PEAKING CAPABILITY OF GENERATING STATIONS.

The peaking availability of generating units would be taken on the basis of the latest norms laid down by CEA. The spinning reserve of 5% for Thermal, Nuclear, Hydro generation and Backing down allowance of 5% for Gas based generation as laid in the present norms of Generation Planning Criteria of CEA may not be taken into consideration for Transmission Planning due to continuing peaking shortage of power in all the regions during eighth plan period and beyond.

Norms for peaking Capability of Thermal Stations :

The peaking capability of generating units would be computed as given below.

Unit Capacity (MW)	Outage rates			Aux. consu-mption (AC) %	Capacity availabilit factor (CAF) %	Peaking capabili factor (PCF) %
	Planned (PMR) %	Forced (FOR) %	Partial (POR) %			
200 MW & Above	10.0	14.0	9.0	10.0	67.0	60.3
Below 200 MW	10.0	16.0	14.0	10.5	60.0	53.7

Note: i) CAF=100-(PMR+FOR+POR)
PCF=CAF-CAF x AC
ii) In case of Eastern and North-Eastern Regions forced outage rate will be increased by 5%.

Norms for peaking capability of Hydro stations

Capital Maintenance (CM) = 3 %
Forced Outage rate (FOR) = 4.5 %
Auxiliary Consumption (AC) = 1.0 %
Capacity availability factor (CAF) = 100 - (CM + FOR) = 92.5 %
Peaking Capability Factor (PCF) = CAF - CAF x AC = 91.5 %

Norms for peaking Capability of Gas based Stations:

The gas based power stations are grouped into two categories namely base load stations and peak load stations. The base load stations are normally Combined cycle power plant which have Gas Turbine units and Steam Turbine units. The peak load stations are open cycle Gas Turbines which are generally used for meeting peak load for about 8 Hours in a day at 80 % of their rated capacity. For combined cycle gas based power station, the peaking capability would be as given below :

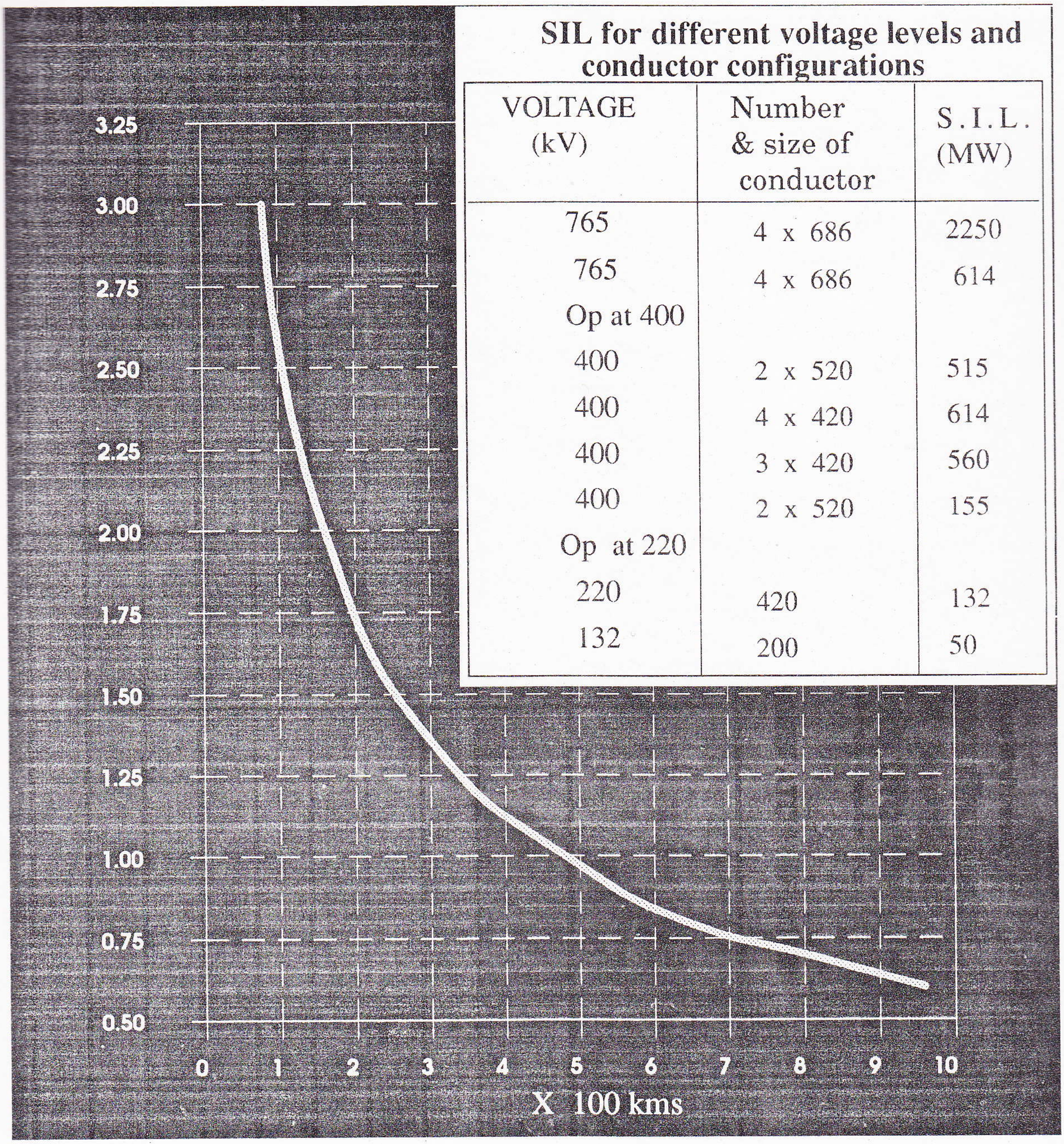
Unit Capacity (MW)	Outage rates			Aux. consumption (AC) %	Capacity availabilty factor (CAF) %	Peaking capability factor (PCF) %
	Planned (PMR) %	Forced (FOR) %	Partial (POR) %			
Gas turbine units	15.0	10.0	10.0	1.0	65.0	64.4
Steam Turbine units	15.0	10.0	10.0	4.0	65.0	62.4

Note: CAF=100-(PMR+FOR+POR)
PCF=CAF-CAF x AC

ANNEX-II

(refer para 4.1)

LINE LOADING AS FUNCTION OF LENGTH



SIL for different voltage levels and conductor configurations

VOLTAGE (kV)	Number & size of conductor	S.I.L. (MW)
765	4 x 686	2250
765 Op at 400	4 x 686	614
400	2 x 520	515
400	4 x 420	614
400	3 x 420	560
400 Op at 220	2 x 520	155
220	420	132
132	200	50

ANNEX-III

(refer para 4.2)

THERMAL LOADING LIMITS

Conductor type and dimension	Ambient temperature (°C)	AMPACITY FOR Maximum Conductor Temperature (°C)		
		65	75	85
ACSR PANTHER 210 sq mm	40	312	413	
	45	244	366	
	48	199	334	
	50		311	
ACSR ZEBRA 420 Sq. mm	40	454	622	
	45	339	546	
	48	240	493	
	50		454	
ACSR MOOSE 520 Sq mm	40	487	684	
	45	345	595	
	48	214	532	
	50		487	
ACSR BERSIMIS 680 Sq. mm	40	565	804	
	45	388	697	
	48	220	621	
	50		565	
AAAC 420 Sq mm	40			762
	45			701
	48			661
	50			632
AAAC 520 Sq. mm	40			843
	45			773 ← 400
	48			726
	50			694
AAAC 560 sq mm	40			882
	45			808
	48			759
	50			725

Assumptions : solar radiations = 1045W/sq.mt., Wind velocity = 2kM/hour
Absorption coeff. = 0.8, Emissivity coeff = 0.45 Age > 1 year

ANNEX-IV

OPERATIONAL STANDARDS

The operational standards normally define the expected level of power system performance under different conditions of system operations and thus provide the guiding objectives for the planning and design of transmission systems. In the absence of any detailed document on operational standards, the following objectives are considered in the context of formulating the manual:

1. The system parameters (voltage and frequency) shall be as close to the nominal values as possible and there shall be no overloading of any system element under normal conditions and different feasible load-generation conditions.

2. The system parameters and loading of system elements shall remain within prescribed limits and not necessitate load shedding or generation re-scheduling in the event of outage of any single system element over and above a pre-contingency system depletion of another element in another corridor. In the case of 220 kV and 132 kV systems this shall hold good for outage of Double Circuit lines. In case of power evacuation from major generating station/complex (when the terrain indicates possibilities of tower failure) the system shall withstand the outage of two 400 kV circuits if these are on the same tower. Also in the case of large load complexes with demands exceeding 1000 MW the impact of outage of two incoming 400 kV circuits (if these are on the same towers) shall be minimum.

3. The system shall remain in synchronism without necessitating load shedding or islanding in the event of Single-phase-to-ground fault (three- phase fault in the case of 220 kV and 132 kV systems) assuming successful clearing of fault by isolating/opening of the faulted system element.

4. The system shall have adequate margins in terms of voltage and steady state oscillatory stability.

5. No more than four 220 kV feeders/ two 400 kV feeders/ one 765 kV feeder shall be disrupted in the event of a stuck breaker situation.

ANNEX- V

DATA PREPARATION FOR TRANSMISSION PLANNING STUDIES

Actual system data wherever available should be used. In cases where data is not available standard data given below can be assumed.

Load flow & Short circuit studies

i) Load power factor shall be taken as per para 3.2.3 of the manual

ii) Reactive power limits for generator buses can be taken as

Qmax = Fifty percent of active generation
Qmin = (-) Fifty percent of Qmax

iii) Desired voltage of generator (PV) buses may be taken between 1.03 and 1.05 for peak load conditions and between 0.98 to 1.0 for light load conditions .

iv) Line parameters (p.u. / km / ckt at 100 MVA base)

Line voltage (kV)	conductor configuration	Positive Sequence			Zero Sequence		
		R	X	B	R	X	B
765	Quad Bersimis	1.9513E-6	4.475E-5	2.4E-2	4.5E-5	1.8E-4	1.406E-2
400	Twin Moose	1.862E-5	2.075E-4	5.55E-3	1.012E-4	7.75E-4	3.584E-3
400	Twin AAAC	1.934E-5	2.065E-4	5.67E-3	1.051E-4	7.73E-4	3.66E-3
400	Quad Zebra	1.05E-5	1.59E-4	6.65E-3	5.708E-3	5.94E-4	4.294E-3
400	Quad AAAC	0.979E-5	1.676E-4	6.99E-3	5.32E-3	6.26E-4	4.51E-3
400	Triple Zebra	1.401E-5	1.87E-4	5.86E-3	7.616E-3	6.949E-4	3.783E-3
220	Zebra	1.547E-4	8.249E-4	1.42E-3	4.545E-4	2.767E-3	8.906E-4
132	Panther	9.31E-4	2.216E-3	5.1E-4	2.328E-3	9.31E-3	

v) Transformer reactance	**Generating Unit**	**Inter-connecting**
(At its own base MVA)	14-15 %	12.5 %

In planning studies all the transformers should be kept at nominal taps and On Load Tap Changer (OLTC) should not be considered. The effect of the taps should be kept as operational margin.

For Short circuit studies transient reactance (X'd) of the synchronous machines shall be used. [Although sub-transient reactance (X"d) is generally lower than transient reactance and therefore short circuit levels computed using X"d shall be higher than those computed using X'd, but since circuit breaker would operate only after 100 msec from fault initiation , the effect of sub-transient reactance would not be present.]

For short circuit studies for asymmetrical faults vector group of transformers shall be considered. Inter-winding reactances in case of three winding transformers shall also be considered.

For evaluating short circuit levels at generating bus (11 kV, 13.8 kV etc.) that unit along with its unit transformer shall be represented separately .

Transient Stability Studies

Transient stability studies shall be carried out on regional basis. Export/Import to/from neighbouring region shall be represented as passive loads.

Voltage Dependency of the system loads

Active loads (P) shall be taken as $P = P_0 (V/V_0)$
Reactive loads (Q) shall be taken as $Q = Q_0 (V/V_0)^2$

Frequency Dependency of the system loads

Active loads (P) shall be taken as $P = P_0 (f/f_0)$
Reactive loads (Q) shall be taken as independent of frequency.
where P_0, Q_0, V_0 and f_0 are values at the initial system operating conditions.

Synchronous machines may be represented as given below
(for all regions except North-eastern region)

Machine Size	**To be represented as**	
less than 30 MW	may be represented as passive loads.	
30 to 100 MW	**Classical model**	**(IEEE type 1)**
100 to 190 MW	Transient model	(IEEE type 2 for Hydro) (IEEE type 3 for Thermal)
200 and above	Sub-transient model	(IEEE type 4 for Hydro) (IEEE type 5 for Thermal)

TYPICAL PARAMETERS FOR THERMAL & HYDRO MACHINES

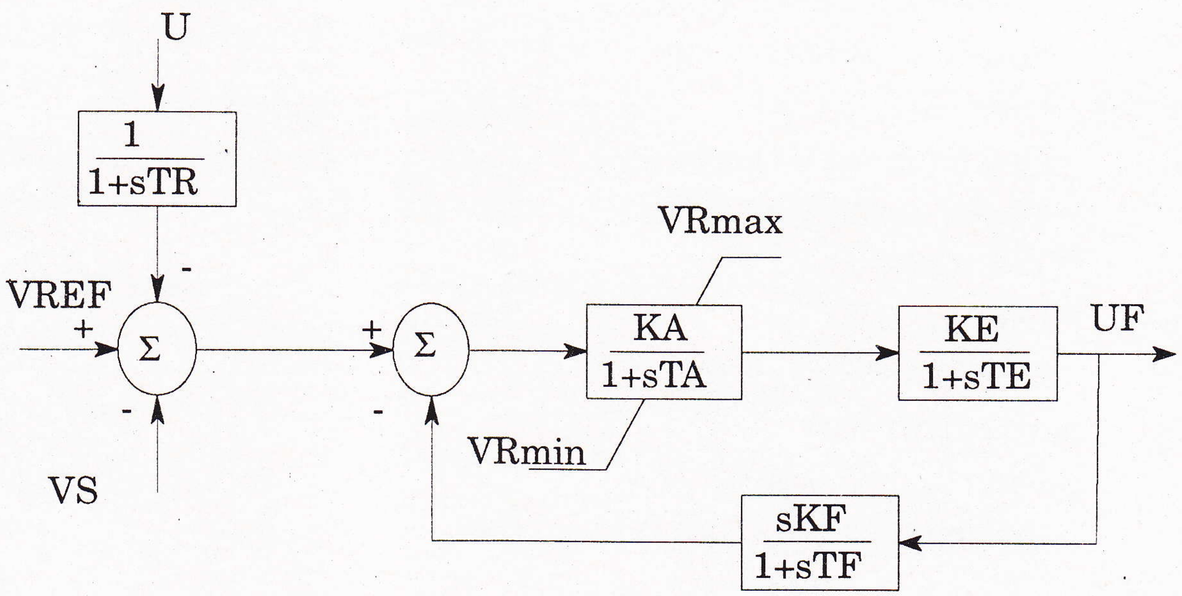
MACHINE DATA - THERMAL / HYDRO

MACHINE PARAMETERS	MACHINE RATING (MW)		
	THERMAL		HYDRO
	500	210	200
Rated Voltage (kV)	21.00	15.75	13.80
Rated MVA	588.00	247.00	225.00
Inertia Constant (H)	3.07	2.73	3.5
Reactance			
Leackage (Xl)	0.14	0.18	0.16
Direct axis (Xd)	2.31	2.23	0.96
Quadrature axis (Xq)	2.19	2.11	0.65
Transient reactance			
Direct axis (X'd)	0.27	0.27	0.27
Quadrature axis (X'q)	0.70	0.53	0.65
Sub-transient reactance			
Direct axis (X"d)	0.212	0.214	0.18
Quadrature axis (X"q)	0.233	0.245	0.23
Open Circuit Time Cont			
Transient			
Direct axis (T'do)	9.0	7.0	9.7
Quadrature axis (T'qo)	2.5	2.5	0.5
Sub-transient			
Direct axis (T"do)	0.04	0.04	0.05
Quadrature axis (T"qo)	0.2	0.2	0.10

Source : M/S Bharat Heavy Electricals Ltd.

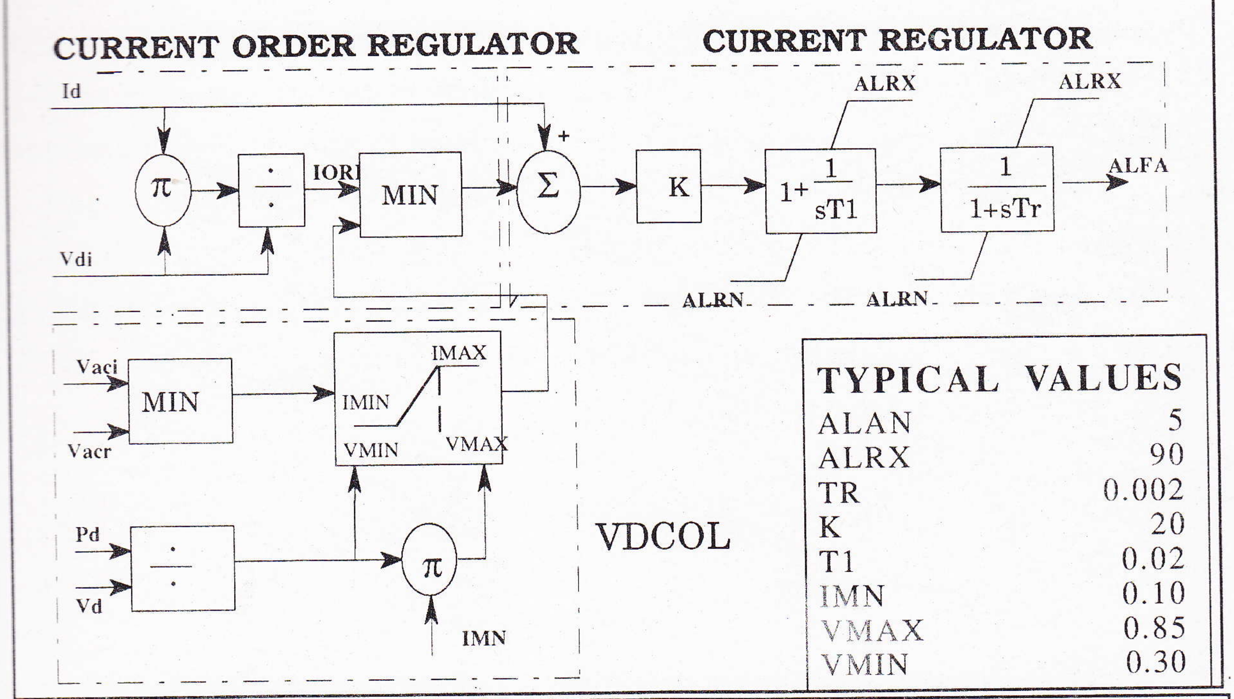
TYPICAL PARAMETERS FOR EXCITERS

Typical parameters	Hydro	Thermal	
		<210MW	>210MW
Transdu. Time Cons. (TR)	0.040	0.040	0.015
Amplifier gain (KA)	25 - 50	25 - 50	50-200
Amplif. Time Cons. (TA)	.04-.05	.04-.05	.03-.05
Regulator limiting voltage			
Maximum (VRmax)	4.0	6.0	5.0
Minimum (VRmin)	-4.0	-5.0	-5.0
Feed back signal			
Gain (KF)	0.01	0.01	.01
Time Constant (TF)	1.00	1.00	1.00
Exciter			
Gain (KE)	1.0	1.00	1.00
Time Constant (TE)	0.7	0.3	0.001

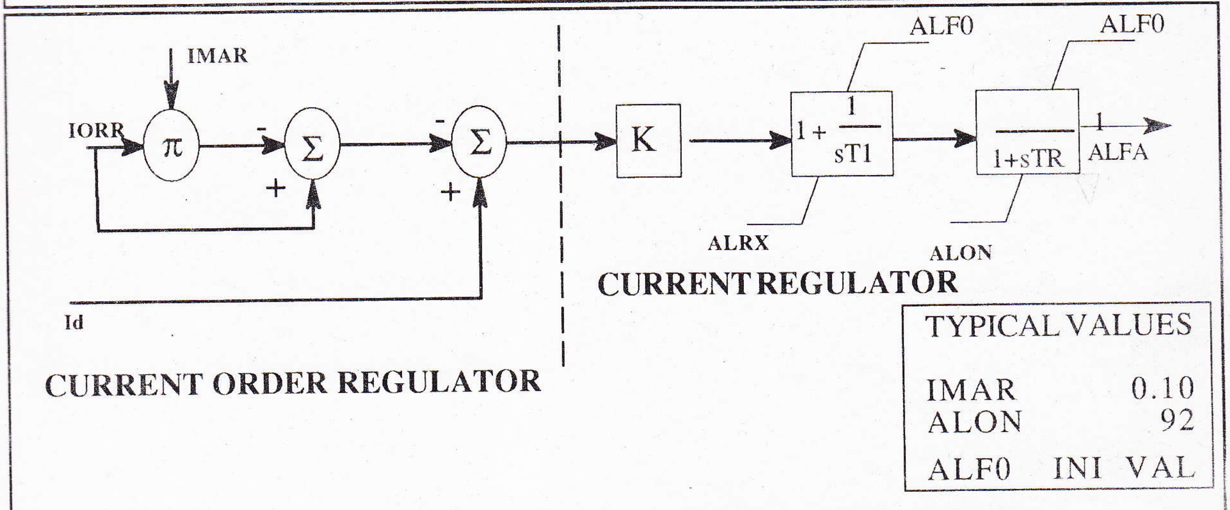


H.V.D.C. data : No standardised DC control model has been developed so far as this model is usually built to the loacl requirements of the DC terminals. Based on the past experience in carrying out stability studies, the following models have been suggested for rectifier and invertor terminals.

DC CONTROL MODEL FOR RECTIFIER (POWER CONTROL)



TYPICAL VALUES	
ALAN	5
ALRX	90
TR	0.002
K	20
T1	0.02
IMN	0.10
VMAX	0.85
VMIN	0.30



TYPICAL VALUES	
IMAR	0.10
ALON	92
ALF0	INI VAL

D C CONTROL MODEL FOR INVERTOR

E.M.T.P. Studies: System shall be, to the extent possible, represented in detail. Parallel circuits/ alternate paths shall also be considered. At least one source shall be represented as type 59 (detail representation). Saturation characteristics of transformers and reactors shall also be considered.

Voltage Stability Studies : These studies are carried out using loadflow analysis program by creating a fictitous synchronous condenser at most voltage sensitive bus i.e. bus is converted into PV bus. By reducing desired voltage of this bus MVAR generation/ absorption is monitored. When voltage is reduced to some level it may be observed that MVAR absorption does not increase by reducing voltage further instead it also gets reduced. The voltage where MVAR absorption does not increase any further is known as Knee Point of Q-V curve. The knee point of Q-V curve represents the point of voltage instability. The horizontal 'distance' of the knee point to the zero-MVAR vertical axis measured in MVARs , is therefore an indicator of the proximity to the voltage collapse.