Arc protected Assembly
How to increase safety of the Switchgear

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Safe switchgear - Arc protected Assembly
Aftermath of Arc accidents
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Aftermath of Arc accidents

(USA statistics)

Arc flash incidents
30,000 / year
Likelihood 1 in 50

Arc flash injury
7,000 / year
Likelihood 1 in 217

Arc flash fatality
400 / year
Likelihood 1 in 3800

*Likelihood was based on an estimation of 1.521 million active electrical workers
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**Reasons of Arc accidents**

<table>
<thead>
<tr>
<th>The most common reasons for arc flash accidents</th>
<th>Human errors</th>
<th>Mechanical faults</th>
<th>Bad connections</th>
<th>Pollution</th>
<th>Animals</th>
</tr>
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<tr>
<th>When do arc flash accidents occur?</th>
<th>25 % without operator</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>10% with operator in front of a closed door</td>
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<tr>
<td></td>
<td>65 % with operator working in the switchgear</td>
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</tbody>
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Dangers associated with arc blast

**Flying debris:**
- Copper expands by a factor of 67,000:1 when turning from solid to vapor (water going from ice to vapor expands with a factor of 40,000:1)
- Molten metal and shrapnel travel as fast as 1600km/hour

**Pressure:**
- The sound of an arc blast can easily surpass 160dB (OSHA limit is 115dB for max 15 minutes, NIOSH limit is 112dB for max 56 seconds)
- Arc blasts can and have caused death at distances above 10ft (3m)

**Extreme heat:**
- Temperature of an arc blast can reach over 20,000 °C (surface of the sun is roughly 5500 °C)
Low-voltage switchgear and controlgear assemblies

- The IEC 61439 series of standards gives rules and requirements for interface characteristics, service conditions, construction, performance and verification of low-voltage switchgear and controlgear assemblies, PSC-ASSEMBLIES.

- The main objective of these standards is to achieve the safe operation of low-voltage switchgear and controlgear assemblies under normal operating conditions as well as under abnormal operating conditions, e.g. occurrence of overvoltage, overload or short-circuit currents. Therefore no characteristics, design and verification requirements are given dealing with the case of an arc fault inside the ASSEMBLY.
Enclosed low-voltage switchgear and controlgear assemblies – Guide for testing under conditions of arcing due to internal fault.

- The occurrence of arcs inside enclosed ASSEMBLIES is coupled with various physical phenomena. For example, the arc energy resulting from an arc developed in air at atmospheric pressure within the enclosure will cause an internal overpressure and local overheating which will result in mechanical and thermal stressing of the ASSEMBLY. Moreover, the materials involved may produce hot decomposition products, either gases or vapours, which may be discharged to the outside of the enclosure.

- Due to the risk of personal injury, damage and loss of energy supply as consequences of arc faults there is a demand for arc fault tested ASSEMBLIES, even though an arc fault in an ASSEMBLY is considered as an unlikely event. The purpose of this technical report is to give guidance on the method of testing of ASSEMBLIES under conditions of arcing in air due to an internal failure.
Scope

- technical report gives guidance on the method of testing of ASSEMBLIES under conditions of arcing in air due to an internal fault.

- The purpose of this test is to assess the ability of the ASSEMBLY to limit the risk of personal injury, damage of ASSEMBLIES and its suitability for further service as a result of an internal arcing fault.

- The test procedure given in this technical report applies only:
  - to enclosed, floor-standing or wall-mounted low-voltage switchgear and controlgear assemblies according to IEC 61439-2 (power switchgear and controlgear assemblies –PSC ASSEMBLIES);
  - to situations when doors and covers of the ASSEMBLY are closed and correctly secured.
Personnel protection is achieved when the following criteria 1 to 5 are fulfilled:

1. Correctly secured doors and covers do not open and remain effectively in place and provide a minimum level of protection in accordance with the requirements of IP1X of IEC 60529.

2. No parts of the ASSEMBLY are ejected which have a mass of more than 60 g except those which are dislodged and fall between the ASSEMBLY and the indicators.

3. Arcing does not cause holes to develop in the external parts of the enclosure below 2 m, at the sides declared to be accessible as a result of burning.

4. The indicators do not ignite (indicators ignited as a result of paint or stickers burning are excluded from this assessment).

5. The protective circuit for accessible part of the enclosure is still effective in accordance with IEC 61439-2.

Passed
Personnel and ASSEMBLY protection is achieved when criteria 1 to 6 are fulfilled:

6. The ASSEMBLY is capable of confining the arc to the defined area where it was initiated, and there is no propagation of the arc to other areas within the ASSEMBLY. Effects of hot gases and sooting to adjacent units other than the unit under test are acceptable, as long as only cleaning is necessary.
Personnel and ASSEMBLY protection with limited operation capability is achieved when criteria 1 to 7 are fulfilled:

7. After clearing of the fault or after isolation or disassembly of the affected functional units in the defined area, emergency operation of the remaining ASSEMBLY is possible. This is verified by a dielectric test according to IEC 61439-2:2011, 10.9.2, but with a test voltage of 1.5 times the rated operational voltage for 1 min. Bending or bowing of doors and covers of the unit under test and adjacent units is acceptable providing it can be readily restored to a minimum level of protection in accordance with IPXXB of IEC 60529. With the exception of the tested zone as declared by the manufacturer, all other units should remain fully operable both mechanically and electrically and are essentially in the same condition as before the test.
Classification with regard to the protection characteristic:

▪ **Arcing class A** – ASSEMBLY providing personnel protection under arcing condition by arc tested zones conforming to arcing conditions in 8.7, criteria 1 to 5, and by arc ignition protected zones, if any;

▪ **Arcing class B** – ASSEMBLY providing personnel and ASSEMBLY protection under arcing conditions by arc tested zones conforming to arcing conditions to 8.7, criteria 1 to 6, and by arc ignition protected zones, if any;

▪ **Arcing class C** – ASSEMBLY providing personnel and ASSEMBLY protection under arcing conditions by arc tested zones conforming to arcing conditions with limited operation in 8.7, criteria 1 to 7, and by arc ignition protected zones, if any;

▪ **Arcing class I** – ASSEMBLY providing a reduced risk of arcing faults solely by means of arc ignition protected zones.
System pro E power is Arc tested Assembly
IEC TR 61641 Technical data

System pro E power is tested according TR61641 under:

✓ 65kA at 480V (0.3s), 4000A

✓ Criteria 1-5 and 6 are achieved

✓ Personnel and ASSEMBLY are protected
System pro E power is Arc tested Assembly
IEC TR 61641 Technical data
System pro E power is Arc tested Assembly
Arc test
Safe switchgear - Arc protected Assembly
Dangers associated with arc blast
Safe switchgear - Arc protected Assembly
Assembly without Arc Guard System™
Safe switchgear - Arc protected Assembly
Assembly with Arc Guard System™

- Energy supplied to arc disconnected after 40ms
Delays of 150-200 ms is normal design to achieve selectivity.

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Why isn’t short circuit protection enough?
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Why isn’t short circuit protection enough?

![Diagram showing the comparison between over load protection, short circuit protection with time delay, and instantaneous short circuit protection. The diagram illustrates the time-current characteristics with and without arc.]
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Arc protection system TVOC-2

- Functional safety (SIL 2)
- Pre-calibrated sensors
- Fiber optic point sensors
- Based on 35 years of experience
- Self supervision system
- No software involved in critical safety functions
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Arc protection system TVOC-2 / How does it work?

1. Arc is detected by the fiber optic sensor
2. Signal is sent to the TVOC-2 arc monitor
3. TVOC-2 arc monitor sends a trip signal to shunt trip of circuit breaker
4. All this occurs in under 2ms
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Arc protection system TVOC-2 / Safety Integrity Level- SIL

Safety Integrity Level (know as SIL) as per IEC-61508 and IEC-62061:

- A measure of safety system performance in terms of Probability of Failure on Demand (PFD), established to define a metric for evaluating a system’s (or function’s) level of operational reliability with regards to maintaining safety
- TVOC-2 is certified with a PFD of $3.49 \times 10^{-03}$ (0.00349) per year for a period of 10 years after it is first connected (as long as suggested maintenance is performed annually)

- **SIL-2 certificate ensures extremely reliable function**
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Arc protection system TVOC-2 / Safety Integrity Level

- To meet SIL-2 safety standards, we need:
  - Redundancy
    - Hardware (IGBT’s, relay outputs, IRF, etc)
    - Software (HMI, PC boards, etc)
  - Reliability
    - Self-monitoring of internal faults
    - All light sensors will be manufactured and tested in similar conditions according to EN ISO 13849-1
  - Reduce the probability of errors caused by external factors
    - Cannot adjust the sensitivity of the sensors
    - Cannot shut down the system for maintenance
    - Cannot change safety configuration parameters via HMI
  - Third-party certification
    - TVOC-2 is certified SIL-2 by TÜV Rheinland
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Installation example
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