

Electrical switchgear and safety:

A concise guide for users





Introduction


This leaflet is aimed at owners and operators of electrical switchgear in industrial and commercial organisations who have little knowledge and expertise available in-house on electrical matters. It summarises the comprehensive advice given in the HSE guide *Keeping electrical switchgear safe*, which is aimed at organisations employing electrical engineering managers and specialists (see ‘Further reading’).

The leaflet provides guidance on the managing of three-phase electrical switchgear with voltage ratings from 400-33 000 volts alternating current (ac). It covers selection, use, care and maintenance. The equipment covered includes switchgear using oil, air, sulphur hexafluoride or vacuum as the interrupting medium. The leaflet deals with circuit-breakers, switches, switch fuses and isolators and also covers contactors operating at voltages above 1000 volts alternating current (ac). It does not cover direct current (dc) switchgear, low-voltage switchgear (voltages up to 1000 volts ac) and switchgear used on single-phase alternating current (ac) traction systems.

The advice contained in the leaflet will help you to keep your electrical switchgear safe and comply with The Health and Safety at Work etc Act 1974, the Management of Health and Safety at Work Regulations 1999 and the Electricity at Work Regulations 1989.

In general, switchgear has a proven record of reliability and performance. Failures are rare but, where they occur, the results may be catastrophic. Tanks may rupture and, with oil-filled switchgear, this can result in burning oil and gas clouds, causing death or serious injury and major damage to plant and buildings in the vicinity. Failures of switchgear can also result in serious financial losses.

The use of modern switchgear containing sulphur hexafluoride gas and/or vacuum has removed the hazard of burning oil but inevitably has introduced other risks that need to be managed. Accident experience has shown that failure usually occurs at, or shortly after, operation of the



equipment. How switchgear is operated, its condition and the circumstances existing in the electrical network at the time of operation, can affect its ability to perform safely.

Managing switchgear

If you use switchgear you are required by law to provide management systems that will ensure safe operation and minimise the risk of injury. Such management systems should include the following:


- an appropriate system of records;
- policies and procedures covering the installation, commissioning, operation, maintenance and removal of the equipment;
- definitions of responsibilities and training requirements for your people;
- an auditing regime to monitor and maintain the effectiveness of procedures.

Records

Check that the records of all switchgear in service, network diagrams and configurations, including prospective fault level values at every relevant point on the system, are available and up to date. If no records are found you will need to prepare these as a matter of urgency.

The switchgear record should include:

- a diagram(s) of the electrical network showing the interconnections between the various plant items including the switchgear and their location(s);
- fault levels at all relevant points;
- types of equipment as part of an asset register, which needs to include details such as manufacturer and type, serial number and year of manufacture, date of installation, voltage and current rating, short-circuit rating and type of operating mechanism;

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- details of operational limitations due, for example, to the possibility of overstressing;
 - 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 the fitting of anti-reflex control handles; and
 - whether there are arc control devices for oil-filled circuit-breakers.

The basic records in the case of a low-voltage installation may also contain electrical installation certificates and periodic inspection reports. See BS 7671 2001: *Requirements for Electrical Installations (IEE Wiring Regulations, Sixteenth Edition)*.

Policies and procedures


Safety of the equipment

Using the information in the records, you should assess the switchgear and the electrical network to identify any potential risks and problems. These can include overstressing of switchgear, presence of equipment having dependent manual operation, absence of anti-reflex control handles and inadequate means of protection against fire.

From this assessment you will be able to identify the necessary remedial action(s) you need to take to ensure that the equipment and systems are being operated safely.

Actions you may need to take urgently could 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;

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- 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 will need to replace the switchgear;
- fitting anti-reflex handles;
- improving measures for protection against fire.


If you do not have sufficient technical expertise in-house to carry out an assessment and decide on the appropriate actions, you should take advice from and employ suitably competent persons/organisations, such as:

- electricity distribution companies;
- switchgear manufacturers;
- switchgear maintenance companies with particular expertise in older types of switchgear;
- consulting organisations specialising in switchgear.

Once you have decided on the actions you need to take, you should develop a plan and timetable to carry them out.

Operating procedures

You should develop operating procedures and select the appropriate category of people for the activities needed for operating, inspecting, repairing, maintaining and testing the switchgear. In all cases, the people you employ will require the appropriate knowledge of the safety rules and



will need to know how to apply the safety documents. You will also need to tell them 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 upon the duties you expect them to have.

Electricity distribution companies, training companies, switchgear manufacturers and technical services companies may employ people who are adequately trained and competent to operate the network and maintain the switchgear. Where you have little knowledge and expertise available in-house on electrical matters, one option is to employ them to do some or all of these activities. You should certainly consider employing someone in-house who is competent to deal with emergencies.


To ensure that the different activities that are associated with switchgear are performed competently and to the safety rules, it is also important to define different categories of people, for example competent and authorised persons. This allows you to clearly define the duties that are expected of them, and what they are **not** authorised to do. Training courses can be prepared to meet the requirements of these categories.

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) because they are fundamental to safety in the use, care and maintenance of plant. The correct use of the safety rules and safety documents is essential.

Responsibilities and training

People operating, inspecting, maintaining and testing your switchgear will need to be made familiar with the procedures, safety rules and safety documents (particularly for high-voltage switchgear). You will also need to tell them their responsibilities to ensure safety and safe working.



As a user of switchgear you are required by law to ensure the people you have selected to be competent persons or authorised persons receive the necessary training so that they are able to carry out their duties in safety and without risk to health. The following organisations 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:

- electricity distribution companies;
- training companies;
- switchgear manufacturers;
- technical services companies.

Auditing regime

It is very important that you implement an auditing regime to ensure that the procedures you have developed are being operated properly. It should also include means to identify and rectify defects in the systems (need for training or retraining etc).

Inspecting and maintaining switchgear

You should regularly inspect, maintain and test all switchgear and its environment, for example the switchroom. In all cases you should do this in accordance with the manufacturer's instructions.

This leaflet cannot cover in detail those aspects of inspection and maintenance particular to each type of switchgear (oil, sulphur hexafluoride and/or vacuum). Also, materials such as oil and sulphur hexafluoride have their own requirements for handling, cleaning, avoidance of contamination, disposal and recycling. There are also hazards associated with their use.



Inspection

You should inspect substations regularly. During the inspection work you should prioritise any remedial actions as follows:

- immediately (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, and 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 should do this at regular pre-determined intervals by, for example, time-based preventative maintenance - see below. You should also do it, particularly in the case of oil-filled circuit-breakers, immediately after it has 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'. However, you should not interpret this to mean that no maintenance is required.



Time-based preventative maintenance

This system of carrying out maintenance at regular, pre-determined intervals has been in use for many years. You decide the frequency of maintenance from factors such as:

- the type of switchgear;
- whether it uses oil, sulphur hexafluoride or vacuum interruptors;
- its age; and
- how often it is operated.

You should also take the maintenance history of the switchgear into account. You should keep records for each item so you can identify aspects such as deterioration in the condition of the equipment. You can then adjust the period between each maintenance 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

This has the advantage that a completely new switchboard installation will use the latest designs on offer from manufacturers.

Replacing/refurbishing switchgear in the existing installation

You will have 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 you need to obtain assurance that the high-voltage insulation components of the busbar system, current transformer chambers, cables and terminations etc have adequate remaining life to justify the costs of partial replacement, refurbishment or retrofitting. 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 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 ensure 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 no longer trading) or small specialist engineering companies.

Only then can you evaluate the economics of refurbishment/retrofit against replacement.



Second-hand equipment

You can buy second-hand switchgear from companies specialising in the recovery of redundant switchgear and in its refurbishment for re-sale. But you need to be sure you only deal with reputable and experienced organisations. Such organisations are required to provide documentation on the use and maintenance of the equipment they sell. This would include information originating 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 could employ an independent consultant to oversee the contract. This can be a worthwhile safeguard against purchase of unsuitable equipment that might turn out to be not fit for purpose.

Measures to limit fires

Failure of switchgear can lead to fires and where oil-filled equipment is involved the incident can be major. A serious incident not only poses potential fire and smoke risks to people in the vicinity and to the building fabric but may also affect other plant. You should therefore carefully consider the measures you need to take and put in improvements where necessary. There are a number of techniques that can be used singularly or in combination to mitigate the effects of a fire and limit smoke spread.

Compartmentation

You can separate substation plant items by fire-resisting barriers to limit the extent of any fire to the item affected, but it is important this does not inhibit any venting that may be required to safeguard against explosion. Also, if you have automatic fire extinction or control then compartmentation is useful.



Control and extinction

Fire-extinguishing systems use extinguishing mediums such as halon and carbon dioxide. Halon is not an ideal choice because of environmental considerations but its use may be necessary in areas where fire hazards are particularly severe and could affect adjacent plant.

These systems require the flooding of fire compartments and often are arranged to operate automatically on detection of a fire. You should ensure that secure measures to make the system non-automatic are available for use by people before entering the protected area. Suitable warning notices and instructions should be prominently displayed at the point(s) of access to the area. These instructions should also be included in the safety rules.

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. Strategies you should consider are:

- 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 0 7176 2359 9

BS 6626: 1985 *Code of Practice for maintenance of electrical switchgear and controlgear for voltages above 1 kV and up to and including 36 kV*

British Standards Institution

BS 6423: 1983 *Code of Practice for maintenance of electrical switchgear and controlgear for voltages up to and including 1 kV*

British Standards Institution

BS 7671: 2001 *Requirements for Electrical Installations (IEE Wiring Regulations, Sixteenth Edition)*

Institution of Electrical Engineers (see 'Other sources of advice' for address)



Further information

British Standards are available from BSI Customer Services,
389 Chiswick High Road, London W4 4AL
Tel: 020 8996 9001 Fax: 020 8996 7001
Website: www.bsi-global.com

HSE priced and free publications are available by mail order from
HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA
Tel: 01787 881165 Fax: 01787 313995
Website: www.hsebooks.co.uk

(HSE priced publications are also available from bookshops and free
leaflets can be downloaded from HSE's website: www.hse.gov.uk.)

For information about health and safety ring
HSE's Infoline Tel: 08701 545500 Fax: 02920 859260
e-mail: hseinformationservices@natbrit.com or write to
HSE Information Services, Caerphilly Business Park, Caerphilly CF83 3GG.



Other sources of advice

British Electrotechnical and Allied Manufacturers Association (BEAMA)

Westminster Tower
3 Albert Embankment
London
SE1 7SL
Tel: 020 7793 3000
Fax: 020 7793 3003

The Institution of Electrical Engineers (IEE)

PO Box 96
Stevenage
SG1 2SD
Tel: 01438 767328
Fax: 01438 742792
e-mail: sales@iee.org.uk

This leaflet contains notes on good practice which are not compulsory but which you may find helpful in considering what you need to do.

This leaflet is available in priced packs of 5 from HSE Books, ISBN 0 7176 2187 1.
Single free copies are also available from HSE Books

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