Arc Flash Resistant Equipment

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Arc flash resistant equipment may be described as the equipment made to withstand the impact of internal arcing fault by meeting the testing requirements of IEEE Guide C37.20.7-2007. In the 1970s, an interest started in Europe in assessing electrical equipment under internal arcing, which lead to IEC standard. This research spread to North America and was used as a foundation for EEMAC G14-1 procedure. The development of IEEE standard heavily relies on Annex AA of IEC standard and adopts many of the refinements originated in EEMAC G14-1 procedure. IEC 62271 - 200 defines the requirements for factory assembled metal-enclosed switchgear and control gear for alternating currents at rated voltage above 1 kV and up to and including 52 kV. It includes indoor and outdoor assemblies and frequencies up to and including 60 Hz. The arc - resistant construction can be used for:

- Medium voltage switchgear
- Low voltage switchgears
- Medium voltage MCCs
- Low voltage MCCs.

Arc Flash Hazard Calculation In Arc-Resistant Devices

It is well known that even if arc-resistant devices are used, additional power system protection, like AFD and differential protection systems, need to be provided to decrease the arcing time and incident energy release. The computation of incident energy, hazard risk category and PPE category for arc-resistant devices and their reductions uses the same methodology as for typical electrical equipment.

Arcing Fault Probability

There is little probability of an internal arc in devices meeting the demands of IEEE C37.20., C37.20.2 and C37.20.3 - 2001, which cover metal-clad and metal-enclosed switchgear though the possibility cannot be completely eliminated. There is an even lower probability of an internal arc in devices that have insulted bus, barriers, compartmentalization, and interlocks, for instance, metal-clad switchgear. If doors or panels are opened for maintenance, which are not supposed to be opened, the devices are no longer arc resistant. Depending upon the construction and testing, it is possible to open the low voltage enclosure of arc-resistant switchgear, without affecting the arc-resistant nature of the equipment. However, all maintenance work cannot be completed simply because devices are arc resistant. NFPA 70E standard defines hazard risk category of 4 for the arc-resistant switchgear, type 1 or 2, with clearing time lower than 0.5 seconds for insertion or removal of the circuit breaker from cubicles with an opened door. However, this situation has to be assessed on a case by case basis depending upon the protection and system short circuit current levels. Sometimes, the circuit breakers will be locally taken out in the modern work environment. Industrial systems are resorting to remote racking, and the staff presence near the device is not needed except to engage the remote tracking system. Hence, arc-resistant devices are no longer arc resistant if any doors or panels are opened, which are not supposed to be opened. As long as panels or doors are not opened, the arc flash risk outside the equipment can be conceived zero. Some arc flash hazard does exist around conventional devices with the door closed. NFPA committee states that: “Normal service of the enclosed electrical devices, working at 600 V or less, that has been adequately installed and maintained by qualified staff is not likely to expose the staff to an electrical hazard”. Hence, a question comes up if it is necessary to spend 20–40% more capital outlay for arc-resistant devices. In Europe, the stress has been on arc containment and protection. In North America, the effort has been put to decrease the arc flash hazard by system innovation and protection systems rather than reinforcing the devices to withstand the internal arcing faults.

IEEE Guide Qualifications

IEEE guide says that a guide cannot mandate or determine device ratings. A standard defines necessary requirements and performance levels that must be reached, checked, and tested for. A guide gives suggestions and rules, leaving performance levels to the end user and manufacturer. IEEE guide states that such devices cannot ensure overall staff protection under all circumstances that may exist at the time of the internal arcing fault. It also clarifies that it is not supposed to give an extra degree of protection to operational staff, who in the typical performance of their duties would be asked to alter the equipment from its normal working conditions. Staff activities or installation conditions not addressed include:

- Staff on top of switchgear
- Any activity that demands staff to be elevated above switchgear base level, that is, use of a ladder or lift
- Switchgear placed on an open grating
- Installations over a cable vault big enough for staff to enter the vault
- Equipment selection according to the guide does not imply protection from device damage or ensure continued operation without disruption of continued electrical service.

Since the typical devices are not arc resistant, a closed door or panel can shatter and release the arc flash products causing staff injury who happen to be in the vicinity of the energized device. Even though this eventuality may be small, it cannot be completely eliminated. With all defined limitations for arc-resistant devices, the incident energy outside an arc-resistant container is zero, as long as it is operated as per the test conditions. No extra PPE is needed for the staff presence in the vicinity of the arc-resistant device. In other words, if an electrical room has all arc-resistant devices, an operator can complete visual inspection, go around the devices, take meter readings, or even open low voltage containers, depending upon the arc-resistant design and testing.

Accessibility Types

The IEEE Guide [1] accessibility types are the following.

Type 1

This equipment type considers switchgear with arc-resistant design and features at the freely accessible front of the equipment only.

Type 2

This equipment type considers switchgear with arc-resistant design and features at the freely accessible exterior (front back and sides) of the equipment only. The accessibility is assigned by choosing the type (either type 1 or type 2) and by adding an adequate suffix to designate the proper performance tested. For the basic presented tests, a suffix A is used, that is, type 1A or 2A, to present the basic rating. The other suffixes are described below.

Suffix B

This presents devices where normal operation involves opening the doors or cover of the containers, particularly identified as low voltage, control, or instrumentation containers. Testing methodologies that are not reproduced here are described for this suffix. The suffixes will be 1B or 2B. Suffix 1B states that the arcing does not create holes in the freely accessible front of the container or in the walls isolating the low voltage control or instrument areas. Suffix 2B states that the arcing does not create holes in the freely accessible front, sides, and rear of the container or in the walls isolating the low voltage control or instrument areas. Smoke entrance in the container under evaluation is allowable. Deformations of internal container walls, without signs of burning from a direct arc strike, that is, a hole, or opening in the walls, that is, torn seams are not the cause of device damage. Meeting the demands of this assessment additionally qualifies the device for installation of instrument and control elements on the door or cover of the container tested without retesting the switchgear for the condition where the door or cover is present with elements installed on it.

Suffix C

This suffix presents devices where isolation from effects of an internal fault is desired between all adjacent compartments within a switchgear installation. This does not mean that devices may be operated with doors, covers, or panels opened. Suffix C designation cannot be applied to devices using an open bus or open frame arrangement. The suffix 1C means that the arcing does not create holes in freely accessible front of the container or in the walls separating the compartments in which arc is started from all adjacent compartments. The suffix 2C means that the arcing does not create holes in the freely accessible front, sides, and rear of the container or in the walls separating the compartments in which arc is started from all adjacent compartments. The exclusion is that in a metal-clad arrangement, a fault in the main bus bar container of the vertical section is allowed to spread into the main bus bar container of the adjacent section, if the bus bars are in the same circuit, but not if the bus bars are in the different circuits. This demands further clarification. If the switchgear is of metal-enclosed arrangement or non-segregated design, an arc flash occurrence can spread within the container, and the only protection is pressure relief vents. In the metal-clad arrangement, the protection is kept because all containers are block segregated and can hold created arc energy to that zone. The four zones are:

- Main bus zone
- Fused contactor zone
- Power cable zone
- Low voltage zone

Nevertheless, this does not mean that there will be no pressure vents.

Suffix D

This suffix presents the devices made for installations where some external surfaces of devices are inaccessible and there is no need to use a type 2 arrangement. Hence, this suffix is only applicable to accessibility type 1. The arcing does not create holes in the freely accessible front and any other surface under evaluation of the enclosure.

The evaluated surfaces need to be mentioned on nameplate:

- SR, right side
- SL, left side
- R, rear

For instance, the designation can be Type 1D-SR. Extra tests are applicable for the suffixes. The manufacturer needs to define a minimum spacing between the room walls and the devices. A minimum ceiling distance shall also be defined, even if an external exhaust system is installed.

IEC Accessibility Types

IEC standard describes the Internal ARC Classification (IAC), which provides an allowance for overpressure acting on doors, covers, inspection windows, etc.

- Type A. Limited to only authorized staff.
- Type B. Unrestricted accessibility, including that of the general public.

The IEC accessibility types are for devices produced [illegible] to IEC specifications, for instance, IEC applies to the MC[illegible]C 61439. These are not interchangeable with[illegible] NEMA specifications.

Arc-Resistant F[illegible]

Arc-resistant ratings c[illegible]esented in the following paragraphs.

Duration Ratings

These are based on devi[illegible]he specified duration. The maximum system [illegible]ee-line short circuit current are part of the [illegible]er more flexibility in choosing the protective re[illegible]making sure that the short circuit currents are cleared within the arc duration rating. The selection of the upstream circuit breaker is still very