

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.

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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

Pollution site severity	Specific creepage distance mm/kV*
Low	16
Medium	20
Heavy	25
Very Heavy	31

* 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

	Reactors/ CBs/Isolators/CVTs/CTs	Transformers
Basic Insulation level	kV(peak) 1950	2400
Basic switching level	kV(peak) 1550	1550
Power frequency	kV (rms) -	830
RIV at 508 kV rms	Micro volts -	1000(Max.)

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:

Three phase rating MVA(Generally Single phase units are envisaged)	Voltage ratio	Tapping range percent	Percent Impedance Voltage	Cooling
630 MVA,800 MVA	21/765	A-off ckt taps/links +2 -6 (8 steps) alternatively B-On load taps +2 -6 (16 steps)	15.0 (tolerance allowed = + 10%)	ONAN/OFAF or OFAF or OFWF or ONAN/ODAF or ODAF/ODWF

Maximum 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 rated voltage seconds : 5

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

Three phase rating HV/IV/LV MVA	Voltage ratio	Tapping range percent	Percent Voltage HV IV	Impedance			Cooling
				HV LV	IV LV		
315/315/105	765/220/ 33	+ 4.5% -7.5% 24 steps	12.5	40	25	ONAN/OFAF or ONAN/ ODAF or ODAF	
630/630/210	765/400/33	+ 4.5 % -7.5% 24 steps	12.5	60	40	-do-	
800/800/266.6		-do-	-do-	-do-	-do-	-do-	
1000/1000/333.3	765/400/ 33	+4.5% -7.5% 24 steps	14.0	65	45	-do-	
	tolerance	±10%	±15%	±15%			

Max. flux density in any part of core and

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 $1.5 \times \frac{U_m}{\sqrt{3}}$ kV, pico coloumbs 500 (Max.)

BUSHINGS :

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

Voltage Rating kV(rms)	Current Rating (Amp)	Creepage (mm)	Distance	Basic Impulse Level (peak) kV	Switching Impulse Level kV(peak)
800	1250	16,000		2100	1550
420	1250 2000	10,500		1425	1025
245	1250	6,125		1025	-
52	2000 5000	1,800		250	-
2) RIV at 508 kV (rms)		micro volts	:		1000 (Max.)
3) Corona Extinction voltage	kV(rms)	:			508 (Min.)
4) Partial discharge level	pico coloumbs	:			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)		
		No shunt reactor in the line	With one of the two shunt reactors failed	Both shunt reactors in service
1	100	0.262	0.197	0.131
2	150	0.393	0.295	0.197
3	200	0.542	0.393	0.262
4	250	0.655	0.491	0.328
5	300	0.786	0.590	0.393
6	350	0.917	0.688	0.459
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	Pneumatic or hydraulic spring charged 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.	
18.	No. of auxiliary contacts	:	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
Utilistation	2000- 1000- 500/1	2000- 1000- 500/1	2000- 1000- 500/1	2000- 1000/1	2000- 1000/1
Transformation ratio	PS	PS	0.2 ISF <10	PS	PS
Accuracy Class	-	-	15 VA		
Rated Burden	4000- 2000- 1000 volts	4000- 2000- 1000 volts	-	2000- 1000 volts	2000- 1000 volts
Min.knee point voltage	10-50-100 mA	25-50-100 mA	-	25-50 mA	25-50 mA
V_k	15-5-2.5 ohm	10-5-2.5 ohm	-	10-5 ohm	10-5 ohm
Maximum Exciting Current at Rated $V_{k/2}$					
Maximum Secondary Winding Resistance.					

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 energistation 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

Not yet finalised.

Capacitor Voltage Transformers

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

Winding	Rated Voltage Volt	Rated burden VA	Accuracy	Purpose
I	110 / $\sqrt{3}$	50	3P	Main I Protection
II	110 / $\sqrt{3}$	50	3P	Main II Protection
III	110 / $\sqrt{3}$	50	0.2	Metering.

3. Transformation Ratio

765 / $\sqrt{3}$ kV
110 / $\sqrt{3}$ V

4. Voltage factor	1.5 for 30 seconds
5. Rated Capacitance pF	4400
6. Stray conductance of the low Voltage terminal over entire carrier frequency range micro-Siemens	50
7. Corona extinction voltage kV(rms)	508(Min.)
8. Partial discharge level at 508 kV(rms) Pico coulombs	Less than 10

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

- 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 upto 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 | : | 150 (balanced)
75(unbalanced) |
| 4. | Bandwidth kHz | : | 50-150 |

B. Line Traps

1.	Rated inductance at system frequency	mH	:	1
2.	Blocking resistance	ohms	:	430
3.	Rated Bandwidth	kHz	:	50-150
4.	Radio Interference Voltage at 508 kV(rms)	Micro volts	:	500(Max.)
5.	Nominal discharge current of protective device connected across main coil	kA	:	10

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		:	+8 dB
	Four wire receive		:	-3.5 dB
	Two wire transmit		:	0 dB
	Two wire receive		:	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.)

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

SURGE ARRESTERS

1.	Type Arrester		:	Gapless (Metal Oxide)
2.	Nominal discharge current	kA	:	20
3.	Rated Arrester voltage	kV(rms)	:	624
4.	Continuous operating voltage	kV(rms)	:	485
5.	Maximum residual voltage at lighting impulse current of 20 KA	kV(peak)	:	1430
6.	Maximum switching impulse residual voltage at 2 kA	kV(peak)	:	1280
7.	Maximum steep current impulse residual voltage at 20 kA	kV(peak)	:	1630
8.	Dynamic over voltage withstand capability for 3 peaks			
	0.3 sec.	kV(peak)	:	1240
1	0.1 sec.	kV(peak)	:	1045
	1.0 sec.	kV(peak)	:	920
	10.0 sec.	kV(peak)	:	865
9.	Discharge capability			
	A- Transmission line class		:	4
	B- Minimum energy capability	kJ/kV	:	28
	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-coloumbs	:	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.

- i) Minimum ground clearances as per Indian Electricity rules. mm 12,400
- ii) As per interference limitations mm 15,500
- iii) Live conductor to grounded metal

	Swing	Clearance
'V' Suspension string (V- 90°)	Nil	5,000 mm
'I' Suspension string		
Zone I & II	Nil	5,100 mm
	22°	4,400 mm
	45°	1,300 mm
Zone III & IV	Nil	5,100 mm
	27°	4,400 mm
	55°	1,300 mm
Zone V & VI	Nil	5,100 mm
	30°	4,400 mm
	60°	1,300 mm

Quadruple tension string

Jumper

Zone I & II Nil 5,100 mm
 15° 4,400 mm
 30° 1,300 mm

Zone III & IV Nil 5,100 mm
 20° 4,400 mm
 40° 1,300 mm

Zone V & VI Nil 5,100 mm
 22° 4,400 mm
 45° 1,300 mm

Pilot string Nil 5,100 mm
 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 |
| 3. Neutral earthing | | : | Earthed through Neutral Grounding Reactor. |
| | | : | Linear upto 1.4 p.u. |
| 4. Magnetisation characteristic | | : | 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. | | : | ± 2 |
| 6. Ratio of zero sequence reactance to positive sequence reactance. | | : | 1.0 (single phase) |
| 7. Noise level at rated voltage and frequency | dB | : | 81 for 50 MVAR
83 for 80 MVAR
85 for 110 MVAR |
| 8. Clearances of terminals in air (phase to earth) | mm | : | 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 | | : | 800 kV oil filled condenser bushing with test tap. No arcing horns shall be provided |
| Neutral Terminal | | : | 145 kV oil filled condenser oil/ SF ₆ bushing |

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	ohms)	To be specified by purchaser after system studies.
5. Magnetisation characteristics		: Linear upto short time current.
6. Terminals		
a) Line end		: 145 kV condenser bushing (as standardised for neutral of 800 kV shunt reactor)
b) Earth end		: 36 kV porcelain bushing
7. Type of cooling		: ONAN
8. Type of cooling Medium		: Mineral oil to IS:335 (and asstandardized for "800 kV Power Transformers")
9. Phase to earth air clearances		
a) Line end	mm	: 1050
b) Neutral end	mm	: 230
10. Insulation levels		
a) Lightning impulse voltage withstand of the line terminal	kV(peak)	: 550
b) One minute power frequency voltage withstand of the earth terminals.	kV(rms)	: 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
4. Winding connection		: Star with neutral left inside.
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
9. Noise level at rated voltage and frequency.	dB	: 74 for 31.5 MVAR 75 for 50 MVAR 77 for 63 MVAR 77 for 80 MVAR
10. Terminals		: 52 kV, 800/2000 A oil filled condenser bushing with

