| Eskom | Standard | Technology |
|---|---|---|

Title: **Specification for Electronic and Microprocessor based Protection and Fault Monitoring Equipment for Power Systems**

Unique Identifier: **240-57649048**

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**Amelia Mtshali**

**Senior Manager: Power Delivery Engineering (DBOUS)**

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This document is **STABILISED**. The technical content in this document is not expected to change because the document covers: *(Tick applicable motivation)*

| | | |
|---|---|---|
| 1 | A specific plant, project or solution | |
| 2 | A mature and stable technical area/technology | X |
| 3 | Established and accepted practices. | |

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Title: **Fault Monitoring Equipment for Power Systems Standard**

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|---|---|---|
| M.H.L. Bower | P. Kara | R. McMurrach |
| Senior Consultant: Protection | Protection Technology & Support Manager | Senior Manager PTM&C |
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Supported by TDAC

D. Odendaal

TDAC Chairperson

Date: 18/3/2013

# CONTENTS

## FIGURES



## TABLES

## 1. INTRODUCTION

This document consists of the title “Standard for Electrical Protection and Fault Monitoring Equipment for Power Systems”

## 2. SUPPORTING CLAUSES

### 2.1 SCOPE

None

#### 2.1.1 Purpose

This standard states the conditions of operation and Eskom's requirements concerning design, construction, components, materials, finishes and testing of electronic and microprocessor-based equipment for protection and fault monitoring systems, as well as certain requirements related to personnel safety. It covers only general requirements; specific requirements for particular equipment will be given in schedule A of an enquiry document or in other standards.

This document is based on Specification CEGB-EES General specification for electronic equipment, and supersedes NWS 1819; "Specification for Electronic Protection and Fault Monitoring Equipment for Power Systems".

#### 2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

This standard applies to all electronic and microprocessor-based protection equipment supplied to Eskom, it also applies to other equipment when called for. Where any departures from this standard are required, schedule A of an enquiry document will detail the extent of the departure(s), giving, where necessary, reasons for these. Where there is any conflict between the requirements of this standard and schedule A of an enquiry document, then the latter takes precedence.

Schedule A of an enquiry document will detail the applications for which equipment is required, its operating facilities and performance requirements. It will also specify input and output characteristics and conditions of operation applicable to the location of the equipment.

When a supplier is unable to meet any requirement given in this standard or in schedule A of an enquiry document, he shall list the deviations and detail their effects, for specific Eskom approval.

When a supplier considers that any clause of this specification is not relevant, Eskom's agreement shall be sought before the supplier regards the particular clause as being not applicable

### 2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

#### 2.2.1 Normative

The following documents contain provisions that, through reference in the text, constitute requirements of this standard. At the time of publication the editions indicated were valid. All standards are subject to revision and parties to purchasing agreements based on this specification are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Information on currently

valid national and international standards may be obtained from the Information Centre at Megawatt Park and Technology Standardization Department. In cases of conflict this specification takes precedence:

[1] IEC 68-2, Environmental testing.

[2] IEC 249-2-5:1987, Epoxide woven glass fabric copper-clad laminated sheet, of defined flammability.

[3] IEC 255-3:1989, Electrical relays - Part 3 Single input energizing quantity measuring relays with dependent or independent time.

[4] IEC 255-5:1977, Electrical relays - Part 5 Insulation tests for electrical relays.

[5] IEC 255-22-1:1988, Electrical disturbance tests for measuring relays and protection equipment - Part 1: 1 MHz burst disturbance tests

[6] IEC 297, Dimensions of mechanical structures of the 482.6 mm (19 in) series.

[7] IEC 326, Printed boards

[8] IEC 326-6, Specification for multilayer printed boards

[9] IEC 352, Solderless connections.

[10] IEC 529, Degrees of protection provided by enclosures (IP Code).

[11] IEC 1000-4-2:1995, Electromagnetic compatibility (EMC) - Part 4 Testing and measurement techniques Section 2 Electrostatic discharge immunity test.

[12] IEC 1000-4-4:1995, Electromagnetic compatibility (EMC) - Part 4 Testing and measurementtechniques Section 4 Electrical fast transient/burst immunity test.

[13] ANSI/IEEE 91, Graphic symbols for logic functions.

[14] BS 142, Electrical protection relays

[15] BS 219, Specification for soft solders.

[16] BS 441:1980, Specification of purchasing requirements for flux-cored and solid soft-solder wire

[17] BS 1706:1990, Method for specifying electroplated coatings of zinc and cadmium on iron and steel.

[18] BS 2011, Environmental testing.

[19] BS 2782, Methods of testing plastics - Part 1 Thermal properties.

[20] BS 3382, Specification for electroplated coatings on threaded components.

[21] BS 4099, Colours of indicator lights, push-buttons, annunciators and digital readouts.

[22] BS 4308:1979, Specification for documentation to be supplied with electronic measuring equipment.

[23] BS 4579, Specification for performance of mechanical and compression joints in electric cable and wire connectors.

[24] BS 4743, Specification for safety requirements for electronic measuring apparatus.

[25] BS 4884, Technical manuals.

[26] BS 5057:1992, Specification for flat, quick connect terminations.

[27] BS 5626, Cellulosic papers for electrical purposes.

[28] BS 6231:1990, Specification for PVC-insulated cables for switchgear and controlgear wiring.

[29] BS 6746:1990, Specification for PVC insulation and sheath of electric cables.

[30] BS 7226:1989, Methods of test for performance of inlet air cleaning equipment for internal combustion engines and compressors.

[31] BS 7625:1993, Specification for voltage transformers.

[32] BS 7626:1993, Specification for current transformers

[33] BS 9000, General requirements for a system for electronic components of assessed quality.

[34] BS 9210:1984, Specification for radio frequency connectors of assessed quality: generic data and methods of test.

[35] DIN EN 50022:1978, Low voltage switchgear and controlgear for industrial use: mounting rails top hat rails, 35 mm wide for snap-on mounting of equipment.

[36] DIN EN 50035:1980, Low voltage switchgear and controlgear for industrial use: mounting rails G-profile for the fixing of terminal blocks.

[37] DIN EN 50045:1982, Low voltage switchgear and controlgear for industrial use: mounting rails: top hat rail 15 mm wide for the fixing of terminal blocks.

[38] ESI Standard 12-1, Terminal blocks.

[39] ESI Standard 12-2, Electrical terminations.

[40] ESI Standard 50-18, Design and application of ancillary electrical equipment.

[41] SABS 1091:1975, National colour standards for paint.

[42] SABS 150, Polyvinyl chloride (PVC) ¾ insulated electric cables and flexible cords.

[43] NRS 002:1990, Graphical symbols for electrical diagrams

[44] SABS 0142, Code of practice for the wiring of premises.

[45] NWP 5283, Protection of electronic equipment against damage by the discharge of static electricity.

[46] ESKSCAAD0: Rev. 4, Specification for continuous analogue indicating instruments for electrical quantities.

[47] OPS 0002, Generation training, operating and maintenance documentation.

### 2.2.2 Informative

None

## 2.3 DEFINITIONS

| Definition | Description |
|---|---|
| acceptance test | Tests to establish that equipment is acceptable to Eskom in the absence of any contractual implications |
| ambient temperature | The free air temperature outside the equipment enclosure at floor level. |
| approval, approved, agreed | Approved or agreed in writing by Eskom. The person representing Eskom in terms of this specification will be stated in schedule A of an enquiry document. Approval may include qualifications and limitations. Approval does not apply to items used outside these constraints |
| boundary terminal | Terminal to which cabling external to the panel is to be connected |

| | |
|---|---|
| Connector | A device for bringing electrical conductors into mechanically secured galvanic contact. |
| end of life | The period after which one or more of the following apply<br>a. equipment maintenance is uneconomic;<br>b. equipment maintenance is difficult or impossible because of non-availability of spares; and<br>c. increase in failure rate occurs beyond the constant failure rate region. |
| Equipment | Assemblies of components, sub-units or sub-assemblies usually contained in a suitable enclosure, and capable of performing an overall specified function |
| Hazardous | Explosive, toxic, injurious, carcinogenic, mutagenic or biologically active; unguarded against electric shock. |
| Label | An inscription on equipment or on a sub-unit, either integral therewith or on a separate piece of material affixed thereto |
| Lug | A connecting device to which the electrical conductor is attached by mechanical pressure or solder and which is secured to a terminal by approved mechanical means |
| Maloperation | Failure of the equipment to function correctly in accordance with its specification |
| panel wiring | All wiring contained in a panel or enclosure. 3.13 performance check: A shortened form of performance test |
| performance test | A comprehensive series of tests which demonstrate that the equipment functions correctly |
| production equipment | Normal standard product which has been subjected to documented production procedures |
| Reliability | The ability to consistently function as specified under stated conditions for a stated time |
| routine test | A group of tests on each item of equipment to ensure that the proven design has been correctly reproduced |
| site test | Tests to establish that the equipment has not suffered any damage during delivery and that it has been correctly installed. Site testing may also establish the overall performance in the field. |
| sub-units or sub-assemblies | Groups of components forming a physically complete assembly but comprising part of the equipment |
| Terminal | A metallic device for connecting electrical conductors |
| test block | An arrangement of terminals for the safe and easy connection of test equipment |
| type test | A group of comprehensive tests performed in terms of a contract on production equipment under controlled environmental conditions to demonstrate that the equipment complies with the requirements of this specification and other relevant specifications |
| withstand test | The ability of the equipment to withstand the specified test conditions without damage. |

### 2.3.2 Classification

a. **Controlled Disclosure:** Controlled Disclosure to External Parties (either enforced by law, or discretionary).

## 2.4 ABBREVIATIONS

None

## 2.5 ROLES AND RESPONSIBILITIES

None

## 2.6 PROCESS FOR MONITORING

None

## 2.7 RELATED/SUPPORTING DOCUMENTS

None

# 3. FAULT MONITORING EQUIPMENT FOR POWER SYSTEMS

## 3.1 REQUIREMENTS

### 3.1.1 Environment

#### 3.1.1.1 General

The conditions described in the following clauses shall be taken as those which equipment should be designed to withstand without the performance being out of limits or the life being shortened unacceptably (see 3.2.3).

#### 3.1.1.2 Temperature and Humidity Classes

For the purpose of this specification the locations in which equipment may be installed have been grouped into five environmental classes, with an additional class for storage and transportation. The classes are shown in Table 1.

**Table 1: Temperature and humidity environmental classes**

| CLASS | COMMENT | AMBIENT TEMPERATURE RANGE | RELATIVE HUMIDITY RANGE | TYPICAL SITING |
|---|---|---|---|---|
| A1 | As IEC A1 | +18 °C to +27 °C | 35 % to 75 % | Air-conditioned computer and equipment rooms etc. |
| 83 | As IEC 83 | +5 °C to 40°C | 5 % to 95 % | Control rooms and equipment rooms |
| *C | Relaxed | -10°C to +55 °C | up to 100 % | Separately, rack or |

| | | | | |
|---|---|---|---|---|
| | version of IEC Class C1 | | | cubicle mounted equipment in plant areas away from high temperature plant but subject to greater extremes than Class 83 |
| C1 | As IEC C1 | -25°C to +55 °C | up to 100 % | Outdoors |
| D | Relaxed version of IEC D2 | -10°C to +85 °C | up to 100% | Adjacent to high temperature plant. |
| | Storage and Transportation | -25°C to +55 °C | 20 % to 95 % | Normal Transit and Storage Conditions |

NOTES

- Due regard shall be taken of the increase in the above temperature maximum when equipmen

is mounted in cubicles or enclosures (see 3.2.4.1)

* Normally applicable. If not applicable, the class will bespecified in schedule A of an enquiry document.

### 3.1.1.3 Mechanical shock

It is not possible to quantify the shock to which equipment is subjected, but the test in 3.6.7.1 checks the ability of equipment to withstand shock conditions which typically occur in maintenance and transportation.

### 3.1.1.4 Mechanical vibration

Vibration levels may be assumed to have a maximum value of 4,9 rn/s" over the frequency range 10Hz to 150 Hz, the most likely vibration frequencies being 50 Hz and harmonics of 50 Hz. In the vicinity of rotating plant, lower frequencies may be experienced. Some equipment may be subject to higher vibration levels and these will be specified in schedule A of an enquiry document.

### 3.1.1.5 Electrical

#### 3.1.1.5.1 Supply characteristics

Electronic equipment will normally operate from one or more of the supplies shown in Table 2 and Table 3. Supplies will be susceptible to short-term interruptions of up to 10 ms. In certain cases, which will be detailed in schedule A of an enquiry document, supply interruptions of up to 100 ms may occur. The tests in 5 are designed to establish that equipment performs correctly with the specified supply.

**Table 2: A.C. Supplies**

| **NOMINAL SUPPLY** | **110 V SINGLE-PHASE** | | 230 V **SINGLE-PHASE** | 400 V **SINGLE-PHASE** |
|---|---|---|---|---|
| | **INSTRUMENT** | **ALTERNATIVE** | | |

| | **SUPPLY** | **SUPPLY** | | |
|---|---|---|---|---|
| **Origin** | **Inverter or motor generator** | **Unit or station transformer** | **Unit or station transformer** | **Unit or station transformer** |
| Voltage tolerance | +10 %<br>-10 % | +20 %<br>-20 % | +20 %<br>-20 % | +20 %<br>-20 % |
| Frequency | 50 Hz | 50 Hz | 50 Hz | 50 Hz |
| Frequency limits | 49 Hz to 51 Hz | 47 Hzto 51 Hz | 47Hz to 51 Hz | 47 Hzto 51 Hz |
| Total harmonic distortion | 10 % | 5% | 5% | 5% |

**Table 3: D.C. Supplies**

| | | | |
|---|---|---|---|
| Nominal supply voltage | 48 V | 110 V | 220 V |
| Normal supply voltage | 52,8 V | 117 V | 234 V |
| Equipment terminal voltage limits | 43 V to 55 V | 88 V to 132 V | 176 V to 264 V |
| Connection to earth | Note 1 | Note 1 | Note 1 |
| NOTE 1:<br>Fully floating supply symmetrically balanced about earth with earth fault detection set<br>detect 10 mA current from either pole to earth. | | | |

**Table 4: Electrical environmental classes**

| **ELECTRICAL ENVIRONMENTAL CLASS** | **TYPICAL SITING AND EXTENT OF ELECTRICAL CONNECTION** |
|---|---|
| I (Low level) | Within control and equipment rooms where the levels of interference are lower than those associated with the classes below. |
| II (Mild) | Within control equipment rooms and other areas associated witt power generation plant. |
| III (Moderate) | Within equipment rooms associated with high voltage switching plant but where a proven equipment interface will be present which will protect the equipment from the more severe |

| | |
|---|---|
| | environment of Class IV. |
| IV (Severe) | Where equipment is sited within high voltage switching compounds (132 kV or above) such that it is subject to higt levels of radiated electrical interference, due to its physica placement or its direct connection to electrical plant. |

### 3.1.1.5.2 Electrical Interference classes

Equipment will normally be installed in the electrical interference environment, class IV listed in table. Any exception to this will be specified in schedule A of an enquiry document

### 3.1.1.5.3 Interference

It is not possible to quantify all interference levels, but tests have been specified in 5 to determine whether equipment is capable of operating in the specified electrical environmental classes of Table 3. The following sources of interference are possible

a. Radio frequency interference

Portable radio communication transmitters are a common source of radio frequency interference when they are operated in close proximity to equipment. A field strength of 10 Vim shall be assumed to be present in the frequency range 27 MHz to 1 GHz.

These field strengths are approximately those expected at a distance of 10 cm from a 0,5 W hand portable radio telephone. These fields can induce currents of the order of 100 mA into cables, screens and metalwork.

In this context, undue reliance should not be placed on the fact that equipment is earthed, as at radio frequency the earth impedance may be significant.

Other possible sources are low level radiation from adjacent equipment including fluorescent lamps and signals from powerful but more distant radio, television and radar transmitters.

In addition to portable radio telephones, other sources of transient high frequency interference may be present, e.g. fluorescent lamps, d.c. relay operation and switching of a.c. supplies.

b. Cable-borne interference

The interference reaches equipment on both power and signal lines mainly as a result of coupling at the source and between cables. The main cause is the rapid change of current due to switching and the operation of fuses, circuit-breakers and relays. It is usually transient in nature with a frequency spectrum extending to the MHz region.

Faults on the electrical power generation and transmission system can give rise to differences in earth potentials at power frequencies and to transient interference up to 20 kV peak.

Lightning and radiation from heavy electrical plant can give rise to interference amplitudes up to 10 kV and with frequency components extending to 100 MHz.

The interference voltage imposed on the equipment in Eskom substations connected by cables employing armouring screening earthed at both ends, is reduced by a factor of approximately 2 at power frequency and up to 10 at frequencies of a few kHz and above.

Table **5** gives typical interference levels.

The tests in 5 have been chosen to demonstrate that equipment will withstand the interference expected.

**Table 5: Interference Levels**

| **POTENTIAL DIFFERENCE AT POWER FREQUENCIES DURING SYSTEM DISTURBANCES** | | | |
|---|---|---|---|
| BETWEEN STATION EARTH MAT AND CONNECTIONS TO REMOTE EARTH | | BETWEEN POINTS ON THE SAME EARTH MAT | |
| NORMALLY | EXCEPTIONALLY | TRANSMISSION SUBSTATIONS | POWER STATIONS |
| Up to 2 kV | Up to 7 kV | 500 V r.m.s. maximum (induced) | 430 V r.m.s. maximum |

## 3.2 DESIGN

### 3.2.1 General

A number of factors shall be considered in the design of equipment so that the objectives of reliable operation over a specific time in a specified environment are adequately achieved. Some designs may be required to be fail-safe and specific requirements such as this will be detailed in schedule A of an enquiry document.

### 3.2.2 Reliability, security and dependability

Detailed information will be required from the supplier to support any claim that the equipment meets the quantitative reliability, security and dependability requirements specified in schedule A of an enquiry document.

If a particular meantime between failure rate or failure rate is not specified, the manufacturer when requested, shall provide sufficient data regarding the equipment to enable an adequate assessment to be made. Failure rates shall be specified as failures per hour x 106, the confidence limits being 60 %. The data presented shall be related to the conditions of use and shall be based on the components failure rate statistics, environmental and stressing factors specified in schedule A of an enquiry document.

Alternatively, field experience may be offered provided that sufficient recorded information is available to justify any claims made.

### 3.2.3 Life

Unless otherwise specified, equipment shall be designed for a working life of at least twenty years in the specified environment and application. Components, component ratings and all other factors determining equipment life shall take this into account. Normal routine and breakdown maintenance shall be assumed and it is accepted that certain consumable components and modules may need periodic replacement or adjustment. However, the tenderer shall state in his tender, the expected frequency of such replacement or adjustment and life expectancy.

If life expectancy is limited by the availability of replacement components, it may be acceptable to meet the design life by the use of a replacement sub-unit using different components but having the same or better overall performance. If the equipment manufacturer/tenderer considers that a design life of twenty

years is impracticable or unreasonable, he shall state the factors of components limiting the life and the estimated achievable life.

### 3.2.4 Environment

#### 3.2.4.1 Temperature and humidity

The equipment shall be designed to operate within its functional specification over the range of the specified environmental classes listed in 3.1.1.2

Equipment, units, or sub-units which are to be mounted within cubicles or enclosures, shall be designed to withstand and operate up to a temperature 15°C higher than the upper temperature limit appropriate to its class.

The design of a cubicle or enclosure shall be such that with all doors closed and covers in place and with all internal equipment correctly mounted and fully operational, the temperature rise at any free air point within it, due to heat generated by working equipment within, shall not exceed 1Q°C unless otherwise approved.

Allowance shall be taken of any heat generated by adjacent panels of plant, and advice on any adverse siting conditions shall be sought by the supplier.

#### 3.2.4.2 Mechanical

a. Shock

The design of equipment shall be such that when subjected to the drop test detailed in 3.6.7.1 neither the performance nor life are affected to such an extent that they are unacceptable to Eskom.

b. Imposed vibration

The design of the equipment shall be such that when subjected to the vibration test detailed in 3.4.6.7.2 neither the performance nor the life are affected to such an extent that they are unacceptable to Eskom.

c. Self-generated vibration

Equipment shall not generate any vibration at a level which could be detrimental to its own performance or that of other equipment, or which could cause annoyance or harm to personnel. Approval shall be sought for levels likely to be significant.

#### 3.2.4.3 Electrical

The design shall be such that the equipment operates within its functional specification throughout the range of electrical disturbance conditions of 3.1.1.5.3 and the supply conditions of 3.1.1.5.1

a. Supply interruptions

The equipment shall be designed so that despite any interruptions which occur in the supply, no damage results; and any change in the output of the equipment, both during and whilst recovering from the interruption, shall either be negligible or be in accordance with the individual requirements specified in schedule A of an enquiry document.

Unless otherwise approved, the equipment shall recover to the required operating conditions within 500 ms of the restoration of the supply.

For interruptions of up to 10 ms, the equipment shall perform as if no interruption had occurred.

Equipment which performs a successful power down and restart during supply interruptions shall retain its historical trip and fault data history and the equipment shall return to its state prior to the interruption.

b. Changeover of supply

If equipment is intended to be used with changeover supplies, the relevant parameters will be detailed in schedule A of an enquiry document, and the design shall take the following into consideration

1. a break time of 100 ms for changeover
2. the differences which can exist between main and alternative supplies
3. the fact that supplies may be out of phase.

c. Interference immunity

Equipment manufacturers shall take all reasonable precautions to minimize the susceptibility of their equipment to interference produced by other equipment. If the design is such that it might be susceptible to interference originating from any cause, the manufacturer shall state this fact in his tender.

If there is evidence that the equipment may be susceptible to radio frequency interference, testing may be required to establish whether or not this is significant and details shall be approved by Eskom. Although the metal enclosure housing the equipment may provide an effective screen to radio frequency interference, the equipment is expected to function satisfactorily when the equipment case is opened for maintenance and testing. Undue reliance shall not be placed upon the fact that the equipment is earthed, as at radio frequencies the earth impedance may be significant.

If for technical or economic reasons the manufacturer cannot meet the requirements of this clause, he shall affix a label conforming to 3.2.10.3, stating that the equipment may be susceptible to radio frequency interference and that radio transmitting equipment should not be operated within "x" metres of the equipment. The label shall be conspicuous by its position, size and appearance and shall, if necessary, be duplicated so that it may readily be seen even if the door or lid is opened. Particular attention shall be paid to minimizing the effects on the equipment of transient over voltages (see 3.1.1.5.3).

d. Self-generated interference

Equipment shall not generate any interference at a level which could be detrimental to its own performance or that of other equipment, or be capable of producing a hazard, discomfort or annoyance to personnel (e.g. electrostatic discharge, radiation, etc.).

Particular levels may be specified in schedule A of an enquiry document but approval shall be sought if they are not specified, and if the levels are likely to be significant. Interference at radio frequencies shall be reduced to below the limits specified in IEC 1000. The earthing and cabling arrangements shall be such that detrimental interference does not result (see also 3.2.8 and 3.2.9).

The electrical noise fed back to the 48/110/220 V batteries shall under no conditions exceed the levels stated below.

- 2 mV r.m.s., 300 Hz to 3 kHz psophometrically weighted.
- 30 mV r.m.s., 25 Hz ripple.
- 50 mV r.m.s., 50 Hz to 300 Hz (single frequency measured selectively).
- 5 mV r.m.s., 3 kHz to 300 MHz (single frequency measured selectively).
- Impulsive noise spikes, periodic and random, 1 volt peak-to-peak, duration 30 ns to 500/-ls.

For the purpose of checking compliance the voltage shall be measured at the rack or cubicle supply terminals and it shall be assumed that the impedance of the d.c. supply at the point of entry to the rack can be regarded as a network comprising a 2m resistor shunted by the series combination of a 0,20 resistor and a 100 /-lH inductor.

e. Insulation and isolation

- All circuits intended to be electrically isolated from external circuits shall be designed to withstand the following voltage levels.

- All circuits requiring isolation (including contacts of switches, relays or contactors) shall have an insulation resistance across the isolating barrier of not less than 20 Mn when measured at d.c. 500 V.
- A circuit intended for connection to a.c. or d.c. 100 V and above, a station battery and a current or voltage transformer shall withstand 2 kV 50 Hz r.m.s. between itself and all other points for 1 min.
- if electrical isolation is necessary to withstand the large differences of earth potential occurring in a Class IV Electrical Environmentas defined in 3.1.1.5.2 then the isolating barrier shall be designed (and tested) to withstand a voltage of 2 x (specified maximum interference level) + 1 kV (see 3.1.1.5.3 b) and Table 4).

If components are not designed to withstand such levels, alternative levels shall be to Eskom's approval.

Circuits intended for connections to pilot wire protection systems may have special requirements for insulation which will be stated in schedule A of an enquiry document.

### 3.2.5 Setting-up, calibration and maintenance

#### 3.2.5.1 Objectives

Equipment shall be designed so that a minimum of routine maintenance is required, in terms of total accumulated time and frequency.

For high equipment availability, the design should allow fault location, rectification (possibly by replacement sub-units) and returning to service to be performed as quickly as possible, preferably with the equipment in situ. The setting-up and maintenance facilities required are detailed in the following clauses.

#### 3.2.5.2 Pre-set controls and adjustable components

The circuit design and the components chosen shall allow optimum setting of pre-set components throughout the life of the equipment. The components shall have adequate resolution and stability.

No components shall require periodic adjustments apart from those adjustments required to change the settings.

Pre-set controls and adjustable components which may require adjustments shall be mounted to allow access to them while the unit is in its normal operating position, with the equipment and adjacent equipment fully operational. Such adjustment shall not require the use of insulated tools.

When it is necessary to provide means of preventing pre-set controls from being inadvertently altered, then such means shall be to Eskom's approval.

#### 3.2.5.3 Removal and replacement of sub-units

The overall system design and the design of sub-units shall be such that it is unnecessary to switch off power supplies while removing or replacing sub-units in an assembly. However, if this is not possible and the power must be switched off, then an appropriate, clear and unambiguous legend shall be prominently displayed on or near the sub-unit concerned.

Facilities shall be provided to prevent the incorrect insertion and connection of a sub-unit (see also 3.2.6.11 a).

### 3.2.5.4 Test points and other maintenance aids

To facilitate setting-up, fault location and maintenance, equipment shall be provided with a sufficient number of easily accessible test points. Precautions shall be taken in the design to protect susceptible components such as metal oxide silicon devices, which might be damaged by static discharges from test equipment or human contact.

Maintenance aids including extension printed wiring boards, jumper leads and special tools, shall be provided. The number of sets offered and the stowage arrangements intended shall be detailed in the tender.

The operation of test facilities built into the equipment shall not generate unwanted outputs and spurious alarms. Test points connected to components which might be damaged by static discharge shall be designed to provide suitable protection.

### 3.2.5.5 Special tools

Eskom's prior approval shall be obtained regarding the use of equipment requiring special tools.

### 3.2.5.6 Loose items

Loose items, such as the mating halves of all connectors shall be supplied with the equipment or shall be forwarded (suitably identified) to the site, or to a contractor nominated by Eskom.

### 3.2.6 Component selection and use

### 3.2.6.1 General criteria

If possible, components shall be selected from those which comply with the relevant specification in the BS 9000 series and shall be Qualification Approved to the General Application Group as defined in 2.3 of BS 9000.

Individual components shall have prior approval and the following factors shall be considered when the choice of component is made for any specific use. The list is neither exhaustive nor arranged in order of importance.

a. Type

- If there is a choice between different constructional techniques or different materials, finishes, etc., the choice shall be made on the required reliability and life considerations.
- If a component is chosen for a particular reliability advantage put forward by a component manufacturer (e.g. the self-healing properties of certain types of capacitors), the equipment design shall ensure that the circuit conditions enable exploitation of the particular property claimed for it.

b. Design characteristics

Circuits shall not depend upon the use of unpublished characteristics of components, or on component parameters not controlled in production. Where circuits use components which operate under unusual conditions such as pulse operation, the tender shall contain documentary evidence that the life, stability and characteristics of the components will be satisfactory.

Standard components only shall be used and any individual selection necessary to obtain a specific value of a particular parameter shall be subject to Eskom's approval.

c. Rating

Components shall be used in service so as to secure the specified equipment life expectancy and reliability. As component failure rates are accelerated by increased temperature, their operating temperatures shall be minimized by derating, optimum physical arrangement, etc. Any other factors which may be relevant to a particular constructional technique such as encapsulation, shall be taken into consideration in the design of the equipment.

Components and materials shall not at any time be subjected to voltages, currents, transients, temperatures, stresses or any other condition outside the operational values

given in the manufacturer's published data over the specified range of temperature and supply variations.

The equipment shall comprise components and materials chosen, rated and used so that, considering the expected operating conditions such as thermal cycling, equipment life and reliability requirements can be met.

d. Tolerances

The design of circuits shall take into account the variations which can occur between component values and characteristics as a result of the factors listed below:

- initial selection tolerance
- temperature co-efficient allowance
- allowance for drift during operational life (ageing)
- allowance for drift during storage (ageing)

The combined effect of all these factors shall be taken into account to assess the worst-case combination. Statistical assumptions that only certain combinations occur simultaneously shall not be made unless the relevant parameters involved are invariably independent.

The design shall be such that changes which occur are either inconsequential or are compensated for. Such compensation shall not use manually adjustable controls and shall not require the use of test equipment that is not generally available.

e. Storage

Components, whether stored as individual items or as parts of completed equipment, may be subject to environments which are not ideal (see 3.1.1.2 ). However, when removed from storage they will be expected to function fully and comply with their specifications.

If any items require special storage conditions have limited storage life or need precautions to be taken in storage, this shall be stated in the tender. In addition, the items shall be labelled so that these facts are apparent whether the packaging has been removed or not.

f. Replacement

The possibility of component failure and consequent replacement shall be borne in mind and the future availability of components shall be established before the design is finalized. If possible, components originating from a single source shall be avoided.

g. Failure mechanisms

In choosing components, the mechanisms by which the components fail (both catastrophic and by degradation) shall be established and the consequences upon the equipment performance resulting from such failures, shall be considered.

Components shall be chosen and used in such a manner that the risk of fire being caused as a result of component failure or a possible short-circuit, is negligible. If there is such a risk, the equipment manufacturer shall state this fact in his tender.

h. Hazards

As far as possible, components which could be a hazard to personnel, either in use or under failure or disposal conditions shall not be used. Where such use appears unavoidable then full details shall be given in the tender (see 3.2.7.3).

### 3.2.6.2 Semiconductors

Semiconductor devices, including integrated circuits, are particularly prone to damage from thermal stress and electrical transients. Circuit design shall ensure adequate derating to take into account duty cycle, frequency of operation and nearby sources of heat. Supply lines shall be decoupled locally where necessary and care shall be taken in the routing of earth and signal lines, particularly in low level analogue and high speed digital circuits.

Consideration shall be given to the most suitable IC technology for the application, e.g. power consumption, speed of operation, noise immunity.

Any special precautions which may be necessary in the handling of sub-units and components, such as those using MOS technology, shall be included in the maintenance handbook, and a suitable precautionary warning attached to the equipment or sub-unit. The requirements of NWP 5283 shall be complied with.

Connections shall be made by soldering except to those devices where replacement would be impracticable if soldering was employed or where removal may be necessary for testing (e.g. microprocessors, memory devices, etc). In these cases the design of the connection device shall be subject to approval.

Unless unavoidable, only devices which are available from more than one source, or for which direct pin-compatible replacements are available, shall be used.

### 3.2.6.3 Fixed resistors

Where design considerations permit, metal oxide film, metal glaze or metal film resistors are preferred for general applications. Carbon composition resistors shall only be used when the required characteristics are such that other types are excluded.

If the use of carbon film resistors is necessary, care shall be taken to select a construction in which maximum protection of the carbon film is provided.

### 3.2.6.4 Variable resistors

The choice of component types shall take into consideration the frequency of adjustment, including the possible need for frequent adjustment during commissioning and fault-finding or calibration

The equipment manufacturer shall ensure that the electrical characteristics and stability of the device are suited to the circuit requirements and to the environmental conditions. Particular attention shall be given to designing for adequate life of the component.

Potentiometers using deposited carbon tracks sometimes referred to as carbon composition, shall not be used. Moulded carbon and conductive plastic tracks are, however, acceptable.

a. Open type variable resistors shall only be used with approval and under the following conditions:

if the control is pre-set and not subject to frequent adjustment, i.e. the effects of drift are not significant

b. where the immediate environment of the component is virtually dust-free.

Zinc oxide and other non-linear resistor devices shall not be galvanically connected to Eskom CT, VT and d.c. circuits (eg substation cabling), and are only permissible within equipment beyond the galvanic isolation barriers.

### 3.2.6.5 Fixed capacitors

The choice of capacitor types and the ratings adopted for the capacitor shall take into consideration the life required from the equipment. The encapsulation and/or sealing of the capacitor shall protect the component against premature failure, and care shall be taken to use only the most reliable types incorporating proven design techniques.

If aluminium electrolytic capacitors are used, they shall be of the long-life type. Electrolytic capacitors shall be mounted within the equipment in such a way that venting of any gas produced is not prevented by liquid covering the vent.

Capacitors shall be mounted so that any liquid that may issue from the component cannot leak outside the equipment enclosure or come into contact with any circuitry.

### 3.2.6.6 Variable capacitors

Unsealed variable capacitors used in unsealed equipment shall be fitted with removable dust covers.

### 3.2.6.7 Transformers and inductors - general

Windings shall be vacuum impregnated or encapsulated. Unless otherwise agreed, lead out wires shall be soldered to the winding, the join being insulated properly and the lead-out wires firmly anchored and preferably terminated on a terminal board mounted on the component itself.

Each winding and termination shall be clearly and unambiguously identified. Oil or liquid-filled transformers shall not be used.

Cores, whether laminated or ferrite, shall be firmly clamped and mounted.

a. Power-supply transformers

(For small power transformers refer to 7.12 of ESI Standard 50 – 18)

An electrostatic screen with provision for earthing shall be fitted between the primary and the secondary windings of all mains transformers. If design considerations preclude this, for example, in switching mode power supply unit transformers operating at a frequency which is high compared with that of the 50 Hz mains, adequate filtering shall be employed to reduce RFI and transient interference effects to acceptable levels.

Each winding and termination shall be clearly and unambiguously identified and, where room permits, the voltage and current ratings of each winding shall be marked on the terminal board or on an identification label.

Interleaving material used for insulation between layers and between windings shall have characteristics not inferior to "Kraft" paper complying with BS 5626, class 1A. The insulation provided between primary and secondary windings shall be such that the transformer can withstand the application of the insulation resistance test in 3.4.6.5.6.

b. Signal transformers

These transformers will be subject to individual acceptance.

### 3.2.6.8 Relays - general

Relays shall be of an Eskom approved type and the equipment manufacturer shall obtain sufficient information or carry out sufficient tests to provide evidence that the relay is suitable for the conditions of use and the environment. If the use of a relay is proposed, this evidence, together with the other

relevant information such as the make and type of relay and its specification, the contact materials and loading, etc., shall be submitted to Eskom for approval.

Unsealed relays or groups of relays shall be provided with protective covers to prevent dust ingress. If possible, for inspection purposes, covers shall be detachable without the need to remove the relay from service.

Unless otherwise necessary for screening purposes, the covers shall be transparent.

Unless otherwise approved, all relay coils shall be suppressed so as to minimize the production of switching transients which would be detrimental to the operation of electronic circuits. Care shall be taken that the ratings of components used for this purpose are adequate for the most arduous operational conditions. Due regard shall be given to the effect of suppression on the timing characteristics of the relay.

a. Open-type relays

Open type relays shall preferably use two contacts in parallel for each function.

b. Hermetically sealed relays

Eskom's prior approval is required before hermetically-sealed relays can be used. Evidence shall be provided to support reliability, life and performance claims

c. Reed relays

Unless otherwise approved, reed relays shall not be used

Care shall be taken where reed relays are permitted, to ensure that contacts are protected against transients, not only from other relay coils but also due to capacitive loading on the contacts (see 3.2.10.8).

d. Relays with mercury-wetted contacts

Care shall be taken in using these relays to ensure that the contacts are protected with a suitable Resistor-Capacitor (RC) network. Diodes or other protective devices may be used to protect the contacts against transients and shall be used in conjunction with, but not instead of, RC contact protection.

### 3.2.6.9 Fuse-links, carriers and bases

For ratings above 0,5 A, fuse carriers and bases shall be used.

Where an alarm indication is required, striker pin fuses may be used.

### 3.2.6.10 Terminal blocks

Wherever possible, preference shall be given to the use of terminal blocks in accordance with ESI Standard 12-1.

The use of terminal blocks containing components such as fuses, isolating links, reed relays, etc., shall be subject to specific approval by Eskom.

### 3.2.6.11 Connectors

a. Multi-pole connectors

Multi-pole connectors shall be subject to Eskom's approval for each application. They shall be provided with means whereby each free plug or socket can be locked in the mated position. They shall also incorporate means for clamping the incoming cable so that the conductors are relieved of any stress.

The design of clamps shall be such that the cable is not compressed sufficiently to cause creep in the insulation.

The design and arrangement of connectors shall be such that incorrect mating cannot occur.

b. In-line connectors for sub-units and interconnections

The following is relevant to both mating parts on in-line connectors for circuit boards, printed wiring, strip wiring, etc. The requirements of 3.2.6.11 a) shall also apply where relevant.

Unless otherwise approved, the contact surfaces of connectors shall be plated with hard gold to a minimum thickness of 5 IJm or shall use other approved methods (e.g. nickel underlay) to reduce contact contamination of the base metal due to any porosity of the gold layer.

Written evidence shall be provided that connectors will meet the following requirement

The initial contact resistance shall not exceed 5 n(2 when measured at a potential not exceeding 10 mV and a frequency not exceeding 1 Hz. After a minimum of 500 matings of the connector pair, followed by the industrial atmosphere test specified in 3.4.6.9, the resistance shall not exceed twice its initial value.

Connector arrangements shall incorporate reliable means to prevent incorrect mating. If the direct insertion or separation force of a sub-unit or connector exceeds 140 N, mechanical means shall be incorporated so that the manual effort does not exceed this value.

c. Push-on connectors

If the use of push-on connectors is approved, they shall be of a type which permits gripping and support for the insulation as well as the conductor and shall be in accordance with BS 5057.

Both receptacles and tabs shall be plated with 0,7 urn of gold, or 13 urn of tin or finished with 14 urn of solder on a 2,5 urn nickel flash.

d. Radio frequency connectors

Unless otherwise approved, radio frequency connectors shall conform to the requirements of the appropriate specification in the BS 9210 range of specifications.

### 3.2.6.12 Control knobs

Control knobs shall be made of finished metal, or of thermosetting plastic incorporating a brass insert.

Their design shall be such that they cannot be removed without the aid of a tool and they shall be positively fixed to the drive spindle in such a manner that they cannot slip. This latter requirement also applies to coupling devices associated with control knobs and shafts.

If, for ease of handling, a relatively large knob is fixed to a relatively small rotary component, care shall be taken to ensure that the end stops on the control are not damaged by normal rotation of the control knob. The end stops shall be designed so that they are not damaged by any torque which may be applied to the knob.

### 3.2.6.13 Light-emitting diodes and filament lamps

Unless unsuitable for the particular application, light-emitting diodes are preferred to filament lamps. If the latter are used, their rating shall be such that an average useful active life of at least 20 000 hours is obtained and they shall have Miniature Edison Screw (MES), Large Edison Screw (LES) or midget flange or grooved bases.

### 3.2.6.14 Lampholders for filament lamps

The design of lampholders shall allow quick and easy lamp replacement. Access shall be from the front of the equipment.

To provide an adequate contact pressure on the base of the lamp, the base contact shall be spring loaded

The design shall be such that there is no possibility of a short-circuit occurring during lamp changing.

The lampholder lens colour shall be in accordance with BS 4099 unless otherwise approved and the lens shall be resistant to flame propagation as covered in BS 2782, Part 5.

The body of the lampholder shall be metal but use of a suitable thermosetting plastic resistant to flame propagation may be acceptable, subject to Eskom's approval.

### 3.2.7 Power supply switching and fusing

Connections to the external power sources listed in 3.1.1.5.1 shall normally be made through switches and fuses or miniature circuit-breakers, both of which shall be an integral part of the equipment.

### 3.2.7.1 Alternating current

Within the equipment the requirements are as follows:

a. Neutral lines shall not be fused.

b. Single-phase supplies shall be double-pole switched.

Multi-phase supplies shall have their phases switched simultaneously. The neutral shall preferably not be switched but connected through a removable link. If it is switched, it shall be interlocked to open after and close before the phase lines.

Power wiring above 110 V nominal which is used for lighting, heating and external power sockets in cubicles, etc., shall conform to SABS 0142. Additional requirements concerning voltages in excess of 110 V nominal may be specified in schedule A of an enquiry document.

### 3.2.7.2 Direct current

Fusing and switching arrangements for all d.c. supplies shall be as specified in schedule A of an enquiry document, and will be in addition to the requirements of 3.2.7.3.

a. Batteries

Batteries shall not be used within electronic equipment without Eskom's prior approval. Where approval is given, the batteries used shall be of a leak-proof type and the following shall apply:

- The type of battery used shall be chosen to suit the particular equipment application.
- If the charge state of the battery has significance with respect to the required integrity and availability of the equipment, some means of establishing the adequacy of the remaining battery capacity shall be incorporated. This may be achieved by methods such as monitoring and alarming for replacement purposes, automatic changeover, etc.
- If in situ charging is incorporated, adequate precautions shall be taken to prevent damage due to overcharging
- Evidence of the battery capacity and life expectancy under the required operating conditions shall be provided by the manufacturer.

- A label shall be fitted to the front panel of the equipment and shall indicate the fact that the equipment is equipped with an internal battery. This label shall also contain a blank space in which the replacement date of the installed battery can be written for maintenance purposes.

b. Power supply units (PSU)

Units designed to transform supply voltages (a.c. or d.c.) into one or more voltages suitable for supplying equipment or sub-units shall be such that:

- if current limiting is incorporated, the protection shall ensure that any overload of the output up to and including short-circuit shall not damage any components within the power supply;
- if current limiting is incorporated and the PSU supplies a number of individually protected loads, the available current under fault conditions in any of the loads shall be sufficient to operate the protective device;
- if voltage limit protection is incorporated, it shall be suitable for the components which comprise the output load;
- in the event of a power supply failure or a protection facility or device operating, an alarm signal shall be provided as specified in schedule A of an enquiry document; and
- in-rush current shall not cause operation of protective devices (e.g. fuse, MCB, etc) or exceed the surge rating of the primary source.

NOTES

- If the equipment is operating from a d.c. supply or a battery, the maximum in-rush current shall not exceed 3 times the normal maximum load current.
- For equipment operating from a.c. supplies, the switch-on surge shall not exceed 10 times the normal maximum load current if its rating is less than 500 VA. For equipment rated between 500 VA and 1 kVA, the surge current shall not exceed 3 times the normal current. If the equipment requires more than 1 kVA, the surge current shall not exceed the value specified in schedule A of an enquiry document.
- they do not generate excessive vibration or acoustic noise (see 3.2.4.2 c)).

c. Auxiliary power supplies

Auxiliary power supplies are required to reduce station battery voltage to the internal operating voltage levels of the static relaying equipment provide galvanic isolation between the station battery system and the static relay circuitry provide surge isolation between the station battery and the static relay circuitry.

Power supplies may be provided in the following ways:

- A dual redundant pair of power supplies for each cubicle which supply all the static equipment within that cubicle. The power supplies may each be connected to a separate battery system; both systems being of the same voltage. The PSUs shall be designed so that if one should fail it shall be automatically isolated and the other supply shall, without break, assume the full load current.
- A separate single power supply unit for each protection function or relay. (Thus there would be several PSUs contained within a cubicle).
- Any other manner approved by Eskom.

The technical requirements are as follows:

Input voltages required will be specified in schedule A of an enquiry document and shall be either d.c 110 V or d.c. 220 V ± 20 %.

- Galvanic and surge isolation

Tests shall be applied between individual power supply inputs, between inputs and ground and between power supply inputs and all other separate circuits (e.g. CTs, VTs, contacts), as detailed in 3.4.5.5.2 to 3.4.6.5.6

### 3.2.7.3 Protection and fire risk minimization

All circuits shall be protected so that in the event of a component failure no damage will occur to any interconnecting cabling, wiring or mounting, and that any other damage that does occur is confined as closely as possible to the fault.

The greatest possible protection consistent with reliability and operational requirements shall be provided, to minimize the risk of fire, both within the equipment and to cabling and wiring.

Particular attention shall be given to circuits where voltages are derived by voltage dropping circuits, in which failure of a component could lead to an excessive supply voltage being applied across other components, possibly creating a fire risk.

Circuits shall be grouped so that following the operation of a protective device, the minimum practicable loss of facilities occurs.

Where items of equipment are grouped physically, e.g. within a cubicle, protective devices shall be grouped, so that it may easily be established which device has operated to facilitate resetting or replacement. Where cubicles are arranged in a suite having internal partitions between sections, each section shall have its own group of protective devices.

The design, location and connections of fuse carriers and bases shall not present a hazard to maintenance personnel when replacing a fuse link. When a fuse is inserted or withdrawn, there shall be no danger arising from overheating, arcing or scattering of hot metal nor any hazard to personnel.

Fuses shall not be soldered into equipment

Protective devices shall, where practicable, be capable of being tested and shall be failsafe.

## 3.2.8 Earthing

Earthing is required for reasons of personnel safety and therefore all electronic equipment (other than portable equipment with self-contained power sources) shall be earthed. The following rules shall apply:

a. All metalwork associated with the structure shall be provided with adequate means for bonding to earth in accordance with the requirements of ESI Standard 50-18.

b. Reliance shall not be placed upon the metalwork as an earth return. Earth conductors shall also be used.

c. The size of the earthing conductors shall be such that with the maximum possible value of fault current, no damaging temperature rises occur before the protective device operates.

d. Earthing conductors and structural metalwork shall not carry any currents other than fault or interference currents.

## 3.2.9 Signal zero reference paths

Zero reference paths shall be arranged so as to avoid equipment maloperation due to imposition of series and/or common mode pick-up under normal and, when required, fault conditions. The latter requirements will be defined in schedule A of an enquiry document. Such conditions could arise as a result of inappropriate selection of the return point for the zero reference, such as to a busbar which carries large return currents generated by other equipment.

### 3.2.10 Construction

#### 3.2.10.1 Equipment mounting practice

Schedule A of an enquiry document will specify where equipment is required to conform to particular construction practices. Where no particular practice is specified, the tender shall give details of the proposed equipment construction.

The constructional practice adopted shall be one which maximizes equipment availability, reliability and life, in addition to allowing economical and efficient maintenance.

Rack-mounted equipment shall conform to IEC 297.

#### 3.2.10.2 Ventilation

Consideration shall be given in the design of the equipment to the need for adequate ventilation. Care shall be taken to prevent localized regions of high temperatures (see 3.2.4.1).

The equipment shall preferably be designed and arranged so that forced cooling is unnecessary. However, where its use is considered necessary, means shall be provided for indicating any significant reduction in air flow, and the equipment shall be protected so that no damage can occur due to failure of the forced cooling. The full requirements of the performance specification shall be maintained until the protective device operates, and the tenderer shall give the length of time the equipment can remain in operation at maximum ambient temperatures without forced cooling. The effect on its subsequent performance shall also be stated.

#### 3.2.10.3 Identification

All labels shall be clear, bold, concise, and durable and shall be fixed in a secure and permanent manner.

a. Equipment Identification

Each item of equipment shall be marked with its serial number, its function, manufacturer's name or trade mark and the code or type number.

Labelling on equipment shall be in accordance with good ergonomic principles so that warning notices, controls, indications, test facilities, fuses, etc., are sensibly placed and logically grouped to facilitate correct and unambiguous identification.

b. Sub-unit and position identification

Each detachable sub-unit shall be marked so as to enable it to be identified with the parent equipment, or marked with the manufacturer's name and type number or code number and where definable, its function.

Each mounting position shall be marked to indicate the sub-unit to be located in that position. Where this is not practicable, a diagrammatic label conforming with previous labelling requirements shall show the mounting position and shall be fixed in an appropriate position.

Sub-units shall be given a positive means of frontal identification approved by Eskom. This shall clearly display the identity of each sub-unit, thus enabling a simple check to be made of the correct positioning of any item in a complex assembly of sub-units.

c. Individualized sub-unit identification

Sub-units which have been individualized shall carry a label giving identification of the individualization. In some cases other visual means of identification may be acceptable, subject to Eskom's approval.

d. Component identification

Component reference letters and numbers shall be marked adjacent to each component. Alternatively, a detailed component layout drawing may be supplied.

The following shall apply in all instances:

- The rating and the circuit identification of each fuse shall be marked adjacent to the fuse holder.
- The function of each control and indicating device shall be marked. The caption and its arrangement shall be subject to Eskom's approval.
- The circuit reference and if possible the function shall be marked adjacent to each pre-set control in a position where it will be clearly visible while the adjustment is being made.
- Identification, as appropriate, shall be marked on or adjacent to each connector.
- Test points shall be individually marked with the circuit diagram reference.
- The polarity of any polarized devices such as diodes shall be marked adjacent to the device.
- Where facilities are provided by items such as tuned circuits, links, switches, ROMs and other programmable devices, to individualize a common type of sub-unit, clear and unambiguous legends shall be fixed on or adjacent to the device to indicate its purpose.

e. Terminal identification

Each terminal shall be clearly and unambiguously identifiable by suitable marking which is on or adjacent to it. Where terminals are arranged in a matrix formation, rows and columns shall be marked so that each terminal is clearly identifiable.

f. Removable internal connection identification

Each removable internal connection (or group of internal connections) shall be clearly and unambiguously identifiable.

### 3.2.10.4 Mechanical protection of equipment and sub-units

It shall be possible to lay equipment and sub-units on any of their faces without causing damage to any components. Where necessary, mechanical guards shall be fitted.

Both during insertion and when in their working position, sub-units shall have adequate clearance between all adjacent items of equipment so that no fouling occurs. The design shall allow for tolerances and other variations such as bow and twist of printed wiring boards.

### 3.2.10.5 Encapsulation

Components which could be damaged due to stresses which may result from encapsulation shall be adequately protected by pre-dipping in an elastic medium, or where applicable, by pre-heating.

The manufacturer shall produce evidence that any heat developed during the encapsulating process, or subsequently in operation, is insufficient to adversely affect any component and that the encapsulating medium has no chemical reaction with any of the components or materials enclosed by it.

The method of making connections through the encapsulant shall not permit the ingress of moisture.

The encapsulation process shall, as far as possible, ensure that the finished product is free from cracks and air pockets and any weaknesses due to components being too near the surface.

Appropriate allowances shall be made to ratings of components which are to be encapsulated.

### 3.2.10.6 Component layout

a. Accessibility

Components shall be located, secured and disposed with respect to each other and the structural members so that they can be inspected, removed and replaced without damage to, or undue disturbance of, other parts of the equipment or wiring.

b. Heat dissipation

Components generating a significant amount of heat shall be adequately spaced both from their mounting board and from other components, particularly those whose life might be shortened or stability impaired by being operated at a temperature higher than necessary.

The equipment shall be manufactured and/or assembled in accordance with the component manufacturer's mounting instructions and shall apply such derating factors as may be appropriate to the method of mounting and the proximity of other components.

### 3.2.10.7 Component and sub-unit fixings (mechanical retention)

All components shall be incorporated in the equipment in such a manner that neither they nor their fixings or connections are affected as a result of the equipment being subjected to the tests specified in 5. Fixing devices such as clips or clamps shall be designed so that they cannot cause damage to the component or its connections. The same requirement applies to additions to components such as heat sinks, heat pipes, etc ..

Permanent fixings such as rivets or bent-over lugs shall only be used for fixed mechanical parts, and not for electrical or electronic components.

All plug-in components, units and sub-units shall be held in place by retainers approved by Eskom.

Lock-washers shall be used with all screwed fittings except where the use of self-locking nuts or fasteners make their use unnecessary.

Eskom's approval shall be obtained before any components are mounted directly on terminal blocks.

### 3.2.10.8 Component mounting (avoidance of excess mechanical stressing)

No stresses which might have a deleterious effect on component life or performance shall result from the connections to or the mounting of a component. Neither shall any operations performed on the components prior to mounting, such as bending nor cropping of leads, subject the components to deleterious stresses.

Component manufacturers' recommendations concerning connection, minimum lead length, spacing, etc. shall be sought and complied with.

When a wire-ended component is mounted on a printed wiring board, the wire ends may be bent slightly to hold the component in place prior to soldering. The direction of such bends shall be in the same direction as the track.

Connections shall not be made closer than 5 mm to the body of components having axial wire-ended terminations.

Bends of an inside radius less than 1 mm shall not be made to wire-ended components. No bend shall commence at a distance of less than 2 mm from the body of the component, unless the bending is carried out on a preforming jig to the approval of the component manufacturer. The bending or cutting of leads shall not cause any damage.

Where a manufacturer wishes to crop or bend the leads of a glass reed insert, evidence shall be provided to show that the process is in accordance with the reed manufacturer's recommendations and does not introduce damage or stresses which could shorten its life.

### 3.2.10.9 Electrical connections

a. Soldered connections - general

Soldered wires and components shall be capable of disconnection without disturbing other connections.

Not more than two wires shall be soldered to anyone tag, unless the tag is specifically designed for more. The wires shall be passed through the hole in the tag and bent by not more than 90'.

Not more than three wires shall be soldered to anyone terminal post. Where terminal posts are used, each wire shall be wrapped around its terminal for at least 27'0 to ensure mechanical retention prior to soldering. To facilitate removal, the wrapping shall not exceed 360'.

For hand soldering, a resin cored tin/lead solder complying with BS 441 and containing approximately 60 % tin shall be used. For solder baths, the solder shall comply with BS 219, Grade A or K and the flux shall be non-corrosive.

b. Component soldering

Soldered connections shall be made only to components designed for connection by soldering. The soldering operation shall not subject the components to temperatures in excess of the component manufacturer's recommended maximum permitted temperature minus an allowance of 20°C.

c. Solderless wrapped connection

Unless otherwise approved, solderless wrapped connections shall be made in accordance with IEC 352.

Normally only two conductors shall be wrapped on to a post and the method of interconnecting posts shall be such that not more than three wraps in total need to be undone in order to remake any particular joint.

The use of secondary wrapped or bound connections shall be subject to Eskom's approval.

d. Crimped connections

Crimped connections shall comply with BS 4579 and the requirements of ESI Standards 12-2 and 50-18.

e. Welded connections

Welded connections shall only be used with Eskom's approval, and evidence shall be provided that no unstable or fatigue-prone alloys are produced when the weld is made.

f. Screwed connections

Screwed connections shall comply with the requirements of ESI Standard 50-18, Section 7.2, where relevant.

The design of screwed connections shall permit connections to remain air-tight after a twenty year life without disturbance. This entails sufficient energy being stored in the screwed connection to allow for creep in the conductor.

Clamping pressure applied to electrical connections shall not be transmitted through insulating materials.

Electrical connections made through screws, bolts or nuts to a chassis, a busbar or a structural member, shall not involve or produce removal of any protective finish except at the contact points.

Earth connections clamped to a chassis or frame shall not be made through fixing screws which may have to be removed during servicing

### 3.2.11 Electrical Conductors

#### 3.2.11.1 Printed wiring boards

rigid (see protection relay special quality requirements in Appendix B)

Unless otherwise approved, all printed wiring boards shall comply with IEC 326.

a. Base material

The base material for printed wiring boards shall be epoxide woven-glass copper-clad laminated sheet, flame retardant grade, complying with IEC249-2-5 Part 2. Other materials shall only be used with Eskom's approval

Multi-layer boards shall be in accordance with IEC326 Part 6. For simple circuits, single-sided printed wiring boards shall be used in preference to double-sided or multilayer boards.

b. Conductor width and spacing

The minimum conductor width shall be 1 mm where there are no density problems. Where practical considerations preclude this, the tracks width may be reduced to 0,5 mm. Unless otherwise approved, the minimum clearance between the edge of the base material and any conductor (other than at a termination) shall be 1,5 mm. Where guides are used, the track shall be clear of the guides by this amount.

In calculating the minimum spacing required, 100 V/mm shall be assumed. However, the minimum spacing between conductors shall normally be not less than 0,5 mm, (this minimum dimension shall also apply after soldering). Where the available space dictates a closer spacing, a minimum separation of 0,25 mm is permissible provided the maximum working voltage between adjacent conductors does not exceed 25 V peak.

The design of the assembled board shall be such that the maximum temperature does not exceed 125°C nor the temperature rise in a conductor exceed 20°C. For synthetic resin bonded paper boards, the corresponding figures are 100'C and 10°C, respectively.

c. Allowable board distortion

Printed wiring boards shall not exceed the following maximum allowable limits of bow and twist. These limits shall be maintained throughout all manufacturing and assembly processes.

- Bow

The maximum allowable bow along any side of the board shall be 0,7 % of the length when measured over any part of the length.

- Twist

Twist is taken as being bow, measured across each diagonal of the board and shall not exceed 0,7 % for epoxide woven glass boards, or 1,8 % for synthetic resin bonded paper boards

d. Identification markirgs

Unless otherwise approved by Eskom, all printed wmnq boards shall be silk screen printed or sign written with component references, board designation and number, and modification table, (see 3.2.10.3). These markings shall be clearly visible after the board has all its components assembled on it.

Where links or dual-in-line switches, etc., are used on a board for the purpose of individualizing one of a generic type of board in an equipment, clear and unambiguous legends shall be silk screen printed or sign written on the board to indicate the purpose of each link or switch position (see 3.2.10.3 d)7)). Where this is not practicable, single symbol markings on the board shall be explained in tables which are appropriately housed within the enclosure.

For frontal identification requirements see 3.2.10.3 b).

e. Track additions and modifications

Generally these are not permitted on production items, but where allowed by Eskom, the modifications shall be individually approved.

f. Protective finish

Where a protective finish is necessary, the equipment shall have a finish which does not have any adverse effect upon the components. A spray-on finish shall not be applied to completed boards. The finish shall be either of a solder-through type or shall be easily removable, and shall be to Eskom's approval.

g. Means of extraction

All plug-in printed wiring boards which cannot easily be extracted by hand from their parent unit or housing, shall be provided with a means of extraction preferably as part of the board, or otherwise by an extraction tool which can be inserted into the board. The last paragraph of 3.2.6.11 b) also applies.

### 3.2.11.2 Flexible printed wiring

Unless otherwise approved, the following shall apply:

a. Flexible printed wiring shall not carry components other than connectors

b. Soft annealed conductors shall be used where flexing occurs.

c. Minimum conductor width shall be 0,6 mm.

d. Minimum conductor spacing shall be 0,6 mm.

e. Minimum clearance between the edge of the base material and any conductor other than at a termination shall be 1,5 mm.

f. The minimum width of the copper gland around a terminating hole shall be not less than 0,4 mm.

g. The following maximum temperatures shall not be exceeded for the materials listed below. Temperature rises in conductors shall be taken into account.

Polyester 80°C

Epoxy 120°C

FEP 180 °C

Polyamide (FEP adhesive) 200°C

Polyamide (no adhesive) 250 °C

Composite laminates, differing adhesives and the presence of glass reinforcement could affect the maximum permissible continuous operating temperature and when a departure from the above is requested, full details of the materials and construction shall be submitted to Eskom.

h. The design of flexible printed wiring shall be such that no significant bending takes place in the area of an overlay or coverlay window.

i. Where it is necessary to incorporate a slit in the wiring, the closed end of the slit shall terminate in an "anti-tear" hole.

j. The minimum bending radius shall not be so small that it results in cracking or deterioration of the base material or the overlay, either at the time of manufacture or due to subsequent ageing during use.

As a design rule, radius/thickness shall be > 30.

Conductors shall preferably be terminated with tubular eyelets which are hard soldered to the conductor. Other methods of termination shall be to approval. Where approval is given for the conductor to be soldered directly through a window in the overlay or coverlay, the conductor termination pad shall have anchoring ears extending under the overlay so as to reduce the possibility of separation of the conductor from the underlay or base

### 3.2.11.3 Conventional wiring within items of equipment

The type of wire used and its insulation shall be chosen so that it is suitable for the conditions of operation and the method of termination. Multi-stranded conductors are preferred for crimped connections. Solid (single-strand) conductors shall be used for wrapped connections. Insulation shall be chosen on consideration of voltage withstand, operating temperature, ease of stripping, creep properties, flammability, scuff resistance, etc. Changes in physical properties such as creep, hardening or softening of the insulating covering, particularly at temperature limits, which can occur under conditions of use shall not be significant.

Wiring shall, unless otherwise approved, be in accordance with BS 6231, BS 6746 or an approved equivalent specification

In general the following requirements shall apply:

a. PVC insulated wiring can be used in Class A 1, B3 and C environments. Depending on the grade, PVC has a minimum temperature rating of -10°C or -20 °C and a maximum temperature rating of 85°C.

b. For Class C1 conditions where the ambient temperature may drop to -25°C, PVC insulation shall not be used. PTFE insulation is preferred but polyethylene may be used.

Alternatively, polyvinylidene fluoride (Kynar) insulation may be used. This material is preferred where wire wrapping is used or where the toughness of the insulation is important.

c. Adequate current derating factors shall be applied for the maximum ambient temperature.

d. Wiring and cabling shall be routed so that its insulation is not subject to injurious temperatures or stresses.

e. Grommets or bushes shall be used where wires or cables pass through metalwork.

   Wiring and cabling shall be adequately supported and clamped. The resulting deformation shall not cause the insulation properties to be outside specified performance limits.

f. Unsheathed wiring shall always be secured with insulating materials and shall not come into contact with metal such as support-structures. This applies especially to tails of incoming paired cables.

g. Wiring terminations shall be of such a length and executed in such a manner that the conductors are not subject to injurious tensile stresses or flexing which might cause fatigue failure, whether as a result of vibration or otherwise.

h. Segregation is preferred to screening to minimize the risk of undesirable electrical noise coupling.

### 3.2.11.4 Materials and finishes

Materials and finishes shall be suitable for the conditions of use, taking into account environmental, wear and ageing factors. Dimensional stability, moisture absorption and resistance to mould growth shall be taken into account. Materials and finishes shall be either non-ignitable or have resistance to flame propagation to BS 2782, Part 5. Plastic materials not used as insulation shall be subject to approval for individual applications.

### 3.2.12 Person nel safety

No approval given or implied by Eskom shall relieve the contractor of any statutory obligations regarding safety.

The equipment shall conform to BS 4743, in addition to the relevant clauses of this standard.

#### 3.2.12.1 Hazardous materials

Unless unavoidable, materials which could be hazardous in normal or fault conditions, shall not be used in the construction of equipment or in components used therein. If such use cannot be avoided, then Eskom's prior approval is required and the materials shall be clearly and unambiguously indicated on the equipment, together with any special instructions.

The instruction manual and operation instructions shall detail the extent to which any hazardous materials are used in the equipment. Instructions shall be given regarding the disposal of such materials or components containing or incorporating such materials. Information relating to hazardous materials need not refer to the use of lead in solder but shall refer to the use of beryllium, mercury, selenium, asbestos and other toxic elements or compounds which might constitute a hazard in use or in the event of damage to or overheating of a component or equipment.

#### 3.2.12.2 Radioactive materials

Radioactive materials shall not be incorporated within equipment covered by this specification.

### 3.2.13 Panel construction

#### 3.2.13.1 General

Panels shall be of the single row type and shall comprise one or more panels mounted side by side to form a composite suite. Unit design shall enable one or more panels to be removed from the end or middle of the suite whilst the remaining panels are in commission. Panels shall be designed so that the front faces line up correctly to withint 2 mm. Any differences in depths shall be accommodated at the rear of the row of panels.

Cubicles shall be 600 mm x 600 mm x 2 400 mm high. Where standard panels are used and these are shorter than the above dimension a valance plate of not more than 200 mm may, with Eskom's prior approval, be used to match heights. The positioning of terminals and trunking are given in Sketch number TO 516 (Rear Access Panels).

Where wires pass through holes in metal, the edges of the holes shall be protected by means of grommets to prevent damage to insulation. Chamfered edges will not be accepted as a substitute for grommets.

Self-tapping screws having sharp points shall not be used in the construction of the enclosure. Self-tapping screws shall not be used for fixing items such as cover plates which have to be removed and replaced. The fixing of non-removable components such as brackets by means of pop-rivets is acceptable.

The channel base frame of each panel enclosure shall be drilled and fitted with holding down bolts to suit pockets to be provided by Eskom. The bolts shall be delivered with the panels.

The channel base frame shall be drilled and fitted with a checker plate support angle in accordance with drawing 0.52/10115.

Suitable means of lifting shall be provided.

### 3.2.13.2 Vertical and horizontal wiring troughs

Wiring troughs shall be provided as shown in sketch number TO 516. Each trough shall be fitted with a cover of insulating material. These covers shall be designed so that they can be fixed in position, and removed without the use of tools. Individual sections of cover shall not exceed one metre in length. Troughs shall be adequately dimensioned to accommodate the maximum number of cables especially where the cables enter the trough.

Proprietary brands of PVC or equivalent material troughing shall be used, but regardless of the type of construction, the design of the trough and cover shall be subject to Eskom approval before manufacture commences.

### 3.2.13.3 Cable gand plates

Removable blank gland plates, in accordance with the relevant drawing, shall be provided. They shall be fixed to the panel by hexagon headed screws to facilitate removal. The gland plates will be drilled on site by Eskom's cabling contractor.

### 3.2.13.4 Earthing

Each panel shall be provided with a 40 mm x 3 mm copper earth bar and one earth connection terminal suitable for a 120 rnrn- stranded or a 12 mm diameter solid copper earth strap.

All metal components of the panel, doors, control devices and all relay frames shall be effectively connected to this earth bar by means of green 2,5 rnrn" PVC insulated earthing conductors. Where specified, a separate earthing conductor shall be provided for static relays. All earth connections shall be as short as possible and shall not be coiled.

Eskom will connect this earth bar to the station earth. The arrangement and detail of the above earth bar and connection terminal shall be to Eskom's approval. The rules detailed in 3.2.8 also apply.

### 3.2.13.5 Wiring supports

All vertical and horizontal wires in each module shall be accommodated in troughing as specified in 3.2.13.2.

Vertical lacing supports of non-magnetic material shall be provided for securing cable tails.

### 3.2.13.6 Term inal strips

Terminal strips shall be in accordance with the provisions of 3.2.14.1 to 3.2.14.4.

### 3.2.13.7 Layout

The terminals of all relays and other panel components shall be readily accessible when the panel is fully wired. Any difficulties experienced, either with layouts or terminal accessibility, shall be referred to Eskom prior to the commencement of the wiring.

### 3.2.13.8 Panel preparation and finish

After fabrication is complete the metal surfaces shall be finished in accordance with Eskom Standard OPS 2366/11-3 Corrosion Protection Specification.

Internal and external surfaces shall be light grey in accordance with SASS 1091, colour number G29 semi-mat.

The base channels, base backplate and checker plate support angle shall be gloss black. Other interior finishes may be acceptable subject to Eskom's approval.

#### 3.2.13.9 Doors

Steel padlockable cover doors shall be provided at the access points of all relay panels. Control panels and fault monitoring panels shall have a rear door only except when fault monitoring panels are installed in a power station environment in which case they shall be equipped with a dustproof see-through door at the front.

#### 3.2.13.10 Classification of enclosures

The classification of enclosures shall be in accordance with IEC 529.

The minimum degree of protection shall be IP 53 for relay panels and IP 43 for control panels.

### 3.2.14 Terminals

#### 3.2.14.1 General

Terminals for connection to external circuits shall be to approval. Not more than two conductors shall be connected to any side of a terminal.

Terminals, except those with solder lugs, shall be suitable for use with crimped or compression type terminations.

Terminals to which external cabling is to be connected (boundary terminals) shall be permanently and indelibly marked in an approved manner.

#### 3.2.14.2 Design and construction

a. Moulding materials shall be self-extinguishing, or resistant to flame propagation, substantially non-hygroscopic, and shall not carbonize when tested for tracking. The mouldings shall be dimensionally stable and have a high impact strength.

b. Mouldings shall be mechanically robust, and shall withstand the maximum possible torque which may be applied to the terminal screws. Terminals where pressure is applied to the moulding when tightening the terminal screw or nut are not acceptable.

c. Steel parts, other than stainless steel shall be plated and passivated. Current carrying parts shall be non-ferrous and plated. All plating shall be compatible with other parts and terminations. Screws into steel shall be steel, stainless steel or phosphor bronze. Steel screws shall be plated and passivated. All plating shall comply with BS 1706 and BS 3382 parts 1,2, and 5.

d. The minimum external creepage distance between adjacent terminals and between terminals and earth shall be not less than 8 mm when determined in accordance with BS 142 Appendix G.

e. Tapped holes shall have not less than 3 full threads. Separate terminals shall be provided on each unit for incoming and outgoing connections, and their contact pressures shall be independent of each other.

f. Tenders shall state the maximum torque and minimum torque to be applied to the terminal screws.

g. Terminal covers, or shrouds shall be of insulation material, self extinguishing or resistant to flame propagation and shall preferably clip into the moulding. Terminal covers or shrouds shall be fitted to all type A and E terminals and to all d.c. and a.c. high power terminals, such as main battery terminals

### 3.2.14.3 4Mounting

Rail mounted terminal blocks shall comply with the following requirements.

a. The dimensions of mounting rails shall be in accordance with DIN EN 50022, DIN EN 50035 and DIN EN 50045.

b. The units shall be spring retained on the assembly rails and when mounted and wired as in service shall be close fitted to avoid the accumulation of foreign matter between adjacent units. End barriers or shields shall be provided for open sided patterns.

c. It shall be possible to replace any unit in an assembly without dismantling adjacent units. It is permissible, however, to loosen any clamping device. Screw retention of any component from the rear of the mounting rail is not acceptable.

### 3.2.14.4 Types

a. Type A direct mounted screw type

- For use in circuits up to 300 V maximum, at currents up to 10 A maximum, continuous rating.
- The general arrangement, showing 3 way blocks, is given in drawing 0.52/10116 (Blocks having any number of ways are acceptable).
- The terminals shall be of the type comprising a moulded stp with integral barriers between adjacent ways. Each way shall be in the form of a solid link of nonferrous metal, tin or nickel plated, which shall be permanently secured to the moulding.
- The screws shall be (tin or nickel plated) brass, and shall be not less than M4.

  Each screw shall be fitted with a single coil, phosphor bronze spring washer.
- Terminal screws in each way shall accommodate up to two lugs having ring tongues.
- Terminals may be screw/screw or screw/solder lug configuration. Solde lugs may be either horizontal or vertical and shall be drilled and/or notched to provide an anchor point for single strand telephone type cables.

b. Type B rail mounted, screw clamp spring loaded insertion type.

- For use in circuits up to 500 V maximum, at currents up to 30 A maximum, continuous rating.
- Figure 0.52/10117 shows the general arrangement.
- The terminals shall be of the type which compress the terminations between two plates by means of terminal screws. Terminals shall also be spring loaded so that the action of the spring is independent of the action of the terminal screw.
- Terminal screws shall be captive within the mouldings and the heads shall not project above the mouldings when fully released. Each terminal shall accept up to two hooked blade type terminations.
- Notwithstanding the requirements of 3.2.14.2 g), all terminal entries shall be shrouded so that no current carrying metal is exposed when hooked blade terminations are fitted.
- Springs shall be aged and shall withstand corrosion. Springs shall not carry current.
- Cross connection facilities shall be provided for commoning two or more adjacent terminal ways without interfering with the terminal openings.

c. Type C and D rail mounted, screw clamp insertion and solder lug types

- Screw clamp type, 500 V maximum, at currents up to 30 A maximum, continuous rating.
- Screw clamp/solder lug and solcer lug/solder lug type, 100 V maximum, at currents up to 10 A maximum, continuous rating.
- Drawing 0.52/10118 shows the general arrangement.
- Screw clamp insertion terminals shall be of the type which compress the terminations between two plates by means of terminal screws. Wire terminations for insertion into this type of termination will be permitted on each terminal. Terminals which require the removal of the screw to attach the termination, or which compress the termination through a washer are not acceptable.
- These terminal blocks may be of the screw clamp/screw clamp or screw clamp/solder lug pattern, as specified in schedule A of an enquiry document. Solder lug/solder lug configurations are only acceptable for the terminations of telephone and single strand instrument cable.
- Solder lugs shall be tinned and notched and/or drilled to provide an anchor point for the conductor.
- Terminal screws shall be captive within the mouldings and the heads shall not project above the mouldings when fully released.
- Terminal entries shall be shrouded so that no current carrying metal, except the solder lug, is exposed when the completed termination is made.
- Cross connection facilities shall be provided for commoning two or more adjacent terminal blocks accepting conductors 1,5 mm and above.
- The creepage distance requirements of 3.2.14.2 d) may be relaxed when this type of terminal is used on circuits having a working voltage of 50 V or less, providing that in no instance is the creepage distance less than 4 mm.

d. Type E rail mounted, stud type

- For use in circuits up to 500 V maximum, at maximum continuous current ratings of 30 A for M5, and 50 A for M6 stud sizes.
- Drawing 0.52/10119 shows the general arrangement.
- Two terminal studs shall be provided for each way, and these shall be of sufficient length to accommodate two ring tongue or flanged spade terminations in addition to a full nut and all necessary plain and spring washers
- M5 studs shall be of phosphor bronze or stainless steel. M6 studs may be of brass, phosphor bronze or stainless steel. Solid studs only shall be provided. Studs which are slotted or drilled to receive the conductor are not acceptable.
- Loose links, where provided, shall be secured by a nut and washers, and shall be of tin plated copper or brass.
- Barriers of insulation material, self-extinguishing or resistant to flame propagation and substantially non-hygroscopic shall be provided between terminal ways. These barriers shall project at least 3 mm above the studs.

e. Pinch screw type

Terminals in which the screw or the means of applying the securing pressure bears directly on the termination or conductor as found on domestic electrical fittings, are not acceptable for use in control/relay panels. Approved terminal blocks, however, used for telecommunication circuits, may be used for the termination of outgoing alarm circuits.

### 3.2.15 Wiring

#### 3.2.15.1 General

Multi-strand (40 or more strands) flexible wire minimum 1,5 rnrn- cross section, 600/1 000 V grade grey PVC insulation in accordance with SABS 150 shall be used on all circuits. Alarm and 50 V control circuits may be varied for which 0,5 rnrn" or 0,75 rnrn- 300/600 V grade multi-strand wire shall be used. Single strand (solid) wire shall not be used for internal panel wiring. Wire with less than 40 strands and more than 7 strands or other minimum cross sections may be used with Eskom's prior approval.

Joints or splices in any wiring are not acceptable.

All panel and equipment terminals shall be completely accessible after the wiring and cabling has been completed.

Each wiring tail shall be of sufficient length to reach its allocated terminal on the item of equipment, plus an additional length of 10 mm to facilitate wiring changes.

#### 3.2.15.2 Wiring supports

All wires in panels between the boundary terminals and the relay racks or equipment terminals, shall be accommodated in troughing.

In the case of vertical terminal rows, panel wiring shall be connected to the side of the terminal strip which is nearest the front of the panel, and cable tails shall be connected to the side nearest to the panel rear. In the case of horizontal terminal rows the panel wiring shall be connected to the lower side of the terminals and the cables shall be connected to the upper side.

Any bridge pieces to loop adjacent terminals shall be fitted as shown on the relevant drawing.

#### 3.2.15.3 Wiring terminations

Not more than two conductors shall be connected to any side of a terminal and where two conductors are connected to a terminal, care shall be taken to ensure that lugs and ferrules are fitted to the conductors so as to allow the wires to approach the terminal as near parallel as possible. An exception may be made in the case of light current electronic components, with Eskom's prior approval.

The stripping of insulation shall be carried out so that no damage to conductors occurs. Any nicked wiring will be rejected. The stripping tools used shall be of the type which permits the length of strip to be pre-set.

All wires and cables less than 6 rnrn- in the panel shall be terminated with pre-insulated crimped connectors of approved types. Other types of lug which are to Eskom's approval may be considered.

All terminations shall be made with the tool recommended by the manufacturer of the lugs. Crimping tools shall be of the type which will not release the termination during normal operation until the crimp has been correctly formed. A double die crimping tool shall be used in order to effect both the lug and insulation support crimp simultaneously.

All wires and cables larger than 6 rnrn" shall be terminated with an approved lug. The lug shall be crimped with a hydraulically actuated hexagonal die tool as recommended by the manufacturer of the lug.

There shall be no bare wire exposed between a lug and the insulation of the wire to which it is crimped.

All tools used shall be regularly inspected and tested with approved gauges, and maintained or repaired as necessary. Tools shall be inspected and tested initially at weekly intervals, but this period may be extended in the light of experience. A log of inspections shall be maintained for Eskom's inspection.

The lugs selected shall be the correct barrel size for the size of wire or cable with which they are to be used, and the dimensions of the tongue shall match the stud, screw or aperture of the terminal to which they will be connected.

A sample of each type of lug, wire, tool and finished connection if not previously approved shall be submitted to Eskom for approval before wiring is commenced.

Table 6 lists the types of lug to be used with various types of terminals.

The size, current and voltage rating shall match the wire and cable used.

**Table 6: Lug types**

| TYPE OF TERMINAL | TYPE OF LUG | REMARKS |
|---|---|---|
| Stud | Ring tongue | Hole in tongue to be correct size to suit stud |
| Direct mounted screw | Ring tongue | Hole in tongue to be of correct size to suit screw |
| Screw type on | Ring tongue | Spade must not be formed by cutting ring tongue |
| rotary switches | | |
| Pinch screw type | Wire pin | Where specifically approved in alarm circuits |
| | | only |

Sample crimped ends, selected at random, may be subjected to tests in situ, to prove their mechanical strength. Such tests will consist of an axial pull, equivalent to approximately 60 % of the nominal breaking load of the conductor only, applied by means of a spring balance or similar device. For the purpose of this specification, the force to be applied when testing crimped terminations on 1,5 rnrn" and 2,5 rnrn" cables shall be approximately 270 N. For 0,75 rnrn- the force shall be approximately 150 N.

### 3.2.15.4 Wiring identification

Wiring leads connected to the boundary terminals shall be permanently marked with an approved type of marking device, with black letters impressed on a white background or black letters on a yellow background provided that the colour selected is consistent throughout the panel and/or suite of panels and is to Eskom's approval.

Interlocking slip-on types of ferrules or one piece ferrules may be used and shall match the size of wire onto which they will be fitted.

For heavy conductors and very light telephone type wiring where the preferred type of marking ferrule is not available, other methods will be subject to Eskom's prior approval.

### 3.2.16 Test blocks

#### 3.2.16.1 General

Every current transformer circuit and voltage transformer circuit entering a protection cubicle shall be provided with an approved individual multi-way test block or specifically approved combination of test terminals located between the panel input terminals located between the panel input terminals and the first protection relay/equipment.

a. Current transformer test block

The test block for a current transformer shall provide for:

- automatic short circuiting of the incoming current transformer circuit.
- measurement of the current in the incomingcurrent transformer circuit of all three phases and the neutral individually, with a test plug and meter.
- injection of test currents into the panel circuits on all three phases and the neutral individually, with a test plug and source.

b. Voltage transformer test block

- The test block for a voltage circuit shall provide for:
- open circuiting of the incoming voltage transformer circuit;
- measurement of the phase to phase and phase to neutral voltage of the incomig voltage transformer circuit with a test plug and meter;
- injection of test voltage into the panel circuits with a test plug and source; and

The test facilities incorporated within individual relays will not be considered as substitutes for the test blocks called for in this specification.

#### 3.2.16.2 Approved test block types

Only the following types of test blocks have been approved for use in Eskom's protection panels.

a. General Electric type PK2 four way and six waytest blocks.

b. ASS Combiflex type RTXP.

Other types of test blocks may in time be added to this list but in the interests of standardization, and consequent reduction in test plugs required by field staff, these will be few and most carefully considered.

#### 3.2.16.3 Location of test blocks

The test blocks shall be located in the lower region of the 19" rack and shall be easily accessible from the front of the panel with the cover door (if fitted) open. Cables hanging from test plugs inserted in the blocks shall not obscure or in any way interfere with any test or operational feature of any equipment mounted in the 19" rack. The minimum height of such test blocks above floor level shall be 150 mm. The recommended location and layout of test blocks are given in the attached sketch number TD-541.

#### 3.2.16.4 Connections to test blocks

The input circuits from the outside plant shall always be connected to the lower terminals of the test blocks and the panel circuits shall always be connected to the upper terminals of the test blocks.

When observed from the front of the panel the phase order of the connections to both the upper and lower terminals shall be (from left to right) red, white, blue, neutral (i.e. RWSN or ASCN or RSTN).

For ASS RTXP test block refer to the applicable Eskom approved scheme drawings.

### 3.2.17 Interfacing details

#### 3.2.17.1 D.C. supply inputs

Direct current auxiliary supplies shall be provided at 110 V or 220 V, as specified in schedule A of an enquiry document.

The supply voltage tolerance is ± 20 % of nominal

#### 3.2.17.2 D.C. contact outputs and inputs

a. Direct current trip outputs

Contacts providing trip outputs shall be rated as follows:

- Make and carry for 200 ms 5A
- Carry for 1 s 30 W @ d.c. 250 V
- Carry continuously
- Break (inductive L1R = 40 ms)

30 A @ d.c.250 V 10 A

Alternatively, if a current operated seal-in is provided, the break current rating may be reduced.

As called for, independent trip output contacts shall be provided per panel. In the case of thyristor trip outputs, 3.2.17.2 a) 4) is not applicable

b. Direct current control and interlock contacts

- Make and carry for 200 ms 5A @ d.c 250V 10A
- Carry for 1 s 2A
- Carry continuosly 30W @ D.C 60V 1 A
- Break (inductive L1R=40ms) 10W@ d,c. 125V

c. Alarm contacts

- Make and carry for 200ms
- Carry continuously
- Break (inductive L1R=40ms)

d. Carrier/channel interface

Communication between the carrier system and the protection system will be through potential-free contacts.

#### 3.2.17.3 A.C.current inputs

Current transformer inputs shall be rated at 1 A nominal with the following overload capabilities:

a. 50 x In for 3 s or 100 x In for 1 s

b. 2 x In continuously

The total burden of the current transformer circuits comprising a single complete protection system shall not exceed 1 VA per phase.

### 3.2.17.4 A.C. voltage inputs

Voltage transformer inputs shall be rated at 110 V phase to phase and 63,5 V phase to ground with the following overload capabilities:

a. 1,7 x Vn for 3 s

b. 1,2 x Vn continuously

The total burden of the voltage transformer circuits comprising a single complete protection system shall not exceed 3 VA for each phase.

### 3.2.17.5 Numbering of terminals

All equipment boundary/interface terminals and the equipment wires connected to those terminals shall have a unique wire/terminal number in accordance with manufacturer's drawings approved by Eskom.

### 3.2.17.6 Location of auxiliary relays and equipment

The necessary relays to provide the output contacts covered by 3.2.17.2 shall be located in anyone of the following four locations:

a. within a relay module

b. on the rear of an individual relay rack

c. on the rear of a face plate mounted in the lowest position on the 19" rack

d. on the rails mounted on the panel side walls between the main terminals and the relay racks.

They shall not be mounted on the rear or roof of any panel.

### 3.2.17.7 Contact multipliers

Where contact multiplication is necessary it shall be achieved in a manner approved by Eskom.

### 3.2.17.8 Su rge proof intertrip relays

Where surge proof intertrip relays are required, they shall be constructed so as to prevent operation when the voltages described in tests 3.4.6.5.3, 3.4.6.5.4, 3.4.6.5.5, 3.4.6.5.6, and 3.4.6.5.9 are applied to the operating coils.

The relays shall, however, operate when a continuous d.c. voltage of::>: 0,8 x the rated voltage is applied. The relays shall not operate when a continuous d.c. voltage of < 0,& the rated voltage is applied.

## 3.3 DOCUMENTATION

### 3.3.1 General

The extent of documentation in respect of the amount required, times and place of delivery, etc., will be detailed in schedule A of an enquiry document. Also specified will be the date by which draft documentation is required for assessing both the degree of compliance of the equipment with its

specification and the adequacy of the documentation. In any event the draft documentation shall be submitted before the formal testing is started.

Documentation shall, where possible, relate solely to the actual equipment supplied. It should not include any irrelevant/superfluous information such as information on variants not supplied on the contract. Where this is not possible, the information which is relevant shall be differentiated from the irrelevant information by some convenient and effective means such as colour coding, divider sheet coding, marker tabs, bevelled corners, etc. It shall include details of any individualization carried out by the manufacturer, and also include a suitable format appropriately placed for the user to enter specific individualizing data or other relevant information.

The documentation shall be durable and robustly bound.

The documentation supplied with all electronic equipment shall be in English and shall comply with BS 4884 and BS 4308. The following requirements shall also apply.

### 3.3.2 Instruction manuals

The size of the manual shall be A4 unless otherwise approved.

In addition to the contents specified in BS 4308 and OPS 0002, the following applies:

a. Information relating to any hazardous materials which may be present in the equipment shall be included in the instruction manual. Instructions shall be given on the safe handling of devices or components as defined in clause 3.2.12.1 and on the disposal procedure to be adopted both when the device or component has to be replaced, and when it has become faulty or damaged so that the hazardous material is no longer contained.

b. Information relating to any implosion, explosion or other hazards which may be associated without the equipment or which may occur in use or in handling shall be included in the instruction manual.

The drawings detailed in 3.3.3 together with any tables, charts or graphs, programme listings and flow charts necessary, shall form an integral part of the instruction manual.

### 3.3.3 Drawings

In addition to the requirements detailed in OPS 0002 all drawings and component lists shall bear the appropriate Eskom drawing number, issue number, title, and details of modifications.

Where practicable, all diagrams shall be drawn so that the main sequence of events of the signal path is from left to right and, where necessary for arrangement purposes, from top to bottom and shall be suitably annotated.

The diagram for anyone unit shall be completely self-contained, self-explanatory, readily related to other circuit diagrams and shall include relevant information such as supply voltage values, interconnecting details, etc. Components external to a unit or sub-unit, but essential to its operation, shall be shown on the diagram enclosed in dotted lines and appropriately identified. If a system extends over a number of drawings, care shall be taken to ensure that the common factors are:

a. related by a drawing/indexing system which is designed for ease of understanding

b. clearly identified by unambiguous and compatible legends

c. specially aligned and order-related.

Unless otherwise agreed, all graphical symbols except logic symbols shall comply with NRS-002. Logic symbols shall comply with ANSIIIEEE 91.

Dimensions, masses etc., shall be in metric units.

All drawings shall be suitable for microfilming.

When appropriate, the following drawings, etc., shall be supplied in accordance with schedule A of an enquiry document.

#### 3.3.3.1 Circuit diagrams

Circuit diagrams are required for each unit, sub-unit and plug-in board used in the complete equipment.

All component symbols shall be marked with their circuit references. Type numbers of semiconductor devices, etc., and nominal values of components shall be marked on circuit diagrams where the component list is not included on the same diagram. Polarized components and components with three or more connections shall have the connection points identified. Supply line potentials shall be shown.

The function of all controls, switches and indicating devices shall be indicated in accordance with the inscriptions on the equipment. The symbols for rotary controls shall be marked with an arrow indicating the effect of clockwise rotation of the spindle when viewed from the operating end.

Relays shall always be shown in the de-energized position. Where they are energized under normal steady conditions, this shall be indicated against each contact set and coil.

Unused contacts fitted to relays, switches or keys or unused logic elements of integrated circuits shall be shown on the diagram in a common area of the drawing.

#### 3.3.3.2 Component lists

Component lists shall state the value, tolerance, rating, type number, manufacturer and purchasing specification number for each component, together with the circuit reference number.

#### 3.3.3.3 Component layout drawings

Component layout drawings shall show the location of each individual component used in a unit, sub-unit and plug-in board, marked with its circuit reference number.

#### 3.3.3.4 Servicing diagrams

Servicing diagrams are required for maintenance purposes and shall show all individual components and their interconnections and aids to rapid fault finding (e.g. waveforms, signal flows, voltages, etc.). For digital systems, all logic elements shall be shown, together with any time sequence charts. Back plane wiring/jumpering schedules shall be provided.

#### 3.3.3.5 Logic diagrams

Logic diagrams shall be provided for digital systems and shall show all logic functions in graphical form. Where appropriate, an algebraic form may be used consisting of a list of logical equations.

#### 3.3.3.6 Block diagrams/flow charts

Block diagrams shall show the flow of information between the identifiable parts of a system, with thickening of lines where necessary, to show the main flow of information. The block functions shall be clearly designated.

#### 3.3.3.7 Panel wiring diagrams

Panel wiring diagrams and charts shall show the inter-unit wiring within cubicles in addition to miscellaneous services provided, i.e. supplies, distribution, alarms, etc.

#### 3.3.3.8 Interconnection diagrams

Interconnection diagrams and charts shall show all connections between cubicles of equipment and all items connected to the equipment by means of external cables. They shall also show the type of cable to be used for these connections and any special terminating arrangements. Special precautions that need to be observed, regarding routing of cables, earthing, cable terminations, etc., shall be shown.

#### 3.3.3.9 Equipment drawings

Drawings shall show the layout of equipment on racks, the identification of units and subunits within a cubicle, and the essential mechanical features of all racks, cubicles, units and sub-units.

Overall dimensions and masses shall also be shown.

#### 3.3.3.10 Installation drawings

Installation drawings shall show details of fixing, mounting, attitude, cable and pipe entries, together with any components or devices required in handling and installing. Details shall also be given of any precautions required in handling and installing.

All relevant dimensions and masses shall be shown.

### 3.3.4 Test Documentation

The test documentation required is detailed in 3.4.

## 3.4 TESTING

### 3.4.1 General

The tests specified in this section are mandatory, and represent the minimum requirements applicable to all types of equipment and will be augmented where necessary by additional requirements. Normally these will be specified in schedule A of an enquiry document.

Eskom may exercise its right to witness all or part of any test or tests. Eskom requires a minimum of 14 days notice of the proposed dates for tests. In all cases the results of the tests shall be properly recorded, together with details of the test equipment. The tests shall be supervised and the test report certified by the responsible person qualified or experienced in the techniques involved. The report shall be sent to Eskom on the completion of the tests.

The contractor shall submit a detailed schedule of the proposed tests for approval not less than 12 weeks before the commencement date of the tests. This schedule shall be complete and include the following information:

a. Date and place of test.

b. Details of the equipment to be tested, such as specification, type and serial numbers, contract reference and all relevant drawings and documentation.

c. A list of all test equipment which may be used, and performance specifications of each test equipment listed, clearly showing that the stability, resolution, accuracy range, capacity, etc. ratings of the chosen equipment are more than adequate for the test performance requirement. When such information is not known, for instance when test equipment has to be specially manufactured, it shall be demonstrated that such equipment performs in the way intended so that its use is acceptable to those witnessing the tests.

d. Details of usage and test equipment and the test methods, together with the connection diagrams and other related data.

e. Description of measurements and observations to be made together with their intended number, frequency, sequence and time duration for each test.

f. Documentation to be used for the recording of all results of testing and also the format of the certifying test documents.

If during the tests any failure occurs, any adjustments are made, or the equipment design is changed, Eskom shall be informed and may require the previous tests to be carried out again.

Where equipment is designed to be connected to other equipment at remote sites where different environmental conditions such as temperature and supply voltage can prevail, tests may be required to demonstrate that these differences do not adversely affect the compatibility of the equipment.

### 3.4.2 Type testing

Unless specified to the contrary, type testing shall consist of performing the tests listed in Table 6 on at least one sample of the design. The tests required for each particular environmental class are indicated by * under the class heading and they shall be applied in the order listed unless otherwise approved

Tests shall be performed on equipment which has not been the subject of previous type testing or, at Eskom's discretion on equipment which has been the subject of any modification which could affect the performance of the equipment.

Normal performance tests shall be performed before any type tests for comparison to determine damage.

Subject to Eskom's approval, evidence of equivalent tests performed on substantially similar equipment may be accepted provided that the test results are available in the form of a fully detailed certified test report.

When relevant, a check shall be made before the commencement of type testing, to ascertain that the equipment as supplied, inspected and adjusted from the production line, is correctly set up. Any differences found between the equipment as supplied and as required by its specification shall be recorded. The measurements taken to establish this shall also be recorded.

The range of all user adjustable controls, including pre-sets, shall be measured and recorded. Pre-set controls shall be checked to ensure that they comply with the requirements of 3.2.5.2 and shall be restored to the design settings. The ease with which this can be done will be noted.

If during testing any further adjustments are required, such adjustment shall only be made with Eskom's approval and repetition of some of the previous tests may be required.

**Table 7: Test required for type testing**

| TEST NUMBER | TEST REF CLAUSE | TEST TO BE APPLIED | TEST TO BE APPLIED FOR PERFORMANCE CHECK OF 3.4.5.2.4 | ENVIRONMENTAL Table 1 1) A1 B3 C C1 D |
|---|---|---|---|---|
| 1 | 3.4.2.1 | I nitial visual inspection | | * * * * * |
| 2 | 3.4.2.3 | Initial performance | At normal voltage | * * * * * |
| 3 | 3.6.7.1 | Drop | At normal voltage, following test | * * * * * |
| 4 | 3.4.6.7.2 | Vibration | At normal voltage, when required | * * * * * |

| | | | | |
|---|---|---|---|---|
| 5 | 3.4.6.5.1 | Electrical impulse | At normal voltage, afte r stress | * * * * * See also Table 3 |
| 6 | 3.4.6.1 | Supply variation | With all possible extreme combinations | * * * * * |
| 7 | 3.4.6.2 | Supply i nte rru pti 0 ns | At normal voltage | * * * * * |
| 8 | 3.4.6.5 | Electrical environmental interference, as listed in table 9. | At normal voltage | * * * * * |
| 9 | 3.4.6.6.1 (a) | Dry heat | At normal voltage, during and following test. | * * * * * |
| 10 | 3.4.6.6.1 (b) | Low temperature | At normal voltage, during and following test | * * * * * |
| 11 | 3.4.6.6.2 | Damp heat | At normal voltage, during and following test | * * * |
| 12 | 3.4.6.6.3 | Sealing | | + + + + |
| 13 | 3.4.6.6.4 | Driving rain | | Outdoor equipment only |
| 14 | 3.4.6.6.5 | Salt corrosion | At normal voltage, following test | + + + |
| 15 | 3.4.6.6.6 | Dust | | + + * * * |
| 16 | 3.4.6.6.7 | Humidity cycling | At normal voltage, during test | + + + |
| 17 | 3.4.6.6.8 | Mould growth | | + + + |
| 18 | 3.4.6.6.9 | Industrial atmosphere | At normal voltage, following test | + + + |
| 19 | 3.4.6.5.6 | Insulation resistance (across isolating barrier) | | * * * * * |
| 20 | 3.4.6.8.1 | Soak | At normal voltage | * * * * * |
| 21 | 3.4.2.5 | Final performance | At normal voltage, and with combination of voltages | * * * * * |
| 22 | 3.4.2.2 | Final visual inspection | | * * * * * |
| * - Mandatory test<br>+ - As required- see text. | | | | |

The initial visual inspection shall be performed to ensure that the equipment is of sound construction and, so far as can be ascertained, meets the requirements of this specification, and schedule A of an enquiry document.

### 3.4.2.1 Final visual inspection

The final visual inspection shall be performed to check whether any damage exists or deterioration has occurred as a result of any of the previous tests or activities. Eskom will determine the action which is necessary as a result of any findings of the inspection, which shall be made known as soon as possible.

### 3.4.2.2 Initial performance test

The initial performance test shall consist of a comprehensive series of measurements of the characteristics of the equipment to demonstrate that its performance is in accordance with its functional requirements, including the detailed requirements of schedule A of an enquiry document and with this specification. This test shall normally be performed at an ambient temperature of 20°C ± 5 °C while supplied at its normal voltage. The supply sources are specified in 3.1.1.5.1.

### 3.4.2.3 Performance checks during and/or following tests

Performance checks will be required during and/or following most tests. They shall take the form of abbreviated performance tests approved by Eskom, and designed to check the effect on the equipment of other tests.

### 3.4.2.4 Final performance test

The final performance test shall consist of a comprehensive series of measurements and observations of the characteristics and performance of the equipment to demonstrate that no unacceptable deterioration has occurred as a result of previous tests. The test shall normally be performed at an ambient temperature of 200C ± 5°C. The equipment shall be tested while supplied at normal supply voltages and subsequently with worst case combinations of supply voltages. The supply sources are specified in 3.1.1.5.1.

### 3.4.3 Routine testing

Routine testing shall comprise a series of tests to confirm that individual production equipment has been correctly manufactured and set up. The quality assurance shall be subject to Eskom's approval and Eskom reserves the right to witness any or all of the tests. An inspection of manufacturing processes such as plating, encapsulation, welding, etc., and separate checks and proof of adequate quality control may be required.

The details of routine testing shall be agreed between the supplier and Eskom prior to the commencement of manufacture of the equipment concerned. If the production equipment differs in any respect from the equipment upon which the type testing was performed, Eskom shall be informed and may require a repetition of those tests which might have been made invalid by the changes in the design of the equipment.

Unless otherwise approved, the tests shall be performed in the order listed in Table 8

**Table 8: Tests required for routine testing**.

| TEST NUMBER | TEST CLAUSE | TEST TO BE APPLIED (UNDER AMBIENT CONDITIONS) |
|---|---|---|
| 1 | 3.4.6.6.3 | Sealing test (where applicable) |
| 2 | 3.4.6.5.6 | Insulation resistance (across isolating barrier) test. |
| 3 | 3.4.6.8.2 | Soak period |
| 4 | 3.4.3.2 | Performance test |
| 5 | 3.4.3.1 | Visual inspection |

### 3.4.3.1 Visual inspection

The visual inspection shall be performed to ensure that equipment complies with the requirements of this specification and schedule A of an enquiry document.

Eskom will determine the action necessary as a result of any adverse finding of the inspection, which shall be made known as soon as possible.

### 3.4.3.2 Performance test

This test shall be performed to check that the equipment is capable of performing all its specified functions and is still within calibration.

### 3.4.4 Site Testing

Details of site testing will be given in schedule A of an enquiry document, but in general they are required to check that:

a. the equipment has been properly installed

b. it is suitable for and functions correctly in its environment.

Where site testing related to interfacing is required, it shall be performed unless otherwise approved, with the equipment correctly installed in its final location and shall demonstrate that the equipment:

c. is compatible with other connected equipment

d. is capable of performing its specified function when interconnected

e. has sufficient range in its variable and interrelated controls.

Where site testing is required it may, at Eskom's discretion, include those tests listed in Table 9

**Table 9: Tests required for site testing**

| TEST NUMBER | TEST REF CLAUSE | TEST TO BE APPLIED | CONDITIONS OF PERFORMANCE TEST |
|---|---|---|---|
| 1 | 3.4.4.1 | Visual inspection | |
| 2 | 3.4.4.2 | Performance test (when interfaced with associated plant and equipment) | At actual site voltage |
| 3 | 3.4.6.3 | Site supply variation tests* | With all possible extreme combinations |
| 4 | 3.4.6.4 | Supply changeover test(s)* | At normal and extreme voltage with changeover of the actual supply arrangement |
| 5 | 3.4.6.5.8 | Site electrical noise tests* | At actual site voltage with all adjacent plant etc. working in all modes |
| 6 | 3.4.6.8.3 | Site soak test (if required) | At actual site voltage |

* When site conditions allow.

#### 3.4.4.1 Visual inspection

Inspections will be performed by Eskom to establish that the equipment has been delivered to site and installed correctly and without damage. Such inspections shall be called for by the installation contractor before another contractor is allowed access to the equipment. This practice shall be enforced whenever two or more contractors require access to equipment to carry out their contract work.

#### 3.4.4.2 Performance test

The performance test shall be done with the equipment fully installed and supplied from the specified sources and correctly interfaced with all its associated plant and equipment. It shall be established that all associated plant and equipment has undergone separate tests before final system tests proceed.

### 3.4.5 Acceptance testing

These tests will constitute evidence for final acceptance by Eskom in respect of any contract and will be detailed in schedule A of an enquiry document.

### 3.4.6 Electrical supply variations and interruptions

#### 3.4.6.1 Supply variation test

Measurements of equipment performance and maximum VA consumption shall be made, for supply voltage and frequency variations in all possible combinations of upper limit,

normal and lower limit as detailed in 3.1.1.5.1. and schedule A of an enquiry document. During these tests the equipment shall function in accordance with its specification.

#### 3.4.6.2 Supply interruption test

The supply input to the equipment under test shall be interrupted for periods of 5 ms, 10 ms, 20 ms, 50 ms, 100 ms, 200 ms and 500 ms as required by Eskom.

The test shall be performed 10 times at random for a.c. supplies and 3 times for d.c. supplies, covering all modes of equipment operation.

All outputs of the equipment shall be monitored throughout this test to ensure that no malfunction occurs and that for such interruptions the equipment either continues to operate successfully or powers-down successfully without loss of historical trip and fault data history and in accordance with schedule A of an enquiry document.

NOTE: For equipment intended for operation with changeover to an alternative supply, Eskom may require a combination of this test and the test detailed in 3.4.6.3 to simulate a changeover condition and demonstrate that the design is satisfactory (see 3.2.4.3 b)).

#### 3.4.6.3 Site supply variation tests

If variable supply conditions exist on site the equipment shall be tested over the full range of changes, site conditions permitting.

### 3.4.6.4 Supply changeover test

When supply interruptions occur due to changeover, etc., on site, the installed equipment shall be tested to demonstrate its compatibility with the changeover requirement in respect of the time of changeover and the voltage/frequency step as defined in schedule A of an enquiry document.

### 3.4.6.5 Electrical environmental interference tests

The electrical tests to be applied will vary from equipment to equipment depending upon the operating environment and the nature of the connection to other items of plant and equipment.

The following tests are to demonstrate that the equipment has been correctly designed and manufactured to function without damage, or when specified, without maloperation when subjected to conditions simulating those which may occur in use. The tests are related to the classification of electrical environment described in 3.1.5.2, and the test values and methods of application are given in the following test clauses and in Table 9. Guidance on the selection of the required electrical tests is given in Table 10

When non-maloperation tests are specified, maloperation shall not occur during the tests or subsequent to them as a result of the tests.

**Table 10: Electrical interference test to be applied during type testing**

| **ELECTRICAL** | | |
|---|---|---|
| **ENVIRONMENTAL** | **TEST AND CLAUSE NUMBERS** | |
| **CLASS (Table 3)** | | |
| | VIA POWER SUPPLIES | VIA SIGNAL CABLES |
| I (Low Level) | • 50 Hz supply transients | • Insulation resistance (3.4.6.5.6) |
| | (3.4.6.5.5) | |
| | • Insulation resistance (3.4.6.5.6) | |
| II (Mild) | • 50 Hz supply transients | • Electrical impulse (3.4.6.5.1) |
| | (3.4.6.5.5) | where specified |
| | or Electrical impulse (3.4.6.5.1). | • Insulation resistance (3.4.6.5.6) |
| | • Insulation resistance (3.4.6.5.6) | |
| III (Moderate) | • Electrical impulse (3.4.6.5.1) | • Electrical impulse (3.4.6.5.1) |
| | • HF Disturbance (3.4.6.5.3) | • HF Disturbance (3.4.6.5.3) |
| | • Fast transient test (3.4.6.5.4) | • Fast transient test (3.4.6.5.4) |
| | • 50 Hz supply transients | • 50 Hz supply transients (3.4.6.5.5) |
| | (3.4.6.5.5) | • Insulation resistance (3.4.6.5.6) |
| | • Insulation resistance (3.4.6.5.6) | |
| IV (Severe) * | • Electrical impulse (3.4.6.5.1) | • Electrical impulse (3.4.6.5.1) |
| | • HF Disturbance (3.4.6.5.3) | • Power frequency (3.4.6.5.2) |
| | • Fast transient test (3.4.6.5.4) | • HF Disturbance (3.4.6.5.3) |
| | • 50 Hz supply transients | • Fast transient test (3.4.6.5.4) |
| | (3.4.6.5.5) | • 50 Hz supply transients (3.4.6.5.5) |
| | • Insulation resistance (3.4.6.5.6) | • Insulation resistance (3.4.6.5.6) |
| * Normally applicable. | | |
| NOTE - Test relating to clauses 3.4.6.5.7, RFI; 3.4.6.5.9, capacitive discharge; 3.4.6.5.10, electrostatic | | |

discharge, respectively to be performed when called for in schedule A of an enquiry document.

### 3.4.6.5.1 Electrical impulse test 1,2/5ijls

This test is to demonstrate that the equipment has been correctly designed to withstand, without damage, the electrical stresses to which it might be subjected in practice. In certain circumstances, this will be a non-maloperation test on part or all of the equipment but this will be specified in schedule A of an enquiry document.

The stresses are related to the classification of the electrical environment outlined in 3.1.5.2.

The test to be applied is based upon IEC 255-5. The impulse wave form is an aperiodic transient voltage without appreciable oscillations having a 1,2).,ts rise time and an exponential decay to half amplitude in 50l-ls.

When a large number of identical interface circuits are used, this test may be restricted to a representative sample, the proportion being to Eskom's approval.

A suggested circuit for the production and application of the test waveform is given in IEC 255-5

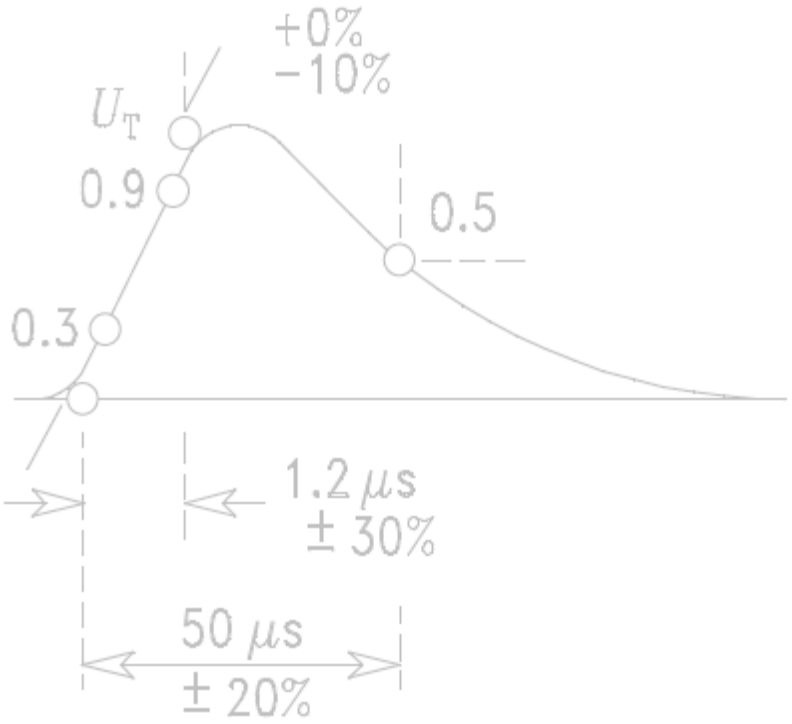


**Figure 1: Test Waveform**

**NOTES**

- Source energy ½ joule for 1.0 kV to 5.0 kV . 2
- Source energy 1/8 joule for .0.5.kV
- Source energy 1/12 joule for 0.25.0 kV . 4
- Source energy impendance 500Q

No less than 3 positive and 3 negative pulse each applied at intervals of not less than 5 s

**Table 11: Method of Application**

| Application Method | Test voltage 'V' (kV) | | |
|---|---|---|---|
| | Class II | Class III | Class IV |
| a) | - | 1,0 | 5,0 |
| b) | - | 1,0 | 5,0 |
| c) | 0,25 | 0,5 | 1,0 |
| d) | 1,0 | 1,0 | 1,0 |

NOTES

Method of application - Test voltage 'V' shall be applied between:

a Each terminal and the safety earth (common mode).

Note: Where practicable all terminals may be connected together.

b Individual terminals of all independent circuits (including power supplies). Where practicable the terminals of each independent circuit may be connected together (common mode between separate circuits).

c Signal terminals of the same circuit (series mode).

d Power supply terminals of battery powered equipment (external supply) (series mode).

Note: A terminal is defined as any connection to or from the equipment including those to power supplies.

### 3.4.6.5.2 Power frequency interference test

A check shall be made that the equipment does not maloperate when a 50 Hz voltage as specified in the table below is applied through a 0, 'luf capacitor. This is not relevant for circuits for which 50 Hz inputs are normal.


**Figure 2: Power frequency interference test**

NOTE: Applied for a period of not less than 2

**Table 12: Power frequency interference test**

| Application Method | Test voltage 'V' (kV) |
|---|---|
| | Class IV |
| a. | 0,5 |
| b. | 0,5 |
| c. | 0,25 |

NOTES

Method of application - Test voltage 'V' shall be applied between:

d. Each terminal and the safety earth (common mode).

Note: Where practicable all terminals may be connected together.

e. Individual terminals of all independent circuits (including power supplies). Where practicable the terminals of each independent circuit may be connected together (common mode between separate circuits).

f. Signal terminals of the same circuit (series mode).

g. Power supply terminals of battery powered equipment (external supply) (series mode).

Note: A terminal is defined as any connection to or from the equipment including those to power supplies.

### 3.4.6.5.3 High-frequency MHz disturbance test

High-frequency disturbance tests are required to determine whether the equipment will operate correctly when specified high-frequency transients which are representative of practical system conditions are applied to the fully energized equipment.

The following test is based on IEC 255-22-1. The following shall normally apply:

a. 1 MHz damped oscillatory waveform with a decaying envelope to 50 % in 3 cycles to 6 cycles shall be applied. The signal shall be generated from a source of 20m with a repetition rate of 400 a second and the duration of the test shall be not less than 2 s; and,

b. when a large number of identical interface circuits are used, this test may be restricted to a sample, the proportion being to Eskom's approval.

Suggested methods for the production and application of the test waveform are given in IEC 255-22-1.

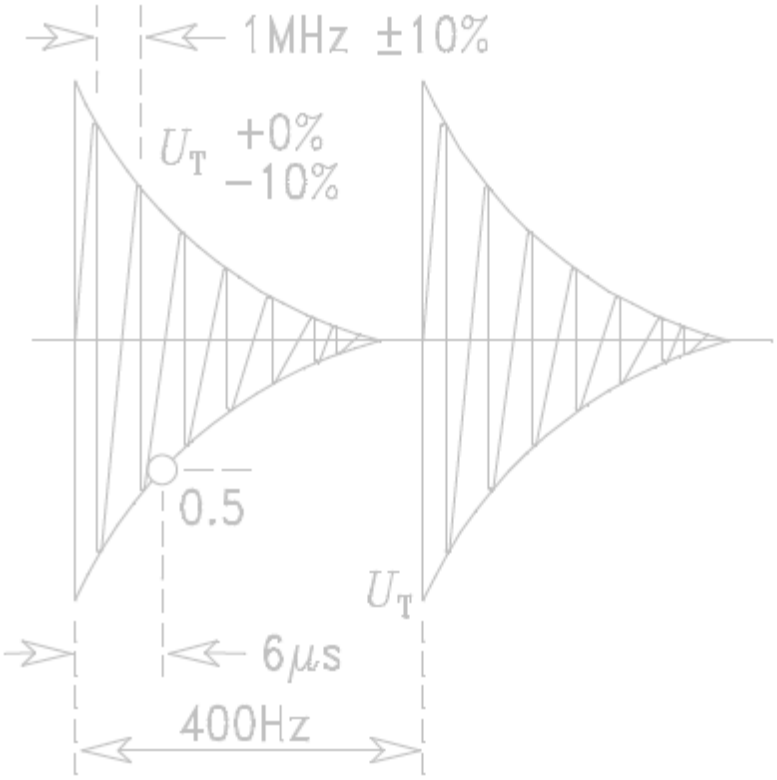


**Figure 3: Test Waveform are Given in IEC 255-22-1**

**NOTES**

- Source impedance 200Q.
- Applied as repetition rate of 400 per second for not less than 2 s

**Table 13: Test Waveform are Given in IEC 255-22-1**

| Application Method | Test voltage 'V' (kV) | |
|---|---|---|
| | Class III | Class IV |
| a) | 1,0 | 2,5 |
| b) | 1,0 | 2,5 |
| c) | 0,5 | 1,0 |
| d) | 0,5 | 1,0 |

NOTES

Method of application - Test voltage 'V' shall be applied between:

a. Each terminal and the safety earth (common mode).

Note: Where practicable all terminals may be connected together.

b. Individual terminals of all independent circuits (including power supplies). Where practicable the terminals of each independent circuit may be connected together (common mode between separate circuits).

c. Signal terminals of the same circuit (series mode).

d. Power supply terminals of battery powered equipment ( aternal supply) (series mode).

Note: A terminal is defined as any connection to or from the equipment including those to power supplies.

### 3.4.6.5.4 Fast transient test

During the test the equipment shall be energized and in a fully operational condition. The test shall be performed with the impulse voltage applied to inputs and outputs of the equipment for at least 2 min. The test shall be performed in accordance with IEOOOO-4-4.

With the test equipment used to generate the test voltage, fully reproducible impulse voltages may not obtained from test to test. An oscilligram showing the performance of the fast transient/burst generator shall therefore be recorded at the beginning or end of the test

Suggested methods for the production and application of the test waveform are given in IEC 255-22-1

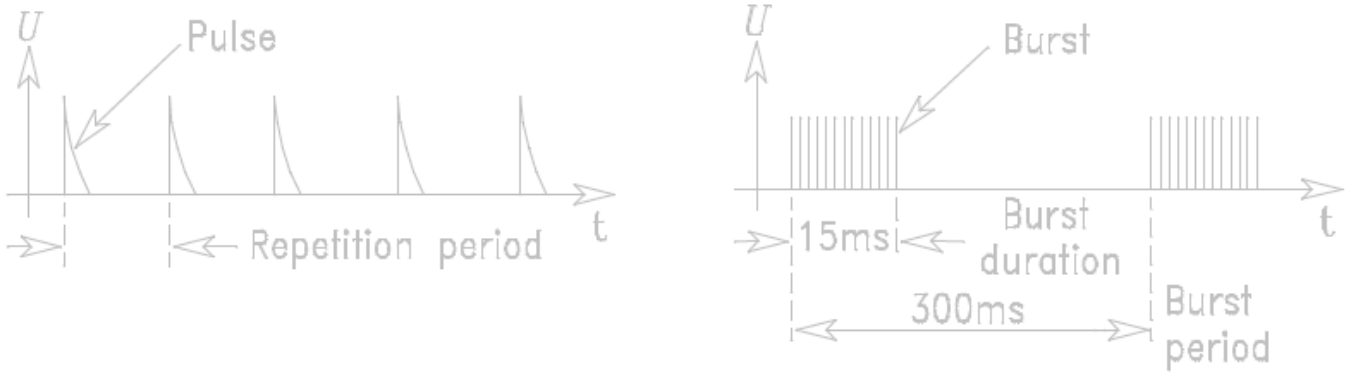


**Figure 4: Fast transient test**

NOTES

- Reception frequency of impulse of severity level.
- Applied as repetition rate of 400 per second for not less than 2 min

**Table 14: Fast transient test**

| Application Method | Test voltage 'V' (kV) | |
|---|---|---|
| | Class III | Class IV |
| a) | 1,0 | 2,5 |
| b) | 1,0 | 2,5 |
| c) | 0,5 | 1,0 |
| d) | 0,5 | 1,0 |

NOTES

Method of application - Test voltage 'V' shall be applied between:

a. Each terminal and the safety earth (common mode).
   Note: Where practicable all terminals may be connected together.

b. Individual terminals of all independent circuits (including power supplies). Where practicable the terminals of each independent circuit may be connected together (common mode between separate circuits).

c. Signal terminals of the same circuit (series mode).

d. Power supply terminals of battery powered equipment ( aternal supply) (series mode).
   Note: A terminal is defined as any connection to or from the equipment including those to power supplies.

### 3.4.6.5.5 50 Hz supply transient test

The equipment shall be subjected to at least 10 randomly phased transient over voltages which shall be applied serially from a generator having a 50n output impedance and a power of 10 W peak. The shape of the transient shall be a nominal half sine wave in accordance with the values given below. A low pass filter may be required in series with the power source.

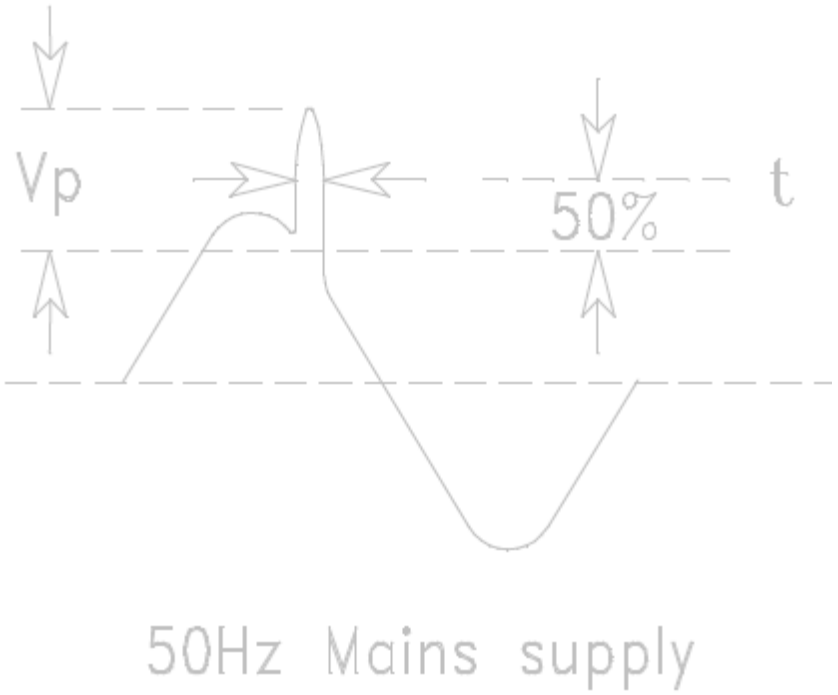


**Figure 5: 50Hz Mains Supply**

NOTES

- Source impendance 500
- At least 10 transients randomly phased to be applied

**Table 15: 50 Hz supply transient test**

| **Test voltage '~' as % of '".m.s.** | |
|---|---|
| Vp% | t ms |
| 100 | 10 |
| 200 | 1 |
| 300 | 0,02 |
| 500 | 0,005 |

NOTES

Method of application - Test voltage 'V' shall be applied between:

a. Each terminal and the safety earth (common mode).

Note: Where practicable all terminals may be connected together.

b. Individual terminals of all independent circuits (including power supplies). Where practicable the terminals of each independent circuit may be connected together (common mode between separate circuits).

c. Signal terminals of the same circuit (series mode).

Power supply terminals of battery powered equipment (external supply) (series mode).

d. Note: A terminal is defined as any connection to or from the equipment including those to power supplies.

### 3.4.6.5.6 Insulation resistance (across isolating barrier) test

When a barrier is used to provide isolation from external circuits, its insulation resistance shall be measured. If the barrier is required to withstand high voltage stresses, then it shall be stressed at the specified voltage to demonstrate its withstand capability and a further insulation resistance test shall be made to ascertain that it has not been significantly degraded as a result of the stress being applied. The tests shall be performed in accordance with IEC 255-5. Test details are given below

The insulation of all circuits which include contacts of switches, relays or contactors for isolation functions shall be tested for insulation resistance. This shall be not less than 20 Mn when measured at d.c. 500 V.

For circuits intended for connection to a.c. 100 V or d.c. 100 V and above, 2 kV r.m.s. shall be applied for 1 min and this shall be followed by a further insulation resistance test.

For circuits intended to provide isolation against large differences in earth potential as in class IV electrical environment as defined in 3.1.5.2, the barrier shall, after the initial resistance measurement, be stressed to the design voltage (see 3.2.4.3 e), and this shall be followed by a further insulation resistance test.

NOTES

a. Resistance measured at a potential of d.c. 500 V applied across the isolating barrier.

   R = R1 > 20 Mn

b. For switches, relays and contactors 500 V is to be applied between

   - The opposite ends of each circuit with contacts in open position.
   - Both ends of each circuit to earth with contacts in closed position.

c. Circuits intended for connection to 100 V (a.c. or d.c). and above to be stressed to a.c. 2 kV for 1 min after initial resistance measurements.

   Stress to be applied between

   - The individual circuits of this type
   - Each circuit of this type and all other circuits including earth. These other circuits can be strapped together electrically for the purpose of this test.

d. Final insulation resistance shall be such that

   R = R2> 20 Mn

e. Barriers to provide protection against large rises in earth potentials to be stressed across barrier at design voltage for 1 min after initial isolation resistance measurement. Final insulation resistance test as above.

### 3.4.6.5.7 Radio frequency interference test

Tests shall be performed, at Eskom's discretion to establish whether the interference effects are significant. For related levels see clause 3.1.5.3 a).

### 3.4.6.5.8 Site electrical noise tests

The extent of these tests will be specified in schedule A of an enquiry document. The tests may involve the operation of high voltage switchgear, and/or a special injection test

No change of state or any operation shall occur when a capacitor of capacitance shown below, charged to 1,5 x Vn volts, is connected between any combination of terminals and any combination of terminals and ground

Master trip circuits

Other protection & control circuits

Carrier/channel interface

#### 3.4.6.5.9 Electrostatic discharge test

10/-IF

When electrostatic discharge test are performed in accordance with IEC 1000-4-2 no maloperation or failure of equipment is permissible.

### 3.4.6.6 General environmental tests

The following tests are to demonstrate that equipment will operate in accordance with its design specification in all environmental conditions up to the extreme values which the equipment may encounter during its operational life.

#### 3.4.6.6.1 Temperature test

Whenever changes in temperature are required to be made in a testing cycle, sufficient time shall be allowed for the equipment under test to stabilize at the new temperature. Evidence of stabilization shall be given in the form of a time/temperature plot of measurements, taken at a number of approved points within the equipment. For the dry heat and the low temperature tests the equipment shall be maintained in an operational state for at least 6 h at the stabilized temperature before performance checks are initiated.

The environmental chamber used for these tests shall be large enough to permit air to circulate freely and to ensure that temperature and relative humidity variations throughout the chamber are minimal.

a. Dry heat test

The dry heat test shall be performed on individual sub-units, units, and, where applicable, on the complete equipment or assembly, with all doors and covers being in place and closed as in normal operation. In special instances, tests may also be required with the cubicle doors open as for normal maintenance.

During this test, the equipment shall be contained in a climatic chamber maintained at the maximum temperature e: 2 0c) and at a relative humidity not exceeding 60 %.

This will either be the maximum class temperature of Table 1 or 15°C higher (see 3.2.4.1). Test conditions shall be in accordance with IEC 68.2.2, Test Bd. Performance checks shall be made at the maximum temperature and repeated when the equipment has been returned to ambient temperature.

The low temperature test shall be performed on individual sub-units, units and, where applicable, on the complete equipment or assembly with all doors and covers in place. During the test, the equipment shall be contained in a climatic chamber maintained at the minimum class temperature (t 2 0c) at a relative humidity not exceeding 60%. Test conditions shall be in accordance with IEC 68.2.1, Test Ad. Performance checks shall be made at the minimum temperature and repeated when the equipment has been returned to ambient temperature.

#### 3.4.6.6.2 Damp heat test

Where covers form part of the item to be tested, they shall be correctly fitted throughout the test, which shall be carried out generally in accordance with IEC 68.2.30, Test Db with the following conditions and procedures:

a. there shall be one cycle;

b. the initial performance check shall be made with the Ejuipment under ambient conditions in the test chamber. Upon completion of this check, the equipment shall be switched off;

c. the upper temperature shall be 40°C;

d. the equipment shall be re-energized 2 h before the beginning of the temperature-fall period and a further performance check performed during the last hour at the elevated temperature. The equipment shall remain energized for the remainder of the test;

e. during the temperature-fall period, saturation (condensation) shall occur within the chamber and at the end of this period another performance check shall be made; and

f. a recovery period of 6 h shall be allowed before the final performance check is made.

#### 3.4.6.6.3 Sealing test

The sealing test is to prove the effectiveness of the methods used to provide a completely sealed unit for weatherproof, protective or immersion purposes. This test is mandatory for sealed equipment when being type tested. When this test is applied the driving rain and dust test need not be performed. As a check on production, an agreed percentage of sealed equipment shall be subjected to the sealing test during routine testing.

The equipment shall be sealed at room temperature and then totally immersed in water containing 2,5 % liquid detergent. The solution and equipment shall then be raised to a temperature of at least 55°C. and shall remain at this temperature for at least 20 min. There shall be no visible leakage indicated by bubbles emanating from the equipment.

While still immersed, the liquid shall then be allowed to cool to room temperature, and on subsequently removing the equipment, drying the outside and opening it, there shall be no evidence of water ingress

Sealed equipment required to operate under pressure or vacuum or operated whilst submerged in water or other liquid, will have its test requirements specified in schedule A of an enquiry document.

#### 3.4.6.6.4 Driving rain test

The driving rain test shall be carried out in accordance with IEC 68.2.17; Test Q. A performance check shall be carried out while the equipment is being sprayed, and at the conclusion of the test all surface water shall be removed from the equipment and after opening the case, the equipment shall be visually examined. There shall be no evidence of water ingress.

#### 3.4.6.6.5 Salt corrosion test

The salt corrosion test shall be carried out in accordance with BS 2011, Part 2.1 kB, Test kB, Severity 1.

At the conclusion of this test there shall be no undue deterioration or corrosion of metal parts, finishes, materials and components. At the end of the recovery period, the equipment shall be subjected to a performance check.

#### 3.4.6.6.6 Dust test

This test need only be done on equipment in Class A 1 and B3 (see Table 6) when they contain moving parts.

The test shall be carried out in a chamber which is capable of maintaining the equipment at a temperature of 35°C ± 2 °C with a relative humidity not exceeding 60 %. The size of the chamber shall be such that the equipment does not occupy more than 50 % of the crosssectional area of the chamber in any plane.

The dust used shall be in accordance with BS 7226, fine grade, up to 75 microns, and the duration of the test shall be 30 min. Alternatively, if approved by Eskom, the dust used may be the BS 7226 coarse grade, up to 150 microns, but in this case the duration of the test shall be 1 h. The dust concentration shall not be less than 1,40 g/m3 and the chamber design and the air velocity shall be such as to create turbulent conditions with a uniform distribution of dust around the equipment.

After allowing sufficient time for the dust to settle, the equipment shall be taken from the chamber and the external dust removed. The equipment shall then be opened and visually examined to ensure that there are no significant deposits of dust within the equipment. If necessary, relay covers shall also be removed to ascertain whether there has been any dust ingress.

#### 3.4.6.6.7 Humidity cycling test

This test shall be performed at Eskom's discretion on an agreed number of samples of components, materials or finishes not already approved, or when the effects of humidity are unknown.

The test shall be performed in accordance with IEC 68.2.30, Test Db with the following conditions

a. the upper temperatures shall be 40°C;

b. there shall be 12 cycles

c. during the temperature-fall period saturation (condensation) shall occur; and

immediately after the end of the test the components or equipment shall be visually examined. There shall be no undue deterioration or corrosion, and tests shall be performed to establish that there has been no significant change in electrical characteristics.

#### 3.4.6.6.8 Mould growth test

The test shall be applied at Eskom's discretion to samples of components, materials and finishes where their resistance to mould growth is unknown or suspect.

The test shall be carried out in accordance with I EC 68.2.10, Test J. After 28 days, the sample shall be apparent to the naked eye, and there shall not be any change in electrical characteristics.

#### 3.4.6.6.9 Industrial atmosphere test

This test shall be applied at Eskom's discretion to samples of components, materials and finishes where they are not already approved or are of unknown performance.

The test shall be carried out in accordance with IEC 68.2.42, Test Kc. The duration of the test will be specified by Eskom and will be 4, 10 or 21 days, and at the conclusion of the test there shall be no evidence of deterioration or corrosion, and tests shall be carried out to establish that there has been not significant change in electrical characteristics.

### 3.4.6.7 Mechanical

#### 3.4.6.7.1 Drop test

The drop test shall be carried out on portable equipment and on units and sub-assemblies, and not on complete racks of equipment.

Casings or dust covers which have to be removed for servicing shall be removed after subjecting equipment to this test to inspect for damage. The test is designed to reveal any weakness of assembly and to ensure that the component mountings are of adequate strength. It is not designed to check whether doors or windows made of glass will fracture. Meters, glass windows, etc., may therefore be removed. The equipment shall not be deemed to have failed the drop test if externally accessible components such as control knobs or connectors are damaged. Eskom may however, require some form of guard to be fitted to prevent such damage.

The equipment shall be dropped from a height of 25 mm onto a steel plate not less than 6 mm thick which has been wet-floated on, and bolted down to a block of concrete at least 0,5 m thick, or an approved equivalent.

The height of drop shall be measured from that point of the equipment nearest to the surface of the steel plate when the equipment is suspended prior to dropping. The equipment shall be dropped in this way a minimum of six times of each of three mutually perpendicular faces. This shall be followed by a visual inspection and performance check.

#### 3.4.6.7.2 Vibration test

The vibration test is to reveal any part or components of the equipment which may be prone to any resonance severe enough to cause possible damage or malfunctioning. It shall be carried out on units and sub-units and not on complete racks of equipment. Tests shall be generally in accordance with IEC 68.2.6. Test Fc, and shall be performed by a vibration test machine having the characteristics specified therein.

The test shall consist of a resonance search over a frequency range of 10Hz to 15(}iz with a severity of not less than 4,9 rn/s" and a sweep rate of not greater than 1 octave a minute, except where a slower rate is necessary to permit adequate observation of possible resonances. As far as possible, the equipment shall be mounted by its normal fixings and the vibrations shall be applied along each of the three mutually perpendicular axes in turn. If necessary, to observe otherwise obscured parts, equipment sub-assemblies may be additionally tested.

Whenever a resonance is detected, a search shall be made on either side of the frequency at which the resonance occurs so that the resonance may be clearly observed and its significance assessed. Any resonances of the equipment shall be reduced to a level acceptable to Eskom by suitable modifications and the complete test repeated. Equipment may be required to undergo a performance check while being subjected to a sweep frequency test as detailed above.

### 3.4.6.8 Endurance

#### 3.4.6.8.1 Soak test

Unless otherwise approved, equipment shall be set up in a manner to simulate normal operating conditions, switched on, and allowed to operate continuously for a minimum period of 100 h. With approval, this period may be broken down into shorter periods if compatible with the function of the equipment.

During the test, measurements and observations shall be made to demonstrate that the equipment fulfils its functional requirement, has adequate stability, and is capable of operation without frequent attention.

The extent of performance monitoring required will depend upon the nature of the equipment under test, and whether the test is applied as part of type or routine testing.

If any failures occur, full details shall be recorded, and evidence that there are no inherent design or manufacturing faults shall be provided. Eskom will then decide whether the test may be restarted or be repeated.

#### 3.4.6.8.2 Soak period

The equipment shall be powered for a period of at least 100 h. The input and output conditions and the function performed throughout this period, shall, unless otherwise approved, be determined by the manufacturer. As one of the main functions of the test is to "burn in" the components, the test should if possible exercise all the components.

#### 3.4.6.8.3 Site soak test

This test will be specified in schedule A of an enquiry document

## 4. AUTHORISATION

This document has been seen and accepted by:

| Name | Designation |
|---|---|
| | Document Approved by TDAC ROD 13 March 2013 |

## 5. REVISIONS

| Date | Rev. | Compiler | Remarks |
|---|---|---|---|
| November 2012 | 0 | M Bower | Draft Document for review created from TST 41-1062 |
| May 2013 | 1 | M Bower | Final Document approved |

## 6. DEVELOPMENT TEAM

None

## 7. ACKNOWLEDGEMENTS

None

# APPENDIX A: PRINTED CIRCUIT CARD QUALITY – PROTECTION RELAYS

The following list of items, which is not necessarily complete gives examples of card quality defects which are not acceptable to Eskom.

a. Solder bridges or splashes between tracks.

b. Solder splashes on gold plated edge connectors.

c. On-board flexible wires exhibiting wicking.

d. Insufficient solder penetration around component leads and up through plated holes.

e. Boards which show signs of rework or repair which is of lower quality than the rest of the board.

f. Blow holes in the solder around a component lead.

g. Joints not properly soldered, such as points made with insufficient heat.

h. Boards not properly soldered, such as points made with insufficient heat.

i. Cuts in tracks which exceed 10 % of track width.

j. Cuts through the edge connector gold plating

k. Cuts, scratches or marks in conformal coating which penetrate to the board substrate or to the track material, or which may reduce insulation.

l. Brush hairs glued to the board by conformal coating.

m. Flux and other residues beneath the conformal coating.

n. Conformal coating on gold plated edge connector.

o. Missing or damaged tracks or pads

p. Component leads long enough to catch on adjacent card front plates during board removal i.e. > 2 mm.

q. Components not fully inserted into theboard so that they do not lie parallel to the board with at least 1 mm of lead protruding from the copper side of the board before soldering.

r. Component leads which are hand soldered from the component side of the board.

s. Components, such as switches or ICs, where all leads (whether used or not) are not correctly inserted into the board.

t. Components soldered to each other on the component side of the board

u. Components which are cracked, burnt, chafed, scratched or shovany sign of damage which is visible to the naked eye.

v. Components showing defects visible to the naked eye in the source manufacturer's coating or sealing process which expose active parts.

w. Components showing any signs of corrosion or corrosion products.

x. Component leads which are bent or strained beyond the component manufacturer's limits or recommendations.

y. Component leads of adjacent components (where leads are not soldered to the same track pad) which touch or which during normal handling can be bent to touch each other on either side of the board.

z. Jumper wires in excess of 30 mm not secured to the board by epoxy cement or similar means.

aa. Jumpers soldered onto component leads on the component side of the board.

bb. Jumper wires with insulation stripped more than 1 mm from the connections.

cc. Boards with missing jumpers or bent jumper pins.

dd. Boards with component sockets where there is any possibility of component movement, lead withdrawal or variation of contact resistance.

ee. The use of dissimilar metals in mechanically secured electrical connections.

ff. Securing nuts of components which are cross threaded.

gg. Securing nuts with less than 100 % penetration of the male thread.

hh. Boards which are warped or twisted by more than 0,7 % of total dimension, or which are difficult to insert because of twist or warp.

ii. Boards with factory set potentiometers that are not sealed.

jj. Boards with incorrect marking of component values or orientation.

kk. Boards with arnbquous or incorrect marking of setting switches, links, jumpers of potentiometers.

ll. Any board which does not perform electrically within tolerances stated in the documentation given to Eskom.

mm. Silk-screening of component numbers and switch link selections shall be clear, unambiguous and not obscured by components

## APPENDIX B: SKETCHES AND DRAWINGS

(informative)

The following sketches and drawings are referenced in this standard and a copy of each is supplied with this standard:

| | |
|---|---|
| Eskom drawing | 0.52/10116 |
| | 0.52/10117 |
| | 0.52/10118 |
| | 0.52/10119 |
| Eskom sketches | TD 516 |
| | TD541 |

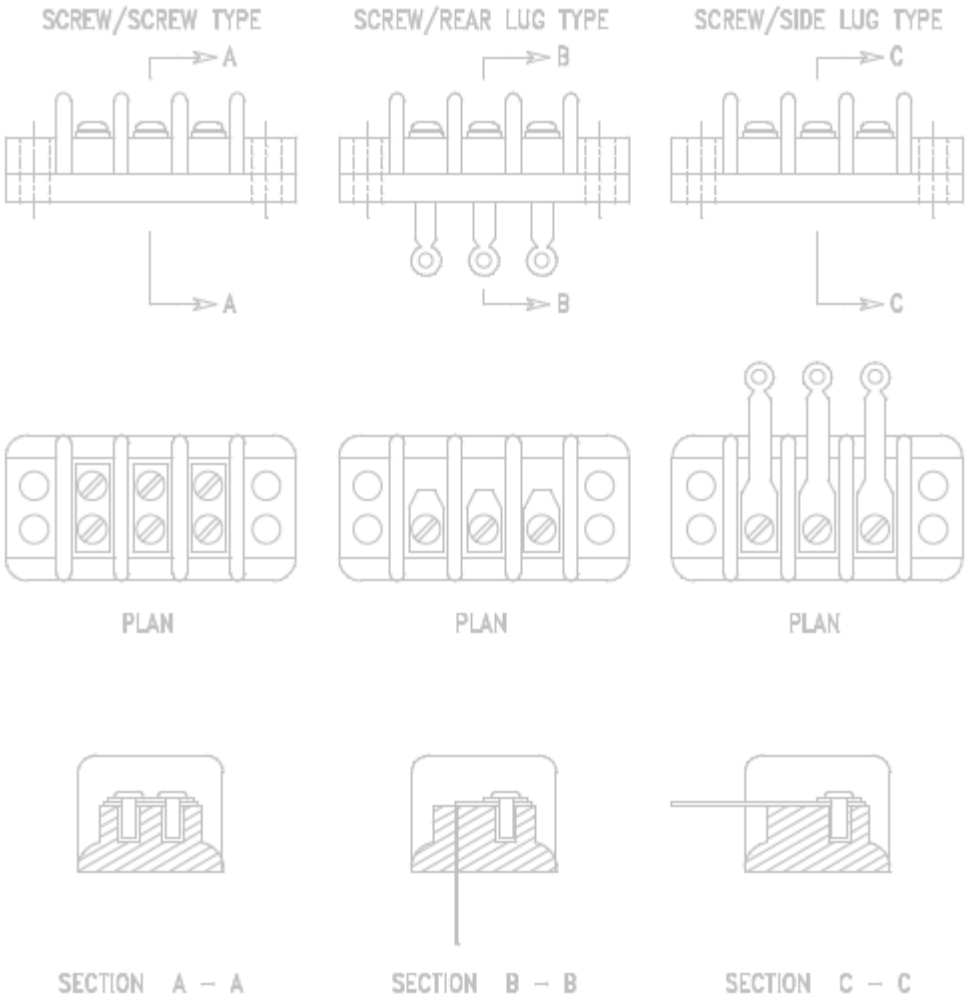


**Figure 6: General arrangement of type 'A' screw terminal block**

NOTES:

a. General arrangement of types showing 3~way blocks 2 With spring washers omitted, terminal screws do not

b. bottom on moulding

c. Mouldings to carry manufacturer's name or trademark

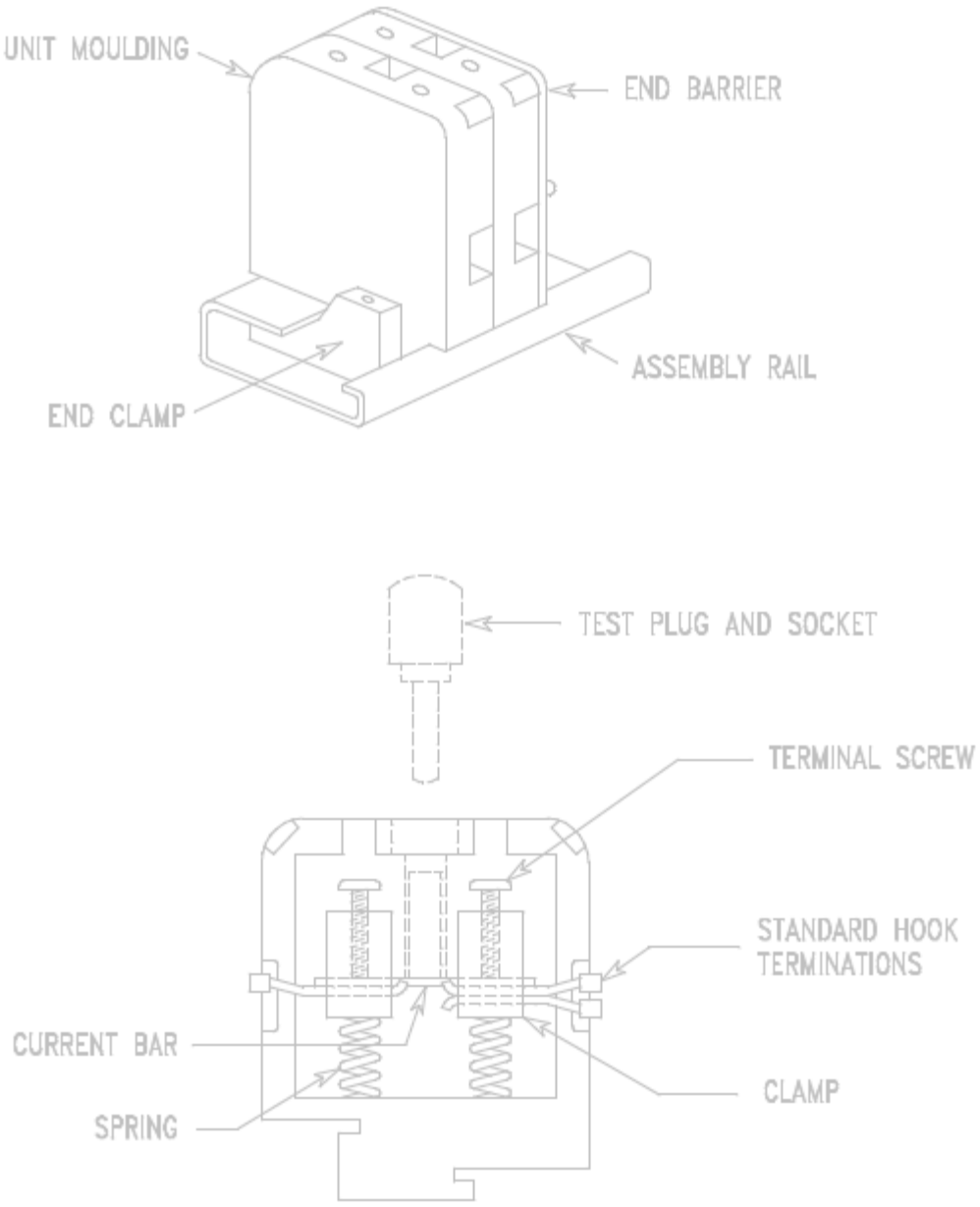


**Figure 7: General arrangement of type 'B' terminal block**

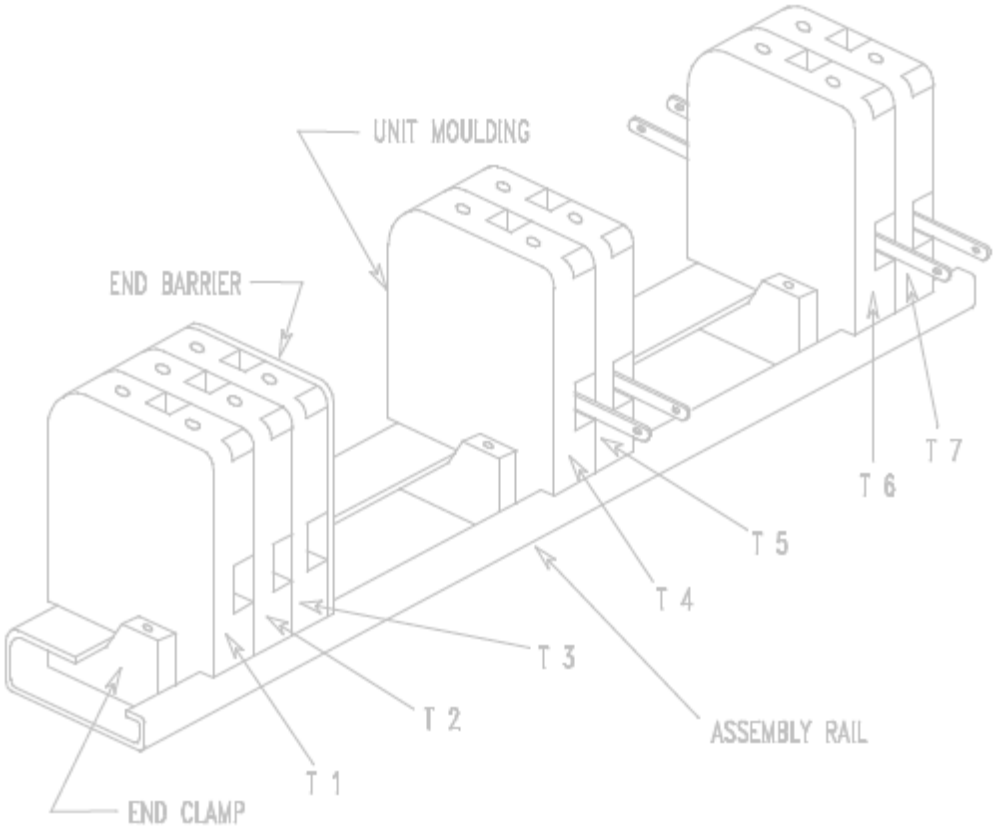


**Figure 8: General arrangement of type 'C' and ‘D’ terminal blocks**

**Table 16: Assembly of Typical Terminal Blocks**

| TYPE | TERMINALS |
|---|---|
| 1 | SCREW / SCREW |
| 2 | |
| 3 | |
| 4 | SCREW / SOLDER LUG |
| 5 | |
| 6 | SOLDER LUG / SOLDER LUG |
| 7 | |

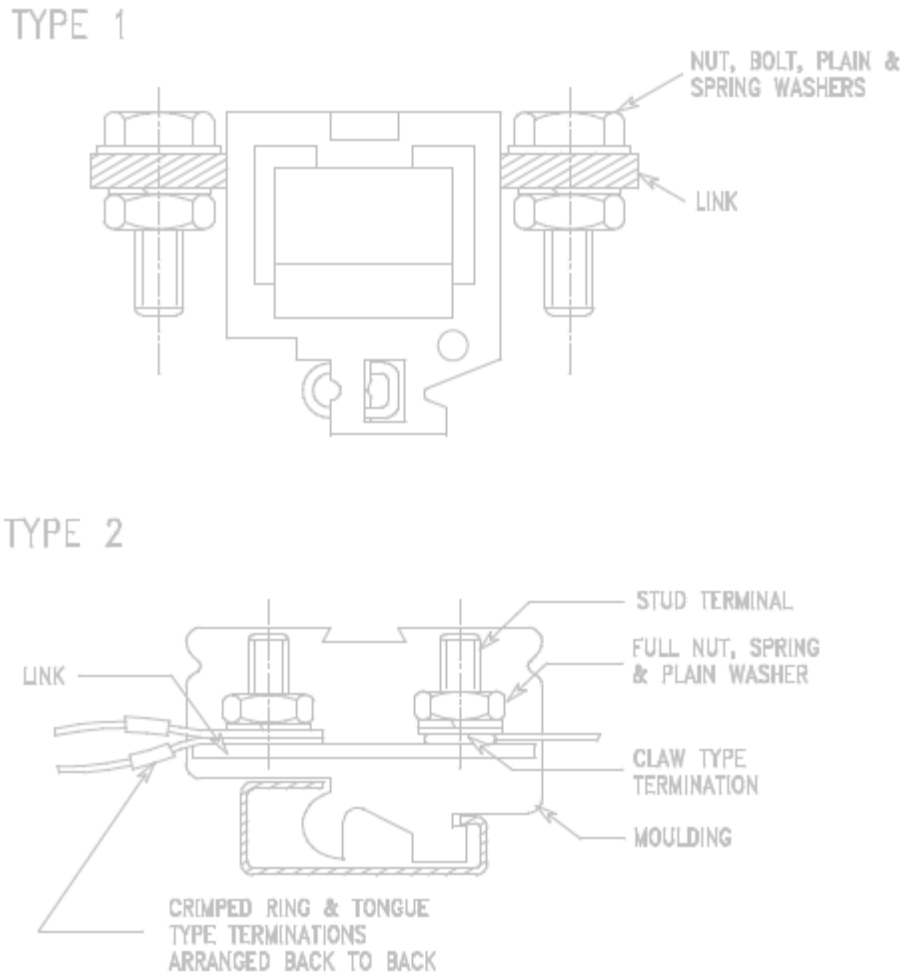


**Figure 9: General arrangement of type 'E' terminal block**

**Table 17**: **General arrangement of type 'E' terminal block**

| **STUD SIZE** | **MAX CURRENT RATING** **(A)** |
|---|---|
| 5mm | 30 |
| 6mm | 50 |

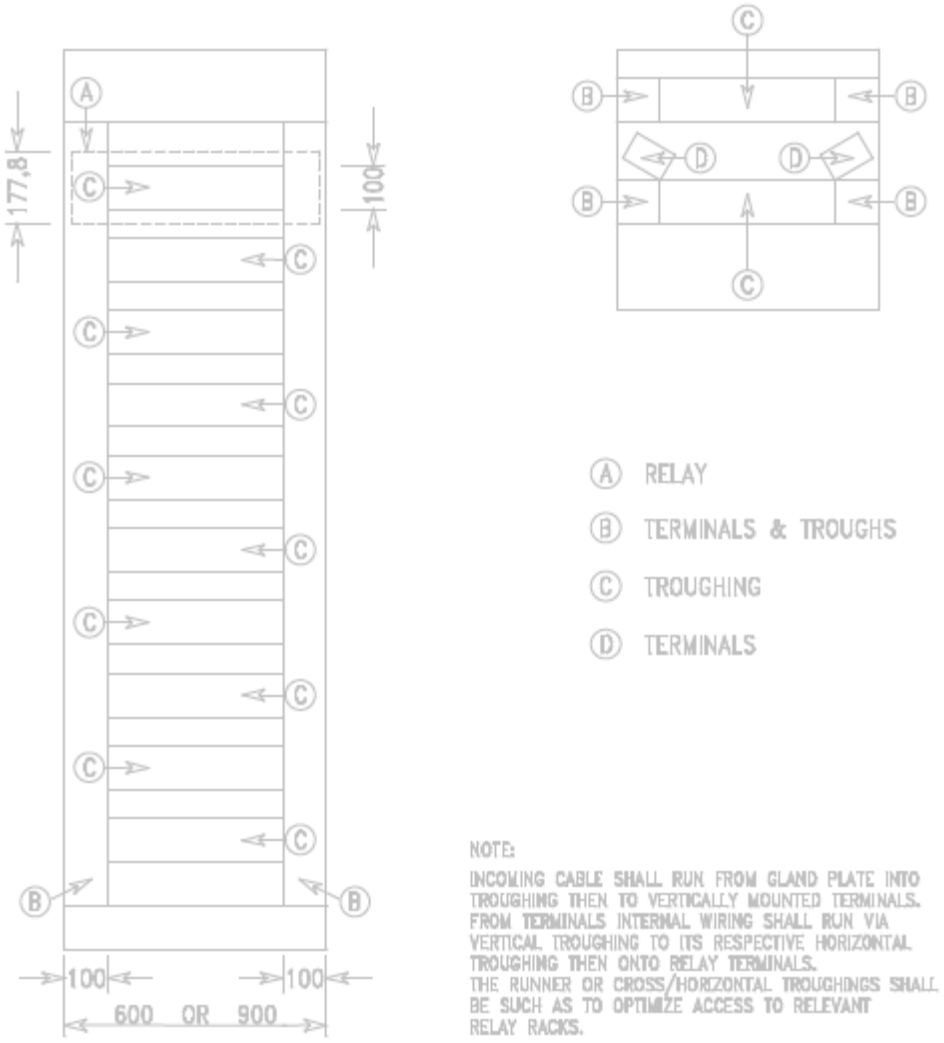


**Figure 10: 19 inch Rack panel (483 mm) - rear access**

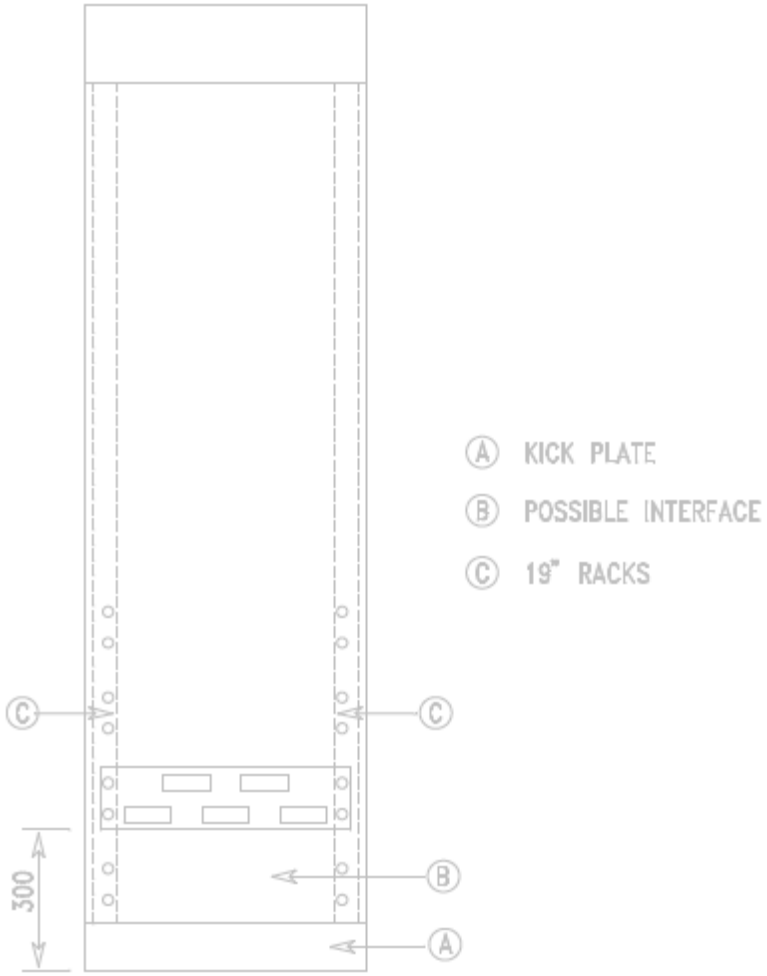


**Figure 11: 19 inch Rack panel (483 mm) - recommended location and layout of test blocks**