STANDARD PARAMETER OF 800 KV CLASS TRANSMISSION SYSTEM IN INDIA

PREFACE

Earlier in the year 1990 Central Electricity Authority (CEA) brought out a report detailing parameters of the 800 kV class equipment and transmission line material based on the recommendations of Working Groups constituted following the decision of Government of India to select 800 kV (with 765 kV as the nominal voltage) as the next higher AC Transmission voltage in the country. Following this, a good number of lines were identified at this voltage. Though some of these lines have been installed maintaining 800 kV class parameters, they are being operated at 400 kV level for want of adequate power development. Accordingly associated substations continue to be at 400 kV level.

But with the initiative taken to have electricity for all by the year 2012, coinciding with the end of 11th five-year plan, now it is a near-reality to charge the above mentioned lines at 765 kV and construct few more intra-regional and inter-regional lines at that level with a dozen or so number of substations. Keeping this in mind and the progress that has been further made and as experienced in few countries that have this class of transmission system, it was felt necessary to revive the Standing EHV Committee of CEA with representations from leading power utilities and manufacturers in the country. As per order of Ministry of Power it was reconstituted in the year 2000. A few meetings took place for revising the salient parameters of 800 kV class of equipment and transmission material and reviewing those for 400 kV level through separate groups. The present report is an outcome of the deliberations in the meetings and inputs received from the members concerned. It is expected that the contents would serve power utilities as the basis of design and engineering of 800 kV transmission system in the country.

New Delhi
December 31, 2002

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Chief Engineer (SETD), CEA

BASIC SYSTEM PARAMETERS OF 800 KV SYSTEMS

1. Rated voltage kV : 800
2. Nominal Voltage kV : 765
3. Rated frequency Hz : 50
4. System Neutral Earthing : Effectively earthed
5. Rated current A : 2000
6. Short circuit current and duration kA : 40 for one second
7. Creepage distance

<table>
<thead>
<tr>
<th>Pollution site severity</th>
<th>Specific creepage distance mm/kV*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>16</td>
</tr>
<tr>
<td>Medium</td>
<td>20</td>
</tr>
<tr>
<td>Heavy</td>
<td>25</td>
</tr>
<tr>
<td>Very Heavy</td>
<td>31</td>
</tr>
</tbody>
</table>

* These are the values suggested in IEC-815, 1986, which is applicable to System Voltage of up to 525kV. As the pollution withstand characteristics is known to be non-linear for higher voltages, requiring increased creepage distance in...
proportion to the non-linearity factor. Studies by ENEL, EPRI, CIGRE suggest that this factor may be as high as 20% for 800 kV System. Hence creepage distances presented in the Table are to be appropriately increased. Further, these values may not be suitable for station insulation since the influence of diameter is considerable on the pollution performance.

8. Insulation Levels

a) Substation equipment

<table>
<thead>
<tr>
<th>Reactors/ CBs/Isolators/CVTs/CTs</th>
<th>Transformers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Insulation level</td>
<td>kV(peak)</td>
</tr>
<tr>
<td></td>
<td>1950</td>
</tr>
<tr>
<td>Basic switching level</td>
<td>kV(peak)</td>
</tr>
<tr>
<td></td>
<td>1550</td>
</tr>
<tr>
<td>Power frequency</td>
<td>kV(rms)</td>
</tr>
<tr>
<td></td>
<td>-</td>
</tr>
<tr>
<td>RIV at 508 kV rms</td>
<td>Micro volts</td>
</tr>
<tr>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

b) Transmission lines

| Basic Insulation level           | kV(peak)     |
|                                  | 2400         |
| Basic Switching level            | kV(peak)     |
|                                  | 1550         |
| Power frequency                  | kV(rms)      |
|                                  | 830          |
| RIV at 508 kV (rms)              | Micro volts  |
|                                  | 500(Max.)    |

**TRANSFORMER**

**Generator Transformers**

1. Ratings:

<table>
<thead>
<tr>
<th>Three phase rating MVA (Generally Single phase units are envisaged)</th>
<th>Voltage ratio</th>
<th>Tapping range percent</th>
<th>Percent Impedance Voltage</th>
<th>Cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>630 MVA, 800 MVA</td>
<td>21/765</td>
<td>A-off ckt taps/links</td>
<td>15.0 (tolerance allowed = +10%)</td>
<td>ONAN/OFAF or OAF or OFWF or ONAN/ODAF or ODAF/ODWF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(8 steps)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A-off ckt taps/links</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>+2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(16 steps)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Maximum flux density in any part of core and yoke at rated MVA, voltage and frequency. tesla : 1.9
Withstand capability for 25% minutes : 1 above the rated voltage

Withstand capability for 40% seconds : 5 above rated voltage

2. Connections : HV Star, Neutral effectively earthed LV Delta

3. Connection symbol : YN, dll (in 3 phase bank)

4. Terminals:
   a) LV Terminals

36 kV, 12500 amps. oil filled type bushing mounted on turrets, suitable for connections to bus bars in isolated phase bus ducts which shall have spacing of 1500 mm for each 210 MVA single-phase unit of the 630 MVA three phase bank.

For each of 266.6 MVA single phase unit of 800 MVA, 3 phase bank, 2 Nos. 36 kV, 12500 Amp bushings per termination shall be used (Total 4 Nos. bushings).

b) HV Terminal line end:

800 kV oil filled 1250 amps. condenser bushing with test tap. No arcing horns shall be provided.

Neutral ends : 36 kV porcelain bushing. No arcing horns shall be provided.

**Auto Transformers**

1. Ratings

<table>
<thead>
<tr>
<th>Three phase rating HV/IV/LV MVA</th>
<th>Voltage ratio</th>
<th>Tapping range percent</th>
<th>Percent Voltage Impedance HV IV HV LV IV LV</th>
</tr>
</thead>
<tbody>
<tr>
<td>315/315/105</td>
<td>765/220/33</td>
<td>+ 4.5%</td>
<td>-7.5%</td>
</tr>
<tr>
<td>630/630/210</td>
<td>765/400/33</td>
<td>+ 4.5%</td>
<td>-7.5%</td>
</tr>
<tr>
<td>800/800/266.6</td>
<td>765/400/33</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>1000/1000/333.3</td>
<td>765/400/33</td>
<td>-do-</td>
<td>-do-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>tolerance</th>
<th>±10%</th>
<th>±15%</th>
<th>±15%</th>
</tr>
</thead>
</table>

Max. flux density in any part of core and
yoke at rated MVA, voltage and frequency                   tesla : 1.9

Withstand capability for 25% above the rated voltage
minutes : 1

Withstand capability for 40% above the rated voltage.
seconds : 5

2. Connection : HV/IV Star auto with neutral effectively earthed : LV-Delta

3. Connection Symbol : YNa0, dll

4. Short Circuit Level :

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Short Circuit Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>800 kV</td>
<td>40 kA (rms) for 1 second</td>
</tr>
<tr>
<td>420 kV</td>
<td>40 and 63 kA (rms) for 1 second</td>
</tr>
<tr>
<td>245 kV</td>
<td>40 kA (rms) for 1 second</td>
</tr>
</tbody>
</table>

5. Terminals:

a) LV Terminals - 52 kV oil filled condenser bushings. The bushings shall be arranged in a line with 1000 mm spacing to allow mounting of phase to phase barriers. No arcing horns shall be provided.

b) IV terminal - 245/420 kV oil filled condenser bushings with test tap. No arcing horns shall be provided.

c) HV Terminal
   Line end - 800 kV oil filled condenser bushing with test tap. No arcing horns shall be provided.
   Neutral end - 36 kV porcelain bushing. No arcing horns shall be provided.

**Insulation Levels:**

Lightning, switching Impulse and Power frequency voltage level.

<table>
<thead>
<tr>
<th>Highest voltage for equipment. Um kV (rms)</th>
<th>Rated withstand lightning (kV)</th>
<th>Impulse voltage switching (kV peak)</th>
<th>Rated power frequency short duration withstand voltage kV(rms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.5(Neutral)</td>
<td>95</td>
<td>-</td>
<td>38</td>
</tr>
<tr>
<td>24(LV of GTs)</td>
<td>125</td>
<td>-</td>
<td>50</td>
</tr>
<tr>
<td>52 (LV of Auto Transformer)</td>
<td>250</td>
<td>-</td>
<td>95</td>
</tr>
<tr>
<td>245</td>
<td>950</td>
<td>-</td>
<td>395</td>
</tr>
<tr>
<td>420</td>
<td>1300</td>
<td>1050</td>
<td>-</td>
</tr>
<tr>
<td>800</td>
<td>1950</td>
<td>1550</td>
<td>-</td>
</tr>
</tbody>
</table>
In the event when transferred surges are higher than 250 (kV peak) the insulation level of tertiary winding and bushing are to be chosen accordingly.

**Partial discharge**

At \( \frac{1.5 \times U_{\text{m}}}{\sqrt{3}} \) kV, pico coulombs \( 500 \) (Max.)

**BUSHINGS :**

1) The voltage and current ratings, basic insulation level and creepage distance of the bushings shall be as follows:

<table>
<thead>
<tr>
<th>Voltage Rating (V(rms))</th>
<th>Current Rating (Amp)</th>
<th>Creepage Distance (mm)</th>
<th>Basic Impulse Level (kV peak)</th>
<th>Switching Impulse Level (kV peak)</th>
</tr>
</thead>
<tbody>
<tr>
<td>800</td>
<td>1250</td>
<td>16,000</td>
<td>2100</td>
<td>1550</td>
</tr>
<tr>
<td>420</td>
<td>1250</td>
<td>10,500</td>
<td>1425</td>
<td>1025</td>
</tr>
<tr>
<td>245</td>
<td>1250</td>
<td>6,125</td>
<td>1025</td>
<td>-</td>
</tr>
<tr>
<td>52</td>
<td>2000</td>
<td>1,800</td>
<td>250</td>
<td>-</td>
</tr>
</tbody>
</table>

2) RIV at 508 kV (rms) micro volts : \( 1000 \) (Max.)

3) Corona Extinction voltage kV(rms) : \( 508 \) (Min.)

4) Partial discharge level pico coulombs : \( 500 \) (Max.)

**CIRCUIT BREAKERS**

1. Type : SF6
2. Installation : Outdoor
3. No. of poles : 3
4. No. of trip circuits : 2 (independent)
5. Rated short circuit making current. kA peak : 100
6. Value of pre-insertion resistor ohm : 450 To limit switching surge over voltage to 1.9 p.u.
7. Pre-insertion time ms : 10
8. Rated operating duty cycle : 0.3 second-CO-3 min.-CO
9. Rated break time ms : 40
10. Closing time ms : 100
11. Difference in the instants of opening of contacts
    - within a pole ms : 2.5
    - between poles ms : 3.33
12. Difference in the instants of closing of contacts between poles ms : 10
13. Rated line charging current
Sl.No. | Line Length(km) | Typical Line Charging current at bus voltage of 1.4 pu (kA) |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No shunt reactor in the line</td>
</tr>
<tr>
<td>1</td>
<td>100</td>
<td>0.262</td>
</tr>
<tr>
<td>2</td>
<td>150</td>
<td>0.393</td>
</tr>
<tr>
<td>3</td>
<td>200</td>
<td>0.542</td>
</tr>
<tr>
<td>4</td>
<td>250</td>
<td>0.655</td>
</tr>
<tr>
<td>5</td>
<td>300</td>
<td>0.786</td>
</tr>
<tr>
<td>6</td>
<td>350</td>
<td>0.917</td>
</tr>
</tbody>
</table>

14. Small inductive current : 0.5 A to 10 A without switching over voltage exceeding 1.9 p.u.

15. Type of operating mechanism or combination of these.
   Anti pumping and trip free

16. First pole to clear factor : 1.3

17. Type of auto reclosing : Single phase and 3-Phase.
   : 10 NO and 10 NC on each pole, exclusively for purchaser’s use. Continuous current 10 A DC. Breaking capacity shall be 2 Amp. min. with circuit time constant not less than 20 ms at 220 V DC. Contacts should be reversible type at site.

DISCONNECTS/EARTHING SWITCHES

1. Type of disconnect : Vertical Break
2. No. of poles : 3
3. Installation : Outdoor
4. Rated peak withstand current kA : 100
5. Rated magnetising current/capacitive breaking & making current. A : 0.7
6. Type of operating mechanism : Electrical/Manual

INSTRUMENT TRANSFORMERS

Current Transformers

1. Rated primary currents A : 2000
2. Rated secondary current A : 1
3. Number of cores : 5
4. Rated continuous thermal current : 120%
5. Parameter | Core I Line/Equipment Protection Main- I | Core II Line/Equipment Protection Main- II | Core III Metering | Core IV Bus bar Protection | Core V Bus bar Protection
---|---|---|---|---|---
Utilisation | 2000-1000-500/1 | 2000-1000-500/1 | 2000-1000/1 | 2000-1000/1
Transformation ratio | 2000-1000-500/1 | 2000-1000-500/1 | 2000-1000/1 | 2000-1000/1
Accuracy Class | PS | PS | 0.2 PS ISF <10 | PS | PS
Rated Burden | - | - | 15 VA | - | -
$V_k$ | 1000 volts | 1000 volts | volts | volts
Maximum Exciting Current at Rated $V_{k/2}$ | 10-50 mA | 25-100 mA | mA | mA
Maximum Secondary Winding Resistance | 15-2.5 ohm | 10-5-2.5 ohm | ohm | ohm

Data for TPY/TPX Core (Alternative to Core I & Core II)

- **i)** Duty cycle: Single/Double energization CO/CO-t-CO
- **ii)** Ratio applicable: 2000/1A
- **iii)** Rated symmetrical short circuit current factor: 20
- **iv)** Rated primary time constant, ms: 80
- **v)** Duration for flow of current
  - Single energisation ms: 240 for CO duty
  - Double energisation ms: 100 & 40 for CO-t-CO duty
- **vi)** Time interval between two successive short circuit current, ms: 1000
- **vii)** Rated burden ohm: 7.5

**Bushing CTs**

**Capacitor Voltage Transformers**

1. Number of secondary windings: 3
2. Rated secondary voltage, burden, accuracy and utilisation

<table>
<thead>
<tr>
<th>Winding</th>
<th>Rated Voltage Volt</th>
<th>Rated burden VA</th>
<th>Accuracy</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>110 /v3</td>
<td>50</td>
<td>3P</td>
<td>Main I Protection</td>
</tr>
<tr>
<td>II</td>
<td>110 /v3</td>
<td>50</td>
<td>3P</td>
<td>Main II Protection</td>
</tr>
<tr>
<td>III</td>
<td>110 /v3</td>
<td>50</td>
<td>0.2</td>
<td>Metering.</td>
</tr>
</tbody>
</table>

3. Transformation Ratio

- 765 / v3 kV
- 110 / v3 V
Protection Schemes

Line Protection

1) Main I

Carrier aided distance protection suitable for use with different carrier modes.

2) Main II

Carrier aided protection based on directional comparison using wave detection or phase comparison principles.

3) Directional Earth fault Scheme

Two sets of directional earth fault relays, one for each main protection to cover high resistance faults.

4) Over-voltage Protection

The relay to have two stages and shall be able to monitor phase to neutral voltage for all the three phases.

Auto Transformer Protection

1) Differential Protection
   (Percentage Biased)

2) High impedance differential protection

3) Over fluxing protection.

4) Back-up directional over current protection.

5) Overload protection.

6) Neutral standby earth protection

7) Delta circulating current protection.

Shunt Reactor Protection

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4.</td>
<td>Voltage factor</td>
</tr>
<tr>
<td>5.</td>
<td>Rated Capacitance pF</td>
</tr>
<tr>
<td>6.</td>
<td>Stray conductance of the low Voltage terminal over entire carrier frequency range micro-Siemens</td>
</tr>
<tr>
<td>7.</td>
<td>Corona extinction voltage kV(rms)</td>
</tr>
<tr>
<td>8.</td>
<td>Partial discharge level at 508 kV(rms) Pico coulombs</td>
</tr>
</tbody>
</table>
1) Differential protection
2) Restricted earthfault protection
3) Back-up protection

**Bus Bar Protection**

High speed differential protection with features for checking the security as required.

**Circuit Breaker Failure Protection**

In the event of circuit breaker failure, all circuit breakers connected to the Bus Section to which the fault circuit breaker is connected shall be tripped with minimum possible time delay.

**Other Equipments**

**a) Distance to Fault Locator**

Distance to Fault Locator shall be installed for identifying the location of faults and for taking preventive measures against fault prone areas.

**b) Disturbance Recording Equipment**

i) Disturbance Recorder

Disturbance Recorder shall be micro-processor based and shall be used to record the graphic form of instantaneous value of voltage and current in all three phases, open delta voltage and neutral current, open or closed positions of relay contacts and breaker during the system disturbance condition.

ii) Event Logging Equipment

The Event Logger is recommended to record the status of 800 kV Switchyard equipment and relays and occurrences of alarms. It shall be possible to accommodate about up to 500 points. Whenever input status change occurs, an immediate printed record would be provided by the equipment.

**POWER LINE CARRIER COMMUNICATION**

A. Coupling Devices.

1. Method of coupling : Phase to phase/3-phase coupling
2. Nominal line side Impedance ohms : 480 (phase to phase)
3. Nominal equipment side Impedance ohms
   - Balanced : 150
   - Unbalanced : 75
4. Bandwidth kHz : 50-150

B. Line Traps
C. PLC Terminal

1. Carrier frequency range kHz : 50-500
2. Carrier frequency band kHz : 4.0/2.5 or integral multiple thereof
3. Nominal Impedance at carrier frequency output ohms : 75 (unbalanced)
4. Return loss within the nominal carrier frequency band. db : Not less than 10
5. Peak envelope power W : Upto 80
6. Speech frequency band Hz : 300-2000 or 300-2400
7. Speech levels
   Four wire transmit
   Four wire receive : +8 dB -3.5 dB
   Two wire transmit
   Two wire receive : 0 dB
   : 7 dB

D. VF Protection Signalling

1. Transmission time msec : 20 (max.)
2. PLC Channel No.1
   Speech + data
3. PLC Channel No.2
   Protection 1 + Express speech
4. PLC Channel No.3
   Protection 2
5. PLC Channel No.4
   Protection 3

E. Coupling Capacitors

1. Installation : Outdoor
2. Rated capacitance Pico Farad : 8800
3. Switching Impulse withstand voltage kV(peak) : 1550
4. Voltage factor : 1.5 for 30 secs.
5. Equivalent series resistance over the entire carrier frequency range. Ohms : less than 40
6. Radio Interference voltage at : 2500 (max.)
508 kV(rms) Micro volts

7. Partial discharge level Pico Coulombs : Less than 10
8. Corona extinction voltage kV(rms) : 508 (Min.)

## SURGE ARRESTERS

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Type Arrester</td>
<td>Gapless (Metal Oxide)</td>
</tr>
<tr>
<td>2.</td>
<td>Nominal discharge current kA</td>
<td>20</td>
</tr>
<tr>
<td>3.</td>
<td>Rated Arrester voltage kV(rms)</td>
<td>624</td>
</tr>
<tr>
<td>4.</td>
<td>Continuous operating voltage kV(rms)</td>
<td>485</td>
</tr>
<tr>
<td>5.</td>
<td>Maximum residual voltage at lighting impulse kV(peak) of 20 KA</td>
<td>1430</td>
</tr>
<tr>
<td>6.</td>
<td>Maximum switching impulse residual voltage at 2 kA kV(peak)</td>
<td>1280</td>
</tr>
<tr>
<td>7.</td>
<td>Maximum steep current impulse residual voltage at 20 kA kV(peak)</td>
<td>1630</td>
</tr>
<tr>
<td>8.</td>
<td>Dynamic over voltage withstand capability for 3 peaks kV(peak)</td>
<td>1240</td>
</tr>
<tr>
<td></td>
<td>0.3 sec.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.0 sec.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.1 sec.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.0 sec.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.0 sec.</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Discharge capability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A- Transmission line class kj/kV</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>B- Minimum energy capability</td>
<td>28</td>
</tr>
</tbody>
</table>

NOTE:- This energy takes into account occurrence of two successive line discharges followed by TOV profile as given at Sl.No.(8).

10. Maximum radio interference/ partial discharge at 508 kV (rms) micro volts/ pico-coulombs : 250/50

## SWITCHYARD LAYOUT

1. Switching Scheme : Double bus Double breaker. Depending on the requirement of purchaser, one and a half breaker scheme can also be adopted. However, the bays arrangements shall be so selected that the rated current of 2000 A for different equipments is not exceeded under any contingency.
2. Clearance (Minimum)
   Phase to earth m : 6.4
   Phase to Phase m : 10.0
   Section clearance m : 10.0

3. Bay details
   i) Bay width m : 45
   ii) Bus size (Tentative)
       a) Rigid bus/equipment
          Inter connecting bus
          : 6" IPS tubular Aluminium pipe
       b) Strung bus/Crossover bus
          : Quad All Aluminium Tarantulla
   iii) Bay Dimensions

<table>
<thead>
<tr>
<th>Low level</th>
<th>High level</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Above ground)</td>
<td>(Above ground)</td>
</tr>
<tr>
<td>(Meters)</td>
<td>(Meters)</td>
</tr>
<tr>
<td>Bus level</td>
<td>12</td>
</tr>
<tr>
<td>Equipment Interconnecting level</td>
<td>12</td>
</tr>
<tr>
<td>Crossover bus level</td>
<td>27</td>
</tr>
<tr>
<td>Span length</td>
<td>15</td>
</tr>
</tbody>
</table>

TRANSMISSION LINE

Conductor:

1. Code Name : ACSR Bersimis
2. Number of sub-conductor /phase : 4
3. Spacing between conductors mm : 450
4. Bundle arrangement : Horizontal Square
5. Nominal Aluminium area sq.mm : 690
6. Stranding and Wire Diameter : 42/4.57 mm Al + 7/2.54 mm St.
7. Overall Diameter mm : 35.04
8. Approximate mass kg /km : 2187
9. Ultimate Tensile strength kN : 146.87
10. D.C. Resistance at 20° C ohms/km : 0.04242
11. Corona extinction kV(rms) voltage phase to ground : 560
12. Modulus of Elasticity kg/cm² : 0.6320 x 10⁶
13. Coefficient of linear expansion per degree C : 21.5 x 10⁻⁶
14. Maximum allowable temperature degree C : 95

Earthwire :

1. Size : 7/3.66 mm G.S.S. wire of 95 Kgf/ sq.mm (1GPa) quality
2. Number of earthwire : 2
3. Overall Diameter mm : 10.98
4. Quality of groundwire kgf/sq.mm : 95
5. Ultimate Tensile strength kgs. : 6972
6. D.C. Resistance at 20º C ohms/km : 2.5

7. Shield angle for towers
   (i) Outer phase : 15º
   (ii) Middle phase: The middle phase shall fall below the circle drawn with two ground wire points as diameter.

8. Modulus of Elasticity kg/cm² : 1.933 x 10⁶

9. Coefficient of linear expansion per degree C : 11.5 x 10⁻⁶

10. Maximum allowable temperature degree C : 53

Disc Insulators and Insulator Strings:

<table>
<thead>
<tr>
<th>Insulator strings</th>
<th>Suspension string</th>
<th>Tension string</th>
<th>Pilot string</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Configuration</td>
<td>V-90º</td>
<td>Quadruple 4 strings in parallel</td>
<td>Single I</td>
</tr>
<tr>
<td>2. Number of discs per string(Size 280x170 mm, EMS=210 KN, creepage distance=370 mm)</td>
<td>2 x 35 (Each limb 35 discs)</td>
<td>4 x 35 (Each limb 35 discs)</td>
<td>1 x 35 (35 discs)</td>
</tr>
<tr>
<td>3. No deformation load (67% of mechanical failing load of 210 KN)</td>
<td>2 x 140 KN</td>
<td>4 x 140 KN</td>
<td>1 x 140 KN</td>
</tr>
<tr>
<td>4. Maximum voltage across any disc across any disc phase to ground voltage of 462 kV(rms)</td>
<td>Not more than 25 kV(rms)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Towers:

1. Number of circuit : Single circuit
2. Configuration : Horizontal
3. Normal span m : 400
4. Wind span : 1.0 x normal span (For plain terrain)
5. Weight span:
   i) Suspension tower, max. min. : 1.5 x Normal span
   (For hilly terrain, the minimum weight span be fixed suitably).
   ii) Angle tower, Downward Upward : 2 x Normal span : 200 m Net span
6. Maximum temperature of current carrying power conductor exposed to sun : 95 º C
7. Maximum temperature of groundwire exposed to sun : 53 º C
8. Clearances:
i) Minimum ground clearance as per Indian Electricity rules: 12,400 mm

ii) As per interference limitations: 15,500 mm

iii) Live conductor to grounded metal

<table>
<thead>
<tr>
<th>Swing</th>
<th>Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>'V' Suspension string (V- 90°)</td>
<td>Nil</td>
</tr>
<tr>
<td>‘I’ Suspension string</td>
<td>Nil</td>
</tr>
<tr>
<td>Zone I &amp; II</td>
<td>22°</td>
</tr>
<tr>
<td></td>
<td>45°</td>
</tr>
<tr>
<td>Zone III &amp; IV</td>
<td>27°</td>
</tr>
<tr>
<td></td>
<td>55°</td>
</tr>
<tr>
<td>Zone V &amp; VI</td>
<td>30°</td>
</tr>
<tr>
<td></td>
<td>60°</td>
</tr>
</tbody>
</table>

**Quadruple tension string**

**Jumper**

<table>
<thead>
<tr>
<th>Zone I &amp; II</th>
<th>15°</th>
<th>4,400 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>30°</td>
<td>1,300 mm</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zone III &amp; IV</th>
<th>20°</th>
<th>4,400 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>40°</td>
<td>1,300 mm</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zone V &amp; VI</th>
<th>22°</th>
<th>4,400 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>45°</td>
<td>1,300 mm</td>
<td></td>
</tr>
</tbody>
</table>

| Pilot string | 20° | 4,400 mm |

iv) Mid span separation mm : 12,400

v) For ground undulation, extra over ground clearance mm : 300
vi) Creep compensation for conductor through tensioning at the time of stringing : Height of tower may be increased instead of considering reduction in temperature over

9) Loadings :

Loadings shall be determined for the two loading combinations including wind on tower as given below :

- Combination I
  - As per IS: 802 -Part I-1995
- Combination II

SHUNT REACTORS

1. Rating (single phase) MVAR : 50, 80, 110 in three phase banks.
2. Winding connection : Star
4. Magnetisation characteristic : Linear upto 1.4 p.u.
   - Slope of the characteristic in the saturated region shall be 0.3 to 0.5.
5. Permissible unbalance current % among single phase reactors of a three phase bank.
6. Ratio of zero sequence reactance to positive sequence reactance.
7. Noise level at rated voltage dB and frequency
   - 81 for 50 MVAR
   - 83 for 80 MVAR
   - 85 for 110 MVAR
8. Clearances of terminals in mm air (phase to earth)
   - 5800
9. Type of cooling : ONAN
10. Type of cooling medium : Mineral oil to IS:335 (and as standardised for 800kV Power Transformers)
11. Terminals
   - Line Terminals
   - Neutral Terminal

145 kV NEUTRAL GROUNDING REACTOR FOR GROUNDING SHUNT REACTOR.

1. Number of phases : 1
2. Maximum continuous current A(rms) : 15
3. Short time current Rating A(rms) ) : To be specified by purchaser after system studies.
4. Rated Impedance : 4 ohms
5. Magnetisation characteristics : Linear upto short time current.
6. Terminals
   a) Line end
   b) Earth end
7. Type of cooling : 145 kV condenser bushing (as standardised for neutral of 800 kV shunt reactor)
8. Type of cooling Medium : 36 kV porcelain bushing
9. Phase to earth air clearances
   a) Line end : 1050 mm
   b) Neutral end : 230 mm
10. Insulation levels
    a) Lightning impulse kV(peak)
        voltage withstand of the line terminal : 550
    b) One minute power frequency kV(rms)
        voltage withstand of the earth terminals : 38
11. Whether full or graded insulation. : Graded insulation

SHUNT REACTOR

(Connected to tertiary of power transformer to provide back-up reactive compensation)

1. Rated voltage kV : 36
2. Number of phases : 3
3. Rating (three phase) MVAR : 31.5, 50, 63, 80
5. Whether full or graded insulation : Full insulation
6. Basic insulation level (for line and neutral end of winding and bushings)
   a) 1.2/50 microsecond lightning impulse withstand voltage kV(peak) : 250
   b) One minute power frequency withstand voltage kV(rms) : 95
7. Magnetisation characteristic : Linear upto 1.3 p.u. voltage
8. Minimum clearance in air
   Phase-phase mm : 530
   Phase-earth mm : 480
   : 74 for 31.5 MVAR
9. Noise level at rated voltage and frequency.
   75 for 50 MVAR
   77 for 63 MVAR
   77 for 80 MVAR
10. Terminals : 52 kV, 800/2000 A oil filled condenser bushing with
INTERFERENCE LEVELS

Transmission Lines

1. RI should not exceed 50 dB for 80% of the time duration during the year.

2. TVI- The minimum signal to noise ratio should be 30.

3. Audio noise level for 800 kV system should be less than 55 dB(A).

4. Electrostatic field should be less that 10 kV/m below the outermost phase (2 m above the ground) and less than 2 kV/m at the edge of the right of way (45 m).

PTCC:

1. Maximum value of induced electromagnetic voltage for fault duration of equal to or less than 200 ms.
   - Volts: 650

2. Maximum value of induced noise (noise interference) to be taken cognizance if noise is persistent.
   - Micro volts: 2000 (measured)