INSPECTION STANDARD

FOR

PRECOMMISSIONING ELECTRICAL TESTS

SECOND EDITION

MARCH 2016

FOREWORD

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS are based on internationally acceptable standards and include selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein.

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The IPS is reviewed and up-dated approximately every five years. Each standards are subject to amendment or withdrawal, if required, thus the latest edition of IPS shall be applicable

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for particular cases to the following address. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard.

Standards and Research department

No.17, Street14, North kheradmand

Karimkhan Avenue, Tehran, Iran .

Postal Code- 1585886851

Tel: 88810459-60 & 66153055

Fax: 88810462

Email: Standards@ nioc.ir

GENERAL DEFINITIONS

Throughout this Standard the following definitions shall apply.

COMPAN:

Refers to one of the related and/or affiliated companies of the Iranian Ministry of Petroleum such as National Iranian Oil Company, National Iranian Gas Company, National Petrochemical Company and National Iranian Oil Refinery And Distribution Company.

PURCHASER:

Means the “Company” where this standard is a part of direct purchaser order by the “Company”, and the “Contractor” where this Standard is a part of contract document.

VENDOR AND SUPPLIER:

Refers to firm or person who will supply and/or fabricate the equipment or material.

CONTRACTOR:

Refers to the persons, firm or company whose tender has been accepted by the company.

EXECUTOR:

Executor is the party which carries out all or part of construction and/or commissioning for the project.

INSPECTOR:

The Inspector referred to in this Standard is a person/persons or a body appointed in writing by the company for the inspection of fabrication and installation work.

SHALL:

Is used where a provision is mandatory.

SHOULD:

Is used where a provision is advisory only.

WILL:

Is normally used in connection with the action by the “Company” rather than by a contractor, supplier or vendor.

MAY:

Is used where a provision is completely discretionary.

CONTENTS: PAGE No.

1. SCOPE 4
2. REFERENCES 4
3. SAFETY 5
4. FIRST AID 6
5. PERMIT TO WORK 6
6. AC MOTORS TESTS 7
6.1 Insulation Tests 7
6.2 Drying Out 9
6.3 Stator High Voltage Tests 9
6.4 Air Gap and Alignment 10
6.5 Final Checks and Direction of Rotation 10
7. MOTOR PROTECTION 11
7.1 Operation Tests 11
7.2 Stability Tests 11
8. TRANSFORMERS 11
8.1 Insulation Tests 11
8.2 Drying Out 12
8.3 Tap Changer Equipment 12
8.4 Cooling Equipment 12
8.5 Measurement of Voltage Ratio and Check of Voltage Vector Relationship 13
8.6 Measurement of No Load Loss and Current 13
9. TRANSFORMER PROTECTION 13
9.1 Operation Tests 13
9.2 Stability Tests 14
9.3 Buchholtz Relay 14
10. GENERATORS 15
10.1 Inspection 15
10.2 Drying Out 15
10.3 Short Circuit Curve 15
10.4 Stator High Voltage Tests 15
10.5 Phase Sequence 15
11. GENERATOR PROTECTION 16
11.1 Differential Protection Primary Injection Tests 16
11.2 Trip Tests 16
11.3 Fault Tests 17
11.4 Stability Tests 17
12. CIRCUIT BREAKERS (Oil Circuit Breakers) 17
12.2 Electrical Inspection 17
12.3 Electro-Mechanical Inspection 17
12.4 General Examinations 18
13. HIGH VOLTAGE TESTING 18
13.1 Circuit Breaker 18
13.2 Cables 18
13.3 Termination and Joints 19
13.4 Busbars and Busbar Connections 19
14. INSTRUMENT TRANSFORMERS 20

14.1 Current Transformers 20
14.2 Voltage Transformers 20
15. TESTS FOR TRANSFORMER OIL 20
15.1 Crackle Test for Moisture 20
15.2 Electrical Tests 20
16. EQUIPMENT FOR USE IN HAZARDOUS AREAS 21
17. BATTERIES 21
17.1 Lead Acid Batteries 21
17.2 Alkaline Batteries 23
18. RECTIFIERS AND INVERTERS 23
19. EARTHING 24
20. SMALL WIRING FOR LIGHTING AND POWER 24
21. OVERHEAD TRANSMISSION AND DISTRIBUTION LINES 24
21.1 Inspection of Lines (Check List) 24
21.2 Measurements 26
21.3 Tests 26
21.4 Precautions During Test 26
22. GUIDANCE FOR PROTECTION 27
22.1 Testing of Relays and Protection Schemes 27
22.2 Test at Manufacturing Works (Informational) 27
22.3 Testing at Site 28

APPENDICES:

APPENDIX A INDUCTION MOROTS TESTS AND PHYSICAL CHECKS 29
APPENDIX B MOTOR CONTROL CENTER 30
APPENDIX C RELAY TEST SHEET 32
APPENDIX D THERMAL OVERLOAD TEST SHEET FOR MOTOR STARTERS 33
APPENDIX E OVERCURRENT AND EARTH FAULT RELAYS TEST SHEET 34
APPENDIX F POWER TRANSFORMERS PHYSICAL CHECKS AND TESTS 37
APPENDIX G GENERATORS CHECK LIST / TEST SHEET 40
APPENDIX H LOW VOLTAGE SWITCHGEAR ASSEMBLY CHECK LIST / TEST SHEET 42
APPENDIX I MEDIUM VOLTAGE SWITCHGEAR ASSEMBLY (PHYSICAL CHECK AND TEST) 43
APPENDIX J ISOLATOR/FUSE SWITCH/CHECK LIST TEST SHEET 45
APPENDIX K DISTRIBUTION BOARD TEST SHEET 46
APPENDIX L METERS CHECK LIST 47
APPENDIX M INSULATION RESISTANCE TEST SHEETS FOR SECONDARY WIRING 48
APPENDIX N CURRENT TRANSFORMERS CHECK LIST / TEST SHEET 49
APPENDIX O VOLTAGE TRANSFORMERS PHYSICAL CHECK LIST / TEST SHEET 50
APPENDIX P SMALL TRANSFORMERS PHYSICAL CHECK LIST / TEST SHEET 51
APPENDIX Q MEDIUM VOLTAGE CABLES INSULATION RESISTANCE AND PRESSURE TESTS 52
APPENDIX R LOW VOLTAGE CABLES INSULATION RESISTANCE TESTS SHEET 54
APPENDIX S MICC CABLE AND CONDUIT INSTALLATIONS 55
APPENDIX T BATTERIES AND CHARGERS CHECK LIST / TEST SHEET 56
APPENDIX U INVERTERS CHECK LIST / TEST SHEET 57
APPENDIX V TRANSFORMER RECTIFIER CHECK LIST / TEST SHEET 58

APPENDIX W EARTHING SYSTEM TEST SHEET 59
APPENDIX X GENERAL WIRING TEST AND CHECK LIST 60

ATTACHMENTS:
ATTACHMENT A CERTIFICATES 61

1. SCOPE

1.1 This precommissioning instructions cover the preacceptance test carried out by the contractor before any equipment is handed over for commissioning. These inspections and tests are additional to the full inspections and tests carried out already at manufacturer's work.

Equipment may consist of:

a) Switchgear, motor control centers and individual motor starters;

b) Rotating electrical machines such as motors and generators;

c) Transformers and transformer rectifiers;

d) Batteries, inverters and UPS;

e) Power factor improvement equipment;

f) Cabling, wiring and earthing;

g) Protective devices and meters;

h) Overhead distribution and transmission power lines;

i) Distribution boards, isolators and fuse switches.

1.2 The results of the tests shall be recorded on the test record sheets typical copies of which form part of this Standard, and the master copy of these sheets will be held by Company.

1.3 Visual inspection of all equipment and materials shall be made before and during installation and testing to ensure that they are correct to the design criteria, and functions correctly, that they are not damaged and have not been deteriorated due to storage or other causes.

1.4 The tests shall be witnessed and approved by the company representative who will accept by signing the appropriate section of the test sheet.

Note 1:

This is a revised version of this standard, which is issued as revision (1)-2012. Revision (0)-1996 of the said standard specification is withdrawn.

Note 2:

This is a revised version of this standard, which is issued as revision (2)-2016. Revision (1)-2012 of the said standard specification is withdrawn.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

IEC (INTERNATIONAL ELECTROTECHNICAL COMMISSION)

IEC 60055 "Paper-Insulated Metal-Sheathed Cables for Rated Voltages up to 18/30 kV (with Copper or Aluminum Conductors and Excluding Gas-Pressure and Oil-Filled Cables)

Part 1: Tests on Cables and their Accessories

Part 2: General and Construction Requirements"

IEC 62271-100 "High-Voltage Switchgear and Controlgear - Part 100: Alternating-Current Circuit-Breakers"

IEC 60076 "Power Transformers"

IEC 60156 "Insulating Liquids – Determination of the Breakdown Voltage at Power Frequency – Test Method"

IEC 60947 "Low Voltage Switchgear and Controlgear"

IEC 60296 "Fluids for Electrotechnical Applications – Unused Mineral Insulating Oils for Transformers and Switchgear"

IEC 60422 "Mineral Insulating Oils in Electrical Equipment – Supervision and Maintenance Guidance"

IEC 61439 "Low-Voltage Switchgear and Controlgear Assemblies"

IEC 62271-1 "High-Voltage Switchgear and Controlgear – Part 1: Common Specifications"

IEC 60502-1 "Power Cables with Extruded Insulation and their Accessories for Rated Voltages from 1 kV (Um = 1.2 kV) up to 30 kV (Um = 36 kV) – Part 1: Cables for Rated Voltages of 1 kV (Um = 1.2 kV) and 3 kV (Um = 3.6 kV)"

IEC 60502-2 "Power Cables with Extruded Insulation and their Accessories for Rated Voltages from 1 kV (Um = 1.2 kV) up to 30 kV (Um = 36 kV) – Part 2: Cables for Rated Voltages from 6 kV (Um = 7.2 kV) up to 30 kV (Um = 36 kV)"

IEC 60502-4 "Power Cables with Extruded Insulation and their Accessories for Rated Voltages from 1 kV (Um = 1.2 kV) up to 30 kV (Um = 36 kV) – Part 4: Test requirements on accessories for cables with rated voltages from 6 kV (Um = 7.2 kV) up to 30 kV (Um = 36 kV)"

IEC 60034-1 "Rotating Electrical Machines – Part 1: Rating and Performance"

IEC 62305 "Protection against lightning"

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-EL-100 "Engineering Standard for Electrical System Design (Industrial and Non-Industrial)"

IPS-E-EL-110 "Engineering Standard for Hazardous Area"

IPS-I-EL-215 "Inspection Standards for Potentially Explosive Atmospheres (Hazardous Area)

IPS-M-EL-132 "Material and Equipment Standard for Medium and High Voltage Induction Motors"

3. SAFETY

It is a must that inspection and testing personnel should be fully familiar with the operation of the various equipment that they are called upon to handle.

Electrical equipment is regarded to be capable of giving rise to danger. Access to part which may be live should therefore be prevented preferably by physical means such as locked enclosure, when access for work on or about such equipment is necessary it should be restricted to qualified persons having sufficient technical knowledge to avoid danger. No person should carry out any testing on any part of apparatus which are normally live unless the following steps are taken:

1) The part to be tested to be made dead.

2) Isolated and all practicable steps taken to lock-off from live conductors.

3) Checked where practicable with voltage indicator.

4) In the case of high and medium voltage apparatus, efficiently connected to earth at all points of disconnection of supply to such apparatus.

5) Adjacent equipment screened where necessary to prevent danger, and "CAUTION" and "DANGER" notices affixed.

6) Released for work by the issue of "Permit to Work" where appropriate.

It is the duty of the person issuing the "Permit to Work" to ensure that the foregoing provisions are complied with and that the person carrying out the work is fully conversant with the nature and extent of the work to be done and with the location of equipment which will remain alive.

Before returning the electrical equipment to service, a final check should be made of the complete apparatus to ensure that all parts are in working order.

Tools or appliances that have been employed during the inspection and test should be checked to ensure that none has accidentally been left inside the apparatus, and that all temporary earth conductors and devices have been removed.

Omission of this precaution has been known to cause serious accidents.

Smoking or the exposure of naked flame such as blow lamp is not allowed where there is the risk of gas explosion or fire hazard.

4. FIRST AID

A placard of instructions for the treatment of persons suffering from electric shock should be affixed in a prominent position. It is desirable that all inspection personnel be trained in the application of the artificial respiration.

First aid equipment should be made available for treatment of burns, cuts and abrasions, the address and telephone No. of the nearest Dr., first aid center, or hospital should be prominently displayed on the premises.

5. PERMIT TO WORK

A permit to work is a written authorization to carry out work on or about electrical apparatus, signed by or on behalf of the person or whom the Owner’s responsibility for safety of supervision rests. It should, as a minimum, set out clearly and concisely the apparatus on which the work is to be done, the extent of the work and the precautions which are to be taken to ensure that the apparatus designed is safe to work on.

Permits to work should only be issued by persons specially authorized in writing by the client to do so. The permits should be numbered serially for reference and should be in duplicate. One copy should be retained by the issuer and one copy handed to and signed as an acknowledgment of its terms by the person carrying out or incharge of the work; he should retain it until the work is completed or stopped.

When the work is completed or stopped, the appropriate section of the permit should be signed by the person to whom it was issued and the permit returned to the issuer for cancellation. In those cases where the permit is returned prior to the completion of the work a note to that effect should appear on the permit, and work should not be recommended until a fresh permit is issued.

The apparatus designated in the permit or permits as "dead" must not again be made alive until every permit covering that apparatus has been cleared by the person to whom it was issued and returned to and canceled by the issuer.

When a person authorized to issue permits to work on the apparatus himself, he should complete a permit to work form, to ensure that he is taking the same precautions as he would, when authorizing work by others.

Before carrying test, visual inspection shall be carried out to confirm that the installation and

material are according to the drawing.

6. AC MOTORS TESTS

6.1 Insulation Tests

The earthing of the frame pedestals and any contactor cubicle or switchbox shall be checked with appropriate ohm meter.

An insulation resistance test shall always be made before connecting to the supply, preferably a few days before the motor is required for service to allow time for drying-out necessary.

6.1.1 Megger test for insulation measurement

All accessories, such as surge capacitors, surge arresters, current transformers, etc., that have leads located at the machine terminals shall be disconnected during this test, with the leads connected together and to the frame or core.

6.1.1.1 Voltage test

Insulation resistance test are usually conducted at constant direct voltage of 500-10000 v having negative polarity. Guidelines for test voltage are presented in table 1.

TABLE 1 – GUIDELINES FOR DC VOLTAGES TO BE APPLIED DURING INSULATION RESISTANCE TEST

Winding rated voltage (V)[a]	Insulation resistance test direct voltage (V)
< 1000	500
1000 - 2500	500 - 1000
2501 - 5000	1000 - 2500
5001 - 12000	2500 - 5000
> 12000	5000 - 10000

[a] Rated line-to-line voltage for three-phase AC machines, line-to-ground voltage for single-phase machines, and rated direct voltage for DC machines or field windings.

6.1.1.2 Acceptable insulation resistance values

The acceptable minimum value of insulation resistance measured in 1 minute is listed at table 2.

TABLE 2 – RECOMMENDED MINIMUM INSULATION RESISTANCE VALUES AT 40°C

Minimum insulation resistance (MΩ)	Motor rated voltage (kV)
10	≤ 1
100	> 1

6.1.1.3 Temperature effect

The insulation resistance value of a winding depends upon the winding temperature and the time elapse since the application of the voltage. In order to avoid the effects of temperature in trend analysis, subsequent tests should be conducted when the winding is near the same temperature as the previous test. However, if the winding temperature cannot be controlled from one test time to another, it is recommended that all insulation test value be corrected to a common base temperature of 40°C using Equation (1).

The correction may be made by using Equation (1):

$R_C = K_T R_T$

Where

R_C is insulation resistance (in MΩ) corrected to 40°C

K_T is insulation resistance temperature coefficient at temperature T°C

R_T is measured insulation resistance (in MΩ) at temperature T°C

$$K_T = (0.5)^{(40-T)/10}$$

6.1.2 Measurement of polarization index (PI)

Polarization index (P.I.) is normally defined as the ratio of the 10 min resistance value to the 1 min resistance value.

The recommended minimum value of polarization index is listed at table 3.

TABLE 3 – RECOMMENDED MINIMUM VALUES OF POLARIZATION INDEX FOR ALL MACHINE COMPONENTS INSULATION CLASSES

Thermal class rating	Minimum P.I.
Class A	1.5
Class B	2.0
Class F	2.0
Class H	2.0

Note 1:

If the 1 min insulation resistance value (at 40°C) is above 5000 MΩ, the calculated P.I. may be ambiguous and can be disregarded.

Note 2:

The P.I. test is not applicable to non-insulated field winding.

6.1.3 If measured values for insulation resistance or P.I. are lower than limits specified at tables 1 and 2, the motor shall be dried out.

However machines rated above 10 MVA should have both the polarization index and the insulation resistance above the minimum recommended values at tables 1 and 2.

6.1.4 A final insulation resistance test, including associated switchgear and cables shall be made immediately prior to the first switching on. A value of at least 10 Mega Ohms for LV motors and approximately 50 Mega Ohms for motors at 3.3 KV and above is usual for machines which have not been exposed to damp.

6.2 Drying Out

In general, motors wound for medium voltages are more likely to need drying out than those with LV windings, due to the greater insulation thickness. Also the dry-out period is likely to be longer. The value of insulation resistance to earth measured cold, is not an entirely reliable basis for deciding whether drying-out is essential before energizing. Even if the majority of the insulation is wet, a very slight drying influence will remove the moisture from the other layers and a good value of resistance will be measured.

Once the conductors are warmed by current the moisture will distribute itself through the insulation and the resistance will fall. Therefore a combination of heating and ventilation is necessary for drying-out.

Drying out may be achieved in one of the following ways:

a) A combined electrical heater and fan blowing hot air through the windings.

b) Small heaters may be placed within the frame; some large machines have built in heaters.

c) The motor, with locked rotor, may be connected to a separate low-voltage AC supply. If necessary with a resistor in series, to circulate not more than 80% full load current through the windings.

d) If no suitable AC is available, all windings should be connected in series and supplied from a variable voltage DC source such as a motor-generator or battery charger. Care should be taken to ensure that the heating is not equivalent to more than 80% full load.

In each of the above cases the frame shall be suitably covered to reduce heat losses and permit the insulation to reach a higher temperature. End covers or inspection plates must be removed to permit water vapor to escape, otherwise the moisture will merely be transferred to the cooler parts of the frame.

In cases of (c) and (d), the current shall be continuously measured. In all cases, values of insulation resistance shall be taken every hour until it becomes constant and then rising for number of hours.

With slip ring machines the rotor shall be short circuited during the dry-out, in order to dry the rotor winding at the same time.

Methods (a) and (b) are the safest although they will probably take longer. Methods (c) and (d) must not be used if the windings are very damp.

Method (d) is especially dangerous in this connection, as partial impregnation of the insulation by copper salts formed by electrolytic action is possible.

In general it is far better to ensure that all motors are stored in dry, warm conditions from the moment they are received and if this is not possible, heaters, of quite low rating, placed within the windings together with tarpaulins covering the stator are adequate to preserve the insulation until the motor is needed. Quick high temperature dry outs are not permitted.

Before dry-out of MV & HV motors, the manufacturer instruction shall be considered.

When drying insulation, the P.I. can be used to indicate when the drying process may be terminated, i.e., the P.I. results have exceeded the recommended minimum values indicated at table 3.

6.3 Stator High Voltage Tests

The high voltage test shall be done according to IEC 60034-1 and following condition.

Care shall be taken that all ancillary equipment e.g. V.T.'s, unit transformers, cables etc. are disconnected. Immediately before applying the test voltage a megger check shall be made. The stator test voltage, from an AC source, is (twice the rated voltage + 1 KV) ×0.8, applied for 1 minute.

If no AC source is available the test may be made using DC supply and in this case; the test voltage is 1.7× the equivalent AC test value, applied for one minute.

6.4 Air Gap and Alignment

To avoid eccentric positioning of the rotor in the stator bore, the air gap and alignment shall be checked based on manufacturer instruction. If there is not any manufacturer's recommendation, the below procedure should be followed:

Where large motors with pedestal bearings have to be erected on site the air gap shall be checked in all sectors. The gap should be as stated on the test certificate, with a discrepancy of not more than ±5% in the four sectors.

The gaps which should be measured with feelers extending the whole length of the motor core, and a second set of readings taken with the rotor turned through 90°, where plain journal bearings are fitted and no provision is made to take thrust load, rotor position shall be checked to ensure that excessive rubbing does not occur.

To avoid eccentric positioning of the rotor in the stator bore, the following procedure for air gap check shall be followed:

The air gap checking shall be carried out at 12 O'clock for four sectors by turning the rotor.

6.5 Final Checks and Direction of Rotation

In the case of large motors the pedestals insulating joints, dowel pins and earthing connections shall be checked in accordance with the manufacturer's recommendation. To avoid circulating current resulted from induced voltage from stator core, one side of the pedestal earth connection shall be opened. The transportation brake pads, inside the sleeve bearing shall be removed. Before an initial run is taken as a precaution the overload setting shall be reduced and the time lags removed to ensure rapid tripping. This change of setting shall be carried out in such a way that motor will not trip during start up period.

6.5.1 A complete check of lubricating system shall be carried out for ascertaining:

a) Proper functioning of lube-oil pressure and associated safety devices.

b) Proper fitting of insulating flanges, gaskets and other bypass-oil pipe line fittings, to ensure that the lube-oil supply lines do not bypass the bearing insulation.

Before energizing the motor the terminal nuts and earth connection nuts shall be checked for tightness, also that the terminal box and bushings are free from moisture and dirt. For motors wound for 3.3 KV and above the above checks are most important. The motor bearings shall be checked to ensure that they have been supplied with the appropriate lubricant, as specified by the manufacturer. The motor shall be uncoupled from the driven unit and more reliable indication of the wetness of the windings shall be done.

6.5.2 If the direction of rotation is correct then the motor shall be run for several hours and tests are made for the followings:

a) Proper lubrication of bearings and operation of lubrication, safety pressure switches, if applicable.

b) Free from leakage of lubrication oil from the pedestals and ingress of lube-oil into the stator.

c) Bearing noise or heating.

d) Local heating of windings.

e) Excessive noise or vibration whilst the motor is running to be met IPS-M-EL-132 requirements.

f) Recording no load current and comparing with manufacturer's test certificates.

g) Speed.

6.5.3 The motor shall be coupled to the driven unit and the coupling shrouds fitted for personnel protection; it is most important that the unit does not turn without these. The driven unit bearings are to be adequately lubricated and if applicable, bearing cooling water checked for flow. The motor

shall be run on full load and the speed, temperature, vibration of bearings, full load current and the balance of current in the three phases shall be checked. If motor protection relays are used they shall be checked visually for stability indication.

7. MOTOR PROTECTION

Before commissioning, the motor protection specified in IPS-E-EL-100 shall be tested. Some of these tests such as thermal or magnetic overloads, undervoltage relays, stall relays and differential protection relays are specified as following:

7.1 Operation Tests

7.1.1 Overload protection

At least two suitable current values for relay operation shall be injected into the motor starter and the time taken for the relay to trip compared with the manufacturer's curve.

7.1.2 Undervoltage protection

The minimum relay operating voltage shall be set. The applied voltage shall be reduced until the relay trips. The tripping point shall be compared with set point value.

7.1.3 Differential protection

The polarity of current transformers located inside the feeder shall be checked to be in line with the motor current transformers located inside the motor based on the relevant drawings. To compare current values at both sides of the motor phase windings and ensure proper operation of the relay upon incept of earth/phase to phase fault, all related CTs shall be short circuited one by one and the relay shall operate and trip the motor starter on its respective phase.

7.1.4 Stall protection

The relays trip contacts operation time and the magnitude of the injected current for trip operation shall be in line with the stall protective relays manufacturers supplied curves and the actual motor acceleration time (from standstill to synchronous speed at applied load).

7.1.5 Field application relays

The automatic/manual operation of synchronous motors field supply contacts shall be checked and ensured that the circuit breaker operates at full rated torque.

7.2 Stability Tests

Start the motor several times and note that the relays and trips do not operate. For large motors the number of starts per hour shall be in compliance with manufacturer's recommendations.

8. TRANSFORMERS

8.1 Insulation Tests

Using a 1000 V or 5000 V (as appropriate) insulation resistance test set to make the following tests:

a) Check earthing of tank and the secondary wiring system.

b) MV to LV winding.

c) MV winding to earth.

d) LV winding to earth.

These values shall approach infinity.

e) Check core to tank insulation with 500 V insulation resistance Test Set having first opened the appropriate link or connection. Verify subsequently the integrity of this connection if applicable.

The condition of the oil shall be examined as follows:

a) Crackle test for moisture in oil.

b) Pressure test for breakdown strength based on Clause 15 of this standard.

c) A detailed oil test procedure is given in Clause 15 of this specification. A sample may be requested for an acidity test. The standards covering transformer and switchgear oils are given in: IEC 60296 and IEC 60156.

8.2 Drying Out

A dry out will be necessary, at the discretion of the Engineer, in any of the following circumstances.

8.2.1 If the winding insulation resistance readings are below 200 Mega Ohms.

8.2.2 If the oil has a low breakdown strength.

8.2.3 If the winding has been removed from the tank.

8.2.4 Transformers shipped in dry air or nitrogen should have pressure in them when opened. If there is no pressure left, the winding shall be dried out.

8.2.5 In any event the manufacturer shall be contacted for special instruction before a dry out is carried out.

8.2.6 Drying out may be carried out using a centrifugal purifier, in which a heater unit forms part of the equipment.

In transformers equipped with inlet and outlet pipe for dry out the centrifugal purifier shall be connected according to the instruction manual.

The transformer can be considered "dried out" when the insulation resistance, having dropped initially, rises and reaches a steady value with a constant temperature being maintained.

8.3 Tap Changer Equipment

If off-load manually-operated equipment is installed, this shall be operated several times to ensure freedom of movement, and the voltage ratio checked at each tap. An estimate of the most suitable tap shall be made and the transformer left and locked at this ratio.

If the transformer is provided with on-load remote operated tap changer equipment all the secondary wiring shall be insulation resistance tested and earthing of cubicles and bonding verified. The voltage ratio on each tap shall be checked and several runs over the complete tap range made in quick succession.

8.4 Cooling Equipment

If provided, the oil circulation and cooling pumps and fans shall be tested, especially any automatic start arrangements.

8.5 Measurement of Voltage Ratio and Check of Voltage Vector Relationship

According to IEC 60076-1, the voltage ratio shall be measured on each tapping. The polarity of single phase transformers and the connection symbol of three phase transformers shall be also checked. If a voltage measurement is used, the voltages of both windings shall be measured simultaneously.

8.6 Measurement of No Load Loss and Current

Measurement of no load loss and no load current shall be done according to IEC 60076-1.

9. TRANSFORMER PROTECTION

Some or all of the following protection systems are usually provided for transformers:

- Differential
- Restricted Earth Fault
- Overload and Earth Leakage As Back-up
- Buchholtz
- Temperature
- Sudden Pressure
- Standby Earth Fault Relay

Before commissioning, the following tests are required at the discretion of the Engineer:

9.1 Operation Tests

9.1.1 Differential protection

According to relay manufacturers publication the polarity of the current transformers should be checked and AC current shall be injected through each current transformer and the tripping of the differential protection relay is to be noted.

9.1.2 Restricted earth fault

After polarity check as above, AC current shall be injected into the neutral current transformer and the tripping of the restricted earth fault relay is to be noted.

9.1.3 Overload and earth leakage

AC current shall be injected into one CT and a short circuit placed on the earth leakage coil. For various values of primary current note the times required for the overload relay to operate. Remove the short circuit from the earth leakage coil and short the overload coils. For various values of primary current note the times required for the earth leakage relay to operate. The setting of time multipliers shall be done according to manufacturer instruction.

9.1.4 Temperature detector device

The temperature detector device shall be checked according to manufacturer instruction and test procedure.

9.2 Stability Tests

9.2.1 Differential

A short circuit shall be placed on the three phases outside the protected zone. The current shall be built up to full load, at which value the relay should not operate and the low impedance milliammeters placed in circuit should not read more than allowed current out of balance.

9.2.2 Restricted earth fault

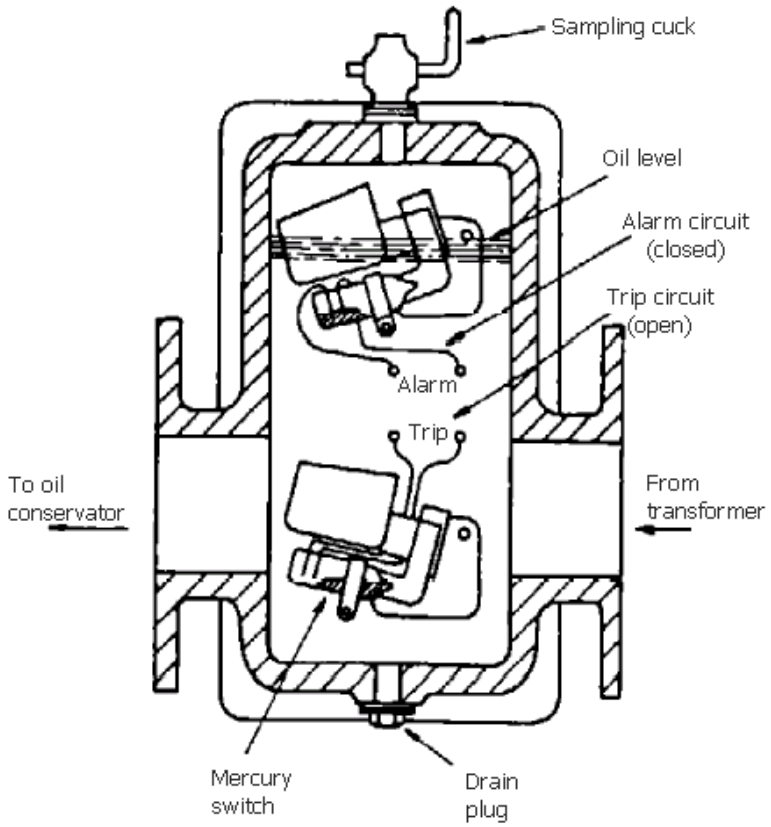
Inject current through a phase CT and the neutral CT and check that no spillover occurs in the earth leakage element. Repeat for each phase.

9.2.3 Overload and earth leakage

Set the overcurrent relays setting at 50%; 75% and 100% repeat 9.2.1, bring up the current, note the tripping of the overcurrent relays and also that the time for operation is appropriate and in compliance with the manufacturer recommendation.

9.3 Buchholtz Relay

Tests to be carried out in accordance with Appendix F, Sheet 1 of 3. The typical illustration of buchholtz for power transformer is as follows:



BUCHHOLTZ

Fig. 1

10. GENERATORS

10.1 Inspection

A visual inspection shall be made to verify the correct air gap, that bearings are free and that the lubricating system is free of dirt and foreign matter.

10.2 Drying Out

10.2.1 Where necessary dry out shall be accomplished before a new generator is run up and excited to full voltage.

Even if a cold insulation resistance test shows a high value of insulation resistance, there may be moisture trapped which will be released during the initial heating of the coils.

10.2.2 The makers instructions for drying out shall always be followed. The normal method is to run the alternator on short circuit at full rated current and reduced speed when applicable so heating both stator and rotor windings.

10.2.3 Where a very low exciter current is required a close watch should be made to ensure that the excitation and short circuit currents do not rise due to exciter instability.

10.2.4 Generally

For medium voltage generator (11 kV upward) the following insulation resistance figures are experienced, exciter field not less than 100 Mega Ohms generator stator not less than 200 Mega Ohms, and generator rotor not less than 50 Mega Ohms. For measuring the stator and rotor insulation resistance a 2500 Volt and 500 Volt insulation resistance test sets may be used respectively.

10.2.5 For 3.3 KV and 6.6 KV generators use 1000 Volt and 500 Volt insulation resistance test sets for stator and rotor respectively.

10.2.6 During drying out, the correct function of thermocouples and alarm systems, if provided shall be noted.

10.3 Short Circuit Curve

If requested by the Engineer and since the necessary connections are already made, the dry out is to be followed by a test to ascertain the short-circuit characteristic of the generator. The relationship between the stator current in all three phases and the field current shall be plotted for a series of values. This should normally be carried out at full speed, although small speed variations will be insignificant. The values of stator current for each phase must be closely comparable.

10.4 Stator High Voltage Tests

The high voltage test shall be done according to IEC 60034-1 and following condition.

Care shall be taken that all ancillary equipment e.g. V.T.’s, unit transformers, cables etc. are disconnected. Immediately before applying the test voltage a megger check shall be made. The stator test voltage, from an AC source, is (twice the rated voltage + 1 KV) ×0.8, applied for 1 minute.

If no AC source is available the test may be made using DC supply and in this case; the test voltage is 1.7× the equivalent AC test value, applied for one minute.

10.5 Phase Sequence

Before phasing in, it is essential to ensure that the phase sequence of the incoming alternator and

the bus bars are the same by either:

a) Phase sequence indicator

b) Synchroscope

c) Lamps

11. GENERATOR PROTECTION

Some or all of the following protection systems are usually provided for alternators:

- Differential protection
- Negative Phase Sequence (NPS)
- Exciter field failure protection
- Overcurrent and earth leakage as back up
- Interturn protection to machines with windings
- Reveres power
- Protection against exciter field earth fault
- Over temperature
- Overvoltage and undervoltage protection
- Unbalance load
- Generator ground relay

Before commissioning a generator, the following tests are required, at the discretion of the Engineer:

11.1 Differential Protection Primary Injection Tests

AC current shall be injected through each terminal so that it energizes one current transformer only and the tripping of the corresponding differential protection relay shall be noted.

11.2 Trip Tests

Close field switch, main generator and earthing circuit breakers with jumpers plugged in, and carry on as follows.

11.2.1 Push the emergency stop button, if provided, and all three above mentioned switches should trip.

11.2.2 Operate the differential protection and NPS (Negative Phase Sequence) relays manually, all switches should again trip. Operation of the differential protection relay should also usually trip the circulating air fan and steam emergency stop valve if provided.

11.2.3 Operate overcurrent relays manually. The main generator circuit breaker should trip.

Note:

The overcurrent relays may be designed as backup to differential protection in which case they should trip the same circuits as the differential protection.

11.2.4 Operate the auto fire fighting relay (if provided for packaged generator) all switchgears and drive control system should trip.

11.3 Fault Tests

11.3.1 Phase fault tests

A short circuit shall be made between two phases within the protected zone. (In the case of generator transformer until the protected zone is extended to include the primary and secondary windings of the main transformer). Current shall be increased by the exciter rheostat until the corresponding differential protection relays operate.

11.3.2 Earth fault tests

One phase in the protection zone shall be connected to earth and the excitation shall be gradually increased until the corresponding differential protection relay operates. The value of the fault current to produce relay operation should be in accordance with the manufacturer's specification, generally this is about 15% full load current.

11.3.3 Field fault

The main field terminal shall be disconnected or earthed and, if provided with an alarm, the appropriate signal noted.

11.4 Stability Tests

11.4.1 A short circuit shall be placed on the three phases outside the protected zone. The current shall be increased to full load, at which value, the NPS (negative phase sequence) and differential protection relays should not operate, and the low impedance milliammeters in the differential protection circuits not read more than allowed current out of balance.

11.4.2 Set the overcurrent relays setting at 50%, 75%, and 100%, repeat 11.4.1, increase the generator current, note the tripping of the over current relays and also that the time for operation is appropriate to these settings. The setting of the overcurrent relays shall be high enough to act as back-up to the differential protection relays and not operate on normal overload conditions.

11.4.3 Connect any two phases together or each phase to earth, outside the protected zone. Increase the current to more than the NPS setting and note that the NPS relay trips.

Note:

When carrying out fault tests and stability tests on a turbo-alternator, run the machine with reduced rpm to prevent overheating of the turbine exhaust hood where applicable.

12. CIRCUIT BREAKERS (Oil Circuit Breakers)

12.2 Electrical Inspection

Test the insulation resistance of main conductors with V.T.'s removed using a 1000 Volt megger and check the insulation resistance approaches infinity.

12.3 Electro-Mechanical Inspection

Clean off all protective greases and dust from the mechanism and contacts. Very slight lubrication should be applied to fulcrums and joints. Excessive lubrication must be avoided as this will lead to dust traps and the lubricant may become plastic at low temperatures. In all cases it is advisable to refer to the manufacturer's instructions before lubrication.

Check the busbar joints nuts and bolts once again according to manufacturers' specification before insulating with material such as exposy resin and PVC encapsulation is applied.

The breaker should close with 80% normal closing voltage and trip with 50% normal voltage. Tap the batteries to check operation at these reduced values.

12.4 General Examinations

Examine all auxiliary switches and contacts for adequate pressure, and robust construction and fitting. Check nuts for tightness, and cable lugs for efficient fitting. An approved method of fixing a cable lug to a terminal is to lock the lug between two nuts onto a stud in the terminal bar. In this way the expansion and contraction of the bar will not slacken the nuts. Operate all circuit breakers, isolators and other switches to ensure that the indicating devices show their correct position. Examine all switchgear earthing considering Clause 19 of this standard.

13. HIGH VOLTAGE TESTING

13.1 Circuit Breaker

The AC test voltage shall be carried out on circuit breaker according to table indicated below if the cables are not connected; the switchgear, busbars and CT chambers may be tested together. If the cables are connected, then the switches must be isolated and tested separately. The CT chambers and spouts shall be tested as part of the cable, subject to approval of the switchgear manufacturer. Tests shall be made as follows:

a) Each phase to earth to be tested while the other two phases earthed.

b) Across the circuit breaker contacts. All the phases shall be joined together on each side of the contacts and the voltage applied between the busbars side and the cable box side.

The circuit breaker frames must be earthed during all the tests. The secondary windings of the C.T.'s shall be short circuited. If the CT chamber and cable box are included for test with the cable a DC source will be used. This shall be applied for 15 minutes and should be in accordance with the reduced voltages for cables given in the IEC 60502-2. (The switchgear manufacturer must give approval before making this test.) After HV testing, all parts must be discharged to earth before handling, and finally insulation resistance test, described in section 12.2 shall be carried out. Pressure tests at power frequency shall be carried out on high voltage circuit breaker and fuse switches at set out in IEC 62271-1 and IEC 62271-100.

Test Voltage (rms) (new equipment only)	Test Voltage (rms) old equipment only	Voltage of Equipment kV (rms)
28,000	18000	12
20,000	11400	7.2
10,000	6400	3.6

13.2 Cables

Before testing, all cable boxes shall be visually inspected to ensure that they are free from moisture and dirt, and that any filling compound is at the correct level. It should be noted however that when selecting a conductor size for use in a motor circuit it should be chosen so that the voltage at the terminal of the motor-when running under full load is in compliance with IPS-E-EL-100. Additionally it is essential that the cables specified in this standard shall be installed only when both cable and ambient temperatures are above a temperature of 0°C and have been so kept for the last 24 hrs. or when special precautions have been taken to maintain the cable above this temperature to avoid risk of damage during handling. Also none of the cables specified in this standard shall be bent during installation, to a radius smaller than the following values: agreeing with IEC 60502-2.

13.2.1 For cables of 3.3 kV and below by use of 500 V megger, an insulation resistance test should

always be made lasting two minutes but in any event until a stable value is indicated. If the insulation resistance is low, the leakage current will be large compared with the capacitive current and the final reading will be reached immediately. If the leakage current is small, and since the capacitive current takes some time to reach its final value, the instrument will not give an accurate reading until a sufficient time interval has passed. The value of insulation resistance should approach infinity.

13.2.2 Above 3.3 kV the cable shall first be insulation resistance tested and then pressure tested in accordance with the following table.

TEST VOLTAGE AFTER INSTALLATION

1	2	3	4
VOLTAGE DESIGNATION	**TEST VOLTAGE (d.c) BELTED CABLES**		**SINGLE-CORE AND SCREENED CABLES**
	Between conductors	Between any conductor and lead or lead alloy sheath	Between any conductor and lead or lead alloy sheath
	Volts	Volts	Volts
600/1000	3500	3500	3500
1900/3300	10000	5800	6000
3800/6600	17000	9800	10000
6350/11000	25000	14400	15000
12700/22000	---	---	30000
19000/33000	---	---	45000

Note:

The voltage applied shall be equal to SKV per millimeter of specified thickness of oversheath subject to a maximum of 25 kV.

13.2.3 Voltage tests on cables with higher ratings than these tabulated are generally made using a DC voltage is given by (2×system line voltage). The voltage in all cases must be applied gradually and maintained for 15 minutes. After a DC test the cable must be earthed for at least five minutes before it is handled, otherwise a high voltage can appear at the conductor due to the energy stored in the dielectric during testing.

13.2.4 Multicore cable sheaths shall be bonded to earth in all cases for testing.

13.3 Termination and Joints

The AC voltage withstand test (between earth and conductor) for terminations and joints for 6 kV to 30 kV power cables shall be carried out with $4.5U_0$ during 5 minutes for AC test and $4U_0$ during 15 minutes for DC test, according to IEC 60502-4.

13.4 Busbars and Busbar Connections

Busbars and busbar connections shall be tested for one minute with alternating current of any available frequency between 25 Hz. to 100 Hz. and approximately of sinusoidal wave. This power frequency voltage shall be applied to all connections and joints as in service. The rms test voltages shall be as given in table below:

As an alternative to the power frequency voltage, a test with a.c. at a voltage not in excess of values given below and test duration of 15 minutes shall be carried out.

BUSBARS AND BUSBAR CONNECTIONS TEST VOLTAGE AFTER ERRECTION ON SITE		
Rated Voltage KV	**Test Voltage AC KV**	**Test Voltage DC KV**
Up to and including 0.6	2.0	3
3.3	8.6	5
6.6	15.2	10.5
11.0	24.0	18.0
15.0	32.0	25.0
22.0	46.0	37.5
33.0	68.0	60.0

14. INSTRUMENT TRANSFORMERS

14.1 Current Transformers

The ratio & polarity shall be checked. Never open-circuit a current transformer when on load, since the primary current does not fall in value but continues to flow and is in effect all magnetizing current. This causes excessive flux densities which give rise to a high secondary voltage, especially when the CT ratio is high, which can be fatal to life. In addition the increased flux can cause overheating, permanent magnetization and failure of the CT insulation. Therefore a check should always be made that the secondary circuit is complete or short circuited before energizing the primary. If a number of CT's are balanced to operate a residual circuit and the other CT's are not subjected to such a heavy burden, they will deliver their correct current and a false residual current will flow through the earth fault coil so causing operation.

14.2 Voltage Transformers

The ratio and polarity shall be checked. If VT's are supplied in oil, drying out will not be necessary unless moisture has penetrated the tank. If VT's are supplied for air insulation a megger test shall be taken and if below 100 megohms on the MV winding, drying out is necessary. MV and LV fuses shall be checked for continuity. Check that there are no parallel circuits on the LV side which can feed back when the VT is out of commission, so making the MV connections live.

This situation can arise from synchronizing frequently. Always open the VT isolator as well as the main isolator when rendering any apparatus dead.

15. TESTS FOR TRANSFORMER OIL

Refer to IEC 60296 and IEC 60156.

15.1 Crackle Test for Moisture

On site, new insulating oil shall be tested for moisture. To accomplish this test pour enough oil into a clean, dry test tube about 125 mm long and 12.5 mm in diameter to fill it to one-quarter of its depth the temperature of the oil shall be 15-25°C. The tube is then heated rapidly in a silent flame until the oil begins to boil; if any audible cracking occurs then water is present. For general procedure for handling, reconditioning, replacing and disposing of insulating oil refer to IEC 60422. Further more, it shall be noted that the use of non-flammable liquids which contain PCB shall be avoided.

15.2 Electrical Tests

15.2.1 Out line of method

The oil is subjected to an AC electric field with continuously increasing voltage, until the oil breaks down.

15.2.2 Test cell

The cell, made of glass or plastic shall be transparent with an effective volume of between 300 ml. and 500 ml. and preferably fitted with a suitable lid.

15.2.3 Electrode

The copper, brass, bronze or stainless steel polished electrode shall be spherical (12.5 mm-13.00 mm diameter) the electrodes are to be mounted at horizontal axis and are 2.5 mm apart.

16. EQUIPMENT FOR USE IN HAZARDOUS AREAS

All equipment to be installed in hazardous areas shall be inspected to ensure:

a) Selection of equipment in compliance with the design IP codes and IEC standard.

b) That the flame proof and explosion proof covers fully bolted and secure.

c) That cable glands Ex types and ingress protections (IP code) are fully achieved.

It is to be noted that since many types of cable glands can be made available at site, care shall be exercised to use suitable glands to meet the proper material, finish and entry threads. Additionally, it is the construction Engineer responsibility to ascertain that the application of cable glands within hazardous area will not cause danger, and ultimately in line with the area classification rules and established regulations, proper workmanship is implemented.

Note:

For precommissioning test of electrical apparatus in potentially explosive atmosphere see also IPS-I-EL-215.

17. BATTERIES

All batteries shall be properly prepared and charged by strictly following the manufacturers step by step recommendations. The following important points shall be taken care during installation and charging process:

17.1 Lead Acid Batteries

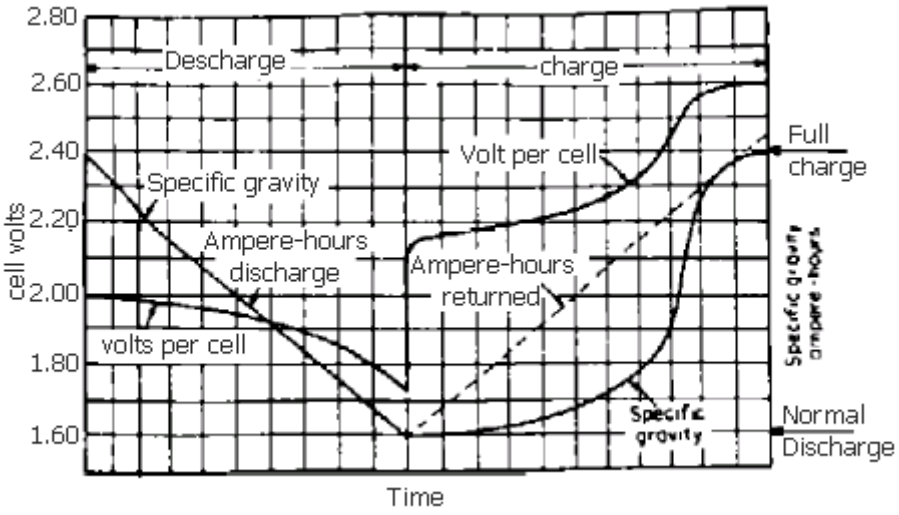
17.1.1 For preparation of dilute sulfuric acid (H_2SO_4), add the concentrated sulfuric acid to distilled water according to instruction of manufacturer.

Caution:

Never add distilled water to concentrated sulfuric acid because considerable heat will be generated from this operation which can be dangerous to the surrounding.

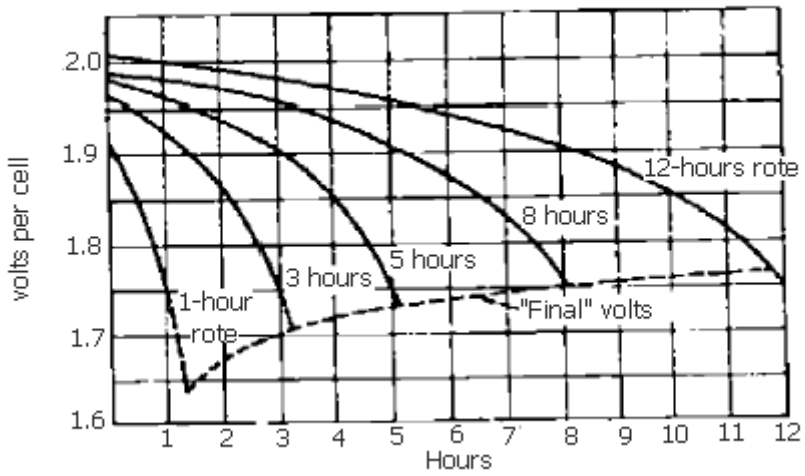
The charge and discharge typical curves showing the electrolyte specific gravity and voltage characteristics in the process as well as the chemical formula of lead acid batteries are shown in Figs. 2 and 3.

$$Pbo_2 + pb + 2H_2so_4 \underset{CHARGE}{\overset{DISCHARGE}{\rightleftharpoons}} 2pbso_4 + 2h_2o$$



PERFORMANCE CHARACTERISTICS OF LEAD-ACID BATTERIES

Fig. 2



DISCHARGE CURVES OF LEAD-ACID BATTERIES AT DIFFERENT HOUR RATES

Fig. 3

17.1.2 The following ranges of specific gravity shall be used for the applications specified below:

1.275 For heavily worked or "cycled" batteries such as electric industrial trucks.

1.260 Automotive service.

1.245 Large engine starting batteries etc.

1.210 Batteries in stationery stand-by or emergency service.

Further more the open circuit voltage of each cell shall be in accordance with the following formula: volts/cell = specific gravity + 0.84 thus the open circuit voltage of a cell with a specific gravity of 1.210 will be 2.05 Volt; one with a gravity of 1.280 will be 2.12 Volt. Therefore during charging process those cells which do not follow the above voltage build up formula, shall be considered as defective.

17.1.3 Where batteries are used for switchgear operation, the discharge capacity shall be checked

to see that the circuit breaker may be operated within the limits shown in the typical curve in 17.1.1 above or specified in IEC 62271-100 without over discharging.

17.2 Alkaline Batteries

The preparation procedure published by the battery manufacturer shall be followed strictly.

The electrolyte used in Nickel/Cadmium batteries shall be a solution of potassium hydroxide with a density of 1.18 to 1.23 g/ml. This solution may also contain lithium hydroxide in amounts varying from 15-50 g/l. This addition will improve the cycle life of the positive plates, especially at elevated temperatures.

The electrolyte used in Nickel/Iron batteries shall be a mixture of potassium hydroxide and lithium hydroxide solutions.

The lithium addition is mainly made because of its stabilizing effect on the capacity of the nickel electrode during cycling.

Typically the composition of the electrolyte is 240 g/l of potassium hydroxide and 50 g/l of lithium hydroxide, corresponding to an electrolyte density of 1.23 g/ml.

17.2.1 Charge characteristics

The charge efficiency can be defined as the ratio of the output of a battery to the input required to restore the Capacity. The charging system of nickel cadmium batteries can be defined as under:

a) Constant current charging.

b) Constant potential charging.

c) Modified constant potential charging with current limitation.

When instructed by the manufacturers of batteries (a) and (b) above can be used in conjunction with the supplied curves, but as an established standard, method (c) shall be used. By this method, the current is often limited to 0.4 × CA or less and the constant potential range used is 1.50-1.65 V.

18. RECTIFIERS AND INVERTERS

18.1 Before energizing the static inverter, all connection and components shall be checked for good and sound termination and secure fixing, the electrolyte type capacitors shall be checked for polished and clean surface with free from electrolyte leakage.

18.2 Check for cleanliness and tightness of all terminals and wiring. In relay and control panels in addition to the manufacturer’s instructions.

18.3 Check that fuses and links inserted, are properly rated and in sound condition.

18.4 Ensure that panels are free from vibration, and that no objects or local heat source obstructs adequate ventilation. Check contact pressure in regard to all auxiliary switches.

18.5 Rectifier units shall be checked for polarity by a direct current battery and a galvanometer set. Insulation resistance test sets shall not be used as the high voltage will be detrimental.

18.6 Rectifiers can be tested with a resistance meter, provided that the battery voltage exceeds 3 Volts. Selenium rectifiers shall show a high resistance in one direction, low resistance in the other. Silicon controlled rectifiers shall show a high resistance for anode to cathode in both directions.

18.7 Check all supply polarities as a reversal can cause damage on inverters.

19. EARTHING

19.1 Check continuity of earth conductors.

19.2 The resistance measured between the earth terminal and all parts of equipment liable to be made live due to an insulation fault must not exceed 0.1 ohm.

19.3 Measure the earth electrode resistance by an earth tester. The value shall not exceed that specified on the drawings.

19.4 Earthing of Apparatus in Power Stations

All metallic parts in proximity to live metal must be efficiently earthed. In areas where flameproof equipment is required all metalwork must be earthed including metal window-frames and doors. The resistance measured between the point of connection of the earth continuity conductor to earth and any other point must not exceed 1 ohm.

19.5 Lightning Conductors

When a lightning conductor is first erected, and scaffolding is available, its resistance shall be measured by an insulation resistance earth test set.

According to the IPS-E-EL-100, the maximum resistance of the earth connection for protection of structures against lightning (one or more electrodes in parallel) is 5 ohms.

20. SMALL WIRING FOR LIGHTING AND POWER

a) Check that all earth sockets in 3-pin outlets are connected to earth.

b) Check that all phases in single pole switches are connected in the phase.

c) Check the insulation resistance of the completed installation:

1) Between phase and neutral with all apparatus disconnected;

2) Between phase and neutral to earth with all apparatus connected.

The value in each case shall not be less than 50 divided by the number of outlets, in Mega Ohms however it shall be more than 1 Mega Ohm, for the whole installation.

21. OVERHEAD TRANSMISSION AND DISTRIBUTION LINES

21.1 Inspection of Lines (Check List)

Check the following: for compliance with construction drawing proper installation and correct functioning.

DESCRIPTIONS	CONDITION	REMARKS
21.1.1 Phasing and phase marking 21.1.2 Continuity of line conductors 21.1.3 arrangement of transpositions (if any) 21.1.4 Continuity of shield wire/cable 21.1.5 Straightness of towers and/or poles 21.1.6 Sign of cracks in insulators 21.1.7 Sign of cracks in arresters 21.1.8 Arc horns 21.1.9 Anti vibration dampers 21.1.10 Guy wires 21.1.11 Anchores 21.1.12 Sign of over-tensioning 21.1.13 Cross arms 21.1.14 Ganged operated switch fuses 21.1.16 Earthing switches 21.1.17 Sectionalizing switches (if any) 21.1.18 Anticlimbing devices 21.1.19 Danger signs 21.1.20Dangermarkingballsinroadcrossing (if any) 21.1.21 Any indication of unexpected hazard 21.1.22 Tower or poles numbering plates 21.1.23 Earthing of lightning shield and wiring 21.1.24 Any sign of washout in foundations 21.1.25 Sign of insulators swing 21.1.26 Any sign of uplift 21.1.27 Any sign of corrosion on towers or poles 21.1.28 Any deviation from route profile 21.1.29 Gantries arrangement and safety 21.1.30 Adequacy of lighting installations and safety of lamp changingin terminal stations 21.1.31 Adequacy and safety of access road		

Signature	Date	Signature (Client)	Date

DESCRIPTIONS CONDITION REMARKS

21.1.1 Phasing and phase marking

21.1.2 Continuity of line conductors

21.1.3 Arrangement of transpositions (if any)

21.1.4 Continuity of shield wire/cable

21.1.5 Straightness of towers and/or poles

21.1.6 Sign of cracks in insulators

21.1.7 Sign of cracks in arresters

21.1.8 Arc horns

21.1.9 Anti vibration dampers

21.1.10 Guy wires

21.1.11 Anchores

21.1.12 Sign of over-tensioning

21.1.13 Cross arms

21.1.14 Ganged operated switch fuses

21.1.16 Earthing switches

21.1.17 Sectionalizing switches (if any)

21.1.18 Anticlimbing devices

21.1.19 Danger signs

21.1.20 Danger marking balls in road crossing (if any)

21.1.21 Any indication of unexpected hazard

21.1.22 Tower or poles numbering plates

21.1.23 Earthing of lightning shield and wiring

21.1.24 Any sign of washout in foundations

21.1.25 Sign of insulators swing

21.1.26 Any sign of uplift

21.1.27 Any sign of corrosion on towers or poles

21.1.28 Any deviation from route profile

21.1.29 Gantries arrangement and safety

21.1.30 Adequacy of lighting installations and safety of lamp changing in terminal stations

21.1.31 Adequacy and safety of access road Signature Date Signature client Date

21.2.3 Clearance from power lines.

21.2.4 Clearance from gas lines.

21.2.5 Clearance from oil lines.

21.2.6 Clearance from water lines.

21.2.7 Clearance from rivers.

21.2.8 Clearance from bridges.

21.2.9 Measurement of sag At every one kilometer the depth of sags shall be measured (using stop watch or any other approved methods). Depth of sag shall be compared, with sag in "SAG-TENSION" data sheet for the span under test, and temperature of time of measurement.

21.2 Measurements

The following measurements shall be made during inspection:

21.2.1 Clearance from crossings

21.2.2 Clearance from buildings

21.3 Tests

21.3.1 Continuity of all dropper lightning earth bars or wires.

21.3.2 Earth resistance at foundation of towers.

21.3.3 Pressure test on transmission and distribution lines shall be in accordance with Tavanir current procedure.

21.4 Precautions During Test

21.4.1 Isolate lines on both ends while electrical tests are carried out.

21.4.2 Discharge lines to earth before and after test (this is very important from safety point of view).

21.4.3 No work shall be carried out on transmission and/or distribution lines when there are signs of

storm and or lightning.

21.4.4 Only sound ladders to be used while inspection is carried out and the ladder shall be tightened to tower by appropriate rope.

21.4.5 Safety belts, electrical safety helmets, safety shoes and safety gloves shall be used wherever required.

22. GUIDANCE FOR PROTECTION

22.1 Testing of Relays and Protection Schemes

The high standard of performance of modern protection arises from the comprehensive testing of equipment which has led to understanding of many of the complex processes which occur when the system is disturbed. It is not always understood that testing is of several distinct categories, each having distinct functions and requirements.

22.2 Test at Manufacturing Works (Informational)

a) Type testing

A new design of relay or scheme is subjected to stringent testing before it is put into production. The object is to prove the design in all respects and to determine all relevant characteristics. To this end, the relay is assembled with all ancillary components including measuring transformers, leads simulated by resistors, pilots where relevant, simulated by a network of resistors, reactors and capacitor of sufficient complexity to reproduce typical line characteristics, and any other special items that may apply to a particular case.

The equipment is connected together to form the complete scheme and is then tested by the application of current which is of magnitude to cover the range of application taking into account the current transformer ratio, and which also has transient characteristics similar to those experienced in service.

Performance is examined with respect to sensitivity, operating speed and stability (where relevant). Burdens, self-heating, contact performance durability and insulation are examined. The equipment is also tested critically with regard to such environmental conditions as the permissible ambient temperature range, the effect of frequency deviation and the resistance to mechanical shock and vibration. Part of such testing is the assessment of the range of errors and the tolerancing of components. Such testing is very expensive; it may occupy several weeks or even months and requires extensive, specialized and high power plant. It is intended to be performed only once for each scheme. The results of the tests are recorded as a permanent reference.

b) Calibration

Each relay manufactured is tested. This is a process not of design proving, but of adjustment, and is therefore to be ranked as a manufacturing process. Hence the tests applied may not have any direct relation to the normal service of the item in question; they are satisfactory provided they enable the equipment to be brought into a standard condition, the tests being chosen for their suitability and convenience in achieving this object.

22.3 Testing at Site

Commissioning:

Unlike a self-contained piece of apparatus which may be expected to function correctly as received, a protection system may require many interconnections with remote parts of the station or even beyond. The complete protection system may comprise the relays and ancillary equipment mounted on the relay board, current and voltage transformers, auxiliary switches in the primary switchgear, DC. power supplies and tripping connections, with interconnections to other stations to complete a 'unit' system or for intertripping or indication purposes.

Clearly, such a complex system of equipment and connections which must be completed on site, should be proved to be correct before the equipment can be considered fit for service. It is necessary, therefore, to carry out such examination and testing as are needed to prove that:

a) All times of equipment are undamaged by transport and handling;

b) The correct items are connected together, e.g. the correct set of CTs is connected to a given set of relays;

c) All connections, including leads and pilots to remote equipment and panel wiring are correct;

d) The correct settings and/or other adjustments are applied according to the design of the protection scheme and the requirements of the primary system.

It will be clear from the above that any degree of type testing has no place in normal site work. Setting aside special site tests which are occasionally planned to investigate conjunctive operation with power plant on a scale which is not readily feasible in a laboratory, attempts to measure detailed relay characteristics on site are likely only to produce misleading results and may result in damage to the equipment. In general, the test equipment for site use, which essentially has to be portable, is unsuitable for detailed investigations, whilst all too often limitation of the facility of operation leads to high current values being sustained for excessive periods. It must always be remembered that relays may be continuously rated only at the maximum continuous current of the circuit and with currents of magnitude corresponding to system faults they may be very short rated.

After visual examination to check that all appears to be in order, a relay should be checked by injection testing to show that it is undamaged.

APPENDICES

CHECK LISTS AND / OR TEST SHEETS

APPENDIX A

INDUCTION MOROTS TESTS AND PHYSICAL CHECKS

Ref. Drawings no.	**Date**	**Revision**	**By**	**Check**	**Approvals**			

Induction Motors (Sheet 1 of 1)
Tests and Physical Checks Location on Site:

Motor Ref. No.	Motor Serial No.	Hp.	FLC	Tests				Checks		Signature	Date	Signature	Date
				Insulation Mega Ω	Light Run (hrs)	Bearings		Cable Term.	Rotation				
						DE	NDE						

Signature	Date	Signature (Client)	Date

APPENDIX B

MOTOR CONTROL CENTER

Ref. Drawings No.	Date	Revision	By	Check	Approvals			

Motor Control Center
Physical Checks and Insulation Resistance Test Sheet (Sheet 1 of 2)

Motor Control		Manufacturer	
Service Volts		Location on Plant	

These Checks to Include Motor Control Center and Remote Control Unit		Signature	Date	Signature Client	Date
Busbars Secured					
Terminal Secured		Pressure Test			
Nuts and Bolts Secured		Equipment	Voltage	Test Voltage	
Operation of Isolators					
Operation of Circuit Breakers					
Operation of Contactors					
Operation of Switchfuses					
Operation of Auxiliary Contacts					
Operation of Associated Relays					
Operation of Local Pushbutton and Resets					
Operation of Indicator Lights					
Operation of Meters		Equipment	Insulation Resistance Mega Ω		
Main Cable Termination and Marking					
Control Cable Termination and Marking			R-E	Y-E	B-E	R-B	R-Y	Y-B
Designation Labels Correct		Phase Bars and Wiring						
Remote Alarms or Indications		Aux. Wiring						
Remote Control Unit Secured and Weatherproofed		Motor Cable						
Operation of Remote Control Devices		Control Cable						
Operation of Remote Ammeters								
Earthing Connection and Continuity								

Signature	Date	Signature (Client)	Date

(to be continued)

APPENDIX B (continued)

Ref. Drawings No.	Date	Revision	By	Check	Approvals			

Motor Control Center Primary Injection Test Sheet									(Sheet 2 of 2)	
Switchgear Ref.			Manufacturer							
Service Volts			Location in Plant							
Contactor Duty	Motor HP	Motor FLC	HRC Fuse	AMM. C/T Ratio	O/L C/T Ratio	105% Test Amps	Set Trip Time	115% Test Amps	Set Trip Time	Remarks
Switchfuse Duty	Switch Rating		SPN/TPN		Fuse Rating					
							Signature	Date	Signature (Client)	Date

APPENDIX C

RELAY TEST SHEET

Ref. Drawing No.	Date	Revision	By	Check	Approvals			
Relay Test Sheet Location on Site							(Sheet 1 of 1)	
Relay Serial No.				Motor No.				
Relay Setting	%Load to Trip		%	Motor Rated Power				
	Plug Setting		%	Motor Voltage				
	Instantaneous Trip		Time	Motor Full Load Amps				
Current Transformers Ratio				Motor Starting Amps				
Test		Current (Amps)	Time (Sec)	Signature	Date	Signature Client		Date
Start Curve								
Running Curve				Note: Instructions of Manufacturer shall be Fully Adhered to during Test				
Single Phasing	R & Y							
	B							
	R & B							
	Y							
	Y & B							
	R							
Earth Fault								
Instantaneous Trips								
Signature		Date		Signature (Client)		Date		

APPENDIX D

THERMAL OVERLOAD TEST SHEET FOR MOTOR STARTERS

Ref. Drawing No.	Date	Revision	By	Check	Approvals

Location on Site……

(Sheet 1 of 1)

Motor
Make……RPM……F.L.C……..Ampere
Type…… Frame……...voltage……

Starter
Make……Type
Rating……

Overcurrent Test:

Director C.T. Operated	Current Rating Ampere	Test Current Rating Ampere	Trip Time From Curve In Second(s)	Trip Time Actual in Second(s)
Cold……	……	……	……	……
Hot……	……	……	……	……

Earth Fault Test: (Where Applicable)
Injected Current…… Ampere
Tripping……..Time……..Second(s)

Ammeter test:
C.T. Ratio……..……Injected Current……Ammeter
Rating……..

Signature	Date	Signature (Client)	Date

APPENDIX E

OVERCURRENT AND EARTH FAULT RELAYS TEST SHEET

Ref. Drawing No.	Date	Revision	By	Check	Approvals			

Location on Site …… (Sheet 1 of 3)

1. Overcurrent Relay
Make & Type……Serial No. …… Rating ……...
1.1 Minimum Operating Current:

Current Setting%

50	75	100	125	150	175	200
Red phase ……						
Yellow ……						
Blue ……						

2. Earth Fault Relay:
Make& Type……..Serial No. ……Rating ……
2.1 Minimum Operating Current:
Setting%.....
Operating……...

Signature		Date		Signature (Client)		Date	

(to be continued)

APPENDIX E (continued)

Ref. Drawing No.	Date	Revision	By	Check	Approvals			

Location on Site …… (Sheet 2 of 3)

3. Timing Test:

Overcurrent Relay at 2x…..%

Earth Fault Relay at 2x……%

From Curve	Actual	Reset Time from
0.5 Max. Time	0.5 Max. Time	
Max. Time	Max. Time	

4. Indicating Ammeters:

C.T Ratio ……..

Inject current (amp): R……. Y……. B…….

Indicated Amp R……. Y……. B…….

5. on load current measurement:

Load amps:

R..... Y..... B……

6. Restricted Earth Fault Relay:

Make & type……Serial No. ……

Rating……

6.1 Maximum Operating Current:

Setting %……..

Operating Amps……

Signature	Date	Signature (Client)	Date

(to be continued)

APPENDIX E (continued)

Ref. Drawing No.	Date	Revision	By	Check	Approvals			

Location on Site …… (Sheet 3 of 3)

7. Standby Earth Fault Relay:

Make & Type…… Serial No. …….. Rating……..

7.1 Minimum Operating Current:
Setting% .....
Operating Amps ……

7.2 Timing Test

Test Made at ……. × Current setting

Max. Time from Curve in seconds	0.5 Max. Time from Curve in seconds	Max. Time Actual in seconds	0.5 Max. Time Actual in seconds	Reset Time from Max. Time in seconds
……	……	……	……	

8. Timing Relay:
Make& Type…… Serial No. ……

Setting in second(s)……
Operating in second(s)……

Insulation Resistance:	Setting left on:
O.C Circuit……	O.C Relay……..
Standby E/F Circuit……...	E/F Relay……..
Restricted E/F Circuit……	Restricted E/F Relay……..……
	Timing Relay……..……..

Remarks:

Signature	Date	Signature (Client)	Date

APPENDIX F

POWER TRANSFORMERS PHYSICAL CHECKS AND TESTS

Ref. Drawings No.	Date	Revision	By	Check	Approvals			

Power Transformers Physical Checks and Tests				(Sheet 1 of 2)	
Transformer Reference			Manufacturer		
Service Volts	Primary	Secondary	Serial No.		
Set at Tapping			Rating K.V.A. Vector Group % Impedance		
Check Phasing					
Check Breather (Colour to be Blue)					
Operation of Buchholtz (Mechanical)					
Operation of Buchholtz (Electrical)					
Buchholtz Trip and Alarms					
Oil Temperature Trip and Alarms		H.V. Test to Earth	Test Volts DC	Time (Sec)	
Netural C/T Ratio					
Primary Cable Terminal and Marking		Primary Winding			
Secondary Cable Terminal and Marking		Secondary Winding			
Netural Cable Terminal and Marking					
Buchholtz Cable Terminal and Marking					
Tapping Switch Set and Padlock		Insulation Test	Insulation Resistance Mega Ohms		
Oil Level					
Oil Leaks		H.V. Winding			
Earth Connection Secured		L.V. Winding			
Compound Gates Padlock		H.V. and L.V. Windings			
Oil Test to IEC 295		Netural/Earth			
Silica Gel		Pilot Cable			

Signature	Date	Signature (Client)	Date

APPENDIX F (continued)

Ref. Drawing No.	Date	Revision	By	Check	Approvals			

Transformers Tap Changer Ratio Test (if Applicable)	(Sheet 2 of 3)

Transformers Reference No.		Serial No.	
Rating kVA		Location on Plant	
Manufacturer			

Tap Position or % Tapping	H.V. Winding Magnetizing Currents		L. V. Winding Secondary Line Volt			
	R	Y	B	R-Y	Y-B	B-R

Signature	Date	Signature (Client)	Date

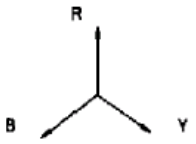
APPENDIX F (continued)

Ref. Drawing No.	Date	Revision	By	Check	Approvals			

(Sheet 3 of 3)

Phasing and Synchronizing Test

Equipment ……
Date Tested ……
Tested by ……..
Signature ……
Signature (Client) ……



	Running V.T. Secondary.	Incoming V.T. Secondary
R-N		
Y-N		
B-N		
R-Y		
Y-B		
B-R		
Phase Rotation Meter		

Incoming Circuit	Running Circuit				
		R	Y	B	N
	R				
	Y				
	B				
	N				

Signature	Date	Signature (Client)	Date

(to be continued)

APPENDIX G

GENERATORS CHECK LIST / TEST SHEET

Ref. Drawings No.	Date	Revision	By	Check	Approvals			

Generators: Check List/Test Sheet
Area Location (Sheet 1 of 2)

K.W.	Voltage	Phase	Wire	50 Hz
Prime Mover Manufacturer	Serial No.			
Generator Manufacturer	Serial No.			

	Description	Result
A	CHECKS AND TESTS BEFORE STARTING 1. Enclosure: 1.1 1.2 Sign of Damage 1.3 Sign of Corrosion 1.4 Sign of Oil Leak 1.5 Sign of Moisture 1.6 Alignment 1.7 Air Gap Clearance of all Quadrant 2. Earthing of Base Plate 3. Netural Earthing 4. Cable Termination 5. Temperature Detectors Quantity 6. Insulation Resistance of Stator Winding 7. Insulation Resistance of Exciter Winding 8. High Voltage Test 9. Lubrication 10. Weather Protection if Outdoor	
B	CHECKS AND TESTS AFTER STARTING 1. Berings: A. Vibration B. Noise C. End Play D. Overheating	

Signature	Date	Signature (Client)	Date

(to be continued)

APPENDIX G (continued)

Ref. Drawings No.	Date	Revision	By	Check	Approvals			

Generators: Check List/Test Sheet (Sheet 2 of 2)
Area Location

K.W.	Voltage	Phase	Wire	50 Hz
Prime Mover Manufacturer	Serial No.			
Generator Manufacturer	Serial No.			

	Description	Result
	2. Free Circulation of Air 3. Protection 4. Indications/Meters/Alarms 5. Phase Sequence 6. Intertrip between Drive and Driven Units 7. Interlocks with Normal Supply 8. Voltage between Phases: R & Y R & B B & Y 9. Voltage between Phases and Neutral: R & N Y & N B & N 10. Over Heating of Stator to be Checked	
B	<u>CHECK OF A.V.R. WHILE GENERATOR SET IS ON LOAD ACCORDING TO BS 4999 PART 140</u> a- Instruction of Manufacturer shall be fully adhered to while generating set is tested. b- Prime mover shall be tested according to manufacturers' recommendation.	

Signature	Date	Signature (Client)	Date

APPENDIX H
LOW VOLTAGE SWITCHGEAR ASSEMBLY CHECK LIST / TEST SHEET

Ref. Drawing No.	Date	Revision	By	Check	Approvals			

Low Voltage Switchgear Assembly Check List/Test Sheet				
Area Location				
Manufacturer				
Equipment No.				
Rated Voltage	Rated Busbar Capacity……Amps			
Service Voltage	Busbar S.C Rating……M.V.A ……Amps			
Phase	Frequency			
Busbar Secured and Continuity Checked				
Cubicles Complete and Satisfactorily Installed				
Assembly Earth Secured and Continuity Checked				
Labeling Satisfactory				
Control Circuit, Trip Circuit and Spring Charging Supplies Available				
Voltage Transformer Satisfactory				
Busbars Insulation Resistance Test by ……..Volt Megger		Busbars Pressure Test		
Test Applied between	Insulation Resistance	Pressure Voltage AC/ DC	Duration Minutes	Leakage Milliamps
R&B	Mega Ω	KV		
R&Y	Mega Ω	KV		
B&Y	Mega Ω	KV		
R+Y+B and Earth	Mega Ω	KV		
Insulation Resistance of Small Wiring and Low Voltage Circuit……. Mega Ω				

Signature	Date	Signature (Client)	Date

APPENDIX I
MEDIUM VOLTAGE SWITCHGEAR ASSEMBLY (PHYSICAL CHECK AND TEST)

Ref. Drawing No.	Date	Revision	By	Check	Approvals

Medium Voltage Switchgear Assembly (Physical Check)	(Sheet 1 of 2)

Switchgear Ref.		Manufacturer		
Service Voltage		Location on Plant		
Circuit Breaker Duty		V.T. Ratio		
Rating		V.T. Fuse Rating	Primary	
			secondary	
Serial No.		Voltage Range		
Type		Ammeter Range		
O/C C.T. Ratio		kWh Meter	Type	
			Serial No.	
E/F C.T. Ratio		Tripping	Type	
			Fuse	
Neutral C.T. Ratio		Closing Mechanism		
Ammeter C.T. Ratio		Tripping Voltage		
		Closing Voltage		

Switchgear Pressure Test	K.V. for minutes	

Alignment of Plug Contacts		Circuit Breaker Truck & Tools	
Alignment of Aux. Plug Contacts		Earthing Signs	
Hand Operation (Latchince) 10 Times		Danger Indicating Light(s)	
Hand Tripping			
Main Contact Alignment			
Main Contact Spring Pressure			
Aux. Contact Alignment			
Operation of AUX. Switches			
Electrical Connections Secure			
Main & Pilot Cable Jointing & Marking			
Operation of Mechanical Interlocks			
Nuts & Bolts Secure			

Oil Tested Before Filling Tank (If Oil Filled)		Signature	Date	Signature (Client)	Date

(to be continued)

APPENDIX I (continued)

Ref. Drawings No.	Date	Revision	By	Check	Approvals

(Sheet 2 of 2)

Medium Voltage Switchgear Assembly
(Primary Injection and Insulation Tests)

Circuit Breaker Duty				Circuit Breaker Voltage						
Relay Type	Setting			Current/Time Curve Test						Remarks
Serial No.	PLUG	TMS		Test 1		Test 2		Test 3		
O/C				Test Amps	Trip Time	Test Amps	Trip Time	Test Amps	Trip Time	
E/F										

	Insulation Resistance						
Equipment	R-E	Y-E	B-E	R-Y	R-B	Y-B	
Circuit Breaker							
AUX. Wiring							
Main Cable							
Pilot Cable							

Electrical Checks		Signature	Date	Signature (Client)	Date
Ammeter					
Voltmeter		Remarks			
KMH Meter					
Indicating Lamps					
Remote Operation Close/Trip					
Intertripping					
Interlocks					
Neon Danger Indicating Lamp					

APPENDIX J

ISOLATOR/FUSE SWITCH/CHECK LIST TEST SHEET

Ref. Drawings No.	Date	Revision	By	Check	Approvals			

Isolator/Fuse Switch Check List/Test Sheet	Area Location Manufacturer		(Sheet 1 of 1)
Type		Rated Voltage	
Board Title		Rated Current	
Circuit Title		Earth Secured & Continuity Checked	
Equipment No.		Operation Satisfactory	
Fuse Rating		Labels Satisfactory	
*I.R. Reading	Mega Ω		
Circuit Title		Earth Secured & Continuity Checked	
Equipment No.		Operation Satisfactory	
Fuse Rating		Labels Satisfactory	
*I.R. Reading	Mega Ω		
Circuit Title		Earth Secured & Continuity Checked	
Equipment No.		Operation Satisfactory	
Fuse Rating		Labels Satisfactory	
*I.R. Reading	Mega Ω		
Circuit Title		Earth Secured & Continuity Checked	
Equipment No.		Operation Satisfactory	
Fuse Rating		Labels Satisfactory	
*I.R. Reading	Mega Ω		
*Note: I.R. Stands for Insulation Resistance			
Signature	Date	Signature (Client)	Date

APPENDIX K

DISTRIBUTION BOARD TEST SHEET

Ref. Drawings No.	Date	Revision	By	Check	Approvals			

Distribution Board Test Sheet		Distribution Board Title Manufacturer Location on Site			(Sheet 1 of 1)	
Type		Rated Voltage				
Equipment No.		Incoming Switch/Fuse Rating				
Busbars Neutral and Connections secure		Name Plate and Circuit Labels Correct				
Busbars Phased Correctly		Cable Term & Marking Satisfactory				
Operation of Isolator/Fuse Switch Satisfactory		Box Earthed and Continuity Checked				
For Flameproof Unit, Check all Flanges are Secure & Satisfactory						

Circuit No.	Cable Size	Duty/Title	Fuse Rating (Amps)	Cable or Conduit Earth Continuity Checked	Insulation Resistance In Mega Ω	
					R.Y.B. to E.	Between Phases

Signature	Date	Signature (Client)	Date

APPENDIX L

METERS CHECK LIST

Ref. Drawings No.	Date	Revision	By	Check	Approvals			

Meter Check List	Area Location Manufacturer	(Sheet 1 of 1)

Title	Location	Type of Meter	Class of Accuracy	Calibration	Remarks

Signature	Date	Signature (Client)	Date

APPENDIX M
INSULATION RESISTANCE TEST SHEETS FOR SECONDARY WIRING

Ref. Drawings No.	Date	Revision	By	Check	Approvals			

Insulation Resistance Test Sheets for Secondary Wiring (Sheet 1 of 1)

Equipment Equipment Reference No.	Manufacturer
Location on Site	

Circuit No.	Control Circuit I.R. Mega Ω		Closing Circuit I.R. Mega Ω		Tripping Circuit I.R. Mega Ω		Indication Circuit I.R. Mega Ω		Metering Circuit I.R. Mega Ω		Anti Cond. Heater Circuit I.R. Mega Ω	
	A	B	A	B	A	B	A	B	A	B	A	B

Notes: I.R. Stands for Insulation Resistance
"A" Is for Insulation Resistance between Cores
"B" Is for Insulation Resistance between Core and Earth

Signature	Date	Signature (Client)	Date

APPENDIX N
CURRENT TRANSFORMERS CHECK LIST / TEST SHEET

Ref. Drawings No.	Date	Revision	By	Check	Approvals

Current Transformers Check List/Test Sheet	Area Location Manufacturer	(Sheet 1 of 1)
C.T. Title	Phase Location	
C.T. Serial No.	Equipment No.	
C.T. Ratio	Accuracy	
Burdon	Short Time Factor	
Frequency		

C.T. Securely Mounted	
C.T. Mounting Assembly Secured and Earthed Satisfactorily	
C.T. Terminal Marking Satisfactory	

C.T. Ratio Checked by Injection Test

Secondary Magnetization Curve:

Volts													
m.A.													

Insulation Resistance Test:

Voltage Level Volts		
D.C. Resistance Measured (of C.T.)		
D.C. Resistance Measured (of Leads)		

D.C. Polarity Test: (Flick Test) Satisfactory

Manufacturers Magnetization Curve Available

Manufacturers Routine/Type Test Results Available

Signature	Date	Signature (Client)	Date

APPENDIX O
VOLTAGE TRANSFORMERS PHYSICAL CHECK LIST / TEST SHEET

Ref. Drawings No.	Date	Revision	By	Check	Approvals

Voltage Transformers Checklist/Test sheet	Area Location Manufacturer	(Sheet 1 of 1)
V.T. Title		
V.T. Serial No.	Equipment No.	
V.T. Ratio	Accuracy	
Burdon	Frequency	
Connection		

V.T. Securely Mounted	
V.T. Connection Secured and Continuity Checked	
V.T. Correctly Earthed and Continuity Checked	
V.T. Terminal Marking Satisfactory	
Tank and Fittings Satisfactory	
Oil level Satisfactory (If Applicable)	
V.T. Ratio Checked	
Manufacturers Routine/Type Test Results Available	

Insulation Resistance Test by … Volt Megger		Pressure Test		
Test Applied between	Insulation Resistance	Pressure Voltage D.C./A.C.	Duration Minutes	Leakage mA
R & B	Mega Ω	kV		
R & Y	Mega Ω	kV		
B & Y	Mega Ω	kV		
R+Y+B and Earth	Mega Ω	kV		
Signature	Date	Signature (Client)		Date

APPENDIX P
SMALL TRANSFORMERS PHYSICAL CHECK LIST / TEST SHEET

Ref. Drawings No.	Date	Revision	By	Check	Approvals			

Small Transformers
Physical Check and Test Sheet (Sheet 1 of 1)

Transformer Reference		Manufacturer	
Service Volts		Serial No.	
Rating K.V.A. Vector Group %Impedance		Location on Plant	

Checks and Tests	Check	Insulation Resistance (Mega Ω)	Remarks
Between Higher Voltage and Lower Voltage Windings			
Higher Voltage Winding to Earth			
Lower Voltage Winding to Earth			
Primary Cable Termination and Marking			
Secondary Cable Termination and Marking			
Earth Connection Secured			
Transformer Securely Mounted			
Transformer Nuts and Bolts checked			

Signature	Date	Signature (Client)	Date

APPENDIX Q
MEDIUM VOLTAGE CABLES INSULATION RESISTANCE AND PRESSURE TESTS

Ref. Drawings No.	Date	Revision	By	Check	Approvals			

Medium Voltage Cables (Sheet 1 of 2)
Insulation Resistance and Pressure Test between Phases and Earth
("R", "Y", and "B" Phases Bunched)
Manufacturer: ……
Location on Site: ……

Cable Ref. No.	Cable Size, Type and Voltage	Megger Test Voltage	Insulation Resistance (Mega Ω)	Pressure Test KV (AC/DC)	Duration (Minutes)	Leakage Current (mA)	Signature	Date	Signature	Date

Signature	Date	Signature (Client)	Date

(to be continued)

APPENDIX Q (continued)

Ref. Drawings No.	**Date**	**Revision**	**By**	**Check**	**Approvals**			

Medium Voltage Cables (Sheet 2 of 2)
Insulation Resistance and Pressure Test between Phases
Manufacturer: ……………………….
Location on Site: …………………….

Cable Ref. No.	Cable Size, Type and Voltage	Test Phase Connection	Megger Voltage	Insulation Resistance (Mega Ω)	Pressure Test Voltage (AC/DC)	Duration of Test (Minutes)	Leakage Current (mA)	Signature	Date	Signature (Client)	Date
		RY to B									
		RB to Y									
		RY to B									
		RB to Y									
		RY to B									
		RB to Y									
		RY to B									
		RB to Y									
		RY to B									
		RB to Y									
		RY to B									
		RB to Y									
		RY to B									
		RB to Y									
		RY to B									
		RB to Y									
		RY to B									
		RB to Y									
		RY to B									
		RB to Y									

Signature	Date	Signature (Client)	Date

APPENDIX R
LOW VOLTAGE CABLES INSULATION RESISTANCE TESTS SHEET

Ref. Drawings No.	Date	Revision	By	Check	Approvals			

(Sheet 1 of 1)

Low Voltage Cables Location on Site: ……
Insulation Resistance Tests Sheet

Cable Ref. No.	Cable Size, Type and Voltage	Test Phase Connections	Insulation Resistance (Mega Ω)	Signature	Date	Signature	Date
		RY to B					
		BR to Y					
		RYB to E					
		RY to B					
		RB to Y					
		RBY to E					
		RY to B					
		RB to Y					
		RYB to E					
		RY to B					
		RB to Y					
		RYB to E					
		RY to B					
		RB to Y					
		RYB to E					
		RY to B					
		RB to Y					
		RYB to E					
		RY to B					
		RB to Y					
		RYB to E					
		RY to B					
		RB to Y					
		RYB to E					

Signature	Date	Signature (Client)	Date

APPENDIX S
MICC CABLE AND CONDUIT INSTALLATIONS

Ref. Drawings No.	Date	Revision	By	Check	Approvals

MICC Cable and Conduit Installations	(Sheet 1 of 1) Lighting and Power Circuits Test Sheet
Location	Distribution Board No.

Circuit No.	Description	Continuity (Ohms)	Installation Resistance Test (Mega Ω)		
			Between Cores	Core to Earth	Complete Insulation to Earth

Signature	Date	Signature (Client)	Date

APPENDIX T
BATTERIES AND CHARGERS CHECK LIST / TEST SHEET

Ref. Drawings No.	Date	Revision	By	Check	Approvals

Batteries and Chargers Check List/Test Sheet				(Sheet 1 of 1)	
Unit Title					
Battery					
Manufacturer		Rated Output Voltage			Volt
Equipment No.		Electrolyte Level Satisfactory			
Cell Voltage	Volt	Specific Gravity			
Battery type		Connections Secure, Polarity and Continuity Checked			
Battery Charger					
Manufacturer		Serial No.			
Equipment No.		Input Voltage			Volt
Rating	Volt	Output Voltage			Volt
Insulation Resistance Of Busbars and AUX, Wiring Satisfactory		Voltages on Full Load	Float		Volt
			Boost		Volt
Mechanical/Electrical Interlocks Satisfactory		Check Operation of Low Battery Volts Detector			
Earth Connection Secure and Continuity Checked		Meter Operation Satisfactory			
Labels Satisfactory					
Polarity Correct					
Charger Protection Setting Checked					
Charger Fail Alarm Checked					
Voltages on No Load	Float	V			
	Boost	V			
Earth Leakage Alarm Checked					

Signature	Date	Signature (Client)	Date

APPENDIX U
INVERTERS CHECK LIST / TEST SHEET

Ref. Drawings No.	Date	Revision	By	Check	Approvals

Inverters Check List/Test Sheet	Area Location Manufacturer	(Sheet 1 of 1)
Unit Title		
Manufacturer	Serial No.	
Equipment No.	Rating	
Input Voltage Range Volt	Output Voltage	Volt

Earthing Connection Secured and Continuity Checked	
Labels Satisfactory	
Inverter Protection Setting Checked	
Output Voltage at Half Load	Volt
Output Voltage at Full Load	Volt
Voltage Regulation within Limits	
Frequency Output Set at	Hz
Output Voltage With Minimum Input Voltage	Volt
Output Voltage With Maximum Input Voltage	Volt

Signature	Date	Signature (Client)	Date

APPENDIX V
TRANSFORMER RECTIFIER CHECK LIST / TEST SHEET

Ref. Drawings No.	Date	Revision	By	Check	Approvals

(Sheet 1 of 1)

Transformer Rectifier Check List/Test Sheet			
Area Location			
Transformer/Rectifier Type			
Manufacturer			
Serial No.		Equipment No.	
Rating	KVA	Input Voltage (A.C.)	Volt
Output Current	D.C. Amps	Output Voltage (D.C.)	From: …… Volt To: …… Volt
Transformer Diagram No.			
Transformer Tank Fittings Secured and Completed			
Transformer Tank Earth Secure and Continuity Checked			
Transformer Tank Oil Level Satisfactory			
Transformer Incoming Switch Fuse Rating			Amp
Transformer Cable Connection Secure and Satisfactory			
* I.R. Reading of Transformer Primary			Mega Ω
Measuring Instruments, Protective Devices Alarms, Etc.			
Selector Switch Operation			
Note: * I.R. Stands for Insulation Resistance.			

Signature	Date	Signature (Client)	Date

APPENDIX W
EARTHING SYSTEM TEST SHEET

Ref. Drawings No.	Date	Revision	By	Check	Approvals

Earthing System Test Sheet (Sheet 1 of 1)

Electrode No.	Type and Material	Length (m)	Location	Resistance (Ω)	Conductor Size	Earth Lead Continuity (Ω)	Terminal Bolt and Nut Secured	Remarks

Signature	Date	Signature (Client)	Date

APPENDIX X
GENERAL WIRING TEST AND CHECK LIST

Ref. Drawings No.	Date	Revision	By	Check	Approvals			

General Wiring Test and Check List (Sheet 1 of 1)

Location: …….

Items to Be Inspected Checked and/or Tested:

No.	Description	Results
1	Impedance of Each Continuity Conductor.	
2	Earth Loop Impedance.	
3	Earth Leakage Protection.	
4	Polarity Through the Installation.	
5	For Single Pole Switch, Phase to Be in Live Conductor Only.	
6	The Insulation Resistance of the Fixed Wiring to Earth is not Less than 1 Mega Ohms.	
7	The Insulation Resistance to Earth of Each Item of Apparatus Tested Separately is not Less Than 0.5 Mega Ohms.	
8	Phase Is Connected to Top Contact of Edison Screw Lamp Holders. Not to Screwed Part.	
9	All Flexible Cords, Switches, Fuses, Plugs and Socket Outlet are in Good Serviceable Condition. Except Those Listed in Inspection Report.	
10	Color Identification are Correct and Complies With I.E.T. Regulations.	
11	There is no Sign or Indication of Unsafe Condition.	

Signature	Date	Signature (Client)	Date

ATTACHMENTS

ATTACHMENT A
CERTIFICATES

The following certificates shall be issued where necessary:

1.1 Safety Clearance Certificate "A"

This certificate will be issued by the Engineer on completion of the work or part of it, and signifies that the work is considered fit to be subjected to the acceptance or pre-commissioning tests, in accordance with the relevant articles of general conditions of contract. This certificate must be signed by the Company representative involved before any testing etc. may commence.

After issue of this certificate the contractor must sign and return the original to the Engineer, since it signifies that he undertakes not to carry out any further work on the equipment without first being issued with a permit to work. This certificate does not imply satisfaction on the part of the Engineer. Defects/omissions to the plant will be issued on certificate "B".

1.2 Plant Clearance Certificate "B"

This certificate will be issued by the Engineer after it has been signed by the Contractor's representative and the Company representative, on completion of the initial operation of the equipment, and it signifies the contractors confirmation of any defects/omissions listed at that time. It also records the date and time that the plant was given its initial operation.

1.3 Clearance Certificate for Company Operation (Certificate "C")

This certificate will be issued by the Engineer and must be signed by the Contractor to signify his permission for the plant to be operated where necessary by the Engineer for operational purposes.

1.4 Internal Taking over Certificate "D"

This certificate will be issued by the Company's site Engineer to the Company's Contract Department, and indicates that the equipment can in part be paid for, to the exclusion of any defects and/or omissions as listed. This certificate will be issued in accordance with the relevant articles of general conditions of contract.

This certificate also details the date from which the maintenance period will commence.

1.5 Taking over Certificate "E"

This certificate will be issued by the Company to the Contractor informing him of:

1) The release of some of the monies against the contract.

2) The date of the commencement of the maintenance period.

3) The agreed list of defects and/or omissions at that stage.

The issue of the certificate will be in accordance with the general conditions of contract but it does not imply an admission that the work has been completed in every respect.

1.6 Internal Contract Acceptance Certificate "F"

This certificate will be issued by the Company's site Engineer to the Company's Contract

Department and indicates that the maintenance period has been completed and signifies his satisfaction that the works have been completed in every respect excepting for the minor work outstanding as listed on the certificate.

1.7 Final Contract Acceptance Certificate "G"

This certificate will be issued by the Company to the Contractor informing him of the release of the outstanding money (less any sum set against minor outstanding work as listed) on the satisfactory completion of the maintenance period at the plant.

The issuance of this certificate relieves the Contractor of his contractual obligations excepting the completion of the minor work outstanding.

1.1 Safety Clearance Certificate "A"

Project .....

Date .....

Number .....

Description and Location of Plant:

To Contractor:

Notice is hereby given that the equipment listed above is being made alive/put into service or by reason of its proximity or relation to other apparatus must be regarded as being alive/in service, and from hrs.....on.....will come under the control of the Company in so far as the area safety is concerned. No further work may be carried out on or near this equipment after this time and date unless the person in charge of this work is in possession of a permit to work, issued by an authorized person employed by the Company.

Will you please sign this form in the space provided below and return the original and retain the duplicate.

Signed .....

Company Engineer

Acknowledgement:

I/We acknowledge recepit of the above notice and confirm that all men in my/our have been duly warned of the above.

Signed ..... **For Contractor** ..... **Time** ..... **Date** ……..

1.2 Plant Clearance Certificate "B"

Project .....

Date .....

Number .....

Description of Plant:

To Contractor:

Contract No.: .....

The above plant was given its initial operation run.....

hrs on..... in the presence of the following witnesses. The Contractor is not authorised to work unless separate work permit is issued by an authorized person.

For the Company **(Signed)** .....

For Contractor **(Signed)** .....

Date ..... ---------- **Signed**

For the Company

1.3 Clearance Certificate for Company Operation (Certificate "C")

Project .....

Date .....

Number .....

Description and Location of Plant:

To Contractor:

As from .....hrs on.....date, the above listed plant/services/circuits may be operated and run by the Engineer and/or his staff, as required for operational purposes, with/without* the Contractors representative present. Please sign the lower portion of this certificate in the space provided and return the original and retain the duplicate.

Date..... **Signed** .....

For the Company

To the Company:

We have noted the above and agree to the operation of the equipment specified.

Date..... **Signed** .....

Contractor's Representative

*** Delete as applicable.**

1.4 Internal Taking Over Certificate "D"

Project .....

Date .....

Number .....

Description of Plant:

To Company Contracts Department:

Contract Number: .....

In accordance with the condition of contract, the Contractor is entitled to a Taking Over Certificate "E" for the above plant. It is proposed that, subject to the exclusion of the following items, the taking over date shall be .....and that it will be, the commencement of the maintenance period.

Release of Retention Money

It is recommended that up to .....% of the contract price be released on the above equipment subject to a deduction of list of Defects and Omissions.

Date ..... **Signed** .....

Company site Engineer

1.5 Taking Over Certificate "E"

Project .....

Date .....

Number .....

Description of Plant Taking Over:

To Contractor:

Contract Number: .....

It is hereby certified that the taking over/completion date for the plant detailed above, apart from the exception listed, is ..... and that the maintenance period of .....months will commence on that date.

Release of Retention Money

Up to .....% of the contract price is release on the above plant subject to a deduction of ..... in respect of the defects.

List of Defects and Omissions

Date ..... **Signed** .....

For the Company

1.6 Internal Contract Acceptance Certificate "F"

Project .....

Date .....

Number .....

Description of Plant Accepted:

Minor Work Outstanding:

To Company Contracts Department:

This is to certify that the.....months maintenance period on the above plant was completed on .....and that all defects omissions and modifications have been satisfactorily cleared with the exception of the minor items listed below and that the plant meets all existing operation requirements.

Date..... **Signed** .....

Site Engineer

1.7 Final Contract Acceptance Certificate "G"

Project .....

Date .....

Number .....

Description of Plant Accepted:

Minor Work Outstanding:

To Contractor:

Contract Number: .....

This is to certify that the .....months maintenance period on the above plant was completed on ..... .The final payment is now made on the above plant, subject to and in respect of defects and omissions as listed below.

Date..... **Signed**.....

For the Company