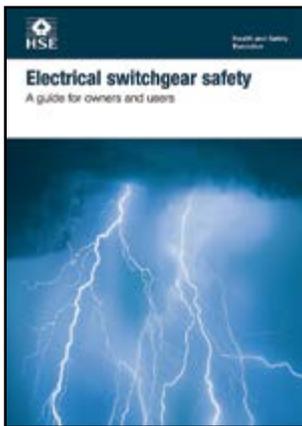


Electrical switchgear safety

A guide for owners and users



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Introduction

This guidance is for owners and operators of electrical switchgear in industrial and commercial organisations with little electrical knowledge or expertise available in-house. It provides a summary of HSG230 *Keeping electrical switchgear safe*, which provides detailed advice for organisations employing electrical engineering managers and specialists (see 'Further reading').

The guidance will help you to keep your electrical switchgear safe by covering selection, use, care and maintenance. It will also help you to manage:

- three-phase electrical switchgear with voltage ratings from 1000–33 000 volts alternating current (ac);
- circuit-breakers, switches, switch fuses, isolators and contactors operating at voltages above 1000 volts ac.

It does not cover direct current (dc) switchgear, low-voltage switchgear (voltages up to 1000 volts ac) and switchgear used on single-phase ac traction systems.

Although switchgear is generally reliable and performs well, failures, though rare, may be catastrophic. Rupturing of oil-filled switchgear tanks will usually result in burning oil and gas clouds, which can cause death or serious injury and major damage to nearby plant and buildings. Failures of switchgear can also result in serious financial losses.

Using switchgear that contains sulphur hexafluoride gas and/or a vacuum removes the hazard of burning oil but introduces other risks that need to be managed. Experience of previous accidents has shown that failure usually occurs at, or shortly after, operation of the equipment. The continuing integrity of the safe operation of switchgear can depend on:

- how it is operated;
- its condition;
- external factors, such as the circumstances existing in the electrical network at the time of operation.

Managing switchgear

As part of managing the health and safety of your business, you must control the risks in your workplace. If you use switchgear you must assess the risks and manage them to ensure safe operation and minimise the risk of injury. A risk assessment is about identifying and taking sensible and proportionate measures to control the risks in your workplace, not about creating huge amounts of paperwork.

You are probably already taking steps to protect your employees, but your risk assessment will help you decide whether you should be doing more.

The following might help:

- Think about how the switchgear could injure or harm the health of your employees and others.
- Ask your employees what they think the hazards are, as they may notice things that are not obvious to you and may have some good ideas on how to control the risks.
- Check manufacturers' instructions or safety data sheets for chemicals and equipment, as they can be very helpful in spelling out the hazards.
- Some workers may have particular requirements; for example, new and young workers, migrant workers, people with disabilities, temporary workers, contractors and lone workers may be at particular risk.

Having identified the hazards, you then have to decide what you need to do to manage them responsibly. Generally, you need to do everything 'reasonably practicable' to protect people from harm. An explanation to what 'reasonably practicable' means is provided at www.hse.gov.uk/risk/faqs/htm. Your strategy for managing the risk should include:

- system information and record-keeping;
- policies and procedures covering the installation, commissioning, operation, maintenance and removal of the equipment;
- allocation of defined roles and responsibilities;
- supervision and training requirements for your people.

Make a record of the significant findings from your risk assessment and what you have in place to control the risks. Any record produced should be simple and focused on controls. If you have fewer than five employees, you do not have to write anything down. But it is useful to do this so you can review it at a later date; for example, if something changes. If you have five or more employees, you are required by law to write it down.

An auditing regime, although not required by law, may help you to monitor and maintain the effectiveness of the procedures.

You are responsible for managing the risks of your business. Many businesses develop the necessary expertise in-house and are well equipped to carry out an assessment and decide on the appropriate actions. If there are things you are not able to do, you may need external help from suitably competent persons or organisations to help you comply with the law, eg:

- electricity distribution companies;
- switchgear manufacturers;
- switchgear maintenance companies with particular expertise in your type of switchgear;
- consulting organisations specialising in switchgear;
- technical services companies.

These people may also be able to provide training for 'competent and authorised persons' (see HSG230 in 'Further reading' for further information on these terms).

You should consider employing someone in-house who is competent to deal with emergencies.

System information

While not a legal requirement, you should keep a record of your electrical installation system information; this can help you keep your equipment safe. If you do decide to keep such information it is prudent to include:

- diagram(s) of the electrical network showing the interconnections between the various plant items, including the switchgear and their location(s) and fault levels at all relevant points;
- types of equipment as part of an asset register, including details such as manufacturer, model, serial number, year of manufacture, date of installation, voltage current and short-circuit rating and details of the operating mechanism;
- details of operational limitations due, for example, to the possibility of overstressing (ie if operated under fault conditions it is unable to cope with the resulting electrical and thermal stress that can sometimes lead to catastrophic failure);
- a maintenance record of each item of switchgear;
- the number of fault clearance operations since circuit-breakers were last maintained (if known);
- details of any modifications carried out; for example, whether there are arc control devices for oil-filled circuit-breakers or the fitting of anti-reflex control handles (these operate one-way, imposing a time delay when they are removed and refitted before carrying out a further operation).

If this information is not available, you will need to verify that your equipment complies with the law or, as a matter of urgency, take the actions necessary to make sure that it will do so.

There will be a low-voltage installation associated with the switchgear and the basic records for this may also contain electrical installation certificates and periodic inspection reports. For more information see BS 7671 *Requirements for electrical installations* in 'Further reading'.

Policies and procedures

Safety of the equipment: Assessing the risks

You should assess the switchgear and the electrical network to identify any potential risks and problems; the system information can help you do this. Risks and problems can include:

- lack of maintenance;
- overstressing of switchgear;
- presence of equipment having dependent manual operation, ie where the movement of the switchgear contacts is directly dependent on the movement of the operating handle by the operator;
- absence of anti-reflex control handles;
- inadequate means of protection against fire;
- limited access and egress.

From this assessment you will be able to identify the action(s) you must take to make sure that the equipment and systems are being operated safely, which may include:

- prohibiting operation of overstressed switchgear when live, including disabling automatic operation to clear faults on the system. This will involve adjustments to electrical protection upstream to ensure the system remains protected;

- preventing access to the switchgear when live;
- reducing fault levels, wherever possible, by reconfiguring the network;
- prohibiting the operation of dependent manually-operated switchgear when live, except under very carefully controlled conditions;
- replacing overstressed switchgear.

Further actions you may need to take (the urgency of which will depend on the results of your assessment) could include:

- replacing overstressed switchgear;
- when possible, replacing the closing mechanism for dependent manually-operated switchgear. When this is not possible, you must replace the switchgear;
- fitting anti-reflex handles;
- improving measures for protection against fire.

Once you have decided on the actions you will take, you must make a plan to carry them out.

Operating procedures

You should develop operating procedures and select the appropriately trained people (see 'Roles and responsibilities') for the activities needed to operate, inspect, repair, maintain and test the switchgear. Those carrying out any of the activities must:

- have the appropriate knowledge of the safety rules;
- know how to apply the safety documents;
- know their responsibilities to ensure safety and for safe working.

Their level of knowledge of the switchgear could range from a general understanding to detailed technical knowledge depending on the duties you give them. For more information see HSG85 *Electricity at work. Safe working practices* in 'Further reading'.

Safety rules and safety documents

You should develop and implement safety rules and a safety documents scheme (for example, use of limitation-of-access and permit-to-work forms) as they are key to safety in the use, care and maintenance of plant. The correct use of the safety rules and safety documents is essential, and HSG85 provides further information.

Roles and responsibilities

People operating, inspecting, maintaining and testing your switchgear will need to be told of their roles and responsibilities to carry out their duties safely and without risk to health. They should also be aware of what they are **not** authorised to do. The people you authorise to do the work (including issuing or accepting permits) must be competent to do the task; that is, they must have the correct training, qualifications and experience.

Supervision and training

The people operating, inspecting, maintaining and testing your switchgear will need to be made familiar with the procedures, safety rules and safety documents. You will need to make sure that they are supervised, as necessary, to follow the rules.

As a user of switchgear you must make sure the people you have selected receive the training necessary for them to be able to carry out their duties in safety and without risk to health. The organisations in the box on p2 can offer a full range of training courses, from general appreciation of site access and responsibilities through to detailed courses on operations, safety and maintenance practice.

Monitoring and review

You must monitor your procedures to check that they are being operated properly and that risks are being properly controlled. Monitoring should also include the means to identify and rectify defects in the systems of work (eg need for training or retraining etc). Periodic reviews must also be carried out to check whether plans, procedures and risk assessments need to be updated. Carrying out a review will also give you assurance that action has been taken and lessons learned as a result of accidents, incidents and inspection reports. For more information see HSG65 *Successful health and safety management* in 'Further reading'.

Record-keeping

As part of your monitoring and review arrangements, you may find it helpful to keep records to help you keep your equipment safe. This should include the system information and the:

- subsequent maintenance record of each item of switchgear;
- number of fault clearance operations since circuit-breakers were last maintained;
- details of any modifications carried out;
- periodic inspections of the low-voltage installation.

Inspecting and maintaining switchgear

You must maintain your switchgear. It should be regularly inspected and tested in accordance with the manufacturer's instructions.

This guidance cannot cover in detail those aspects of inspection and maintenance particular to each type of switchgear (oil, sulphur hexafluoride and/or vacuum). Chemicals such as oil and sulphur hexafluoride have their own hazards and requirements for handling, cleaning, avoidance of contamination, disposal and recycling (visit www.hse.gov.uk/chemicals for further information).

Inspection

You should inspect the switchgear environment, for example the switchroom or substations, regularly. During the inspection you should prioritise any remedial actions as follows:

- Immediate. This should always be the case when security of the substation enclosure has been interfered with.
- Earliest possible opportunity.
- Next scheduled maintenance.

You should include the following items in the inspection schedule:

- Switchgear environment (switchroom access and surrounds, including fence and external walls if outdoors):

- signs of water getting in/dampness;
 - signs of unauthorised access and/or interference;
 - condition of firefighting equipment and warning notices;
 - general housekeeping;
 - signs of abnormal conditions such as high temperature, smell of hot substances or ozone, presence of smoke, signs of fresh leakage of oil or compound, distortion and evidence of sooting on enclosures.
- General condition of switchgear, such as corrosion, evidence of leaks, fluid levels, presence/condition of labels, padlocks and key exchange interlocks, condition of instruments and protection equipment.
 - Condition of ancillary equipment such as batteries and chargers, control panels etc.

Maintenance

You must maintain switchgear, and do this at regular intervals. You should also carry out maintenance, particularly in the case of oil-filled circuit-breakers, immediately after they have operated to switch off an electrical fault in the network. Certain types of switchgear (such as that using sulphur hexafluoride and vacuum) are sometimes designated or described as 'low maintenance', but that does not mean that no maintenance is required.

You should decide the frequency of maintenance based on:

- the type of switchgear;
- whether it contains oil, sulphur hexafluoride or a vacuum;
- the manufacturer's instructions;
- its age;
- how often it is operated;
- its maintenance history.

Keeping records for each item will help you identify aspects such as deterioration in the condition of the equipment. You can use this information to consider whether to adjust the time between each maintenance period accordingly.

Selecting new, replacement or refurbished switchgear

When your assessment shows that switchgear needs to be replaced you should consider the following options, taking advice as necessary:

- replacing the switchboard in its entirety;
- replacing/refurbishing switchgear in the existing installation, when there are a number of options:
 - replace the individual switchgear units (moving and fixed portion);
 - refurbish the switchboards or individual switchgear units;
 - retrofit the switchgear (this usually applies to circuit-breakers).

Factors to take into account before selecting switchgear

Before you can decide how to proceed, you need to obtain assurances that the high-voltage insulation components of the busbar system, current transformer chambers, cables, terminations etc have adequate remaining life to justify the costs of partial replacement, refurbishment or retrofitting.

Generally, you need to do everything reasonably practicable to protect people from harm. It is essential that an overall assessment of the switchgear is carried out. This

includes a condition assessment of the high-voltage insulation by using partial discharge measurement techniques and the evaluation of available test data and relevant standards. Where circuit-breakers are under consideration, you also need to consider the:

- condition of the secondary wiring, protection and control equipment;
- interlocking and earthing arrangements in relation to current safety standards;
- short-circuit ratings;
- venting arrangement (where appropriate);
- rating of the existing (fixed) equipment – is it adequate to ensure the replacement equipment can be used to its full rating?

The availability of spares plays a role in the decision process. You should make sure that both strategic items (eg bushings, current transformer chambers, cable boxes, operating mechanisms) and routine maintenance items (eg arcing contacts, turbulator inserts, gaskets, tripping and closing coils) are available. Do this by contacting the original equipment manufacturers, their successor companies (if the manufacturer is no longer trading) or small specialist engineering companies.

Only then can you evaluate refurbishment/retrofit of the switchgear versus replacement.

Second-hand equipment

You can buy second-hand switchgear from companies specialising in the recovery of redundant switchgear and its refurbishment for re-sale. You need to be sure you only deal with reputable organisations. Re-sale organisations are required to provide documentation on the use and maintenance of the equipment they sell. This includes information from the original equipment manufacturers. The companies supplying the refurbished equipment should ensure all relevant items are dealt with during overhaul, upgrades, modifications etc. However, you should make sure the equipment is suitable and you may want to employ an independent consultant to oversee the contract if you don't have sufficient knowledge or expertise in-house.

Measures to limit fires

Fire legislation applies to all commercial premises and you must manage any fire risk by carrying out a fire risk assessment. More information is available from: www.hse.gov.uk/fireandexplosion/index.htm which also has links to information on general fire precautions.

Failure of switchgear can lead to fires and, where oil-filled equipment is involved, the incident can be major. Fire and smoke pose risks to people in the vicinity, the building fabric, and may also affect other plant. You must consider the measures you need to take and put in improvements where necessary. There are a number of techniques that can be used alone or together to mitigate the effects of a fire and limit smoke spread.

Compartmentments

You can use fire-resisting barriers (compartmentments) to separate substation plant items; these will limit the fire spreading to nearby items or areas. However, it is important this does not reduce any venting that is required to protect against explosion. Compartmentments can be useful if you have automatic fire extinction or control.

Control and extinction

Fire-extinguishing systems use a variety of extinguishing mediums, eg carbon dioxide (CO₂), halon etc. These systems flood the fire compartments and often operate automatically on detection of a fire. If the fire-extinguishing system works by replacing the air you should make sure that there are secure measures to prevent the system from discharging when people are in the protected area. Suitable warning notices and instructions on how to de-activate and re-arm the system should be prominently displayed at the point(s) of access to the area. These instructions should also be included in the safety rules. HSG230 provides more information.

You should also review the use and provision of portable fire extinguishers and the procedures for checking these and any permanent systems. Where problems are identified in design, operation or during inspections you should ensure corrective actions such as replacement, recharging and relocation etc are taken.

Fire prevention and detection

The most appropriate control measure is prevention. You should ensure:

- good management of the plant items, for example careful control of workmanship. There is a greater likelihood of an incident occurring after replacement or maintenance of equipment;
- careful monitoring of any degradation of oil and dielectric insulation;
- reduction of possible ignition sources;
- good housekeeping.

An appropriate automatic fire detection system could provide the electrical plant room or area with early fire detection and alarm features. This could also be linked with a control/extinction system to provide fast-response fire suppression or control.

Further reading

Keeping electrical switchgear safe HSG230 HSE Books 2002
ISBN 978 0 7176 2359 4 www.hse.gov.uk/pubns/books/hsg230.htm

Electricity at work. Safe working practices HSG85 (Second edition)
HSE Books 2003 ISBN 978 0 7176 2164 4 www.hse.gov.uk/pubns/books/hsg85.htm

Successful health and safety management HSG65 (Second edition)
HSE Books 1997 ISBN 978 0 7176 1276 5 www.hse.gov.uk/pubns/books/hsg65.htm

BS 6626:2010 *Maintenance of electrical switchgear and controlgear for voltages above 1 kV and up to and including 36 kV. Code of practice* British Standards Institution <http://shop.bsigroup.com/>

BS 7671:2008+A1:2011 *Requirements for electrical installations. IET Wiring Regulations. Seventeenth edition* British Standards Institution/Institution of Engineering and Technology <http://shop.bsigroup.com/>

Further information

For information about health and safety, or to report inconsistencies or inaccuracies in this guidance, visit www.hse.gov.uk/. You can view HSE guidance online and order priced publications from the website. HSE priced publications are also available from bookshops.

This guidance is issued by the Health and Safety Executive. Following the guidance is not compulsory, unless specifically stated, and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance.

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Tel: 020 8996 9001 email: cservices@bsigroup.com.

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