

Australian Standard[®]

Maintenance of electrical switchgear



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- Australian British Chamber of Commerce
 - Australian Electrical and Electronic Manufacturers Association
 - Australian Railway Association
 - Energy Networks Association
 - Engineers Australia
 - Testing interests
-

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Australian Standard[®]

Maintenance of electrical switchgear

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PREFACE

This Standard was reviewed by the Standards Australia Committee EL-007, Power Switchgear, to supersede AS 2467—1981.

This Standard is republished from AS 2467—1981, without technical alterations.

Referenced Standards have been updated.

The objective of this Standard is to provide basic recommendations for the safety of personnel in proximity to or engaged in maintenance of electrical switchgear and includes detailed recommendations for particular types of switchgear.

This Standard sets out a standard of good practice and generally takes the form of recommendations. Compliance with it does not confer immunity from relevant statutory and legal requirements (see Clause 1.3).

The terms ‘normative’ and ‘informative’ are used to define the application of the Appendix to which they apply. A normative Appendix is an integral part of a standard, whereas an informative Appendix is only for information and guidance.

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STANDARDS AUSTRALIA

Australian Standard
Maintenance of electrical switchgear

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard sets out procedures and recommendations for the maintenance of electrical switchgear. It is applicable to electrical switchgear having rated voltages not greater than 145 kV. At voltages above this level the design of equipment, system operations and consequently maintenance requirements and practices may differ significantly from those at voltages up to this level. However, the principles formulated in this Standard as good practice, especially those regarding the safety of personnel, are for the most part applicable at the higher voltages.

The Standard does not apply to the maintenance of electrical switchgear—

- (a) of sealed construction intended only to be returned to the manufacturer for adjustment and repair; or
- (b) used in explosive atmospheres and in coal mines. Reference should be made to appropriate Standards for the maintenance of electrical equipment used in explosive atmospheres and in coal mines.

1.2 RATIONALE

Electrical switchgear, by the nature of the service it renders, does not automatically call for the maintenance attendance which is necessary to ensure its effective functioning at all times. Its normally quiescent state does not generally draw attention to incipient faults or deterioration or to the danger resulting from neglect.

It follows therefore that only an organized system of routine maintenance planned to include all necessary details can ensure continued safe and satisfactory operation of an electrical system with a minimum risk of breakdown and the consequent interruption of supply.

NOTE: In this Standard, the words ‘examination’ and ‘inspection’ have a meaning strictly as defined in Clauses 1.6.4 and 1.6.6 respectively.

1.3 OBJECT

The object of this Standard is to provide in a convenient form a record of those matters which technical knowledge and experience have shown to be important in keeping electrical switchgear, both indoor and outdoor, and its associated apparatus in an acceptable condition. It also draws attention to the precautions which should be observed in order to secure the safety of personnel while maintenance is in progress, and in this respect the following matters are covered:

- (a) Safety rules.
- (b) Safety features of equipment.
- (c) Measures to minimize hazards to plant and to ensure continuity of service.
- (d) The use of electrical testing to detect insulation weakness or the deteriorating condition of insulation.

1.4 APPLICATION

The application of Sections 2 to 14 is as follows:

- (a) *Section 2* sets out general provisions and rules for the safety of personnel engaged in the maintenance of switchgear, first aid and the responsibility of authorized persons.
- (b) *Section 3* sets out general design considerations for a switchgear installation, safe practices for the use of equipment emergency exits, instruction and warning notices and provision of facilities to minimize the risk of injury, damage to equipment and fire.
- (c) *Section 4* deals with the determination of the frequency of maintenance operations for items of switchgear, components and materials in relation to service duty and conditions of use.
- (d) *Section 5* applies to the maintenance of switchgear, intended to be serviced, for voltages up to 1000 V a.c. and 1200 V d.c.
- (e) *Section 6* applies to the maintenance of air-break switchgear for voltages above 1000 V a.c. and 1200 V d.c. A number of the recommendations in this Section are applicable to other types of high-voltage switchgear and reference is made in subsequent Sections to appropriate clauses of Section 6.
- (f) *Section 7* applies to the maintenance of oil switchgear.
- (g) *Section 8* applies to the maintenance of air-blast circuit-breaker switchgear and compressed air handling equipment in installations of such switchgear.
- (h) *Section 9* applies to the maintenance of vacuum circuit-breaker switchgear.
- (i) *Section 10* applies to the maintenance of sulphur hexafluoride (SF₆) switchgear and special safety measures necessary due to the properties of this gas.
- (j) *Section 11* sets out diagnostic testing methods and procedures which are recommended to prolong the intervals between dismantling of equipment for routine maintenance.
- (k) *Section 12* applies to the maintenance of auxiliary equipment items such as batteries, compressed air plant, transformers, earthing connections and oil handling plant.
- (l) *Section 13* applies to the maintenance of protective apparatus, fuses and relays.
- (m) *Section 14* deals with the testing and maintenance of electrical insulation.

1.5 STATUTORY AND LEGAL REQUIREMENTS

This Standard represents a standard of good practice and generally takes the form of recommendations. Compliance with this Standard does not confer immunity from relevant statutory or legal requirements.

Appendix E lists examples of the Acts and Regulations which apply in the various States.

1.6 DEFINITIONS

For the purpose of this Standard, the following definitions apply. Those marked with an asterisk (*) are illustrated graphically in Appendix D.

1.6.1 Acceptable conditions*

The condition in which an item is able to perform its required function and/or meet the relevant specification.

1.6.2 Electrical station

A building, room(s) or designated space which houses the electrical equipment in an installation.

NOTE: An electrical station may also be known as a substation, switchroom, etc.

1.6.3 Emergency action

Action which must be put in hand immediately to avoid serious consequence.

1.6.4 Examination

An inspection with the addition of partial dismantling as required, supplemented by means such as measurements and non-destructive tests in order to arrive at a reliable conclusion as to the condition of an item.

NOTE: An examination should be followed by an operational check.

1.6.5 Failure (breakdown)*

The termination of the ability of an item to perform its required function.

NOTE: Failure can be gradual, sudden, partial or complete.

1.6.6 Inspection

Maintenance action comprising a careful scrutiny of an item carried out without dismantling and using all the senses as required to detect anything which causes the item to fail to meet an acceptable condition.

NOTE: An inspection may be followed by an operational check.

1.6.7 Item

Any part of equipment including a composite which can be individually considered.

1.6.8 Maintenance

A combination of any actions carried out to retain an item in, or restore it to, an acceptable condition.

1.6.8.1 *Non-routine maintenance*

Unplanned maintenance which is not the result of a breakdown.

1.6.8.2 *Preventive maintenance**

Maintenance carried out with the objective of preventing breakdown and which may include routine or non-routine maintenance. (See also Appendix B.)

1.6.8.3 *Post-fault maintenance*

Maintenance necessary on switchgear after a specified number of fault clearance operations.

1.6.8.4 *Repair or corrective maintenance**

Maintenance necessary to restore to an acceptable condition an item which has ceased to meet an acceptable condition.

1.6.8.5 *Routine maintenance*

Maintenance organized and carried out in accordance with a predetermined policy or plan to prevent breakdown or reduce the likelihood of an item failing to meet an acceptable condition.

1.6.9 Operational check

An action carried out to determine whether an item functions correctly.

1.6.10 Test

A measurement carried out to determine the condition of an item.

1.6.10.1 *Diagnostic testing*

A technique involving the establishing of comparative data for monitoring and checking the condition of equipment.

1.6.11 Overhaul

Maintenance of an item including examination and replacement or rebuilding as required. Overhaul can be further categorized as follows:

- (a) Minor overhaul or servicing—an overhaul which is limited to lubrication and/or replacement of consumables.
- (b) Major overhaul.

An overhaul which includes major dismantling and/or replacement of items to complete the maintenance.

SECTION 2 SAFETY OF PERSONNEL

2.1 GENERAL

In view of the potential dangers associated with electrical equipment, appropriate measures shall be taken to safeguard personnel.

NOTE: Attention is drawn to the statutory requirements applicable to persons engaged in the maintenance of electrical switchgear and associated equipment.

2.2 RESPONSIBILITY

2.2.1 Statutory requirements

It is the responsibility of engineers and other supervisory personnel engaged in electrical work or operations to become acquainted with the statutory requirements applicable to their industry.

2.2.2 Authorized person

Any person to whom responsibility for electrical safety is delegated should be designated as an authorized person.

2.3 FIRST AID

A notice giving instructions for the treatment of persons suffering from electric shock should be affixed in a prominent position in all locations where maintenance is carried out. Furthermore first aid equipment should be available for the treatment of personnel.

The address and telephone number of the nearest ambulance, first aid centre or hospital should be prominently displayed on the premises.

It is strongly recommended that all electrical maintenance personnel be trained in both the rescue of people and the application of resuscitation techniques.

NOTE: Consideration should be given to the training of staff in the rescue of people from live high-voltage areas.

2.4 ACCESS

Access to electrical stations should be restricted and, where necessary, suitable barriers should be installed to prevent access to enclosures, chambers, cubicles or cells containing exposed live conductors.

2.5 SAFETY RULES

2.5.1 General

Safety in the control, operation and maintenance of switchgear is best achieved by the observance of a simple code of safety rules. Electricity supply authorities and other organizations have produced their own safety rules which specify procedures for operating and for initiating and carrying out work on particular items of equipment or apparatus. It is recommended that in all premises the occupier should draft a set of safety rules appropriate to his type of electrical installation, covering the operation of and work to be carried out on the equipment on his premises.

2.5.2 Anticipating dangers

The policy to be followed when drafting safety rules should attempt to foresee any danger that can or may develop and to institute procedures and methods which will inhibit danger as far as practicable.

2.5.3 Familiarity with rules

The best rules are of no avail unless all persons operating or working on the equipment covered by the rules are thoroughly conversant with them and with the relevant statutory requirements and comply strictly with them.

2.5.4 Supply authority rules

Where a consumer carries out switching or maintenance work on switchgear controlled by a supply authority, the consumer shall ascertain and comply with the supply authority's safety rules.

2.5.5 High-voltage equipment

Safety rules should be so drafted as to prevent any person being exposed to danger from live conductors. A good aid, particularly for high-voltage equipment, is the use of an access permit procedure similar to that described in Appendix A, Paragraphs 25 and 26. Relaxation of these principles should be permitted only where the design of apparatus precludes strict compliance and then only with special precautions to avoid danger.

NOTE: An example of comprehensive safety rules is given in Appendix A. These are the Electrical Safety Rules issued by the Energy Authority of New South Wales and it is recommended that the person on whom responsibility for electrical safety rests should incorporate or adapt these rules, as appropriate, in drafting a set of safety rules to cover his particular installation.

SECTION 3 SAFETY PROVISIONS FOR MAINTENANCE OPERATIONS

3.1 GENERAL

The performance and safe operation of electrical equipment is dependent on the initial design of the electrical station and the layout, installation and environment of the equipment. It is therefore important that these aspects be considered at the design and installation stages.

Clauses 3.2 to 3.16 list the operation and maintenance procedures which should be carried out to maintain the safety provisions.

3.2 AVOIDANCE OF MOISTURE AND DUST

The entry of moisture and dust into electrical equipment and its associated control equipment can cause malfunction. During all maintenance operations an inspection should be carried out for evidence of dampness or condensation in all electrical equipment and if this is observed, remedial action should be taken, e.g. by the improvement of ventilation, the provision of heaters or other suitable means.

Where practicable, the entry of dust should be prevented.

3.3 CONTAINMENT OF FAULTS

The physical separation of switchboards into sections and the provision of fire-resistant barriers can assist in the more rapid restoration of supplies after a fault, and the containment and limitation of possible damage. The inspection of an electrical station should include inspection of any seals provided on cable access points and any other provision made to prevent the passage of flame, smoke, gas or liquid or of any fire-resisting barriers.

Where steps have been taken in an electrical station to prevent the spreading of an oil spillage, such as the provision of dwarf walls, raised door thresholds or catchment areas, these should be inspected to see that they are effective, and that any gravel or pebble bed used is in a porous condition.

3.4 FIRE EXTINGUISHING EQUIPMENT

3.4.1 Availability of equipment and training of personnel

All personnel carrying out maintenance on switchgear where there is a fire risk should have available some means of fighting fire, either by appliances permanently in the premises or by temporary appliances provided during the period of the work, and should be trained in the use of such appliances.

3.4.2 Suitability for intended purpose

The type of fire extinguishing equipment provided for use on electrical equipment should be compatible with the electrical equipment and not dangerous to use in the situation, e.g. water fire extinguishers are not generally suitable for use on oil fires and can also cause further damage to electrical equipment and endanger personnel.

3.4.3 Inspection and labelling

Fire extinguishing equipment should be inspected regularly to the manufacturer's instructions. The equipment should be labelled with the type of extinguishing medium and with instructions for use.

3.4.4 Renewal or recharge after use

Fire extinguishing equipment should be renewed or recharged immediately after use.

3.4.5 Automatic fire extinguishing installations

Where automatic fire extinguishing installations are provided, this provision should be prominently indicated by a notice outside the electrical station, which should also show the procedure to cancel the automatic feature. The procedures to safeguard personnel against danger when entering chambers fitted with automatic fire extinguishing equipment, or when in chambers in which fire extinguishing equipment has operated, are given in Appendix C.

3.5 EMERGENCY EXITS

All emergency exits should be clearly labelled inside and out and properly secured to prevent the entrance of an unauthorized person from outside whilst at all times allowing free escape from inside. All emergency exits should be inspected during inspection of the electrical station and shall be kept clear.

3.6 LIGHTING

Adequate lighting, either fixed or portable or a combination of both, shall be provided to ensure safe access and working conditions for all personnel in electrical stations.

3.7 ACCESS

Electrical stations should be designed to prevent access and interference by unauthorized persons. Inspections should be made to see that this security is maintained. Doors and other means of entry should be kept secure by locking or other suitable methods.

To avoid danger, working space and access ways provided to apparatus and equipment which is to be worked upon or operated should be properly maintained and kept free of obstructions. (See AS 2067 for information on safety clearances.).

Provisions for access to allow work on equipment should be as recommended by the manufacturer. Work platforms should not be erected around the equipment until after the equipment has been isolated, earthed and made inoperative. The leaning of ladders against porcelain insulation is not generally recommended.

3.8 EARTHING EQUIPMENT

3.8.1 Availability of earthing equipment

Earthing (see Appendix A) is an essential safeguard for personnel carrying out work on high-voltage equipment and suitable earthing equipment should be available; this may consist of special earthing contacts provided in the switchgear, equipment for attachment to the switchgear, or portable equipment. (See also Appendix A, rule 23.)

3.8.2 Suitability of earthing equipment

Earthing equipment should be of an approved type and have adequate current-carrying capacity to suit the fault level of the installation.

3.8.3 Inspection

Before each use it is good practice to inspect earthing equipment, particularly connections and insulation. Earthing sticks should be subjected to high-voltage testing at regular intervals.

3.8.4 Permanently stored earthing equipment

Earthing equipment permanently stored in an installation should be kept in storage particularly made for that purpose, and included in the inspection of the installation.

3.9 EARTH MATS

The integrity of the connection between an earth mat and switchgear operating handle(s) should be regularly inspected.

3.10 INSULATING MATS, STANDS, SCREENS AND OTHER SIMILAR EQUIPMENT

Permanent and portable insulating mats, stands or screens should be inspected and maintained in good condition. Insulated gloves of adequate capacity and of sound quality (see AS 2225) should be available to personnel when required. Insulated gloves should be tested at regular intervals.

3.11 VERIFICATION THAT CONDUCTORS ARE NOT ALIVE

Prior to the application of any earthing leads, equipment required to be earthed should be proved dead. Any indicating device used for this purpose should be tested in the approved manner both immediately before and immediately after use.

3.12 PROTECTION AGAINST INDUCTION

When work is being carried out in e.h.v. stations, special precautions may be necessary to protect personnel against induction.

3.13 DETECTION OF HAZARDOUS GASES

Where ingress of hazardous gases into an area containing electrical installations may occur, suitable indicators should be provided to indicate the presence of such gas.

3.14 DANGER FROM STORED ENERGY

Special precautions should be taken to avoid hazards when work is to be carried out at locations where stored energy is available due to compressed air, other gases or mechanical means such as spring latched mechanisms.

3.15 PORTABLE ELECTRIC TOOLS

Where handlamps and portable tools operating from voltages not exceeding 250 V are used, they shall comply with AS/NZS 60598.2.8 and AS/NZS 3160, as appropriate, and should be of double insulated construction.

It is further recommended that, where practicable, hand lamps and portable electric tools be operated on voltages not exceeding 32 V.

The use of trailing cables should be minimized and any such cable should be of adequate construction and properly protected, e.g. by earth-leakage circuit-breakers preferably of the current-operated type. Cable connectors should be of suitable design for the environment in which they are operating.

All portable equipment should be regularly inspected and tested and have a label showing the due date for the next test attached. Where practicable, the equipment should be inspected before each use.

3.16 INSTRUCTIONS, NOTICES AND LABELS

3.16.1 Availability and display

Adequate instructions, diagrams and data shall be available to persons operating, in charge of work or working in electrical stations, to ensure proper and safe control of equipment and isolation for working.

Notices and labels required by statutory regulations shall be displayed together with any other notices or labels necessary for identification of equipment and its function.

3.16.2 Removal and replacement of identification labels

Where more than one unit of switchgear is out of service in the one switchroom, particular care should be taken to avoid inadvertent removal, replacement or exchange of labels which have previously been attached to the switchgear units removed from service.

3.16.3 Caution and danger plates

Adequate quantities of caution and danger plates should be kept in the electrical station for immediate use with the number of safety locks (see Appendix A, rule 7) required for the operation of the equipment. (See also AS 1319.).

3.16.4 Emergency exits

Emergency exits should be clearly labelled as such inside and outside. The labels should be clearly visible even under adverse conditions.

SECTION 4 FREQUENCY OF MAINTENANCE OPERATIONS

4.1 GENERAL

Because of the widely varying conditions of operation of individual switchgear installations, it is not always possible to lay down a general recommendation for the intervals between maintenance operations. These intervals may vary greatly depending upon the design of the switchgear, the duty that it is called on to perform, and the environment in which it is situated.

4.2 PLANNING THE FREQUENCY OF MAINTENANCE OPERATIONS

4.2.1 Manufacturer's instructions

When the frequencies of maintenance operations for particular items of plant are being planned, the manufacturer's instructions should be consulted.

4.2.2 Newly commissioned equipment

4.2.2.1 *Examination prior to commissioning and within 12 months of commissioning*

Switchgear of all types irrespective of the class of duty should be examined prior to commissioning and inspected or examined within 12 months of commissioning. The latter examination should prudently be carried out before the end of the manufacturer's warranty period.

Particular attention should be paid to the tightness of any fixings and fastenings (especially those associated with moving parts and conductor joints), internal cleanliness, condition of insulation, recommended clearance, and setting and efficacy of the close/open operations as a whole.

These inspections or examinations can give guidance on the intervals that might be allowed to elapse between future inspections, examination and overhaul operations with reference to particular service conditions. When estimating these intervals it would be necessary to consider the condition of the equipment at the time of the examination with regard to the following:

- (a) Contamination of external insulation.
- (b) Condition of internal insulation including oil where appropriate.
- (c) Condition of contacts, interrupting devices and connections.
- (d) Condition of operating mechanisms and their lubrication.
- (e) Condition of weather seals and gaskets.
- (f) Condition of protective finishes and signs of corrosion.

4.2.2.2 *Contacts, arc-control devices and internal insulation*

The condition of contacts and arc-control devices will normally depend on the number of operations performed by a circuit-breaker and whether such operations are load or fault-current breaking. It will assist if a log of switching operations is kept.

Similar considerations may apply to the condition of the internal insulation, but in this case the influence of moisture ingress may be relevant, this factor being generally affected by the length of time in service.

4.2.2.3 Mechanisms

The condition of mechanisms is affected by the number of operations, the environmental surroundings, and the period of service.

4.2.2.4 Basis for the determination of intervals between maintenance operations

The intervals between maintenance operations may be based on the number of operations performed or on fixed time intervals, the preferred basis being determined by the electrical, mechanical and environmental duties imposed on the switchgear. In practice a combination of these criteria may be used in the light of service experience with individual installations.

NOTE: An example of a typical fault openings form is given in Appendix B.

4.2.3 Records

It is important to keep records of the maintenance carried out. In this connection a record of the 'as found' condition of the equipment can give an effective indication of the maintenance required and a means of assessing any necessary change in frequency. A review of these records may highlight design or application defects.

It should be noted that whilst excessive operations may dictate more frequent maintenance the converse cannot normally be held to be true.

NOTE: Examples of typical maintenance record forms are given in Appendix B.

4.2.4 Routine maintenance

4.2.4.1 Basis for organization

It is preferable that routine maintenance be organized on the basis of regular inspections supplemented at more extended intervals with operational checks and examination with some dismantling as required. The inspections should ensure that no damage or distress has been sustained in the course of operations whereas the examination enables the reconditioning of the contact system, the lubrication and adjustment of mechanisms together with a more detailed inspection and testing of insulation to be carried out.

4.2.4.2 Diagnostic testing

It is recommended that where practicable and where the importance of the circuit deserves special consideration, diagnostic testing be carried out to determine such characteristics as timing, minimum operating voltage or pressures, and contact and insulation resistance. These, by comparison with previous similar tests, will provide guidance to possible deterioration and may indicate a need to vary maintenance intervals under particular service conditions. (See also Section 11.)

4.2.4.3 Switchgear controlling continuously operated plant

For switchgear controlling continuously operated plant it may be necessary to coordinate maintenance with the demands of the production program.

4.2.4.4 Different items of plant at a common location

In assessing maintenance intervals for different items of plant at a common location, e.g. indoor and outdoor switchgear of different voltages at one station, the number of site visits may be minimized by arranging for any different intervals of maintenance to be common multiples of the period allocated to the items requiring most frequent attention.

4.2.5 Post-fault maintenance

Following fault operation it is good practice to inspect a circuit-breaker at the earliest opportunity. Circuit-breakers complying with the requirements of AS 60947.2, AS 62271.100 and AS 2184 are capable of performing at least a rated operating sequence at the rated short-circuit current and more operations are usually permissible at lower values without intermediate maintenance.

Based on operating experience and on test evidence, the user, preferably after reference to the manufacturer for information, may decide on a permitted operating sequence which may in certain circumstances, e.g. vacuum circuit-breakers, be well in excess of the rated operating sequence. It is necessary, however, to ensure that the permitted operating sequence for particular circuit-breakers is not exceeded without post-fault maintenance being carried out.

4.3 INSULATING OIL

4.3.1 General considerations

The interval between tests and between reconditioning of oil will depend on the nature and frequency of operation of the switchgear under normal service conditions, together with special considerations when frequent operations take place under low leading or lagging power factor (capacitive or inductive load) conditions.

4.3.2 Environmental conditions

Environmental conditions may have a detrimental effect on insulating oil and special attention should be paid to switchgear operating under adverse environmental conditions.

4.3.3 Deterioration and contamination

Deterioration of oil in switchgear depends mainly on the duty of the equipment and the efficiency of its arc control device and the effects of the environment in which it is situated. The optimum period between tests and reconditioning should be based on experience, and/or consultation with the switchgear manufacturer.

The contamination of insulating oil may be a limiting factor on the allowable time between maintenance operations on the main switchgear. (See also Clause 7.3.1.8.).

NOTES:

- 1 The presence of carbon particles alone in oil does not necessarily indicate that the oil is in an unacceptable condition.
- 2 Where insulating oil is used for insulation purposes only, special testing techniques such as dissolved gas analysis may be necessary to detect deterioration of the oil or associated insulation.

4.3.4 Normal maintenance tests

Electrical strength tests, and where ingress of moisture is likely, water content tests in accordance with AS 1883 are recommended as the normal maintenance tests. There is normally no necessity to test for acidity or flashpoint in switchgear insulating oil.

4.3.5 Auto-reclosing duty

Where switchgear is employed for auto-reclosing duty, the user may decide upon the acceptable number of operations before oil is tested, by reference to operating experience, test experience and/or consultation with the switchgear manufacturer.

4.4 RECOMMENDED INTERVALS

4.4.1 General

The recommended intervals given in Clauses 4.4.2 to 4.4.5 are a guide to the setting up of a maintenance program. If no suitable experienced electrical engineer is available in the user's organization, assistance and/or advice should be obtained from other sources such as the manufacturer of the equipment, or the local supply authority.

4.4.2 Operational check of a circuit-breaker

An operational check of circuit-breakers (see Clause 6.4) should be made at regular intervals.

4.4.3 Indoor switchgear

For switchgear installed in indoor situations which are dry and well ventilated, and where the atmospheric conditions are not unduly corrosive and the switchgear is on normal distribution duties, e.g. used infrequently to make or break normal load currents, the following is given as a guide:

- (a) *Inspect* regularly, with a maximum interval of 12 months.
- (b) *Examine* normally at 5-year intervals. For switchgear controlling circuits without alternative supplies and where interruptions would cause difficulties, this interval may be extended but the intervals should be based on experience gained from inspection and overhaul.
- (c) *Overhaul* should only be carried out when and to the extent that inspection, examination or diagnostic testing indicates it to be necessary. However, a maximum interval of 15 years may be advisable.

NOTE: The intervals quoted are given as a guide and are based on a three-stage maintenance policy of inspection, examination and overhaul. Where the policy is based on two stages, i.e. inspection and overhaul, the maximum advisable interval between overhauls should be reduced to 10 years.

4.4.4 Outdoor switchgear

For outdoor switchgear where the atmospheric conditions of the site are reasonably clean and the switchgear is not subject to excessive pollution such as occurs in some industrial or coastal areas, for normal distribution duties the intervals given in Clause 4.4.3 should be considered, but these may need to be reduced to cater for any adverse conditions.

4.4.5 Frequent operation or adverse atmospheric conditions

For switchgear which is frequently operated, or situated in adverse atmospheric conditions, the intervals between maintenance operations will be less than those stated in Clause 4.4.3. In the case of circuit-breakers operated frequently to control, e.g. an electric arc furnace or similar equipment, the intervals between maintenance operations could be measured in weeks.

In such cases it may be preferable to relate the intervals to the number of switching operations rather than time.

NOTE: See Clause 5.7 for a summary of recommended maintenance operations.

SECTION 5 MAINTENANCE OF SWITCHGEAR INTENDED TO OPERATE AT VOLTAGES UP TO 1 0 0 0 V a . c . AND 1 2 0 0 V d . c .

5.1 PRE-MAINTENANCE REQUIREMENTS AND PRECAUTIONS

5.1.1 Safety of personnel

To establish safe working conditions for maintenance of switchgear operating at voltages up to 1000 V a.c. and 1200 V d.c. the requirements given in Sections 2 and 3 should be complied with.

5.1.2 Equipment to be rendered inoperative

It is preferable that all equipment to be worked on be made dead and isolated and all closing and opening devices be made inoperative. If it is not practicable to make the equipment dead and isolated, at least all closing and opening devices should be made inoperative. This can usually be achieved as follows:

- (a) *For closing devices*—by the discharge of any stored energy devices and by the removal of fuses or links in the control closing circuits.
- (b) *For tripping devices*—by the tripping of any tripping devices and by the removal of fuses or links in the tripping and auxiliary circuits. Any stored energy devices should have their energy discharged.

5.1.3 Manufacturer's operation and maintenance instructions

The equipment manufacturer's operation and maintenance instructions should be read in conjunction with this Standard.

5.1.4 Replacement parts

It is important to ensure the suitability and interchangeability of replacement parts.

5.2 FREQUENCY OF MAINTENANCE

The interval which can be allowed between consecutive maintenance operations on switchgear for operation at voltages up to 1000 V a.c. and 1200 V d.c. will depend on the operating conditions of the circuits controlled. Section 4 outlines the criteria which should be considered when the intervals between maintenance operations are being decided.

5.3 DIAGNOSTIC TESTING

Where practicable, the maximum use should be made of diagnostic testing techniques to indicate the condition of equipment and to prolong the intervals between dismantling. It is important that records be kept of all diagnostic tests so that comparisons can be made and trends estimated; 'tick lists' alone which indicate only that measurements have been taken are not sufficient.

Diagnostic techniques applicable to switchgear are given in Section 11.

5.4 ROUTINE MAINTENANCE

5.4.1 Inspection

5.4.1.1 *General inspection*

A general inspection of the electrical station should be made, attention being given to general cleanliness, heating ventilation, and other relevant requirements detailed in Section 3. During this inspection, the condition of weather seals, signs of corrosion, leakage of oil or compound, any unusual smell which may indicate overheating, and any noise which may indicate electrical discharge or looseness of components should be investigated.

Also, as far as is reasonably practicable, any external insulation, trip mechanism, shutter mechanism earth connection and other visible parts should be inspected for any signs of abnormality.

Inspections should be made to ensure that any ancillary equipment, spare fuses, special tools or other equipment required for the operation of the switchgear are available and in good order.

5.4.1.2 *Inspection of specific items of equipment*

Attention should be given to the items where a clause number is shown in column 3 of Table 5.1 (see Clause 5.7).

5.4.2 Examination and overhaul

5.4.2.1 *General*

Overhauls should only be carried out on such items that an inspection, examination or manufacturer's recommendation indicates to be necessary. Clauses 5.4.2.2 to 5.4.2.13 give operations which may be required to be carried out during maintenance.

5.4.2.2 *Cleaning*

All loose external dirt should first be removed. In the cleaning of switchgear it is most important not to use what is generally known as cotton waste. Material used for this purpose should be clean and free from loose fibres, metallic threads and similar particles. Brushes and blower nozzles should contain no metallic material.

Care should be taken to prevent loose parts, tools metal filings or dirt falling into the apparatus.

Cleaning fluids should be very carefully selected to ensure compatibility with organic insulation plastics, valve gear and bearings, rubber and synthetic 'O' rings, and other materials used in the construction of the equipment. They should also be safe for use by personnel.

5.4.2.3 *Insulation*

Insulation should be inspected, cleaned and renewed where necessary. Porcelain and moulded insulation should be inspected for cracks or other defects. Bonded and laminated fibrous and other organic insulation should be inspected for signs of tracking, treeing, blistering, delamination or mechanical damage. On this type of equipment, which often cannot be isolated, insulation resistance tests are only necessary where the insulating material is suspect or when the connected circuits are to be tested.

For further information on the maintenance and testing of insulation see Section 14.

5.4.2.4 *Equipment enclosures*

Operation of any heaters should be verified, and any anti-condensation finishes inspected for signs of deterioration.

5.4.2.5 *Contacts*

The following recommendations apply to contacts:

- (a) Contacts should be examined for burning, overheating, misalignment or other damage and reconditioned or renewed as required. It should be verified, by means of special tools if provided, that bolted or wedge type contacts are correctly tightened.

Overheating may be caused by overloading, loose connections, insufficient contact force, ineffective fuse-link contact or lack of alignment of switch contacts, and sometimes may be detected only with the equipment on load.

- (b) Slight discoloration or burning of bare copper or copper alloy contacts is not necessarily harmful but may be removed by suitable abrasive cloth or a fine file. The amount of material removed from contacts should be kept to a minimum and the manufacturer's recommended profile should be maintained. It is important that the spring force between the contact surfaces should not be significantly reduced.

Modern high-pressure point or line contacts will normally carry their rated current satisfactorily even if there is some pitting of the surface. Large beads or ridges on the contacting members that would seriously impede closing or opening should be removed.

- (c) It is usually undesirable to attempt to clean or dress tipped or plated contacts and the manufacturer's recommendations should be followed. Silver or silver-plated contacts seldom require cleaning despite a black appearance. If it is required to clean them, silver polish may be used.
- (d) When contacts are refitted, renewed or refurbished, the contact force, alignment and wipe should be verified.
- (e) Any flexible braids should be inspected, especially for fraying at the terminations, and renewed if necessary. Where exposed to the atmosphere, the braids may be treated with a suitable protective compound which will not impair their flexibility.
- (f) Any recommendations of the manufacturer for treatment of the contacts should be followed. Caution should be taken with the use of lubricants in dusty situations.

5.4.2.6 *Arc-control devices and interpole barriers in the vicinity of the arc*

Arc-control devices and interpole barriers in the vicinity of the arc should be examined and cleaned or, if badly burned, renewed.

Where the surface finish of an arc-control device is critical to its performance, the device should not be abraided during cleaning, but renewed.

Any air-puffer device should be checked for correct operation.

As far as is reasonably practicable, arc-control devices should be examined to ensure that they are securely fastened, correctly adjusted and electrically connected. All adjustments should be carried out in accordance with the manufacturer's instruction.

5.4.2.7 *Mechanisms*

Mechanisms should be cleaned and examined and any worn parts renewed. It should be verified that circlips are correctly seated and that split pins are opened.

5.4.2.8 *Indicating devices and interlocks*

The following recommendations apply to indicating devices and interlocks:

- (a) Indicating devices such as mechanical 'ON' and 'OFF' indicators, semaphores, etc. should be inspected to ensure that they are in good order and operating correctly.
- (b) Correct operation of any interlocks and padlocking devices should be verified and any adjustments required should be made.

Provided the necessary precautions have been taken, it should also be verified that interlocks inhibit the incorrect actions.

5.4.2.9 Connections

It should be verified that all joints are sound and that good contact is maintained on current-carrying, main earth and secondary earth connections.

NOTE: Care should be exercised when re-making aluminium connections (see AS 62271.301).

5.4.2.10 Fuses

It should be verified that fuse connections are tight and that the rating of fuses is correct.

Fuse-links should be inspected for signs of deterioration.

The fusible elements of semi-enclosed fuses should be renewed where deterioration is suspected.

5.4.2.11 Cable terminations

Any compound-filled cable termination associated with the switchgear should be inspected for compound leakage or distortion and any defect corrected. Cable tails and risers should be inspected for overheating of connections or distortion.

5.4.2.12 Contactors

In addition to any relevant previous operations, the following should be carried out:

- (a) Remove loose particles and dust from arc chutes and replace the arc chutes where necessary. Inspect contacts and springs. Contacts should normally be allowed to bed in until erosion necessitates replacement.
- (b) Pivots should be lightly lubricated if required (refer to manufacturer's instructions) and armature pole faces cleaned. It should be verified that any shading rings are in position.
- (c) Contacts should be free to operate and should not foul the arc chutes.
- (d) The alignment and security of the tube and flexible connections of mercury tube contacts should be verified.

5.4.2.13 Busbars and busbar chambers

Any barriers and supports should be examined as is reasonably practicable, and in accordance with the following:

- (a) *Air insulated equipment* For air insulated equipment the examination should include any dismantling required to enable connections to be inspected and any chambers to be cleaned.
- (b) *Compound filled equipment* For compound filled equipment, the examination should be limited to the verification of the filling level and an inspection for signs of leakage of the compound, moisture ingress and irregularities on the surface of the compound.

5.4.2.14 Final verification

Before the equipment is returned to service, the following should be done:

- (a) Verification of tightness of circuit and earth connections.
- (b) Verification of insulation resistance of circuit including auxiliary wiring.
- (c) An operational check.

5.5 POST-FAULT MAINTENANCE

Depending on the design and duty of the switchgear, inspection may be necessary after operation on fault. Where such an inspection is necessary attention should be given to the following:

- (a) *Cleaning* Insulation and other parts should be cleaned and inspected for signs of cracking, burning, tracking or other damage.
- (b) *Contacts and arc control devices* Contacts and arc control devices should be inspected for burning or other damage and reconditioned or renewed where necessary. The contact force, alignment and wipe should be verified. (See also Clause 5.4.2.5.)
- (c) *Mechanisms* The mechanism should be checked for correct operation.
- (d) *Insulation resistance* The insulation resistance should be checked before the equipment is returned to service.

5.6 MAINTENANCE OF AUXILIARY EQUIPMENT

Recommendations applicable to auxiliary equipment which may form part of the switchgear are given in Section 12.

5.7 SUMMARY OF MAINTENANCE OPERATIONS

The maintenance operations recommended for switchgear intended for operation at voltages up to 1000 V a.c. and 1200 V d.c. are summarized in Table 5.1. A reference to the clause number in column 2, 3, 4 or 5 indicates that this type of maintenance operation is appropriate.

NOTE: See Clause 6.9 for a summary of recommended maintenance operations.

TABLE 5.1
MAINTENANCE OPERATIONS FOR SWITCHGEAR INTENDED FOR
OPERATION AT VOLTAGES UP TO 1000 V a.c. AND 1200 V d.c.*

1	2	3	4	5
		Routine maintenance		
Maintenance operation	Pre-maintenance requirements	Inspection	Examination and overhaul	Post-fault maintenance
Safety of personnel	5.1.1			
Equipment to be replaced inoperative	5.1.2			
General inspection		5.4.1.1	5.4.1.1	
Diagnostic testing			5.3 and Section 11	
Cleaning			5.4.2.2	5.5
Insulation		5.4.2.3	5.4.2.3	
Enclosures			5.4.2.4	
Contacts		5.4.2.5	5.4.2.5	5.5
Arc control devices		5.4.2.6	5.4.2.6	5.5
Mechanisms		5.4.2.7	5.4.2.7	5.5
Indicating devices and interlocks		5.4.2.8	5.4.2.8	
Connection			5.4.2.9	
Fuses		5.4.2.10	5.4.2.10	
Cable terminations		5.4.2.11	5.4.2.11	
Contactors			5.4.2.12	
Busbars and busbar chambers			5.4.2.13	
Final verification			5.4.2.14	5.4.2.14
Auxiliary equipment		Section 12	Section 12	5.5

* The number quoted in the columns refers to the appropriate clause number.

SECTION 6 MAINTENANCE OF AIR - BREAK SWITCHGEAR INTENDED FOR OPERATION AT VOLTAGES ABOVE 1 0 0 0 V a . c . AND 1 2 0 0 V d . c .

6.1 PRE-MAINTENANCE REQUIREMENTS AND PRECAUTIONS

6.1.1 Safety of personnel

To establish safe working conditions for maintenance of switchgear operating at voltages above 1000 V a.c. and 1200 V d.c., the requirements given in Sections 2 and 3 should be complied with.

6.1.2 Equipment to be rendered inoperative

Power-closed switchgear together with any associated remote controlling equipment should be rendered inoperative. This can usually be achieved by taking the action described in (a) to (h) below as appropriate:

- (a) *Solenoid-closed switchgear*—the main solenoid supply should be isolated.
- (b) *Spring-closed switchgear*—the spring should be discharged, and for a motor-wound spring-closing mechanism, the motor supply should first be isolated.
- (c) *Pneumatically-closed switchgear*—the air system of the switchgear concerned should be exhausted and locked off, the local air receiver drain valves being left open and where practicable locked open during the whole of the time that work is being carried out on the gear.

For switchgear of the fully pressurized type, the switchgear should be in the manufacturer's recommended position, open or closed, for the draining of gas from the receiver. If necessary the manufacturer's instructions should be consulted.

NOTE: It is important to note that freezing of the drain valve can occur during draining so that although air has ceased to pass through it, the pressure in the receiver may still be above atmospheric pressure. To ensure that the air pressure has been completely released, the pressure gauge should be checked to ensure that it is reading zero, i.e. atmospheric pressure.

- (d) *Stored energy devices*—should be discharged.
- (e) *Tripping devices*—should be tripped.
- (f) *Fuses or links*—should be removed.
- (g) *Removable or withdrawable switchgear*—before any work is carried out on the fixed isolating contacts, the contacts should be isolated and earthed.
- (h) *Shutters*—any shutters or other devices preventing access to isolating contacts which may be live, should be locked closed.

6.1.3 Manufacturer's operation and maintenance instructions

The equipment manufacturer's operation and maintenance instructions should be read in conjunction with this Standard.

6.1.4 Replacement parts

The suitability and interchangeability of replacement parts should be verified.

6.2 FREQUENCY OF MAINTENANCE

The interval which can be allowed between consecutive maintenance operations on switchgear for operation at voltages above 1000 V a.c. and 1200 V d.c. will depend on the operating conditions of the circuits controlled. Section 4 outlines the criteria which should be considered when the intervals between maintenance operations are being decided.

6.3 DIAGNOSTIC TESTING

Where practicable the maximum use should be made of diagnostic testing techniques to indicate the condition of equipment and to prolong the intervals between dismantling. It is important that records be kept of all diagnostic tests so that comparisons can be made and trends estimated; 'tick lists' alone which indicate only that measurements have been taken are not sufficient.

Diagnostic techniques applicable to switchgear are given in Section 11.

6.4 OPERATIONAL CHECK

Where practicable every circuit-breaker should be tripped and re-closed at regular intervals, to verify that it is capable of satisfactory operation. The tripping should be initiated by the electrical operation of the trip coil.

The interval between operational checks may vary from less than 6 months to more than 5 years depending on the operating conditions.

6.5 ROUTINE MAINTENANCE

6.5.1 Inspection

6.5.1.1 *General inspection*

A general inspection of the substation or switchroom should be made, attention being given to general cleanliness, heating, ventilation and other relevant requirements detailed in Section 3. During this inspection, the condition of weather seals, signs of corrosion, leakage of oil or compound, any unusual smell which may indicate overheating, and any noise which may indicate electrical discharge or looseness of components should be investigated. Also, as far as is reasonably practicable, any external insulation, trip mechanism, shutter mechanism, gas vents, earth connection and other visible parts should be inspected for any signs of abnormality.

Inspections should be made to ensure that any ancillary equipment, spare fuses, special tools or other equipment required for the operation of the switchgear are available and in good order.

6.5.1.2 *Inspection of specific items of equipment*

Attention should be given to the items where a clause number is shown in column 3 of Table 6.1 (see Clause 6.9).

6.5.2 Examination and overhaul

6.5.2.1 *General*

Overhauls should only be carried out on such items as an inspection, examination or manufacturer's recommendation indicates to be necessary.

Clauses 6.5.2.2 to 6.5.2.21 give operations which may be required to be carried out during maintenance.

6.5.2.2 *Cleaning*

All loose external dirt should first be removed. To avoid ingress of dirt into any internal portion of the circuit-breaker, any joint or gasket should be cleaned prior to commencing any dismantling. This is particularly important in the case of pneumatic valve gear, as relatively small particles of dirt can cause damage, leakage or malfunctions.

In the cleaning of switchgear it is most important not to use what is generally known as cotton waste. Materials used for this purpose should be clean and free from loose fibres, metallic threads and similar particles. Brushes and blower nozzles should contain no metallic material.

Care should be taken to prevent loose parts, tools, metal filings or dirt falling into the apparatus.

Cleaning fluids and lubricants applied after cleaning should be very carefully selected to ensure compatibility with organic insulation, plastics, valve gear and bearings, rubber and synthetic 'O' rings, and other materials used in the construction of the equipment. They should also be safe for use by personnel.

6.5.2.3 *Insulation*

Insulation should be inspected, cleaned and renewed where necessary. Porcelain and moulded insulation should be inspected for cracks or other defects. Bonded and laminated fibrous and other organic insulation should be inspected for signs of tracking, treeing, blistering, delamination or mechanical damage. Insulation resistance tests are strongly recommended as these give an indication of the condition of the insulation.

For further information on the maintenance and testing of insulation see Section 14.

6.5.2.4 *Equipment enclosures*

Operation of any heaters should be verified and any anti-condensation finishes inspected for signs of deterioration.

6.5.2.5 *Contacts*

The following recommendations apply to contacts:

- (a) Contacts should be examined for burning or other damage and reconditioned or renewed as required. It should be verified that any backing springs are exerting the correct force and that the contacts are in correct alignment.

It will be expected that the arcing contacts will show signs of burning and erosion, but this will not be harmful provided that it is not excessive and provided that the correct lead between the arcing and main contacts can be obtained. The security of any arc-resisting tips should be checked. It should be remembered that the normal duty of arcing tips is to carry the arc root but if excessive burning and/or erosion is present the tips should be renewed.

- (b) Hinge contacts should be examined for any signs of overheating, burning, welding or other damage, and be reconditioned, adjusted or replaced as necessary. If such damage is found, the cause should be investigated. Contacts should be inspected for signs of arcing in other than normal places.
- (c) Slight discoloration or burning of bare copper or copper-alloy contacts is not necessarily harmful but may be removed by suitable abrasive cloth or a fine file. The amount of material removed from contacts should be kept to a minimum and the manufacturer's recommended profile should be maintained. If necessary, the contacts should be renewed. It is important that the spring force between the contact surfaces not be significantly reduced.