

Code of practice for

Maintenance of electrical switchgear for voltages above 36 kV

UDC 621.316.3.027.3.004.5

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW



Document Sharing Hub

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Power Electrical Engineering Standards Committee (PEL/-) to Technical Committee PEL/92, upon which the following bodies were represented:

- ASTA Certification Services
- Association of Supervisory and Executive Engineers
- British Railways Board
- Copper Development Association
- Department of the Environment, Property Services Agency
- Electrical Installation Equipment Manufacturers' Association (BEAMA)
- Electricity Supply Industry in England and Wales
- ERA Technology Ltd.
- GAMBICA (BEAMA) Ltd.
- Health and Safety Executive
- National Economic Development Office
- Transmission and Distribution Association (BEAMA)

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- British Coal
- British Gas plc

This British Standard, having been prepared under the direction of the Power Electrical Engineering Standards Committee, was published under the authority of the Board of BSI and comes into effect on 30 October 1987

© BSI 07-1999

The following BSI references relate to the work on this standard:
Committee reference PEL/92
Draft for comment 83/26114 DC

ISBN 0 580 16141 2

Amendments issued since publication

Amd. No.	Date of issue	Comments

Contents

	Page
Committees responsible	Inside front cover
Foreword	iii
Section 1. General	
0 Introduction	1
1 Scope	1
2 Definitions	1
Section 2. Safety	
3 Responsibility	3
4 Procedures for safe systems at work	3
5 Isolation and access for maintenance	3
6 Preparing for work	4
7 Fire extinguishing equipment	4
8 Testing	5
9 Disposal of scrap	5
Section 3. Common requirements relating to maintenance	
10 Manufacturer's instructions	6
11 Newly commissioned equipment	6
12 Frequency of maintenance	6
13 Records	7
14 Replacement parts	7
15 Cleanliness	7
16 Marking of covers and connections	8
17 Quality of connections	8
18 Maintenance and testing of insulation	8
19 Maintenance of safety earthing continuity	9
20 Shutters, locking devices etc.	9
21 Interlocks	9
22 Ventilation	10
23 Equipment heating and lighting	10
24 Lifting devices	10
25 Tripping and closing supplies	10
26 Equipment tools, spares and test instruments	10
27 Conclusion of maintenance	10
Section 4. Additional requirements relating to the maintenance of specific items	
28 Circuit-breakers	11
29 Switches	19
30 Disconnectors and earthing switches	20
31 Busbars and busbar chambers	20
32 Relays	20
33 Protective, measuring and control transformers	21
34 Cable boxes and terminations	22
35 Compressed air plant	22
36 Ancillary and auxiliary circuits	22

	Page
Appendix A Typical example of safety rules	23
Appendix B Graphical illustration of some of the terms and definitions given in clause 2	38
Appendix C Example of maintenance record card	39
Appendix D General recommendations relating to personal hygiene and safety at SF ₆ installations	40
Appendix E Recommendations for the content of the switchgear manufacturer's handbook	42
Figure 1 — Graphical representation of terms and conditions given in clause 2	38
Publications referred to	Inside back cover

Foreword

This code of practice has been prepared under the direction of the Power Electrical Engineering Standards Committee. It is a revision of those clauses of CP 1011:1961 and BS 5405:1976 covering equipment rated above 36 kV. BS 6423:1983 covers voltages up to 650 V, and BS 6626:1985 covers the range from 650 V to 36 kV. Therefore CP 1011:1961 and BS 5405:1976 are withdrawn. This code of practice represents a standard of good practice and takes the form of recommendations.

Attention is drawn to the following:

- The Health and Safety at Work etc. Act 1974
- The Health and Safety (First Aid) Regulations 1981
- Code of Practice for the Health and Safety (First Aid) Regulations 1981
- The Electricity Supply Regulations 1937
- The Factories Act 1961
- The Electricity (Factories Act) Special Regulations 1908 and 1944
- The Mines and Quarries Act 1954
- The Coal and other Mines (Electricity) Regulations 1956
- The Quarries (Electricity) Regulations 1956
- The Miscellaneous Mines (Electricity) Regulations 1956
- The Coal and other Mines (Mechanics and Electricians) Regulations 1965

It is essential that all persons responsible for electrical work or operation make themselves acquainted with the appropriate statutory requirements.

It has been assumed in the drafting of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people. Some factors that affect the performance and safe operation of equipment are dependent on the initial design, associated equipment, environment, location and installation. These should be considered at the appropriate stage.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 44, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

0 Introduction

The purpose of this code of practice is to provide in a convenient form guidance on those matters which technical knowledge and experience have shown to be important in keeping equipment in an acceptable condition. It is intended for the guidance of those actually carrying out the maintenance work as well as for administrative personnel. It is therefore strongly recommended that this code, together with manufacturer's instructions for each specific item, be made readily available for all concerned. This code of practice can only draw attention to general issues and the definitive reference for any user's particular equipment is the manufacturer's handbook.

The normally quiescent state of electrical switchgear and some controlgear does not automatically draw attention to incipient faults, deterioration or danger resulting from neglect and the consequent need for maintenance. It follows therefore that an organized system of routine maintenance will facilitate continued safe and acceptable operation of an electrical system with the minimum risk of breakdown and consequent interruption of supply.

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

1 Scope

This code of practice covers the maintenance of electrical switchgear having rated voltages above 36 kV. At these voltages the equipment is physically large and overhaul and maintenance is usually carried out on site. For similar reasons in the case of SF₆ switchgear the volume of gas is relatively large.

Recommended procedures for maintenance of the principal components of equipment are included and guidance is also given concerning replacement parts. Particular emphasis is placed on the use of the manufacturer's handbook as the definitive reference for any user's particular equipment.

Reference is made to the precautions to be observed in order to secure safety of personnel whilst maintenance is in progress. A typical example of safety rules is included in Appendix A. Some comments are also made regarding safety features of equipment and measures to minimize hazards to plant and to ensure continuity of service. In addition, notes are given on the subject of electrical testing as the means for detecting insulation weakness or the deteriorating condition of insulation.

NOTE The titles of the publications referred to in this code of practice are listed on the inside back cover.

2 Definitions

For the purposes of this British Standard the following definitions apply.

2.1

switchgear

a general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, and also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures, intended in principle for use in connection with generation, transmission, distribution and conversion of electric power

NOTE This is identical with the definition given in BS 4727-2:Group 06, where other definitions relating to switchgear may also be found.

2.2

high-voltage (HV)

above 650 V

2.3

equipment

electrical switchgear

2.4

item

any part of equipment including a composite unit which can be individually considered

2.5

acceptable condition

the condition in which an item is able to meet the requirements of the relevant specification and perform its required functions

NOTE See also Appendix B.

2.6

failure (breakdown)

the termination of the ability of an item to perform its required function; failure can be gradual, sudden partial or complete

NOTE See also Appendix B.

2.7

maintenance

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

2.8

routine maintenance

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

2.9

non-routine maintenance

unplanned maintenance which is not the result of a breakdown

2.10

preventive maintenance

maintenance carried out with the objective of preventing breakdown and which may include routine or non-routine maintenance

NOTE See also Appendix B.

2.11

repair or corrective maintenance

maintenance necessary to restore an item to an acceptable condition

2.12

emergency action

action which must be taken immediately to avoid serious consequence

2.13

post-fault maintenance

maintenance which may be necessary on switchgear after a specified number of fault clearance operations

2.14

inspection (inspect)

a 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. They may include an operational check

NOTE See 2.18.

2.15

servicing

work carried out to ensure that the equipment is kept in an acceptable condition, which usually does not involve any dismantling, and is typically limited to cleaning, adjustment and lubrication

2.16

examination (examine)

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

2.17

overhaul

work done with the objective of repairing or replacing parts which are found to be below standard by examination, so as to restore the component and/or equipment to acceptable condition

2.18

operational check

an action carried out to determine whether an item functions correctly

2.19

test

a measurement carried out to determine the condition of an item

2.20

diagnostic test

a comparative measurement carried out to monitor the condition of an item

2.21

manufacturer's handbook

written information issued by the manufacturer of the equipment which should include guidance and instructions concerning installation, commissioning, operation and maintenance of the equipment

NOTE The content of this handbook is outlined in Appendix E.

Section 2. Safety

3 Responsibility

Electrical equipment should be regarded as being capable of giving rise to danger, not necessarily of an electrical nature, and it is essential that all persons responsible for electrical work make themselves acquainted with the relevant statutory requirements. A list of some relevant publications is included in the foreword.

All persons concerned with the maintenance of equipment should conduct themselves in accordance with the provisions of the statutory requirements and take reasonable care for the health and safety of all those carrying out the work, and of others who may be affected by their acts or omissions at work.

A notice giving instructions for the treatment of persons suffering from electric shock should be affixed in a prominent position in the vicinity in which work on electrical installations will be carried out. It is strongly recommended that all electrical maintenance personnel be trained in the application of resuscitation and know how to summon medical help.

4 Procedures for safe systems at work

It is recommended that in all premises, the employer or occupier should formulate and update as needed during the life of the equipment a set of safety rules or procedures, appropriate to the type of electrical installation, covering the safe access for the purpose of maintenance to, and the operation of, the equipment on his premises. (See typical example in Appendix A.) Where the employer or occupier is not competent, the formulation of a set of safety rules may be contracted out to a competent authority.

Where switching or maintenance work has to be done on equipment fed directly from a source of supply not under control of the employer or occupier or the persons actually carrying out the work, then special care is required. It will be necessary for all parties mutually to agree procedures and methods of work in order to ensure the safety of persons carrying out the work, and for these agreed procedures to be incorporated in the rules and procedures for the installation.

Care should also be taken to prevent equipment being worked on becoming energized due to the automatic or inadvertent starting of standby or emergency generators.

In addition, the employer or occupier should ensure that precise instructions exist, based on the manufacturer's handbook, for the safe handling, maintenance and testing of the equipment. The employer or occupier should also make arrangements for monitoring to ensure that the foregoing procedures are effectively performed.

Those concerned with the maintenance of equipment should familiarize themselves with the plant it controls and report any changes which may affect the equipment. During maintenance work all personnel should pay particular attention to warning notices or instructions incorporated on the equipment or set up temporarily during the maintenance procedures.

5 Isolation and access for maintenance

5.1 General

The policy to be followed in making equipment available for maintenance should always be that it should be isolated, proved dead where possible and immediately earthed.

5.2 Procedures

No electrical conductor should be regarded as being safe unless it has been isolated, discharged to earth and, where necessary, earthed at all points of supply.

Precautions should be taken to ensure that the isolated equipment cannot be re-energized from an alternative source of supply.

Voltage indicators should always be proved before and after use. It is good practice to inspect earthing devices before every use. Earthing connections including leads and associated terminations need to be of adequate capacity for the duty at the point of application.

Barriers preventing access to enclosures containing live conductors should normally be kept locked.

Where one person isolates and another does the work, the person responsible for isolating should demonstrate effectively to the other that the equipment is dead and safe and that there are adequate safeguards to prevent re-energization.

Adequate quantities of suitable locks, caution notices and temporary barriers should be available for use to facilitate safe working and to prevent conductors from being accidentally electrically charged when persons are working thereon, and also to warn of the presence of any live conductors. Such notices should be clearly legible, prominently displayed, made from durable material and kept up to date. Suitable precautions should be taken to identify circuits and equipments at the front and back of switchboards where this provision does not already exist.

Any disconnectors used for isolation should be locked to prevent movement to the ON position. Any shutters giving access to live conductors should also be padlocked in the closed position.

Equipment enclosures frequently contain circuits having sources of supply different from that of the main circuit, such as interlocks, alarms, heating and lighting circuits, etc., and these circuits are not always isolated when the main circuit is disconnected. Conductors and terminals associated with these circuits should be shrouded where necessary to prevent accidental contact and identified with warning notices. Particular care should be taken to avoid danger from reverse energization of voltage/control transformers or the open-circuiting of current transformer secondaries. Removal and retention of fuse links or bolted links should only be used as a means of isolation when suitable precautions are taken to prevent duplicates being inserted.

Contactors should never be considered as a means of isolation.

Reliance should never be placed on control circuit isolation, switching or electrical interlocks to prevent accidental or inadvertent re-energization of the main or other auxiliary circuits.

Where the component to be maintained is completely withdrawn from the equipment, and thus from all sources of electrical supply, that component may be regarded as a safe piece of equipment and no longer subject to the safety rules referred to in paragraph 1 of clause 4.

6 Preparing for work

Working space, entry ways and exitways provided to apparatus and to equipment which is to be maintained should be kept clean and free from obstruction. Spare parts, tools, instruments, insulating screens, insulated tools, portable earthing devices and gloves associated with the equipment or the work to be performed should be housed in proper receptacles provided for the purpose, and kept in proper condition.

Adequate lighting, either fixed, portable or a combination of both, should be provided as necessary to ensure safe access and working.

Portable electrical tools and inspection lamps should preferably be operated from a system with a voltage no greater than 110 V with either the star point of a three-phase or the mid-point of a single-phase transformer low voltage winding earthed. If mains voltage portable tools need to be used, they should be of all-insulated or double-insulated construction and the use of a residual current device is recommended. All portable electrical equipment should be regularly inspected and tested.

NOTE Further advice on the safe use of portable tools is contained in HMG publication guidance note PM 32 available from HMSO, 49 High Holborn, London WC1 for personal callers, or by post from HMSO, PO Box 276, London SW8 5DT.

The ingress of moisture, dirt, vermin, etc., into electrical equipment can cause malfunction and danger. Care should be taken to prevent such ingress whilst work is in progress, and covers should be replaced as soon as access to the chamber is no longer required. Before final closure of any compartment, a careful inspection should be carried out to make sure no foreign matter or loose material is present.

Before work is undertaken in any chamber containing high-voltage conductors, tests using suitable voltage indicators should be carried out. These should include tests between each phase and earth to ensure all conductors are dead. Voltage indicators should always be proved before and after use.

When work is being carried out with adjacent pneumatically operated or air-blast circuit-breakers in service, due precautions need to be taken to protect personnel from the effects of noise caused by these circuit-breakers should they operate. Where circuit-breakers are fitted with silencers no problems should occur, but if they are unsilenced consideration should be given to the use of ear defenders.

7 Fire extinguishing equipment

All personnel carrying out maintenance on equipment where there is a fire risk or using flammable materials in processes requiring flame or other sources of heat should have fire fighting appliances available for ready use. These appliances may be installed permanently by an occupier or employer for use in the premises or they may be temporary appliances provided for the period of work. Employees should be trained in the use of portable appliances and know how to summon further assistance.

If a fixed automatic fire extinguishing installation is installed, a prominent warning notice should be displayed at the entry to the protected area. The notice should also include instructions for preventing automatic operation when persons are working within the protected area. The prevention and restoration of automatic operation should be subject to appropriate safety procedures, e.g. by including a reference on the relevant permits-to-work.

The type of fire extinguishers provided for use on or near electrical equipment should be compatible with the equipment and safe to use. Further advice on fire prevention and fire fighting may be obtained from the local Fire Prevention Officer.

8 Testing

8.1 General

Care should be taken when applying test voltages to ensure that they are the lowest value required for the purpose with the minimum current output. Where equipment is capable of storing a charge this should be safely discharged after every test.

NOTE 1 Further advice on electrical testing is available; one publication is Health and Safety Series Booklet No. HSG(13) "Electrical testing"¹⁾.

NOTE 2 Electrical equipment may be damaged by the application of test voltages and currents of incorrect value and polarity. Some electronic equipment is particularly vulnerable.

8.2 Use of test instruments (oscilloscopes, etc.)

Instruments should be of a type suitable for the measurements which are to be made so that a malfunction or the introduction of transients and/or reversed polarities into the connected circuits is avoided. The manufacturer's instructions should be observed.

An earthed instrument lead may create danger if it is applied to an active signal circuit which is normally floating. It is recommended that the instrument casings are earthed at all times but, where the nature of test precludes this, extraordinary care should be taken by the operator to secure his own safety and that of others by the adoption of a safe system of work. It is recommended that suitably protected test leads are used at all times.

9 Disposal of scrap

Care is needed in the disposal of removed items or materials since some give rise to health or environmental danger unless properly handled, e.g. polychlorinated biphenols (PCBs) or asbestos. In case of doubt, reference should be made to the manufacturer's instructions or the appropriate Local Authority.

¹⁾ Available from HMSO.

Section 3. Common requirements relating to maintenance

10 Manufacturer's instructions

It is essential that personnel engaged on maintenance of equipment ensure that they have ready access to the relevant manufacturer's handbook and that it is used as the major reference guide to methods of working, dismantling, reassembly and restoring to service.

11 Newly commissioned equipment

All newly installed equipment should have a full and detailed inspection, and a complete range of tests and operational checks, as part of the commissioning procedure. The manufacturer's handbook and other information supplied with the equipment should detail the procedures to be followed. From a subsequent maintenance point of view the most important factor is to keep careful records of the condition of the equipment and, in particular, to make notes of the actual settings of any adjustable components. Reference to these notes at future maintenance operations will help in deciding what interval of time should elapse between such operations (see clause 13).

It is advisable for all equipment to be inspected shortly before the expiration of the manufacturer's warranty.

12 Frequency of maintenance

12.1 General

NOTE Some items are not intended to be maintained but may have to be renewed periodically.

Because of the widely varying conditions of operation of individual installations, it is not possible to lay down precise recommendations for the intervals between maintenance required under all circumstances. These intervals may vary greatly depending upon the design of the equipment, the duty that it is called on to perform and the environment in which it is situated. From experience and/or by consultation with the manufacturer the person responsible for planning the maintenance can decide how long it would take for any item of equipment which is in good condition to deteriorate to a condition which may give rise to trouble under normal conditions of usage.

In any switchgear installation, a distinction can be made between the device which carries out the switching operation and the rest of the equipment which performs a supporting role of connection, containment, etc.

The latter components are only likely to need periodic inspection and servicing to ensure that the equipment is free from dirt, damp and deterioration, such as corrosion of metalwork and contamination of insulation.

The switching device and its operating mechanism have moving parts subject to wear after extended use, and contacts, arc control devices and arc extinguishing fluids which are subject to deterioration at a rate depending on the design of the device and the frequency of switching operations.

In recent years a new arc extinguishing medium, sulphur hexafluoride gas (SF_6), has been used in circuit-breakers and other switching devices, and one of the principal objectives of using this new medium is to extend the life of the components associated with current interruption, often up to the anticipated economic life-time of the equipment. In the most onerous conditions of frequent switching (e.g. several operations per day) it is expected that overhaul will be required for this type of equipment and the manufacturer should be consulted. With this class of equipment, periodic inspection and operational checks will give information to ensure that the correct components are in acceptable condition.

For other types of equipment (e.g. oil or air-blast devices) the manufacturer's handbook should be consulted for guidance as to the capability of the arc interrupting components for continuing service. This guidance should be checked and supplemented by keeping careful records of inspections and operational checks so that user experience can be built up in the operational environment. The manufacturer's handbook should also be consulted for information as to how essential settings should be checked and on the acceptable range of values for continuing service.

Whilst abnormally frequent operation may necessitate an increase in maintenance frequency the converse is not necessarily true.

Semiconductors (power and control) and similar items and assemblies should be left undisturbed since they are easily damaged inadvertently. An inspection for and the removal of dust should suffice.

12.2 Routine maintenance

It is recommended that routine maintenance be organized on the basis of periodic inspections supplemented at more extended intervals with operational checks and examination. Examinations should ensure that no undue damage or excessive wear has been sustained in the course of operations and will reveal the need for overhaul of the contact systems, or servicing of mechanisms together with a more detailed inspection and testing of insulation as appropriate.

Routine diagnostic testing can be a useful aid in establishing the frequency of maintenance because a comparison with previous similar tests will provide guidance to possible deterioration and may indicate a need to vary maintenance intervals under the particular service conditions.

12.3 Post-fault maintenance

The need for, and extent of, post-fault inspection and maintenance should be determined by consulting the manufacturer's handbook and by past experience and will depend on a number of factors such as the magnitude of fault current, the number of fault operations, the condition of the arc extinguishing medium and the effectiveness of the arc control devices.

Particular attention should be given to some older classes of switchgear which, experience has shown, need post-fault maintenance.

In the case of low maintenance equipment, e.g. SF₆, post-fault maintenance may not be necessary and routine maintenance may be sufficient to ensure that the equipment is in satisfactory condition.

It is also desirable to include on the service record reference to the number of fault operations, together with an indication of the likely fault current, if known (see clause 13).

13 Records

Records are of value in establishing the frequency of maintenance; therefore careful note should be taken of relevant items each time maintenance is performed.

Records should be set up when the equipment is installed and should contain at least the following information.

- a) Manufacturer's details, including nameplate particulars of the equipment installed, its serial number and manufacturer's order number (if known) and the date of installation.
- b) Place where the manufacturer's handbook and list of recommended spare parts can be found.
- c) Date of last maintenance operation and note of the operation counter reading at that time, or an estimate of the number of operations.
- d) Type of maintenance carried out.
- e) Record of any findings where the condition of the equipment varied from the expected, the action taken and the condition of important components when the equipment was put back in service.
- f) Details of fuse link type and ratings, and relay settings.
- g) Details of the system maximum fault levels, and any changes to them.

NOTE An example of a maintenance record card and check list is given in Appendix C. Every significant fault or breakdown should be recorded and analysed with a view to taking action to prevent its recurrence.

14 Replacement parts

14.1 Care should be taken to see that all replacement parts are correct and suitable for the duty particularly when these parts are not available from the original manufacturer. Consumable spare parts and copies of manufacturer's component lists with exploded view drawings where provided should be kept readily available to maintenance staff.

14.2 When ordering replacement parts it is advisable that nameplate particulars are quoted including the serial number or other manufacturer's identification number.

14.3 Every care should be taken to prevent the use of defective or potentially defective parts.

15 Cleanliness

For equipment to operate satisfactorily it is essential that it is kept adequately clean and that natural or forced ventilation is not restricted (see also clause 22). However, care should be taken not to disturb equipment needlessly. Before removing covers, breaking gasketed joints or opening doors, precautions should be taken to prevent ingress of dirt, dust and loose objects. For internal cleaning a suction cleaner is recommended.

It is advisable when cleaning insulation to wipe across the likely tracking path and not in line with it. Avoid damage to insulating material, surface damage may lead to early failure by making it more susceptible to tracking.

Chamois leathers or plastic sponges should be used when cleaning oil compartments.

"Cotton waste" should not be used for cleaning. If cloths are used they should be chemically clean and free from loose fibres, metallic threads and similar particles.

Where the recommended maintenance procedures permit the use of solvents for cleaning or degreasing, it is essential that the liquids used are compatible with the equipment.

Non-flammable and non-toxic solvents should be chosen where possible, or suitable precautions against fire and toxic effects should be observed.

If painting is necessary, care should be taken to avoid its application to pivots, bearings, insulating surfaces, labels and notices.

16 Marking of covers and connections

All covers, cable terminations, etc., should be marked carefully before removal to ensure correct replacement.

Disturbed connections or temporary connections made for testing purposes should be clearly marked to facilitate reconnection. The service connections must be restored and the temporary connections and markings removed before the unit is returned to service.

17 Quality of connections

Connections which have not been disturbed should be checked for soundness. It may be possible to detect a bad connection by looking for signs of overheating.

If it is necessary to break bolted joints, the section of the manufacturer’s handbook dealing with installation should be consulted for guidance on remaking the joint.

Moveable contacts (e.g. plugs, sliding connections) should be inspected as far as is reasonably practicable for correct functioning, cleanliness and signs of overheating.

Flexible connections (e.g. braids) should be inspected for signs of fraying and loss of flexibility, and renewed if necessary.

18 Maintenance and testing of insulation

18.1 General

It is important that insulation is inspected periodically. Modern insulation materials and systems are very reliable and stable but when equipment is made available for maintenance, the opportunity should be taken to inspect the insulation. Where practicable, 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, delamination or mechanical damage.

WARNING. When testing, adequate precautions need to be taken and it is recommended that the sanction-for-test procedure is used. A typical example is shown in Appendix A.

18.2 Routine testing and inspection

Insulation resistance measurements between poles and between poles and earth are comparatively easily made and are the most suitable for insulation testing under service conditions, but to facilitate their proper interpretation, systematic testing and recording methods are essential. These tests are strictly comparative, in that for each item tested a judgement concerning any potential deterioration can only be made by experience based on earlier results. For this reason the test equipment and method used should be the same on each occasion, and the test values should be carefully logged, preferably on forms drawn up for this purpose, together with a record of the temperature and humidity conditions at the time of the test.

The voltage which should be applied to primary insulation when making resistance tests varies according to the voltage rating of the equipment. The following is a guide to test voltages.

3-phase voltage rating of primary insulation of equipment	Test voltage recommended for insulation resistance test (to earth and between phases)
Up to 1 kV	1 kV (d.c.)
Above 1 kV to 3.6 kV	2 kV (d.c.)
Above 3.6 kV	5 kV (d.c.)

After testing, conductors should be discharged to earth.

The insulation resistance of small wiring and ancillary components should be tested at a voltage not exceeding 500 V d.c.

NOTE Certain types of equipment, e.g. apparatus incorporating semiconductors, may not withstand this test voltage and therefore appropriate measures should be taken for their protection.

A steady fall in insulation resistance over a period of time is indicative of insulation deterioration. A relatively low value which remains reasonably constant may be acceptable.

The types of insulation usually met with on distribution switchgear comprise moulded resin, laminated material and (increasingly rarely) porcelain. With all these materials the results of the resistance measurements are mainly governed by the surface condition of the material and the humidity.

Therefore the insulation tests should be accompanied by a careful visual inspection of the insulation surface as already indicated. In laminated insulation, tracking, which tends to start at the edges of metalwork, often occurs beneath the surface of the insulation, and is indicated as a surface blister.

18.3 Insulating oil

Adverse environmental conditions may have a detrimental effect on insulating oil and special attention should be paid to equipment operating under such conditions, e.g. by making checks initially at fairly frequent intervals until experience is gained.

In normal use the interval between tests of oil will depend on the nature and frequency of use of the equipment. The optimum period between tests should be based on experience and/or consultation with the manufacturer.

THE CONTAMINATION OF INSULATING OIL MAY BE A LIMITING FACTOR ON THE ALLOWABLE TIME BETWEEN MAINTENANCE OPERATIONS.

Electric strength tests, and where ingress of moisture is likely, water content tests, in accordance with BS 5730, are recommended as the normal maintenance tests. There is normally no necessity to test for acidity or flash-point.

NOTE 1 In equipment where The oil is used for arc extinction, the presence of carbon particles is a normal expectation in operation and does not necessarily indicate that the oil is in an unacceptable condition. [See 28.2.2 a).]

NOTE 2 To ensure satisfactory service, the utmost care in handling the oil is essential and guidance on this is given in BS 5730.

18.4 Bushings on open-terminal equipment

The oil level on oil-filled terminal bushings should be periodically checked and if any marked change occurs, particularly if accompanied by signs of oil leakage, the manufacturer should be consulted.

With compound filled bushings a resistance measurement will not necessarily indicate the presence of moisture. Where practicable, once every five years or so at a convenient opportunity, the space above the compound should be inspected for signs of moisture ingress. If the presence of moisture is suspected, the bushing should be returned to the manufacturer for checking. Where covers are removed, care should be taken on reassembly to ensure that all joints are properly made. During inspection it should be verified that the earth connection is satisfactory. (See also 18.6.)

18.5 Sulphur hexafluoride (SF₆)

The gas density should be checked at regular intervals where gauges or indicators are incorporated into the equipment.

Where facilities are provided, samples should be taken and checked as described in 28.4.4 b).

18.6 Arc gaps

Ensure that arcing horns, where provided, are secure and gap dimensions correct.

19 Maintenance of safety earthing continuity

All exposed metal work should be effectively earthed. It is very important to ensure that earthing connections are mechanically and electrically sound, and that all contact screws are tight and good contact is maintained. Particular care should be taken to reinstate fully all bolts and screws, together with any locking devices that may have been disturbed during the maintenance operation.

20 Shutters, locking devices, etc.

The mechanical features should be particularly checked for correct functioning and the inhibiting of incorrect actions under all conditions. Mechanisms should be free from corrosion and freely operating with all nuts, locking devices, etc. secure.

Unless otherwise stated in the manufacturer's handbook, servicing should be limited to occasional light lubrication applied to bearings, shafts and pivots. Thin machine oil should be used on actuating levers and rollers.

21 Interlocks

21.1 Purpose

Equipment interlocks are incorporated in the design of the switchgear to ensure its safe operation.

21.2 Knowledge of interlocking requirements

A person responsible for checking or maintaining any interlock system should have a thorough understanding of the extent, nature, function and purpose of the interlocks, together with the necessary knowledge and experience of the plant. The manufacturer's handbook and any relevant plant diagrams should be available for reference.

21.3 Maintenance of interlock systems

This should include implementation of the following recommendations, depending on the types of interlock installed.

a) *Mechanical aspects.* All moving parts should be clean, adequately lubricated and be free to move as intended. Any evidence of wear or excessive free play should be investigated and, if necessary, reference made to the manufacturer. All fixing devices should be secure.

b) *Electrical aspects.* All control wiring should be inspected for signs of damage and terminations checked for tightness. If in doubt concerning the condition of the insulation it is recommended that an insulation resistance test be carried out (see 18.2).

21.4 Functional test

Where the relevant busbar and/or feeder circuits can be made dead, all interlocks should be functionally tested before equipment is restored to service. These checks should be carried out in both the positive and negative modes to ensure that the interlock system not only permits fulfilment of the intended operational sequence, but also prevents, when necessary, unintended or unsafe action.

When an interlock is found to be defective and remedial action cannot be implemented immediately, steps need to be taken to ensure safety by other adequate means.

22 Ventilation

Ventilated equipment should be examined to make sure that the air flow is not restricted in any way and, in the case of forced ventilation, that any airflow interlock operates correctly. Filters, if any, should be cleaned or renewed as necessary.

23 Equipment heating and lighting

The operation of heaters, lights, emergency lighting installations and changeover equipment for alternative low-voltage (LV) supplies, where fitted, should be verified.

WARNING. These circuits often remain live when the equipment is otherwise isolated.

24 Lifting devices

The maintenance of lifting devices should be carried out at regular intervals. In some types of equipment these form an integral part of the item and should be dealt with during the maintenance of the equipment. Some lifting devices are portable; these should be separately maintained in accordance with the manufacturer's recommendations, and should be examined and tested in accordance with statutory requirements.

25 Tripping and closing supplies

It is particularly important that tripping and closing supplies be maintained in good order. Compressed air plant and battery installations should be regularly maintained, including associated indicators and alarms, in line with the manufacturer's instructions. (See also clause 35 and clause 63 of BS 6423:1983.)

26 Equipment tools, spares and test instruments

Tools, spares and test instruments stored local to and associated with a particular equipment should be regularly checked against an inventory.

27 Conclusion of maintenance

Equipment should be restored to a correct working condition with particular attention to items and settings which have been disturbed and it should be ensured that there is no potential hazard from loose or extraneous equipment, tools or wiring. Safety barriers and shrouds should be reinstated, all covers including those of instruments and relays replaced with all securing bolts properly tightened and all doors resecured and locked where locks are fitted to achieve the original degree of protection.

Any procedures required under plant safety rules should be carried out.