Switchroom management & controls

Energy UK Safety Rules Working Group
Contents

Energy UK Switchroom Working Group
Working Group Objectives
Member Composition

The Basis for Sound Decision Making

Fault Level and Arc Flash Studies

1. Switchboard Location
2. Operating Cycle/Frequency of Operation

Reducing the Hazard through Applied Controls

1. Eliminate
2. Reduce
3. Isolate
4. Control
   4.1 Access Control
   4.2 Switchroom Access Training
   4.3 Inspection and Maintenance
   4.4 Switchgear not within a designated Switchroom
   4.5 Switchroom Signage
   4.6 Switchroom Access Locations
   4.7 Work within Switchrooms
   4.8 Remote Switchroom monitoring and warnings
   4.9 Pre-switching Work instructions, Switching instructions, Point of Work, Risk Assessments

5. Personal Protective Equipment (PPE)
   5.1 Arc Flash PPE

6. Discipline
   6.1 Management Key Performance Indicators (KPIs)

Annex 1: Industry example of a Graded Approach to Switchroom Access

Energy UK Switchroom working group

Working Group Objectives

To share the approach taken by operators to manage the risk posed by Electrical Switchrooms and the operation of Switchgear.

For the purpose of the document, the practices deployed by various operators have been collated in line with the ERIC PD model:

• **Eliminate** – the safest control measure is to eliminate the hazard completely.

• **Reduce** – it is not always possible to totally eliminate the hazard. However, it may be possible to take reasonable steps to reduce the level of risk posed.

• **Isolate** – can the hazard be managed through isolation/separation from the operators in the plant.

• **Control** – consideration is given to organisational and technical controls such as safe systems of work, procedures, training, supervision, safety devices and tools to carry out the task.

• **Personal Protective Equipment** – in the event that the hazard still presents a risk, suitable Arc Flash PPE will limit injury in the event of a failure.

• **Discipline** – the effectiveness of the controls applied require monitoring to ensure that all controls are maintained, enforced and reviewed.

---

Energy UK Switchroom Working Group member composition

<table>
<thead>
<tr>
<th>Member Name</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doug Smart</td>
<td>EDF Energy</td>
</tr>
<tr>
<td>Graeme Smith</td>
<td>Uniper</td>
</tr>
<tr>
<td>Angus Page</td>
<td>Engie</td>
</tr>
<tr>
<td>David Bowie</td>
<td>Scottish Power</td>
</tr>
<tr>
<td>Derek Rippon</td>
<td>Engie</td>
</tr>
<tr>
<td>Phil Mitchell</td>
<td>Centrica</td>
</tr>
<tr>
<td>Robert Thompson</td>
<td>SSE</td>
</tr>
<tr>
<td>Stephen O’Neil</td>
<td>Energy UK</td>
</tr>
<tr>
<td>Tanisha Beebee</td>
<td>Energy UK</td>
</tr>
</tbody>
</table>
Fault Level and Arc Flash Studies:

- HV Switchboard Arc Flash/Fault Level Calculations undertaken by a professional service provider are a common and key factor in any assessment.
- LV Switchboard Arc Flash/Fault Level Calculations, whilst less common, have in a number of examples throughout the industry highlighted that the risk is greater in terms of arc incident energy and/or duration. Therefore, LV Switchboards should, where practical, be included in any location assessment of arc flash risk without justification.
- Due to the complex nature of the Arc Flash/Fault Level Calculation studies the use of professional third parties should be considered to undertake the study and provide the initial options for risk reduction.
- It is assumed that if a switchboard is well maintained, and that all cubicles or circuit enclosures are locked using the facility normally provided that any fault that may occur will be contained within the enclosure.
- The inclusion of the Arc Flash/Fault Level Calculation results on Switchroom and or Switchgear Electrical Warning Signs can add valuable information to users when entering buildings or when undertaking switching, racking and isolation activities. (Note: the design of the switchgear should deem it safe for normal switchroom access, although this should be kept to a minimum and only by personnel authorised to enter.)

### Protection Settings A

<table>
<thead>
<tr>
<th>No.</th>
<th>Voltage Level (KV)</th>
<th>Name</th>
<th>Bolted current (kA)</th>
<th>Arching current (kA)</th>
<th>Arching time(s)</th>
<th>Incident energy (cal/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>UNIT BD</td>
<td>18.88</td>
<td>18.13</td>
<td>1.49</td>
<td>20.49</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
<td>FGD UNIT 1</td>
<td>26.41</td>
<td>25.22</td>
<td>3.52</td>
<td>55.17</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>STATIONBD_A</td>
<td>25.73</td>
<td>24.58</td>
<td>1.11</td>
<td>33.17</td>
</tr>
<tr>
<td>4</td>
<td>3.3</td>
<td>Unit 1A</td>
<td>28.71</td>
<td>27.37</td>
<td>1.10</td>
<td>39.64</td>
</tr>
<tr>
<td>5</td>
<td>3.3</td>
<td>STNSER1A</td>
<td>19.66</td>
<td>18.88</td>
<td>2.41</td>
<td>57.88</td>
</tr>
<tr>
<td>6</td>
<td>0.415</td>
<td>Turb Aux A1</td>
<td>41.33</td>
<td>17.68</td>
<td>0.16</td>
<td>6.23</td>
</tr>
<tr>
<td>7</td>
<td>0.415</td>
<td>CoaPLT_1A</td>
<td>24.47</td>
<td>11.64</td>
<td>1.08</td>
<td>26.77</td>
</tr>
<tr>
<td>8</td>
<td>0.415</td>
<td>U1BHA-TB1</td>
<td>12.21</td>
<td>6.69</td>
<td>2.23</td>
<td>39.39</td>
</tr>
</tbody>
</table>

### Fault Level Arc and Flash Studies

Prior to making any decisions concerning the management of switchboards it is appropriate to make an assessment of the level of risk posed by the switchgear and the switchboard. A number of factors will influence this:

1. **Switchboard Location:**
   - HV and LV Switchboards are generally located within designated switchrooms providing a secure, clean and dry operating environment. However, a number of operators have (predominantly) LV Boards situated outside of switchrooms, in turbine halls, boiler houses, ancillary buildings and pump houses. This will affect both the operating environment of the switchboard and also the possibility of individuals being in the location of the switchboard in the event of an incident. These factors need to be considered when establishing operating regimes, maintenance schedules, transit routes for staff and emergency arrangements.

2. **Operating Cycle / Frequency of Operation:**
   - The operating cycle and method of operation will need to be considered when undertaking a risk based approach to the management of Switchgear Fault Levels and Arc Flash Calculations.
   - So far as is reasonable practical, options to reduce the local operation of switchgear should be explored to reduce the risk to an individual at the board. This has been achieved by a number of locations through the retrospective installation of plant based isolators at actuators to achieve actuator isolation, reducing the risk of entry to a switchroom and from the operation of switchgear local to a switchboard.
   - The type of apparatus will affect the associated hazards for example; oil circuit breakers vs vacuum circuit breakers.
   - The type and quality of switchgear installed may pose a greater Arc Flash hazard. The degree of hazard from the apparatus installed can be understood by defect reports and incident records, for example, ENA NEDeR database and local records.
Reducing the hazard through applied controls

Additional controls will be specific to each site and the assessment of each dependent upon a number of local factors, age, occupation rates, operating cycle, and arc flash/fault levels. Additional controls should be considered within the context of being “so far as is reasonable practicable” and ALARP.

Having established the risk presented by the switchboard due to Arc Flash/Fault Level and hence the risk posed to individuals either through direct operation or due to Arc Flash/Fault Level and hence the risk posed to individuals either through direct operation or due to Arc Flash/Fault Level and hence the risk posed to individuals either through direct operation or due to arc flash/fault levels, it is important to consider the practicality of undertaking all tasks on an isolated (“dead”) system, i.e. off load switching / maintenance.

An alternative option is to employ Zone Selective Interlocking (ZSI) schemes.
• The retrofitting of modern fast acting, solid state protection devices can result in a significant reduction in fault clearance times and therefore potential arc energy levels.
• The installation of a “two position switchable relay” will switch the switchgear protection relays to a “super sensitive” mode during operational activities and therefore quicker fault clearance, which will in turn reduce arc incident energy levels. It’s not uncommon for new large scale systems, or within cubicles or circuit enclosures, to separate themselves from the equipment.
• Developing in robotic operating mechanisms to rack in/out breakers remotely is becoming commercially available and will remove the operator from being immediately in front of the switchgear.
• The installation of remote switching of electrical equipment will eliminate the need for entry for routine check and to provide a visual check of the environment in the event of an incident can effectively reduce the potential for exposure.

1. Eliminate
• The first consideration should be to assess the practicability of undertaking all tasks on an isolated (“dead”) system, i.e. off load switching / maintenance.
• The installation of CCTV to monitor switchrooms remotely to prevent the need for entry for routine check and to provide a visual check of the environment in the event of an incident can effectively reduce the potential for exposure.
• The installation of enhanced Arc Flash containment, so that there is “no loss of containment” from the switchboard in the event of an incident.
• The installation of environmental monitoring (i.e. humidity alarms, de-humidifiers / HVAC units etc.) to control the atmosphere within switchrooms will contribute to maintaining equipment integrity.
• Switchroom integrity inspections will include an assessment for moisture/water entry into the building.
• The use of remote switching of electrical equipment will always be preferable over local switching so as to allow the operator to be isolated from the switchgear when it is operated.
• Where remote switching through control schemes the use of traditional lanyards should be utilised by operators to separate themselves from the equipment.
• Development in robotic operating mechanisms to rack in/out breakers remotely is becoming commercially available and will remove the operator from being immediately in front of the switchgear.
• In all, the adoption of remote switching should be considered when making a decision concerning switchboard protection and switchgear operation. Where remote switching is not currently installed, the control scheme may enable modification to enable such operations. A justification should be recorded on boards which do not enable remote switching, which will detail other additional controls.
• Where reasonably practicable when work is to take place within the boundary established by Arc Flash/Fault Level Calculations, or within cubicles or circuit enclosures.

2. Reduce
• A reduction in arc energy can be achieved by reviewing the fault level protection setting following the arc flash study. This may result in achieving faster protection response times and therefore quicker fault clearance resulting in a reduction in arc energy being generated.
• The installation of a “two position switchable relay” which will switch the switchgear protection relays to a “super sensitive” mode during operational activities and then back to a normal running mode following the operations to prevent spurious trips can be used to capture operational faults and speed clearance times.

3. Isolate
• Access controls should be in place for all switchrooms to prevent unauthorised access.
• The use of positive pressure will further control the entry of dirt and waste to switchrooms and help to maintain equipment integrity.
• The installation of environmental monitoring (i.e. humidity alarms, de-humidifiers / HVAC units etc.) to control the atmosphere within switchrooms will contribute to maintaining equipment integrity.
• Switchroom integrity inspections will include an assessment for moisture/water entry into the building.
• The use of remote switching of electrical equipment will always be preferable over local switching so as to allow the operator to be isolated from the switchgear when it is operated.
• Where remote switching through control schemes the use of traditional lanyards should be utilised by operators to separate themselves from the equipment.
• Development in robotic operating mechanisms to rack in/out breakers remotely is becoming commercially available and will remove the operator from being immediately in front of the switchgear.
• In all, the adoption of remote switching should be considered when making a decision concerning switchboard protection and switchgear operation. Where remote switching is not currently installed, the control scheme may enable modification to enable such operations. A justification should be recorded on boards which do not enable remote switching, which will detail other additional controls.
• Where reasonably practicable when work is to take place within the boundary established by Arc Flash/Fault Level Calculations, or within cubicles or circuit enclosures.

4. Control
4.1 Access Control
• Access controls should be in place for all switchrooms to prevent unauthorised access.
• The issue of switchroom access keys, cyber keys or access codes are issued to individuals for switchroom access the need for a central point to coordinate entry should be established and ideally this is via the station control room or the safety document office.
• Where access is issued from a central office/control room the use of a work control card and/or safety document provides a formal record of the pre-job briefing and arrangements in place.
4.2. Switchroom Access Training

- Switchroom access training is required to enable authorisation and should include access control process, switchroom hazards and controls, arc flash risk, hierarchy of controls, switching, racking and isolation methods to remove the operator from the equipment where possible.

- The consideration to grade the training enables a tiered approach to switchroom access dependent upon the activity and interaction with the apparatus.

- Training and authorisation requires a defined refresher period and should enable the inclusion of recent events, incidents and switchgear developments both internally and externally.

- First Aid training, including Artificial Respiration Techniques for electricians and Senior Authorised Persons should be considered as best practice and included within the competence matrix, with defined refresher dates. The ability and means to summon help must be included in the basic training for those entering any switchroom.

- Training for Authorised Person/Senior Authorised Person on switchgear operation will require the inclusion of a practical element to demonstrate competence in the operation and racking in/out of the switchgear. Increasingly best practice adopted is for sites to install training switchgear with control supplies live for normal operation.

- A training switch board enables individuals to practice racking in/out breakers on a “dead” board, also to simulate fault finding and to simulate non-standard operation scenarios.

- Best practice has established three levels of switchroom training, ranging from general access level (cleaning/painting) through a standard level required for maintenance of isolated equipment, to a higher level for operational activities.

- Detailed training and role competences are required for all employees required to work in switchrooms. Where contract staff are authorised to work in switchrooms oversight of contract competence systems and training is required by the client.

4.3. Inspection and Maintenance

- Switchroom and Switchgear maintenance and inspection routines should be proportionate to the environment and consider the environment, the equipment age and switching regime.

- The use of Key Performance Indicators / Process Safety Performance Indicators for preventative maintenance to provide leading indicators should be adopted to provide oversight of plan versus reality.

- Switchroom housed switchgear will benefit from a dry, clean environment and should be installed in an environment as defined by the OEM.

- Switchgear not housed in switchrooms will require an enhanced level of inspection and maintenance due to the risk of moisture and dirt ingress.

4.4. Switchgear not within a designated Switchroom

- For switchgear outside of switchrooms additional consideration is required in terms of demarcation, this can be through the use of painted lines on the floor, handrail barriers and warning signs.

- To prevent inadvertent operation of switchgear outside of controlled switchrooms, consideration should be given to locking off the control and selector switches. Plastic shield covers should be fitted to E-stops etc.

- Human factors should be considered to manage behaviours around switchboards not in switchrooms, including the unauthorised storage of plant and equipment in the vicinity, individuals congregating in the vicinity of switchboards, management of cleanliness, and individuals interacting with staff whilst undertaking maintenance or operational activities.
4.5. Switchroom Signage

• Signage/posters covering the actions to be taken in the event of electric shock should be positioned in a prominent position within the switchroom.

• Signage external to the switchrooms should provide sufficient information concerning access control, voltage levels, fault levels, arc flash boundary and PPE requirements.

4.6. Switchroom Access Isolations

• Consideration should be given to the appropriate actions to be taken with respect to disarming switchroom fire protection immediately prior to access; arrangements should be captured within operational procedures and included within the switchroom training material.

• A risk assessment should be recorded identifying the controls to be applied for disarming of switchroom fire protection and how this is managed and recorded.

4.7. Work within Switchrooms

• Work within switchrooms should be graded and an appropriate level of instruction provided to cover general through to access for operation and maintenance.

• Work within the boundary established by Arc Flash/ Fault Level Calculations, or within cubicles or circuit enclosures, should be subject to task specific risk assessment. Isolation is preferred but where this is not reasonably practicable the risk assessment should consider the requirement for the wearing of additional Arc Flash PPE.

Examples of work of this type include:

• Removal or insertion of switchgear trays from or to the switchboard
• Racking in / out of circuit breakers
• Local switching operations
• Fault finding within cubicles
• Electrical testing within cubicles
• Electrical maintenance within cubicles
• The use of generic written instructions should be carefully considered when used for tasks within the switchrooms, such as sweeping the floor.

• Consideration should be given to the size of working within a switchroom and should be considered in context of the work being undertaken and the risk from routine/ non-routine switchgear operation.

• Access to switchrooms should be managed to avoid periods of peak operations, such as during plant procedures when pumps/fans could be starting/stopping more than during normal operation.
4.8. Remote Switchroom monitoring and warnings

- The use of switchroom public address systems to warn of switchgear operation should be considered to pre-warn of planned operations.
- Alternatively, the use of a switchroom warning claxon should be considered to pre-warn of planned operations.
- The use of CCTV within switchrooms relayed back to control rooms provides additional security and monitoring.

4.9. Pre-switching Work Instructions, Switching Instructions, Point of Work Risk Assessments

- Sites should risk assess the requirement for issuing switching instructions and defining “normal routine operations”.
- Sites should risk assess the decision to classifying the racking of single feed switchgear in/out and earthing of circuits as routine operation and hence not requiring the formal issuing of switching instructions for racking in/out or earthing of circuits.
- The development of standard operating practices for the operation of switchgear with associated risk assessments should be managed as a formal document with an owner and review date. Operators must be authorised to enact these procedures as part of their training.
- The GEN/SIP Switchgear Risk Assessment Tool should be considered to aid with completing switchgear risk assessments, operating procedures, training requirements.

5. Personal Protective Equipment (PPE)

5.1. Arc Flash PPE

- Companies have used Arc Flash studies to specify Arc Flash PPE requirements.
- The wearing of Arc-Flash PPE should not need to be stipulated if there are alternative means of controlling or eliminating the hazard.
- Arc Flash PPE can be issued personally to operators to manage. Non-Arc Flash PPE should also be issued to prevent the Arc Flash PPE becoming overly contaminated with oil/dirt which can impair the protection provided.
- Separate laundry arrangements should be considered for Arc Flash PPE; wash counts and cleaning products should be considered when evaluating the life of Arc Flash PPE.
- Specific Arc Flash undergarments are available and should be considered as part of the layered PPE. Consideration should be given to sites prohibiting melting/burning type garments not to be worn during switching to prevent them from burning/melting onto the skin.
- It may not be possible to wear the relevant class of PPE in some circumstances. These may include areas such as where access/egress is restricted or any situation that makes the work more dangerous. In these circumstances a specific risk assessment should be undertaken detailing additional controls.
6. Discipline

6.1. Management Key Performance Indicators (KPIs)

- Site switchrooms and switchgear should be assessed for criticality and risk; maintenance routines and programs should be based upon this evaluation.
- Operators should establish management information KPIs to monitor the delivery of preventative maintenance against planned schedules.
- The identification of Safety Critical Devices and Systems should be used to inform inspection and maintenance schedules and the level of monitoring.
- Failure rates, near hits and repair work provide valuable insight to future maintenance plans, equipment upgrades and feeds into switchgear/switchroom access risk assessments.
- All operators should be kept abreast of industry standards, and good practice developments through ongoing training and awareness.
- Staff training and competence to work in switchrooms/operate switchgear should be tracked and recorded formally within a site competence management system.
- Procedure review dates and ownership should be managed within a comprehensive Business Management System.
- Inspections, Job Freeze Reviews and Audits should be recorded formally and held for future reference, gaps and improvement opportunities should be managed with tracked actions through to closure. If the action is not to be progressed, the justification should be recorded with the audit and alternative controls considered.
- Switchgear failures are recorded and investigated to identify root cause and provide insight into potential engineering solutions.
- Investigations and action tracking is prioritised and tracked through to closure.
- Compliance with switchroom audits is monitored.
- Internal and external audits are conducted of the process, systems and individuals working in switchrooms/operating switchgear.
- Switchgear failures should be reported to the Electricity Networks Association for formal recording and wider dissemination across the UK Electricity Supply Industry via National Equipment Defect Reporting System (NEDeRS).

Appendix 1: Industry example of a graded approach to switchroom access

Category 1 (High Degree of Risk)
- A high level of control over access and switching must be established and maintained.
  - Persons must not be in the switchrooms without the knowledge of a Responsible Person.
  - No pre-arranged switching should take place whilst persons are in the switchrooms.

Category 2 (Low Degree of Risk)
- Access to all switchrooms should be controlled by locking the switchroom doors.
  - Keys will only be issued to individuals who have received training and have been nominated competent to access switchrooms.
  - Where temporary access is required then either the individual concerned should be trained or be accompanied at all times by a Person nominated for access to the switchroom.

Category HV Switchrooms
- Before entry to, and on exit from a Category HV Switchroom, the individual must contact the Responsible Person (e.g. the Control Person, Senior Authorised Person or other designated Responsible Person).
  - The name, time of entry and subsequent exit should be recorded in writing such that the record is available to all Persons likely to be responsible for all or any, operational activities, within the switchroom (e.g. remote switching).
  - If switching is to take place whilst any switchroom is occupied then the person carrying out the switching shall ensure that the switchroom is vacated whilst the switching takes place.
  - Some circuit breakers will operate automatically, (e.g. Protection Trip or Crash Start facilities). It is impractical in these instances to vacate the switchrooms prior to the switching taking place, but Persons entering must be made aware of this risk.

Category LV Switchrooms
- Before entry to, and on exit from a Category LV Switchroom, the individual must contact the Responsible Person (e.g. the Control Person, Senior Authorised Person or other designated Responsible Person).
  - Individual Key holders are responsible for ensuring that switchrooms are locked and secure when they leave.