers*

*DS 5-20: Electrical Testing*
Case Study #1

- Site Information
  - A simple manufacturing facility
  - 24/7 operation
  - Utility power is the single electric power source
Case Study #1

Utility line 69 kV

12 kV

480 V
Case Study #1

- Damage Investigation
  - Explosion & fire involving 480V cabinets
  - Tank rupture of the mineral oil-filled 12 kV/480V transformer
  - Minimum business interruption: contingency plan in place
Case Study #1

- Damage investigation
  - Key contributing factor: Lack of adequate maintenance
    - 12 kV switchgear’s battery - discharged
    - 480 V circuit breaker: seized
    - 12 kV fuse for transformer had a known problem
Case Study #1

- Conclusion
  - Overall maintenance program needs improvement
  - Contingency plan minimized the BI
  - No fire following: no combustible load in the electrical room
Case Study #2

- Site Information
  - A simple manufacturing facility
  - 24/7 operation
  - Utility power is the single electric power source
Case Study #2

- **Site Electrical system:**
  - Utility power: 69 kV
  - 480V feeder
  - Solid grounded system
  - Fused switch with ground fault protection
  - >100 ft. bus bar above the production area
  - 40 years old
Case Study #2

- Electrical PM
  - Annual IR scan
  - Annual transformer oil sample – screen & DGA
  - 3 year switchgear PM
Case Study #2

- The incident
  - Bus bar failed (close to the plug-in)
  - Aluminum bus & enclosure steel frame vaporized
  - Suspended ceiling above blew off
  - Hot particles from the bus duct explosion ignited the combustible material above the ceiling and a fire followed
Case Study #2

- Damage investigation
  - Ground fault protection did not operate
  - Fuses of two phases melted
  - Entire bus damaged
  - Significant smoke/water damage to food product
  - 100% production shutdown
Case Study #2

- Damage investigation
  
  - GFP
    - Unknown setting of GFP
    - No electrical study to identify setting
    - No recorded testing/maintenance
  
  - The 480 V bus bar
    - No documented maintenance activities
Case Study #2

- Conclusion
  - Coordination study needed for GFP
  - Test GFP during 3 year PM
  - Improve bus PM
  - Fire related issues
    - Automatic sprinkler installation
    - FD pre incident planning
Questions