Can arc fault protection be provided when maintaining LV switchgear?

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Arc flash incidents are a major concern to maintenance managers. Statistics show that 65% of arc flash incidents occur when undergoing maintenance or fault finding, so this naturally leads us to the exploration of methods to reduce likelihood of an arcflash incident during maintenance - arc fault protection.

Several Australian Standards attempt to provide warning of, and guidance to reduce the effects of, an arc flash. AS/NZS 4836: 2001 - Safe Working on Low-voltage Electrical Installations warns that persons working on or near exposed energised conductors should be aware that arcs produced under fault conditions can cause severe flash burns and injuries as a result of flying debris and in particular, that over current protection may not safeguard the worker.

AS/NZS 3000: 2007. The wiring rules, requires that for new LV switchgear installations arc fault protection must be provided in accordance with Clause 2.5.5, which states “Protection against arcing fault currents while the equipment is in service, or is undergoing maintenance, shall be provided for heavy current switchboards.

Is it safe to perform maintenance on an energised demountable switchboard, as long as the incoming protection is set to that recommended in the standard?

Take a typical mining application example: a 415 V, 4000 A main switchboard, fed from a 3 MVA5% impedance transformer, resulting in a prospective fault current of approximately 80 kA. According to the formula given in the standard, this results in a recommended trip setting of 24 kA/269 ms. From experience we know, to provide protection against arc flash burns, the breaker would need to trip and extinguish the arc in less than 35 ms.

In the above example, if an arc was initiated when undergoing maintenance in a compartment with the door open, the result would be devastating:
- Brilliant flashing light, loss of sight
- Hot gases, molten metal particles. Arc temperatures can reach up to 2000°C
- Severe or even fatal burns
- Extreme noise, hearing loss, tinnitus
- Pungent toxic odours. Vestibular function damage
- Pressure wave, shrapnel which may attain velocities of 300 m/s. The inadequacy of this PPE is recognised in both NFPA70E & IEEE1584, which emphasises that PPE is the lowest in the hierarchy of controls. AS/NZS 3000:2007 suggests that internal arc fault containment (IAC) is an enhancement of internal separation and clearly states that IAC is not to prevent the initiation of an arc when undergoing maintenance.

It is very important to realise that IAC does not provide switching operators or maintenance staff any protection if any doors are open or if any covers are not properly closed and fixed in place.

Internal arc fault containment (IAC) relies on the switchgear door being closed. If it is not possible to shut down the switchboard the worker must protect himself with the appropriate level of arc flash PPE (Typically Cat 3-4). Category 4 PPE is cumbersome and uncomfortable and affords limited mobility and visibility. This has resulted in the users’ demand for safer and more user-friendly arc fault protection solutions. The users are looking at ways to eliminate the need for PPE levels higher than Category 2.
The most effective way to eliminate the arc fault risk while undergoing maintenance is to not work live. A more realistic and effective solution is fully withdrawable switchgear.

- The most important benefit of fully withdrawable switchgear is that it allows the safe removal of the starter without the use of tools. The individual starter can be removed without interfering with other functional units. It is also possible to replace the starter with a spare, which means only a few minutes interruption to that particular drive. Maintenance and testing of the starter can be performed in a safe area where there is a low fault level auxiliary supply.
- Clearly, a fixed or demountable solution is inherently unsafe. A safer solution is withdrawable where all operations are performed with the doors closed. To fully satisfy the arc fault protection requirements, the complete switchgear should be internally arc fault tested to AS/NZS 3439.1 Appendix ZD or IEC/IR 61641: 2008.

Internal arc fault containment

If you want arc fault protection on your complete switchgear so your people are protected no matter where they are in relationship to the switchgear, and so there is no need to wear Cat 4 PPE when entering the switch room, then the answer is clearly no. Why? The “standard” tests in AS/NZS3439.1 only verify your safety if the arc is initiated after the starter short circuit protection (SC/PD) device. What if the arc is initiated on the line side of the SC/PD? What if there is an arcing fault in the adjacent module or on the busbars when you are removing the starter?

- The point of initiation of the arc needs to be clearly specified by the purchaser:
  - Point a - standard tests to AS/NZS3439 (the fuse interrupts the fault in 2 ms). Major concern is line side re-strikes.
  - Point b - line side of protective device.
  - Point c - distribution bus.
  - Point d - incomer.
  - Point e - main bus.

If only the outgoing units are tested to AS/NZS3439.1, 2002 Annex ZD for “Standard IAC, we consider this switchboard can only be regarded as being partially arc fault contained. For complete IAC protection where an arc is initiated on the line side of the starter units, on the distribution bus, main bus and incoming units this must be specified as “Special Tests” to AS/NZS 3439.1: 2002.

AS/NZS 3439.1: 2002 recognises the danger of limiting requirements to the load side by stating that “Special tests may be required to simulate arcing faults initiated in the compartments tested by failure of a protective device itself, failure at the incoming terminals or connections to a protective device from the main supply or where the connections are not adequately shrouded, the transfer of an arcing fault from the load side to the line side of a protective device”. However, it is not mandatory to consider and provide a solution for this scenario.

Commitment to safety

Miners are very safety conscious and are committed to a safety policy of “don’t work live” and “zero harm”. How can they run an effective, efficient and safe operation using Demountable switchgear? Do they shut down the switchboard to do maintenance or fault finding? Or do the workers put on their Cat 4 suits before they enter the switch room?

In practice, this is a concern as the most rudimentary maintenance does not happen as the switchgear can’t be shut down. Other concerns are whether the switchgear is dead, you need to test the connections with a meter. There is a significant risk of creating an arc flash when live testing.

Conclusion

To summarise, there are three main design concepts for LV switchgear that we believe contribute significantly to the prevention of arc flash related incidents:

- Fully withdrawable functional units;
- All switching and racking functions are performed without opening the compartment door; and
- Internally arc-fault contained (IAC) on the complete switchgear.

The basic premise of these three design techniques is to prevent the occurrence of an arc flash in the first place, and recognise that more than 80% arc flash-related incidents that cause harm to personnel, occur when work is being carried out on a piece of electrical equipment. If we can remove the need for work to be carried out on live equipment, then we also remove the danger to personnel.

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