PRE-COMMISSIONING PROCEDURES FOR TRANSMISSION LINES

INTRODUCTION

Over all procedure, safety rules, statutory requirements, dispatch procedures, switching sequences, observations, passing criteria and documentation of test results have been documented in this report.

The detailed inspection and handing over documents are required to be checked for the entire length of transmission line before energization.

The detailed inspection/test procedures for each activity have been elaborated in separate section of this documentation. The contents of this report are as following:

1. Definition
2. Overall procedures
3. Safety procedures
4. Inspection
5. Statutory requirements
6. Handing over
7. Protective system
8. Dispatch procedures
9. Switching procedures
10. Testing
11. Energization
12. De-energization
13. Observations and duration
14. Passing criteria
15. Documentation

1.0 DEFINITION

'Main transmission lines' means all high pressure cables and overhead lines (not being an essential part of the distribution system of a licensee) transmitting electricity from a generating station to another generating station or a sub-station, together with any step-up and step-down transformers, switch-gear and other works necessary to and used for the control of such cables or overhead lines, and such buildings or part thereof as may be required to accommodate such transformers, switch-gear and other works and the operating staff thereof;

'Power system' means a system under the control of the Government or any Board of generating company or other agency and having one or more:

(i) Generating station, or

(ii) Main transmission lines and substations, or

(iii)Generating stations and main transmission lines and substations

'Regional electricity board' means any of the boards as constituted immediately before the commencement of the electricity laws (amendment) act, 1991, by resolution of the Central Government for ensuring integrated operation of constituent system in the region;

‘Regional load dispatch centre’ means the centre so designated where the operation of each of the regional electricity grids constituting the country's power system is coordinated;

‘Sub-station’ means a station for transforming or converting electricity for the transmission or distribution thereof and includes transformers, convertors, switch-gear, capacitors, synchronous condensers, structures cables and other appurtenant equipments and any buildings used for that purpose and the site thereof, a site intended to be used for any such purpose and any buildings used for housing the staff of the sub section;

‘Tie-line’ means a line for the transfer of electricity between two power systems together with switchgear and other works necessary to and used for the control of such line.

2.0 OVERALL PROCEDURE

First it is to be ascertained that the transmission line to be energized is ready for operation and has been properly handed over (released) in writing. This will include all safety aspects, electrical inspector clearance, PTCC clearance, statutory clearance, and final inspection, if any.

Instruction for the work and supervision is given by the test leader (line in - charge).

However all switching and all operational activities will be executed by the regular operators.

Line charging instructions received from the site engineer are clearly understood by the Line in-charge and doubts, if any, are to be got clarified prior to the energisation of the line.

Once the line is handed over for charging no work shall be permitted without a valid WORK PERMIT.

When the whole system has been energized, including the AC line, it will be kept in this state for 8 hours or more for ‘soaking’ with continuous inspection and monitoring. However recommendations of the site engineer may be checked. Otherwise it may be put into continuous operation.

3.0 SAFETY PROCEDURES

Energization implies an abrupt and serious change of the working conditions in the plant.

In order to avoid serious accidents, thorough information must be imparted to all personnel involved in the construction of transmission line. The engineer must ensure that due publicity has been made to the public in all the villages/areas along the line route cautioning them against climbing the towers etc. and that the line is proposed to be charged on so and so date. It is also to be confirmed that the AGENCIES involved in the construction activities shall not carry out any job on the said line without a valid WORK PERMIT.

It shall be ensured before charging that all men, material, tools and plants and any temporary earthing on any part of the entire length of line are removed.

It must be ensured that any power supply / low voltage charging used as anti-theft measure must be disconnected and isolated to avoid accidental connection.

All equipment tests and pre-commissioning tests must have been completed, re-terminated (in case cables were isolated for testing purpose) and documented.

The system must be formally declared ready for energization and handed over for operation in writing.

4.0 INSPECTION

Before the line is scheduled to be handed over for the pre-commissioning/energization the same shall be inspected by engineer and the contractor as follows:

Such an inspection shall include:

(i) Right of way/way leave/electrical clearance.

(ii) Foundation and revetments/protection work.

(iii) Tower & tower accessories.

(iv) Hardware fittings.

(v) Insulators.

(vi) Conductor & earthwire.

(vii) Accessories for conductor & earthwire.

(viii) Aviation warning signals(light/globules/painting).

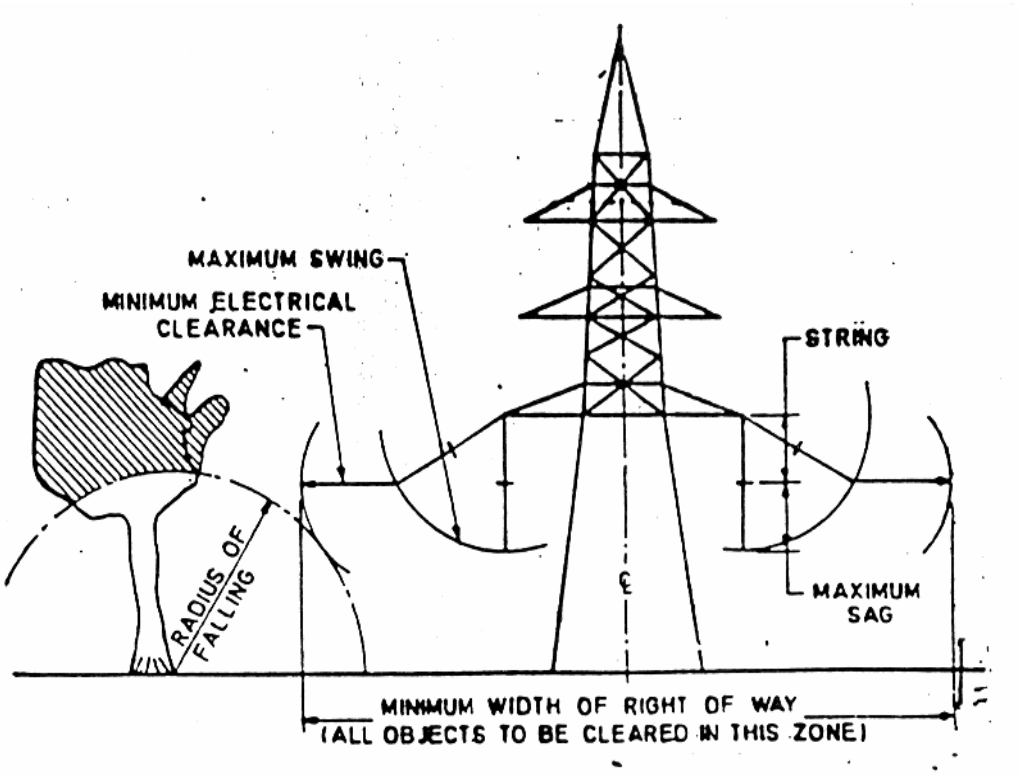
4.1 RIGHT OF WAY/WAY LEAVE/ELECTRICAL CLEARANCE

4.1.1 Right of way/way leave clearance

Ensure that no tree/tree branches are falling within the zone of minimum clearance specified as per Fig. 1.

Guidelines of forest/environmental rules shall be followed to avoid excessive tree cutting i.e. all the trees should be cut from ROUTE level in the 3 meter corridor below each line conductor/earthwires. In the balance corridor, trees branches are only to be lopped to attain the specified clearance as per table no 1.

TABLE NO.1	
CLEARANCE FOR RIGHT OF WAY	
Transmission line voltage (in kV)	Minimum right of way (in mts.)
132	27
220	35
400	52(S/C)
400	48(D/C)



NOTE — Portion of tree falling within clearance zone to be lopped or trimmed.

FIG. 1 LINE CLEARANCE (RIGHT-OF-WAY) REQUIREMENTS

4.1.2. Electrical clearance

In case of line crossings, clearance between lowest conductor of line and top conductor of the other line shall be adequate as follows:

(Minimum clearances in mm between lines when crossing each other)

Sl. No.	Nominal system voltage	132kV	220kV	400kV
1	132kV	3050	4580	5490
2	220kV	4580	4580	5490
3	400kV	5490	5490	5490

Jumpers in the tension tower are properly intact with conductor and form a parabolic shape in order to achieve adequate clearance from super steel structure.

4.1.2.1. Ground clearance

Normally at the time of construction adequate clearance is provided between lowest conductor and ground, but due to delay in charging/commissioning there arc chances of dumping/heaping soil, earth and concrete etc. or staking bricks etc. which may cause reduction in ground clearance. In such cases the stored materials shall be removed.

Ensure that there is no temporary or permanent construction of houses or shades below the line. If the same has been constructed they shall be removed before charging.

The various clearances are given below as guidance however all the clearances indicated by approved drawings are to be referred.

The ground profile at the time of commissioning shall be checked with the profile approved at the time of check survey.

Ground clearance of lowest conductors at critical points/where ever the lowest conductor is touching the ground shall be checked in the field from any of the prevalent method and the values of ground clearance at these critical points shall be recorded in the prescribed format.

In case of hilly terrain and for building clearance, the side clearance from conductors and jumpers at critical points shall also be checked and recorded for all phases of conductor/earthwire towards hill/ building side.

The permissible minimum ground clearances for different voltages are as given below.

Voltage(kV)	Ground clearance(mm)
132	6100
220	7015
400	8840

4.1.2.2. Clearance for telephone line crossings

The minimum clearances between the conductors of the power line and telecommunication lines are specified as follows:

Voltage(in kV)	Clearance(mm)
132	2745
220	3050
400	4880

The vertical clearances between conductors and between conductor and earth-wire shall be checked randomly say in any one span of all sections and 10 sections of hilly areas from single line diagram of the towers.

4.2. FOUNDATION AND REVETMENTS / PROTECTION WORK

4.2.1 Foundation:

There shall not be any damage/uneven settlement of foundations. For this, tolerances in levels of all four stubs should not exceed the criteria provided in the annexure-C of IS -5613 (part -3/section 2):1989.

It is to be ensured that back filling of foundation is properly done. Soil shall be filled over all legs upto ground level.

Extra surface earth after foundation back filling shall be removed from legs of the tower beyond a lead distance of 30 mtrs.

Any crack or break in chimney, if found, shall be repaired.

4.2.2 Revetments/protection:

Cracks/damages to revetments shall be repaired.

Wherever revetments are provided, weep holes shall have slope such as to flush out the deposited water away from tower platform.

In case of hilly terrain, the benching area should be leveled properly. The area around tower shall have proper slope for drainage of rain water.

SPECIAL FOUNDATION

4.3 TOWER AND TOWER ACCESSORIES

4.3.1. Normal tower

After completion of a transmission line, all the towers shall be thoroughly checked before charging the line. Special attention shall be given to the points as mentioned below:-

Deformed/buckled/missing/rusted members and nuts and bolts

It is to be ensured that no members are bend, deformed or rusted have been used in towers and if so, the same shall be replaced.

If any members is found missing, a new member shall be fixed as per erection drawing of towers.

Nuts shall be sufficiently tightened for the required torque specified by Engg. Deptt./approved drawing. Minimum 2/3 complete threads shall be projected outside the nut. All bolts shall have their nuts facing outside of the tower for horizontal connection and downwards for vertical connections.

Nuts & bolts shall be properly tack welded/punched as per the specification and proper zinc rich paint shall be applied. It shall be ensured that the circular length of each welding shall be at least 10mm.

It shall also be ensured that all extra blank holes provided on tower members are filled with correct size of nuts & bolts.

4.3.2 Special towers

In addition to the above checks for towers, ladders and platforms provided in special towers shall be properly tightened and no foreign material shall be left out on such platforms.

Earthing of towers

Ensure that proper earthing of tower has been done and earthing strip is neither damaged or broken and is properly fixed to the stub.

In case of counter poise earthing, it is to be ensured that earthwire is sufficiently buried in the ground and no where it has drag out during cultivation. The length of counter-poise is normally 30 mtrs as per TS.

Before charging of the line, ensure that resistance is below 10 ohms. If the value (before stringing) has been recorded higher than 10 ohm earthing shall be changed to counterpoise type.

Earthing of special towers shall be verified as per approved drawings applicable for special towers/special foundation. (In case of anchor foundation bolt/anchor plate welded with last leg of special tower.)

4.3.3. Tower accessories

All the danger plates, number plates, circuit plates, and phase plates shall be in position & and as per the specification.

All plates shall be properly tightened.

It shall be ensured that phase plates are fixed in correct phase sequence. Specially at transposition towers, the phase plates in the correct phase sequence shall be provided at each towers or end tower as per the specification of the line.

It shall be ensured that the anti-climbing device (ACD) is provided, at the suitable height of tower. In case of barbed wire ACD, barbed wire shall be tightly fixed. In case of spike type ACD, all spikes shall be properly fixed and oriented towards outer face of tower.

It shall be ensured that the step bolts (for normal towers) are provided upto the peak of tower. Any missing step bolts shall be replaced.

Fixing of birds guards (upto 220 kV/wherever applicable) shall be ensured.

4.4. HARDWARE FITTINGS

Tightening of all bolts and nuts are to be checked upto specified torque.

Check the fixing of all security clips (W/R type clips).

Surface condition of corona control rings and distance/alignment between tower side arcing horn (wherever applicable) and line side arcing horn/corona control ring to be checked as per approved drawings.

Ensure that, no. of insulators per string is lesser by one number as compared to no. of discs in normal string (upto 220 kV) at approach spans to the terminal ends (approx last 1.5km).

To restrict the swing of jumpers, the provision of pilot strings in case of tension towers shall be verified from the approved drawings.

4.5 INSULATORS

All the damaged/broken insulator discs shall be replaced.

Unusual deflection in suspension strings if observed shall be rectified.

The insulators shall be cleaned before charging.

IR value of individual disc of at least 5 insulators at random shall be checked by 5/10 kV megger.

4.6. CONDUCTORS and EARTHWIRES

Surface condition

Surface of the conductors shall be free from scratches/rubs.

Ensure that conductor strands are not cut and opened up. Wherever strands are found cut/damaged/scratched, they must be repaired with repair sleeves/repair

protective rods in case the nos. of damaged strands are within specified limits(normally upto $1/6^{th}$ nos. of strands in the outer layer).

4.7. ACCESSORIES FOR CONDUCTOR AND EARTHWIRES

4.7.1. Joints

All joints on conductor/earthwire shall be away from the tower at a distance of at least 30 metres or as provided in the technical specification (TS).

Ensure that not more than one joint in a conductor is provided in one span or provided.

Ensure that no mid span joint is provided in major crossings for main roads, railway crossing and major rivers etc. or provided in TS.

Ensure that all mid span joints on conductors/earthwire and repair sleeves of compression type are free from sharp edges, rust and dust. Wherever grease are specified the same shall be applied in the joints.

4.7.2. Clipping

Ensure that conductor is not over tightened in the suspension clamps.

4.7.3 Spacers, vibration dampers and copper bonds

Placement and no. of spacers/dampers between two sub-conductors on each phase shall be verified as per spacer/damper placement chart.

Damaged/missing spacers shall be replaced and loose/displaced spacers shall be tightened/relocated.

Spacing of vibration dampers from the tower and spacing between damper to damper in case two vibration dampers (VD) were provided, shall be verified as per the damper placement chart. All loose/ displaced VD shall be properly tightened/relocated and missing VDs shall be provided.

To be ensured that no copper bond is loose/missing.

4.7.4 Jumpers

Verify electrical clearance of jumpers to tower body as per design.

All the jumpers shall be checked properly. In case, jumpers (conductor/earthwire) are found loose, it shall be tightened sufficiently.

4.7.5 Foreign material

Ensure that all foreign materials viz dead bird. fallen tree branches, bird nests etc. on conductors, earthwires, jumper, insulator string, cross arms are re-moved.

4.7.6. Others

It shall be ensured that all temporary/local earthing, guys, T & P(tool & plants), foreign material and other loose material which were used during stringing/tower erection have been removed.

In case there is any change in the ground profile before commissioning of line from the approved profile, the extra earth/obstruction/temporary sheds/any other construction shall be removed.

4.8 AVIATION WARNING/OBSTRUCTION SIGNALS (LIGHTS/ GLOBULES/ PAINTING).

It shall be ensured that following measures have been taken in the line/ towers falling within obstruction zone of civil aviation and defense establishments as per their requirement and our specification.

Day markers

Painting of full/top portion of towers with red/orange and white paints.

Globules on earthwires have been provided.

Night markers

It shall be ensured that proper aviation lights at the peak level/at specified heights of towers have been provided along with solar panels/battery banks/control cubicles and other accessories as per specification. The functioning of lights with simulation to be checked/verified.

5.0 STATUTORY REQUIREMENT

5.1. The concerned authorities shall be informed before commissioning the lines and their approval obtained in accordance with Indian electricity act, 1910 and Indian electricity rule, 1956 and electricity supply act 1948.

5.2 Before charging of the line PTCC approval from P&T department shall be obtained.

6.0 HANDING OVER

The transmission line shall be inspected prior to energization and a formal handing over document to be jointly signed by the contractor and the engineer. However all contractual taking over has to be resolved separately as per the terms and conditions of the contract. The handing over shall be limited to the completion of erection and ready for energization.

Any outstanding points or remaining activities are to be listed jointly by the engineer and the contractor and signed jointly. The remaining activities/outstanding points are classified in the following category.

Details of the sections:

(a) List of outstanding activities remaining in any part of the line

(b) A list of temporary arrangements introduced.

(c) Check list records properly documented, completed and signed.

(d) Original tracing of profile, route alignment, tower design, structural drawings, bill of materials, stringing charts (initial and final as applicable) etc. of all towers/line returned to the owner.

With the outstanding activities mentioned above are solved or with only minor points without influence on the charging remain (minor issues) handing over of the transmission line shall be accepted by the pre-commissioning team. This handing over for energization with or without remaining activities shall be made by the engineer to the commissioning in charge in writing .

Shortcomings noticed during the inspection, 'list of outstanding activities' shall be recorded and a copy of the format is to be given to the responsible parties like contractor etc. for corrective action to be taken on a time schedule.

7.0 PROTECTIVE SYSTEM

Before energization it must be ascertained that all protective systems for the unit to be energized are operative.

This includes confirmation that the protections have been properly tested and that the tests have been documented.

It also includes verification by inspection or otherwise, if necessary by repetition of trip test, that the protections are actually functionally enabled. This verification serves to prevent that energization takes place of a unit where a protection has been disabled for test or other reason.

8.0 SWITCHING PROCEDURES

For each activity the instructions to the operators and the communications to the dispatchers will be made in writing or by confirmed telephone messages. The switching procedures first to be properly documented step by step and understood by everybody involved in the switching operation prior to the enerzisation. Any clarification required in the procedures must be resolved. The format established by the owner for switching orders and operational data logging shall be followed.

The implication of this is that each and every activity must be listed and described, so that complete information is available for detail investigation, if required in future.

9.0 TESTING AND MEASUREMENT PROCEDURES

9.1 Earth resistance measurement

Normally earth tester is used for measuring

(a) soil resistivity.

(b) earth resistance

(i) Prior to the testing of soil resistivity and earth resistance the operation manual of the testing instrument available at site may be referred and procedures to be adopted for measurement of soil resistivity and earth resistance.

A typical earth tester has 4-terminals C1, P1, C2, P2 and 4-similar electrodes are driven in the ground at equal distances and connected to the instruments in the order of C1, P1 and P2, C2. Then the handle is

rotated or button is pressed and the reading of the resistance is read on the megger scale. If R is the resistance measured then the

Specific resistivity = $2 \pi aR$

where a is the distance between the electrode and R is the resistance in ohms measured on the megger.

(ii) In order to measure earth resistance of electrode of the substation it could be connected to C1 and the value of R could be read in the scale with the rotation of the handle of the megger. This will give the earth resistance. The value as far as possible shall be below 10 Ohm. To improve the value, water shall be sprinkle at the earthing pit.

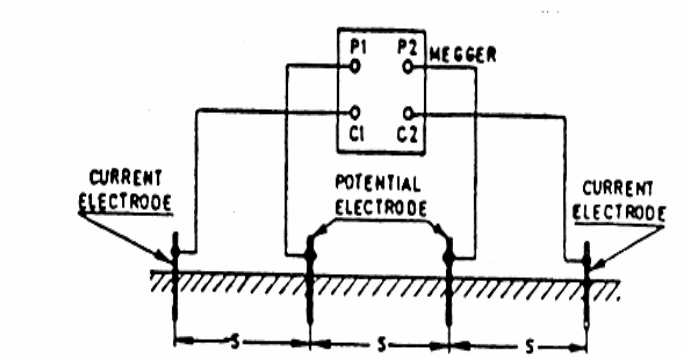


fig : 2 Test connection for a four terminal Megger

9.2 Before commissioning of the lines following tests may be carried out.

9.2.1 Insulation resistance test

This test may be carried out with the help of a 10 or 12 KV megger preferably power driven to ascertain the insulation condition of the line. In case 5 kV megger is used for insulation resistance measurement it shall be ensured that the induced voltage (CVT reading) is less than the instrument withstanding capacity otherwise it is likely that the instrument may be damaged.

This test is to be carried out first prior to the continuity test.

Measurement of insulation resistance

One of the most common devices used for testing electrical insulation is the megger insulation tester.

The DC test voltage is generated by a permanent magnet generator. This generator is turned either by hand or by an electric motor. In either case a slip clutch maintains the generator speed at a constant value so long as the slipping speed is exceeded. A constant voltage is important when the insulation under test has a high capacitance. Common generator output voltage are 500, 1000, 2500 and 5000 volts.

Many meggers have a ‘guard’ terminal as well as ‘line’ and ‘earth’. The guard terminal is useful shall one wish to exclude part of the insulation under test from

the measurement. This is possible since current flowing to the generator via the guard circuit does not pass through the deflecting coil.

Another use of the guard circuit is to shield the 'line' lead between the megger and the apparatus under test. This prevents leakage to ground from the 'line' lead which would invalidate the megger reading.

Insulation resistance is the ratio V_{DC}/I_{DC}.V_{DC} is applied across two conductors separately by the insulation under test.

I_{DC} is the current flowing through/over the insulation. For a healthy and clean insulation the megger reading is in mega-ohms to infinity. For dirty in, insulation and defective, moist insulation the meggers shows a very low insulation resistance value.

Megger test gives clear indication about the health, cleanliness and dryness of the line/equipment insulation.

5KV/10KV/12KV megger may be used for the transmission line keeping all safety requirements, permit to work, clearance from statutory bodies and other conditions prevailing at the sub-station where charging of the line is being co-ordinated.

9.2.2 Conductor continuity test

9.2.2.1 The objective of this test is to verify that each conductor of the overhead line properly connected electrically (the value of electrical resistance of line does not vary abnormally from that of a continuous conductor of the same size and length). The electrical resistance of the conductor shall be measured with a whetstone bridge or other suitable instrument, if available taking the safety aspects of equipment as well as testing engineer.

A simple method of continuity test is illustrated below:

Once the insulation test is completed and the results confirms no short circuit carry the following:

Sending end	Receiving end	Results(in ohms)	Remarks
Close R-phase - GS	Megger R-phase	Zero/low	1. GS means ground switch 2. All GS open condition.
Open Y-Phase-GS	Megger Y- phase	High	
Open B-Phase-GS	Megger B- phase	High	
Open R-Phase-GS	Megger R- Phase	High	
Close Y-Phase-GS	Megger Y- phase	Zero/low	
Open B-Phase-GS	Megger B- phase	High	
Open R-Phase-GS	Megger R- phase	High	
Open Y-Phase-GS	Megger Y- phase	High	
Close B-Phase-GS	Megger B- phase	Zero/low	

If the above test results are OK it confirms the continuity of the line.

9.2.2.2 The continuity test of the line with proper phase indication or phase marking can be checked by continuity test as described below:

Sending end	Receiving end megger between	Results (ohms)
Connect R & Y- phase, B-phase & all GS open	R & Y- phase Y & B- phase B & R- phase	Zero/ low High High
Connect R & B- phase, Y- phase & all GS open	R & Y- phase Y & B- phase B & R- phase	High High Zero/low
Connect Y & B- phase, R-phase & all GS open	R & Y- phase Y & B- phase B & R- phase	High Zero/low High

If the test results are OK it confirm that marking of the phases are in order.

9.2.2.3 Phase Sequence

Once the line is charged from one end, without closing the breaker at the other end the phase sequence is to be checked from the CVT output by the help of phase sequence meter. In case there are other feeders available, phase sequence is to be RECHECKED by the measurement of secondary voltage of both the feeders (new line & available charged line).

Let the secondary voltage of CVT is 110 volts (ph to ph) for both the circuit. In case of correct phase sequence the voltage reading shall be as follows:

New circuit	Old circuit	Voltage
R-Phase	R-Phase	0
R-Phase	Y-Phase	110
R-Phase	B-Phase	110
Y-Phase	R-Phase	110
Y-Phase	Y-Phase	0
Y-Phase	B-Phase	110
B-Phase	R-Phase	110
B-Phase	Y-Phase	110
B-Phase	B-Phase	0

In case the results are not matching the phase sequence in to be rechecked and reconfirmed before closing the breaker.

10.0 ENERGIZATION

Execution of the energization is simply the last event in the switching sequence, switching of the close control button for the relevant circuit breaker.

11.0 DE-ENERGIZATION

Instructions about de-energization will be given only if this is part of the test. Otherwise de-energization will be considered part of regular operation.

12.0 OBSERVATION AND DURATION

Visual and audible inspection (look and listen) of the relevant equipment and reading of permanent instrumentation will be made.

The system shall be charged at least for 8 hours. During this time continuous monitoring and inspection will be maintained in control room, auxiliary systems areas and switch yards.

This will include frequent, scheduled inspection of all equipment and reading of all permanent instruments and recorders, and surge arrester counters, especially system parameters as per standard procedures adopted by the owner.

13.0 PASSING CRITERIA

Neither insulation breakdown nor protective system actions must occur. No irregular equipment behaviour noise, vibration, high temperature is permitted.

Corona discharges may not be 'unreasonable'. Local discharges that may be attributable to sharp points shall be carefully located and recorded. After termination of the energization the equipment shall be closely inspected and the points rounded or covered.

No unscheduled changes of system nor of equipment is permitted during the 8 hour energized condition.

14.0 DOCUMENTATION

Switching and operational activities will be recorded in regular manner in the operator's log. Likewise all readings of permanent instruments. Copies of this log, notes on special observations from inspections and other measurements will constitute the test records.

- END -