THE CONSEQUENCES OF AN ARC FAULT IN OIL-FILLED SWITCHGEAR
Arc Phenomena
Arc Phenomena

Arc fault - facts

- Most devastating type of fault in a MV and LV switchgear

- Current flow through ionized air -> plasma

- Most arc faults are caused by human errors.

- 80% of un-forced arc faults starts in the cable compartment as a phase to ground or phase to phase arc fault.

- A single phase arc fault develops fast to a three phase low impedance high power arc fault.
Arc Phenomena

Reasons

- Human errors
  - accidental touching
  - accidental dropping of tools
  - working in “wrong” feeder

- Mechanical failure – part falling
- Lose connections (bar-bar ; bar-cable)
- Vibrations
- Insulation failure
- Dust & Impurities buildup
- Condensation
- Corrosion
- Animals
- Forgotten parts / tools
- Over-voltage stress - narrow gap
Arc Phenomena

**PHASE 1:- COMPRESSION** (10….30ms)
- Current flow through ionized air
- Plasma effect
- Rapid release of energy
- Strong light emission

**PHASE 2:- EXPANSION** (20….50ms)
- Copper expands 67 000 times when vaporized (1,5cl -> 1m³)
- Shock/Pressure wave, 4 bar in a few ms
- Sound wave

**PHASE 3:- EMMISSION**. (50….100ms)
- 80% of energy heat radiation, 20 000 °C
- Wide radiation spectra

**PHASE 4:- THERMAL OR ‘BURN-THROUGH’**
(100….300ms)
- Spray of molten metal droplets
- Hot shrapnel flying in all directions
- Toxic gases (CuO2)
- Steel and copper fire
Arc Phenomena

600V, 65kA, 300ms
Arc Phenomena

Arc pressure and temperature curve

Temperature [°C]
Pressure [Bar]

20,000°C
2Bar

3A0712 cubicle (Bus 3A07 feeder from UAT)
Arc Phenomena

Result

- It may cause safety hazard to personnel through radiation, thermal convection, arc blast and flying particles, and toxic impact.

- The economic consequences are often very significant.

- Direct damage to equipment causes often only a fraction of the total costs.

- Indirect costs due to long interruption of processes can be quite substantial, not to forget the possible medical and legal expenses, if there are humans involved.
Why Arc Protection?

- Save Lives
- Extend lifetime of old switchgear
- Safe and reliable distribution
- Over current protection tripping time is typically 200…500ms
- Phase to ground arc fault cannot be protected by E/F protection relay where tripping time can be seconds!
- Arc protection gives a 100% selective trip of the faulty zone ALWAYS with a tripping time of less than 7ms... including earth faults (Io(arc))

Arc Phenomena

- TOO SLOW

40kA, 12kV
60ms total arc clearing time

40kA, 12kV
300ms total arc clearing time
AQ 100 Series
AQ 100 Series

Characteristics of arc protection

- Speed, no intentional delays
- Sensitive, current set-points just above loads
  sensitive ground-fault set points
- Selectivity, trip only affected feeder(s)
- Secure, dual-sensing prevents false trips
- FULL self-supervision
AQ 100 Series

Provides you

- Speed
- Reliability
- Flexibility
- Simplicity
AQ 100 Series

Speed
- 7ms Tripping time regardless if incomer or outgoing feeder
- 2ms with High Speed Output
AQ 100 Series

Reliability

- EMC tested according or IEC 60255 (protection relay standard)
- Full self-supervision with non-volatile memory including:
  - All sensor
  - Wiring and unit interconnections
  - CT connections
  - Internal electronics
  - Output relays
  - Power supply
  - Dipswitches

- Each unit has own built-in power supply
- Total isolation for high EMC levels
- Supports long distances between units
- Hard-wired communication between units
AQ 100 Series

Flexibility

- Scalable from small stand alone systems to multi zone full selective schemes.
- Daisy chained Arc sensor installation up to 200m
AQ 100 Series

Simplicity

- Standard Arc Schemes AQ-SAS™:
  pre-tested schemes with setting and wiring instructions from instruction booklet according to your specific application

- No external multiplying- or lockout relays needed. Everything “on board”

- Auto configuration
  unit configures itself with touch of one push button

- Single push button operation
AQ 100 series units

AQ 110P
Current, point sensor and trip unit

AQ 110F
Current, fiber loop sensor and trip unit

AQ 101
Point sensor and trip unit

AQ 102
Fiber loop sensor and trip unit

AQ 01
AQ 06,07
Point sensor
Fiber loop sensors
Arc sensors

AQ 01 – Arc light point sensor

AQ 06 – Arc light plastic fiber sensor

AQ 07 – Arc light glass fiber sensor
AQ 01

AQ 01 sensor

- Arc light point sensor unit
- Maximum 3 sensors in line (up to 100m line)
- Snap-in cable connector for quick installation
- Shielded cable connection
- IP 61 mechanical protection
- EMC compatible with IEC60255-22-4 (Fast transient 4kV)
- Vibration proof
AQ 01 sensor

- 3 sensors in one line (up to 100m line) = easy wiring
- Plug-in cable connector for = easy and fast installation
- Self-supervision including photodiode (light pulse) = 100% self-supervision
AQ 100 Series

- Compact size
- Novel current sensing technology
- Multi drop arc point sensor support
- Optimized cost structure
- Single push button operation
- Customizable text pocket for LEDs
- Fully non-volatile indications
- Wide range auxiliary power supply
- Up to 4 trip output in each unit
- Complies with the Protection Relay Standard
AQ 101 Point Sensor Unit

LED indication
- Power LED
- Error LED (full self-supervision)
- Sensor activation
- Trip indication
- Binary input activations (2 pcs)
- Binary output activation

Push button:
- Installation of device
- Reset of activations

Text pocket
- for LED dependent customer texts
AQ 101 Point Sensor Unit

Inputs

- 4 Arc sensor inputs (max 3 sensors / input)
- 2 x Binary inputs (threshold 24/110/220 Vdc)
- Wide range power supply, 24...80Vdc / 80...240Vac/dc
- Arc fiber loop sensor (optional)
- Dedicated smoke sensor input (occupies one sensor input)

Outputs

- 3 Selective trip relays outputs (T1-T3)
- 1 Lock-out relay (safety loop) or trip relay (T4)
- 1 Self-supervision alarm relay (CO)
- 1 Binary output (configurable L> or TRIP, 0V / 24Vdc)
AQ 102 Fiber Sensor Unit (available Q2/2011)

LED indication:
- Power LED
- Error LED (full self-supervision)
- Sensor activation
- Trip indication
- Binary input activations (2 pcs)
- Binary output activation

Push button:
- Installation of device
- Reset of activations

Text pocket
- for LED dependent customer texts
AQ 102 Fiber Sensor Unit (available Q2/2011)

Inputs:
- 3 Fiber loop sensor channels
- 2 x Binary inputs (threshold 24/110/220 Vdc)
- Wide range power supply, 24...80Vdc / 80...240Vac/dc

Output:
- 3 Selective trip relays outputs (T1-T3)
- 1 Lock-out relay (safety loop) or trip relay (T4)
- 1 Self-supervision alarm relay (CO)
- 1 Binary output (configurable L> or TRIP, 0V / 24Vdc)
AQ 110P Current and Point Sensor Unit

LED indication
- Power LED
- Error LED (full self-supervision)
- Sensor activation
- I> pick up (separate for each phase)
- Io> Pick up
- Binary input activations (2 pcs)
- Binary output activation
- High Speed Output (HSO) activation (2 pcs)
- Trip indication (T1, T2, T3 and T4)

Push button:
- Installation of device (press for 3s.)
- Reset of activations

Text pocket
- for LED dependent customer texts
AQ 110P Current and Point Sensor Unit

Inputs:

- 3 current inputs (1A / 5A)
- Io input (1A / 5A)
- 4 Arc sensor inputs (3 sensors / channel)
- 1 fiber sensor channel (optional)
- 2 x DI
- Wide range power supply, 24...80Vdc alt. 80...240Vac/dc

Outputs:

- 4 Trip relays
- 2 High Speed Outputs (HSO) *
- 1 Lock out relay (option)
- 1 Self-supervision alarm relay (CO)

* Can be used as 2ms Trip Outputs
AQ 110F Current and Fiber Sensor Unit (Q2/2011)

LED indication
- Power LED
- Error led (full self-supervision)
- Sensor activation
- I> pick up (separate for each phase)
- Io> Pick up
- Binary input activations (2 pcs)
- Binary output activation
- HSO activation (2 pcs)
- Trip indication (T1 and T2)

Push button:
- Installation of device (press for 3s.)
- Reset of activations

Text pocket
- for LED dependent customer texts
Inputs
- 3 current inputs (1A / 5A)
- Io input (1A / 5A)
- 3 Fiber loop sensor channels
- 1 fiber output (optional)
- 2 x DI
- Wide range power supply, 24...80Vdc alt. 80...240Vac/dc

Outputs
- 4 Trip relays
- 2 High Speed Outputs (HSO) *
- 1 Lock out relay (option)
- 1 Self-supervision alarm relay (CO)

* Can be used as 2ms Trip Outputs
## Product features

<table>
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<tr>
<th>Features</th>
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<th>AQ 110P</th>
<th>AQ 102</th>
<th>AQ 101</th>
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<tbody>
<tr>
<td>Wide range power supply (18-72Vdc or 80-265Vac/dc)</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>3 phase current detection (1/5A)</td>
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<td>Residual current detection (1/5A)</td>
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<tr>
<td>Max number of point sensors</td>
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<td>12</td>
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<tr>
<td>Max number of fiber loop sensors</td>
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<td>1 (option)</td>
<td>3</td>
<td>1 (option)</td>
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<tr>
<td>Connectivity to AQ 2000 arc quenching system</td>
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<tr>
<td>High Speed Outputs (2ms trip time)</td>
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<tr>
<td>Number of trip relays (7ms trip time)</td>
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<td>4*</td>
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<td>System failure relay</td>
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<tr>
<td>Binary outputs (24Vdc)</td>
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<tr>
<td>Binary inputs (24/10/220Vdc)</td>
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<td>2</td>
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<tr>
<td>Push button</td>
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<td>Non-volatile memory</td>
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<td>✔️</td>
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<tr>
<td>Indication LEDs</td>
<td>20</td>
<td>20</td>
<td>12</td>
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</table>

*Optionally one normally closed electronic lock-out/trip relay available
Applications

Using the Standard Arc Schemes

AQ-SAS™

INSTRUCTION BOOKLET
Standard Arc Schemes
AQ 100 Series
One Incomer Scheme

- MV application
- Point sensors
- Selective feeder trip
- Master trip
- Full CBFP

*) Included in AQ SAS Instruction Booklet
One Incomer Scheme

SAS™ Ib1*

Non-selective Feeder Trip

- MV/LV application
- Point sensors
- Master trip
- Full CBFP

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One Incomer Scheme

SAS™ Ib1*

Non-selective Feeder Trip

- MV/LV application
- Point sensors
- Master trip
- Full CBFP

*) Included in AQ SAS Instruction Booklet
One Incomer Scheme

LV and MV applications
Fiber loop solution
Master trip
Full CBFP

Non-selective Feeder Trip

*) Included in AQ SAS Instruction Booklet
2 Incomer 1 Tie breaker Scheme

- MV application
- Point sensors
- Selective feeder trip
- Master trip
- Full CBFP

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2 Incomer 1 Tie Breaker Scheme

- MV application
- Point sensors
- Master trip
- Full CBFP

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2 Incomer 1 Tie Breaker Scheme

- MV application
- Point sensors
- Master trip
- Full CBFP

*) Included in AQ SAS Instruction Booklet
Multi-Incomer Schemes

- MV application
- Point sensors
- Selective feeder trip
- Master trip
- Full CBFP
AQ 2000 - arc quenching system

- up to 17.5kV
- 40kA, 1s
Wind power application

- PMSG protection (Permanent Magnet Synchronous Generator)
- High temp fiber optic sensor AQ 08 applied to generator windings
- Inverter cabinet arc protection
- LV switchgear arc protection
TNB Double Busbar Scheme with Section Breaker
Conclusions

- Arcteq provides full arc protection and mitigation solution
- AQ 100 series can be used in low-end stand-alone applications and up to more complex and selective systems
- AQ saves significantly total project life cycle cost

SAS™