E) *Magnetization Current Test(At 10kV for 400kV and above transformer)*

a) Apply 1 Phase, AC supply on HV Terminals and keep IV and LV open

Tap Position	Voltage Applied (Volts)		Current Measured (mAmps)		Remarks
LOWEST	R - N		R - Ø		
	Y - N		Y - Ø		
	B - N		B - Ø		
NORMAL	R - N		R - Ø		
	Y - N		Y - Ø		
	B - N		B - Ø		
HIGHEST	R - N		R - Ø		
	Y - N		Y - Ø		
	B - N		B - Ø		

b) Apply 1 phase, AC supply on IV Terminal and keep HV & LV open

Tap Position	Voltage Applied (Volts)		Current Measured (mAmp)	
Normal	2R – 2Y		R – Ø	
	2Y – 2B		Y – Ø	
	2R – 2B		B – Ø	

Note:

i. Excitation current < 50 mili-Amperes, then difference between two higher currents should be less than 10%.
ii. Excitation current > 50 mili-Amperes, then difference between two higher currents should be less than 15 %.
iii. Value of center leg should not be more than either outside for a three phase reactor.
iv. Results between similar single phase units should not vary more than 10%.

F) *Short Circuit Impedance Test*

Ambient Temperature ____________________ OTI Reading _________________

a) HV TO IV

Tap Number	1 R		1Y		1B	
	IV of R Φ and N shorted, LV open		IV of Y Φ and N shorted, LV open		IV of R Φ and N shorted, LV open	
	Voltage (Volt)	Current (Amp)	Voltage (Volt)	Current (Amp)	Voltage (Volt)	Current (Amp)
Lowest						
Nominal						
Highest						

b) IV TO LV

Supply Nominal tap	2U1-N, ……....V	2V1-N,……….V	2W1-N, ……...V
Short all LVs and HV Open and measured current in Amp			

c) HV TO LV

Supply	Short All 3 LV Bushings, HV Open and Measured Current in Amp		
	Nominal tap	Highest tap	Lowest tap
1U1-N, ……....V			
1V1-N,……….V			
1W1-N, ……...V			

Note: The measurement is performed in single phase mode.

G) Insulation Resistance Measurement

a) Insulation Resistance Measurement of Cable and others (Using 500 Volt Megger)

Ambient temp in º C ______________________

Sl. No.	Description	Status		Remarks, If Any
		Yes	No	
1	Control wiring			
2	Tap changer			
	a) Motor			
	b) Control			
3	Cooling System			
	a) Motor Fan			
	b) Motor Pump			
	c) Control wiring			

Note: Permissible limit of IR value should be > 50 M Ω

b) Insulation Resistance Measurement in MΩ(Using 5000 V Megger)

Ambient temp in º C ________________________

Main Winding	IR Value			Dielectric Absorption Coefficient DAI= 60 Sec / 15 Sec	Polarisation Index PI= 600 Sec / 60 Sec	Remarks
	15 sec	60 sec	600 sec			
Combination for Auto transformer						
a) HV+IV / LV						
b) HV+IV / E						
c) LV / E						
Combination for 3 winding transformer						
a) HV+IV / LV						
b) HV+IV / E						
b) HV+IV+LV / E						

Note:- Permissible limit of IR value should be > 500 M Ω for 66kV & above at 30°C, DAI should be >1.3 and PI should be >1.25

H) Core Insulation Test (After oil circulation)

Shorting link between CC, CL & G to be removed and IR value to be taken between CC-G, CL-G & CC-CL by applying 2 kV DC

Terminals	Insulation Value	Terminals	Insulation Value
CC-G		CC-CL	
CL-G		Semi-shield –G (if provided) at 1 kV	

Note:

i. Permissible value > 500 MΩ
ii. In case core insulation values are less than the permissible limit matter to be referred to OEM for corrective measures and same to be checked during internal inspection for any abnormality
iii. Ensure shorting of CC-CL & G after the completion of the testing

I) Voltage Ratio Test

a) Turn Ratio : HV / IV

Tap Position	Ratio			Factory Ratio			% Deviation		
	R	Y	B	R	Y	B	R	Y	B
1									
2									

Tap Position	Ratio			Factory Ratio			% Deviation		
	R	Y	B	R	Y	B	R	Y	B
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
In Reverse order									
For all Tap									

b) Ratio : HV / LV

Tap Position	Voltage Applied			Voltage Measured			Ratio			Factory Ratio			% Deviation		
	1R-N	1Y-N	1B-N	3R-3Y	3Y-3B	3R-3B	R	Y	B	R	Y	B	R	Y	B
Lowest															
Normal															
Highest															

c) Ratio : IV / LV(For all Tap if OLTC is on Neutral side)

Tap Position	Voltage Applied			Voltage Measured			Ratio			Factory Ratio			% Deviation		
	2R-N	2Y-N	2B-N	3R-3Y	3Y-3B	3R-3B	R	Y	B	R	Y	B	R	Y	B
Normal															

Note:

1. The variation of result should be within ± 0.5 % from specified values (i.e. factory test result)
2. Measurement to be done by Automatic Turns ratio meter

J) *Tan δ And Capacitance Measurement*

a) Tan δ And Capacitance Measurement Of Bushing

BUSHING DETAILS

Details	High Voltage Side			Intermediate Voltage Side		
	R - Ø	Y - Ø	B - Ø	R - Ø	Y - Ø	B - Ø
Make						
Type						
Sl.	No.					
Style No / Drawing No						

DETAILS	LOW VOLTAGE SIDE		
	R - Ø	Y - Ø	B - Ø
Make			
Type			
Sl. No.			
Style No / Drawing No			

Ambient temperature ______________________________

a) HV side

VOLTAGE	CAPACITANCE (MEASURED VALUE)						REMARKS
	R - Ø		Y - Ø		B - Ø		
	SITE	FACTORY	SITE	FACTORY	SITE	FACTORY	
Measurement of C1							
2 K	V						
10 KV							
Measurement of C2							
1 K	V						

VOLTAGE	TAN δ (MEASURED VALUE)						REMARKS
	R - Ø		Y - Ø		B - Ø		
	SITE	FACTORY	SITE	FACTORY	SITE	FACTORY	
Measurement of C1Tan δ							
2 K	V						
10 KV							
Measurement of C2 Tan δ							
1 K	V						

b) IV side

VOLTAGE	CAPACITANCE (MEASURED VALUE)						REMARKS
	R - Ø		Y – Ø		B - Ø		
	SITE	FACTORY	SITE	FACTORY	SITE	FACTORY	
Measurement of C1							
2 K	V						
10 KV							
Measurement of C2							
1 K	V						

VOLTAGE	TAN δ (MEASURED VALUE)						REMARKS
	R - Ø		Y – Ø		B - Ø		
	SITE	FACTORY	SITE	FACTORY	SITE	FACTORY	
Measurement of C1 Tan δ							
2 K	V						
10 KV							
Measurement of C2 Tan δ							
1 K	V						

c) LV side

VOLTAGE	CAPACITANCE (MEASURED VALUE)						REMARKS
	R - Ø		Y - Ø		B – Ø		
	SITE	FACTORY	SITE	FACTORY	SITE	FACTORY	
Measurement of C1							
2 K	V						
10 KV							
Measurement of C2							
1 K	V						

VOLTAGE	TAN δ (MEASURED VALUE)						REMARKS
	R - Ø		Y – Ø		B – Ø		
	SITE	FACTORY	SITE	FACTORY	SITE	FACTORY	
Measurement of C1 Tan δ							
2 K	V						
10 KV							
Measurement of C2 Tan δ							
1 K	V						

b) TAN δ AND CAPACITANCE MEASUREMENT OF WINDING

Ambient temperature ______________________________

VOLTAGE	WINDING COMBINATION	TEST MODE	CAPACITANCE		TAN δ		REMARK
			SITE	FACTORY	SITE	FACTORY	
2 KV	HV-IV/ LV	UST					
10 KV							
2 KV	HV-IV/ LV+G	GST					
10 KV							
2 KV	HV-IV/ LV Guarded	GSTg					
10 KV							
2 KV	LV/ HV-IV	UST					
10 KV							
2 KV	LV/ HV-IV+G	GST					
10 KV							
2 KV	LV/ HV-IV Guarded	GSTg					
10 KV							

Note:
i. C2 values shall be only for record purpose.
ii. For bushing acceptable Limit for Tan δ1 should be comparable (+/- 0.001) with factory value subjected to max of 0.004 & Tan δ2:-0.01
iii. For winding acceptable Limit for Tan δ1 should be comparable (+/- 0.001) with factory value subjected to max of 0.005 & Tan δ2:-0.01
iv. Acceptable Limit for Capacitance -5% to + 10%

K) *Measurement Of Winding Resistance (In mΩ)*

Ambient temperature in º C______ OTI Reading ______ WTI reading _____

A) HIGH VOLTAGE SIDE(IN CASE OLTC IS ON LINE SIDE)

Tap Position	Winding Resistance(HV-N)			Resistance At 75º C			Factory Value At 75º C			% Deviation		
	1R1 – 2R1	1Y1 – 2Y1	1B1 – 2B1	1R1 – 2R1	1Y1 – 2Y1	1B1 – 2B1	1R1 – 2R1	1Y1 – 2Y1	1B1 – 2B1	1R1 – 2R1	1Y1 – 2Y1	1B1 – 2B1
1												
2												
3												

Tap Position	Winding Resistance(HV-N)			Resistance At 75º C			Factory Value At 75º C			% Deviation		
	1R1 – 2R1	1Y1 – 2Y1	1B1 – 2B1	1R1 – 2R1	1Y1 – 2Y1	1B1 – 2B1	1R1 – 2R1	1Y1 – 2Y1	1B1 – 2B1	1R1 – 2R1	1Y1 – 2Y1	1B1 – 2B1
4												
5												
6												
7												
8												
9b												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												

Reverse Order For All Tap Position

Tap Position	Winding Resistance(HV-IV)			Resistance At 75º C			Factory Value At 75º C			% Deviation		
	1R1–2R1	1Y1–2Y1	1B1–2B1	1R1–2R1	1Y1–2Y1	1B1–2B1	1R1–2R1	1Y1–2Y1	1B1–2B1	1R1–2R1	1Y1–2Y1	1B1–2B1
TAP.…												
TAP…												
TAP…												
TAP…												

B) INTERMEDIATE VOLTAGE SIDE(FOR ALL TAP IN CASE OLTC IS ON NEUTRAL SIDE)

Between Windings	Resistance	Resistance At 75 °C In Ohms		% Deviation
	Site Value@ ----ºC	Factory	Site	
2R1 – N				
2Y1 – N				
2B1 – N				

C) LOW VOLTAGE SIDE

Between Windings	Resistance Site Value@ ----ºC	Resistance At 75 °C In Ohms		% Deviation
		Factory	Site	
3R1 – 3B1				
3Y1 – 3R1				
3B1 – 3Y1				
Across winding (for 1-phase unit)				

NOTE:

i. Formula for calculating the resistance at 75°C: $R_{75} = R_T\,(235+75)/(235+T)$, where R_T = Resistance Measured At Winding Temperature T.
ii. Permissible limit: ±5% variation between phases or from Factory test results
iii. LV winding resistance at factory measured without formation of delta. However measurements carried out at site are after formation of delta. Hence a correction factor of 1.5 times to be applied in site results

L) Oil Characteristics

Sample to be taken prior to charging to Transformer and it should fulfill the following:

DATE OF OIL SAMPLING	B.D.V.	MOISTURE	TAN δ	RESISTIVITY	INTERFACIAL TENSION
Permissible Limit	**70KV(min)**	**5 PPM(Max)**	**0.01 at 90°C (Max)**	**6x 10 ^12 Ω - cm at 90º C (Min)**	**0.0 35 N/m at 27ºC (Min)**

DISSOLVED GAS ANALYSIS

DISSOLVE GASES	H2	CH4	C2H4	C2H6	C2H2	CO	CO2	O2	N2	TCG
Before Charging										

Note:-

i. TCG should be below 1%
ii. One fresh oil sample per lot (from drum) shall be sent to Lab for carrying out Oxidation Stability test

M) Operational Test and Checks of Other Equipments

a) Test On OLTC

SL. NO	DESCRIPTION	STATUS		REMARKS
		OK	NOT OK	
1	Visual inspection of equipment			
2	Manual operation on all taps (local) with confirmation of the no. of revolutions and locking at extreme taps			
3	Over load device of driving motor			
4	Local operation (electrical)			
5	Remote operation (electrical)			
6	Tap position indicator			
7	Check operation with master follower Scheme (parallel operation)			
8	Out of step relay			
9	Step by step contactor			
10	Limit switch			
11	Winding resistance at all taps			
12	Continuity test of winding during one complete cycle of operation			

b) Checking of cooling Equipments

SL. NO.	DESCRIPTION	STATUS		Remarks
		OK	NOT OK	
1	Rotation direction of Pumps			
2	Rotation direction of Fans			

c) Protection Check

EQUIPMENT FAN NO	SETTING VALUE	PICKUP VALUE	SINGLE PHASING PREVENTION CHECK
1			
2			
3			
-			
-			
Pump No.			
1			
2			
3			
4			

N) Checks on Bushing CT's

(a) Rated Data And Duty

CORE	RATIO	CLASS	BURDEN	KVP	PROTECTION / METERING
Core-I					
Core II					
Core III					
Core IV					
-					

(b) Insulation Resistance Measurement Of Bushing Ct's(Using 500v Megger)

Measurement Between	Unit	HV			IV		
		R – Ø	Y - Ø	B - Ø	R - Ø	Y - Ø	B - Ø
Earth - Core I	M Ω						
Earth - Core II	M Ω						
Earth - Core III	M Ω						
Earth - Core IV	M Ω						

Measurement Between	Unit	LV			Neutral
		R - Ø	Y - Ø	B - Ø	
Earth - Core I	M Ω				
Earth - Core II	M Ω				
Earth - Core III	M Ω				
Earth - Core IV	M Ω				

Measurement Between	Unit	HV			IV		
		R – Ø	Y - Ø	B - Ø	R - Ø	Y - Ø	B - Ø
Core I – Core II	M Ω						
Core I – Core III	M Ω						
Core I – Core IV	M Ω						
Core II – Core III	M Ω						
Core II – Core IV	M Ω						
Core III – Core IV	M Ω						

MEASUREMENT BETWEEN	UNIT	LV		
		R - Ø	Y - Ø	B - Ø
Core I – Core II	M Ω			
Core I – Core III	M Ω			
Core I – Core IV	M Ω			
Core II – Core III	M Ω			
Core II – Core IV	M Ω			
Core III– Core IV	M Ω			

(c) **CONTINUITY TEST OF BUSHING CT'S (in Ω)**

Continuity, Check between Terminals : **OK / NOT OK**

CORE	BETWEEN TERMINAL	HV			IV		
		R - Ø	Y - Ø	B - Ø	R - Ø	Y - Ø	B - Ø
Core – I	1S1–1S2						
Core – II	2S1–2S2						
Core – III	3S1–3S2						
Core – IV	4S1–4S2						

CORE	BETWEEN TERMINAL	LV			NEUTRAL
		R – Ø	Y – Ø	B – Ø	
Core – I	1S1–1S2				
Core – II	2S1–2S2				
Core – III	3S1–3S2				
Core – IV	4S1–4S2				

(d) SECONDARY WINDING RESISTANCE OF BUSHING CT'S (IN OHM)

i. HV side

CORE	BETWEEN TERMINAL	UNIT	R - Ø		Y - Ø		B - Ø	
			FACTORY	SITE	FACTORY	SITE	FACTORY	SITE
Core I	1S1 – 1S2	Ω						
Core II	2S1 – 2S2	Ω						
Core III	3S1 – 3S2	Ω						
Core IV	4S1 – 4S2	Ω						

ii. IV side

CORE	BETWEEN TERMINAL	UNIT	R - Ø		Y - Ø		B - Ø	
			FACTORY	SITE	FACTORY	SITE	FACTORY	SITE
Core I	1S1 – 1S2	Ω						
Core II	2S1 – 2S2	Ω						
Core III	3S1 – 3S2	Ω						
Core IV	4S1 – 4S2	Ω						

iii. LV side

CORE	BETWEEN TERMINAL	UNIT	R - Ø		Y - Ø		B - Ø	
			FACTORY	SITE	FACTORY	SITE	FACTORY	SITE
Core I	1S1 – 1S2	Ω						
Core II	2S1 – 2S2	Ω						
Core III	3S1 – 3S2	Ω						
Core IV	4S1 – 4S2	Ω						

iv. Neutral Side

CORE	BETWEEN TERMINAL	UNIT	FACTORY	SITE
Core I	1S1 – 1S2	Ω		

v. External Neutral CT (if provided)

CORE	BETWEEN TERMINAL	UNIT	FACTORY	SITE
Core I	1S1 – 1S2	Ω		

(e) Polarity Test Of Bushing CT's

With 1.5 V DC supply (Connect +ve at P1 and –ve at P2)

i.

CORE	BETWEEN		HV			IV		
			R - Ø	Y - Ø	B - Ø	R - Ø	Y - Ø	B - Ø
Core I	1S1 (+ve)	1S2 (-ve)						
Core II	2S1 (+ve)	2S2 (-ve)						
Core III	3S1 (+ve)	3S2 (-ve)						
Core IV	4S1 (+ve)	4S2 (-ve)						

ii.

CORE	BETWEEN		LV			NEUTRAL
			R - Ø	Y - Ø	B - Ø	
Core I	1S1 (+ve)	1S2 (-ve)				
Core II	2S1 (+ve)	2S2 (-ve)				
Core III	3S1 (+ve)	3S2 (-ve)				
Core IV	4S1 (+ve)	4S2 (-ve)				

Note: Extra row may be added for additional cores

(f) CURRENT RATIO TEST

Primary Injection through Primary Injection Kit at Primary Terminal P1 – P2
Measure current on the secondary Terminals. In case of factory fitted turret CTs, current ratio may be carried out by CT analyzer

i. HV side R – Phase side

Core S1 - S2	Primary %	Current Actual	Secondary Current	Theoretical Ratio	Actual Ratio	% Of Error
Core I (1S1 – 1S2)	20%					
	80%*					
Core II (2S1 – 2S2)	20%					
	80%*					
Core III (3S1 – 3S2)	20%					
	80%*					
Core IV (4S1 – 4S2)	20%					
	80%*					

ii. HV side Y – Phase

Core S1 - S2	Primary %	Current Actual	Secondary Current	Theoretical Ratio	Actual Ratio	% Of Error
Core I (1S1 – 1S2)	20%					
	80%*					
Core II (2S1 – 2S2)	20%					
	80%*					
Core III (3S1 – 3S2)	20%					
	80%*					
Core IV (4S1 – 4S2)	20%					
	80%*					

iii. HV side B – Phase

Core S1 - S2	Primary %	Current Actual	Secondary Current	Theoretical Ratio	Actual Ratio	% Of Error
Core I (1S1 – 1S2)	20%					
	80%*					
Core II (2S1 – 2S2)	20%					
	80%*					
Core III (3S1 – 3S2)	20%					
	80%*					
Core IV (4S1 – 4S2)	20%					
	80%*					

iv. IV side R – Phase

Core S1 - S2	Primary %	Current Actual	Secondary Current	Theoretical Ratio	Actual Ratio	% Of Error
Core I (1S1 – 1S2)	20%					
	80%*					
Core II (2S1 – 2S2)	20%					
	80%*					
Core III (3S1 – 3S2)	20%					
	80%*					
Core IV (4S1 – 4S2)	20%					
	80%*					

v. IV side Y – Phase

Core S1 - S2	Primary %	Current Actual	Secondary Current	Theoretical Ratio	Actual Ratio	% Of Error
Core I (1S1 – 1S2)	20%					
	80%*					
Core II (2S1 – 2S2)	20%					
	80%*					
Core III (3S1 – 3S2)	20%					
	80%*					
Core IV (4S1 – 4S2)	20%					
	80%*					

vi. IV side B – Phase

Core S1 - S2	Primary %	Current Actual	Secondary Current	Theoretical Ratio	Actual Ratio	% Of Error
Core I (1S1 – 1S2)	20%					
	80%*					
Core II (2S1 – 2S2)	20%					
	80%*					
Core III (3S1 – 3S2)	20%					
	80%*					
Core IV (4S1 – 4S2)	20%					
	80%*					

Note:-*Minimum current shall be 1000A or 80% whichever is achieved. In case of any abnormality, ratio test to be carried out at 40% and 60% also.
Permissible limit: Protection core-±3% and Metering core- ±0.5%

(a) MAGNETISING CURVES PERFORMANCE

(Not to be done for metering Core)
Knee Point Voltage (KVp) = ………………..Volt

i. HV Side R – Phase

Voltage		Unit	Current Measurement			
To Be Applied	Actual Value		Core – I 1S1-1S2	Core – II 2S1-2S2	Core – III 3S1-3S2	Core – IV 4S1-4S2
0.25 x KVp		mA				
0.50 x KVp		mA				
0.75 x KVp		mA				
1.00 x KVp		mA				
1.10 x KVp		mA				

ii. HV Side Y – Phase

Voltage		Unit	Current Measurement			
To Be Applied	Actual Value		Core – I 1S1-1S2	Core – II 2S1-2S2	Core – III 3S1-3S2	Core – IV 4S1-4S2
0.25 x KVp		mA				
0.50 x KVp		mA				
0.75 x KVp		mA				
1.00 x KVp		mA				
1.10 x KVp		mA				

iii. HV Side B – Phase

Voltage		Unit	Current Measurement			
To Be Applied	Actual Value		Core – I 1S1-1S2	Core – II 2S1-2S2	Core – III 3S1-3S2	Core – IV 4S1-4S2
0.25 x KVp		mA				
0.50 x KVp		mA				
0.75 x KVp		mA				
1.00 x KVp		mA				
1.10 x KVp		mA				

iv. IV Side R – Phase

Voltage		Unit	Current Measurement			
To Be Applied	Actual Value		Core – I 1S1-1S2	Core – II 2S1-2S2	Core – III 3S1-3S2	Core – IV 4S1-4S2
0.25 x KVp		mA				
0.50 x KVp		mA				
0.75 x KVp		mA				
1.00 x KVp		mA				
1.10 x KVp		mA				

v. IV Side Y – Phase

Voltage		Unit	Current Measurement			
To Be Applied	Actual Value		Core – I 1S1-1S2	Core – II 2S1-2S2	Core – III 3S1-3S2	Core – IV 4S1-4S2
0.25 x KVp		mA				
0.50 x KVp		mA				
0.75 x KVp		mA				
1.00 x KVp		mA				
1.10 x KVp		mA				

vi. IV Side B – Phase

Voltage		Unit	Current Measurement			
To Be Applied	Actual Value		Core – I 1S1-1S2	Core – II 2S1-2S2	Core – III 3S1-3S2	Core – IV 4S1-4S2
0.25 x KVp		mA				
0.50 x KVp		mA				
0.75 x KVp		mA				
1.00 x KVp		mA				
1.10 x KVp		mA				

Note:-

a) Test to be carried out by Automatic CT analyzer

b) CT should not saturate at 110% of Knee Point Voltage (KVp)

c) If Knee Point Voltage is not mentioned then Knee Point Current may be taken into consideration.

O) ***Protection And Alarms***

a)

SL.NO	DEVICE	SET FOR		PROVED	
		ALARM	TRIP	ALARM	TRIP
1	Winding temperature	**100**	**110**		
2	Oil temperature	**90**	**100**		
3	Oil flow failure		NA		NA
4	Pressure relief valve	NA		NA	
5	Main tank Buchholz relay				
6	OLTC Buchholz relay	NA		NA	
7	Fan failure		NA		NA
8	Low oil level (MOG)		NA		NA
9	Differential relay	NA		NA	
10	Over load relay		NA		NA
11	Restricted Earth fault relay (REF)	NA		NA	
12	Back up O/C & EF relay (HV & IV)	NA		NA	
13	Inter trip , if any	NA		NA	
14	Trip free check	NA		NA	
16	Over flux (HV & IV)				
17	SPR relay (if provided)				
18	On line DGA				

b) Protection setting applied as per CC-Engg. approved settings

Yes	No	Remarks

c) Stability test of differential and REF protection

Ok	Not Ok	Remarks

NOTE : Prove the tripping of associated break ers by actual operation of the various devices and relays as per the schemes.

d) Delta formation of single phase units and spare switching arrangement scheme checked

Yes	No	Remarks

P) Final Documentation Review

a) Factory test results are available

Yes	No

b) All electrical test results compared with factory test results & found to be in order

Yes	No

c) Final documents of Pre- Commissioning checks reviewed and approved

Yes	No

d) Document regarding spares equipment, O&M manuals etc available at site

Yes	No

e) After modification, if any, "As built Drawings" are available at site

Yes	No

Q) Checks After Charging of Transformer

Record the following after charging

a) Any abnormal sound emanating from the transformer

Yes	No	Remarks

b) No load current at relay terminal

R - Ø	A
Y - Ø	A
B - Ø	A

c) Temperature at the time of charging

OTI	º C
WTI	º C
AMBIENT	º C

d) Maximum temperature after 24 hours____________º C

e) OLTC electrical operation checked in idle charged condition from minimum position to maximum position & back to normal position

Yes	No	Remarks

f) Thermo vision scanning done at least after 24 hours of loading & repeated after one week.

Yes	No	Remarks

g) Dissolve gas Analysis

DISSOLVE GASES	24 HRS AFTER CHARGING	7 DAYS AFTER CHARGING	15 DAYS AFTER CHARGING	1 MONTH AFTER CHARGING	3 MONTH AFTER CHARGING
H_2					
CH_4					
CO					
CO_2					
C_2H_4					
C_2H_6					
C_2H_2					
O2					
N2					
TCG					

Note: If any abnormal increase in fault gasses observed after 24 Hrs. of charging, immediate oil sampling to be sent to Lab for confirmation and matter shall be referred to OEM

Signature:	**Signature:**	**Signature:**	**Signature:**
Name:	**Name:**	**Name:**	**Name:**
Designation:	**Designation:**	**Designation:**	**Designation:**
Organization: (Supplier Representative) (Wherever Applicable)	**(Erection Agency)**	**(POWERGRID Site I/C)**	**(POWERGRID Commissioning. Team) Members:** **1.** **2.** **3.** **4.**

PRE-COMMISSIONING FORMATS FOR REACTOR

I. GENERAL DETAILS

DETAILS	
Region:	**Sub-Station:**
LOA No. :	**Make:**
Sr. No.:	**Type:**
Equipment identification No.:	
Year of Manufacture:	**Rating:**
Voltage Class :	**Cooling Type:**
Type of Neutral Grounding:	**Oil Make:**
Oil type:	**Oil quantity:**
Quantity of Radiator	**Date of Receipt at site:**
Date of Starting of Erection:	**Date of Completion of Erection and Oil filling:**

II. SEQUENCE OF TESTS TO BE CARRIED OUT FOR REACTOR

SL. NO.	NAME OF TEST	TESTING KIT DETAILS			TEST RESULTS Ok/Not Ok
		MAKE	RATING / MEASU RING RANGE	DATE OF LAST CALIBRATION	
1	Core Insulation Measurement upon arrival of equipment at site				
2	Insulation Resistance Measurements Of Bushing Cts				
3	Continuity Test Of Bushing Cts				
4	Secondary Winding Resistance Of Bushing Cts				
5	Polarity Test Of Bushing Cts				
6	Current Ratio Test				
7	Magnetizing Curves Performance				
8	Measurement of Resistance of Earth Pit and Main Grid				
9	Frequency Response Analysis				
10	Magnetization Current of Windings				
11	C & Tan δ Measurement Of Bushing				
12	C & Tan δ Measurement Of Windings				
13	C & Tan δ Measurement Of NGR Windings(If any)				

SL. NO.	NAME OF TEST	TESTING KIT DETAILS			TEST RESULTS Ok/Not Ok
		MAKE	RATING / MEASURING RANGE	DATE OF LAST CALIBRATION	
14	Insulation Resistance Measurement of Winding				
15	Insulation Resistance Measurement of Cable				
16	Core Insulation Measurement after oil filling				
17	Measurement of Winding Resistance				
18	Measurement of Winding Resistance of NGR				
19	Protection And Alarm Tests				
20	Stability Test Of Differential And Ref Protection				
21	Contact Resistance Measurement				
22	Vibration Measurement				

Comments of Commissioning Team on test Results:

Comments of Corporate-OS on test Results (To be attached separately)

Manufacturer Recommendation on test Results (To be attached separately)

Signature:	**Signature:**	**Signature:**	**Signature:**
Name:	**Name:**	**Name:**	**Name:**
Desgn.:	**Desgn.:**	**Desgn.:**	**Desgn.:**
Organization: (Supplier Representative) (Wherever Applicable)	**(Erection Agency)**	**(POWERGRID Site I/C)**	**(POWERGRID Commg. Team) Members:** **1.** **2.** **3.** **4.**

III. CHECKS AFTER RECEIPT OF REACTOR AT SITE:

A) *N2/ Dry Air Pressure & Dew Point Record*

Inspection Action	Date Of Meas.	N2/ Dry Air Pressure	Dew Point	Ambient Temperature	Remarks
During dispatch at factory					
After receipt at site					
Storage at site before commissioning					

Note:

1. Refer **graph 2.1.3 fig.1 in** POWERGRID doc no d-2-03-xx-01-01 rev-01 for maintaining N2/ Dry air pressure and dew point during storage(To be maintained in a separate sheet/ Register)
2. Any noticeable drop in N2 during storage at site is observed, then matter to be referred to Manufacturer and CC-OS).
3. If Reactor is received with zero N2 pressure then matter to be referred to Manufacturer and Corporate-OS prior to erection

B) *Impact Recorder Analysis*

No of Impact Recorder installed: ______________________________

Make of Impact Recorder(s) ______________________________

Type of Impact Recorder(s) ______________________________

Date of removal of impact recorder from equipment ______________________________

Sl.No.	Check Points	Status		Remarks
1	Functionality of Impact recorder at the time of dismantling from main unit	On	Off	
2	Joint data downloading carried out at site immediately after receipt	Yes	No	
3	Analysis of joint report received from manufacturer before charging	Yes	No	

Note:

1. Manufacturer to provide necessary software and downloading tools to respective sites so that data downloading can be carried out at site jointly by POWERGRID & Manufacturer
2. Permissible limit for maximum shock in any direction shall be 3g
3. Impact Recorder should be switched off and detached from the Reactor when the main unit has been placed on its foundation.

C) *Core Insulation Test (Immediately after Receipt at Site)*

Shorting link between CC, CL & G to be removed and IR value to be taken between CC-G, CL-G & CC-CL by applying 1 kV DC

Terminals	Insulation Value	Terminals	Insulation Value
CC-G		CC-CL	
CL-G		Semi-shield –G (if provided) at 1 kV	

Note:

i. Permissible value > 500 MΩ
ii. In case core insulation values are less than the permissible limit matter to be referred to OEM for corrective measures and same to be checked during internal inspection for any abnormality
iii. Ensure shorting of CC-CL & G after the completion of the testing

D) ***Internal Inspection***

SL. No.	Internal Inspection	Status	
		Yes	No
1	Details photographs of all visible parts /components are taken during internal inspection. (refer procedure 2.3)		
2	Any abnormality observed during internal inspection		
3	Matter referred to manufacturing, CC-QA & I , CC-ENGG and CC-OS		

Details of abnormality observed during internal inspection (if noticed) _______________

____

____

IV. REACTOR ERECTION

A) ***Checks / Precautions During Erection :***

Sl. No.	Description	Remarks
1	Total Exposure of Active part of Reactor to atmosphere in hours (To be kept minimum)	
2	Dew point of dry air generator / dry air cylinders, during exposure of active part of Reactor	
3	Available of Oxygen in % before entering in Reactor tank	
4	N2/ Dry air pressure in PSI while Reactor is kept sealed in between different erection activities	
5	Ensure Leakage test of Air cell / bellow carried out	
6	Check Hermitically sealing is intact in all Bushings by OEM / Expert	

B) ***Evacuating And Oil Filling***

a) Before filling oil, each drum has been physically checked for free moisture and appearance

Yes	No

b) Details of oil filter machine (As per latest TS of Reactors)

Make ______________________ Capacity_________________________

Sl.No	Description Of Works	Remarks / Reading
1	Changing of Lubricating oil of vacuum pump	
2	Cleaning of Filter packs	
3	Flushing of whole filter machine with fresh oil	
4	Vacuum obtained without load (milli bar)	

c) Vacuum pump for evacuation of Reactor

Sl.No	Description of Works	Remarks / Reading
1	Changing of Lubricating oil of vacuum pump	
2	Vacuum obtained without load (milli bar)	
3	Diameter of vacuum hose (50 mm)	
4	Employ of Dry ice chamber	

d) Oil storage tank

Capacity______________________ Quantity__________________________

Sl.No	Description of Works	Remarks / Reading
1	Silica gel breather provided in the tank	
2	Any opening left uncovered	
3	Inside painted or not	
4	Cleanliness of inside of pipes/ hoses to the storage tank	

e) Exposure during erection

Sl.No	Description of Works	Remarks / Reading
1	First day exposure (in hrs)	
2	Second day exposure (in hrs)	
3	Third Day exposure (in hrs)	
4	N2 pressure applied after each days erection work (in PSI)	
5	Ambient Temperature (in degC)	
6	Average Relative Humidity	
7	Weather Condition(Rainy / Stormy / Cloudy / Sunny)	

Note:

i. Erection activities to be carried out in sunny weather and RH<60%

f) N2/ Dry Air sealing in case of delay in oil filling

Sl.No	Description of Works	Remarks / Reading
1	No. of Cylinders used for displacing the air inside the tank	
2	N2 admitted from bottom valve	
3	Valve at diametrically opposite end at top kept open	
4	No. of Cylinders used for building up to 4- 5 psi(.3kg/cm^2)	

g) Leakage Test through pressure

Sl.No	Inspection Actions	Date	Time	Remarks / Reading
1	Fill dry N2/ dry air till pressure of 4- 5psi (.3 kg/cm^2) achieved			
2	To be kept for 24 Hrs			
3	In case pressure remain same, check for dew point			
4	If dew point is achieved, proceed for evacuation			
5	**In case of drop in pressure, attend the leakages and repeat the pressure test**			
6	If dew point is not OK, dry air/ N2 cycle to be carried out till desired dew point is achieved			

h) Schedule for Vacuum & Tightness Test

Sl.No	Inspection Actions	Date	Time	Remarks / Reading
1	Starting of evacuation on complete unit			
2	Stopping of evacuation below the pressure of 5 kPa (50 mbar)			
3	Pressure P1 in kPa after 1 hour of stopping evacuation			
4	Pressure P2 in kPa after half an hour of reading pressure P1			
5	Leakage = (P2-P1) x V , V= Oil quantity in Cu mtr ***If leakage<3.6, continue evacuating** **If leakage > 3.6, attend leakage and repeat process as per Sr. No. 1 to 4.**			
6	Start of Vacuum reaching below 0.13kPa(1 Torr)			
7	Break of vacuum *** Vacuum process to be continued for 24 hrs Up to 145 KV, 48 hrs for 145 to 220kV and 72 hrs for 420 kV and above**			

i) Record of drying out process (if carried out)

Sl.No	Activity	Date	Time	Remarks / Reading
1	**First Nitrogen purging cycle**			
	Pressure of Nitrogen 0.15 kg/cm2			
	Dew Point after 48 Hrs			
	Temperature with heaters on condition around the Reactor Tank(Refer procedure)			
2	**First Vacuum cycle**			
	Vacuum achieved			
	Rate of condensate collection(Hourly basis)			
	Duration of vacuum after achieving 1 to 5 torr			
3	**Second Nitrogen purging cycle**			
	Pressure of Nitrogen 0.15 kg/cm2			
	Temperature with heaters on condition around the Reactor Tank(Refer procedure)			
	Dew Point after 24 Hrs			

Note:

i. If dew point is within the permissible limit oil filling under vacuum may be started otherwise vacuum/ Nitrogen purging with heating cycle to be continued till desired dew point is achieved.

j) Schedule for Oil filling and Settling

Sl.No	INSPECTION ACTIONS	DATE	TIME	REMARKS / READING
1	Ensure measurement of Particle counts during oil filtration in oil tanks(If specified in the contracts)			
2	Oil Filling in Main Tank			
3	Oil filling in Conservator tank			
4	Oil filling in diverter switch			
5	Hot oil circulation (minimum 2 cycles or depending on oil parameters) at oil temperature 55-60 deg C.			
6	Start of oil settling			
7	End of oil settling *** Minimum settling time to be given 12 hrs for 145 KV , 48 hrs for 145 to 420kV and 72 hrs for 765 kV & above**			

v. PRE-COMMISSIONING CHECKS:

Sl. No.	Description Of Activity	Status		Deficiencies, If Any
		Yes	No	
1	REACTOR and its Auxiliaries are free from visible defects on physical Inspection			
2	All fittings as per out line General Arrangement Drawing			
3	Check Main Tank has been provided with double earthing			
4	Check neutral is grounded through separate connections. Ensure metallic requirements as per specification (e.g. Cu) in earthing strips used			
5	Check that Marshalling Box, , Radiator Bank & Fan(if any) etc. has been earthed			
6	All nuts and bolts are tightened correctly as per specified torque (as per manufacturers recommendation)			
7	Check tightness of Terminal Connectors			
8	Check leveling of Reactor and its accessories			
9	Erection Completion Certificate along with list of outstanding activities reviewed			
10	Any Paint removed / scratched in transit has been touched up			
11	Bushings are clean and free from physical damages			
12	Oil level is correct on all Bushings			
13	Check brazing of all Bushings Leads			
14	Check oil leakage through any Joints / Valves etc.			
15	Check oil drain valves are properly closed and locked			
16	Check oil level in Main Conservator tank			
17	Check oil level at conservator matches with oil temperature of Reactor			
18	Check OTI and WTI pockets and replenish the oil, if required			
19	Check all valves for their opening & closing sequence			
20	Check the colour of the breather silica gel			
21	Check availability of oil in the breather cup			
22	Check tightness of bolt of main unit after placed on foundation			
23	Check busing test tap is grounded			
24	Check the operation of flow sensitive shut off valve between main tank & conservator, if any			

Sl. No.	Description Of Activity	Status		Deficiencies, If Any
		Yes	No	
25	Check the functioning of SPR (Sudden pressure relay) ,if any			
26	Check no debris, loose T&P and oil strains on and around the Reactor			
27	Check door seals of Marshalling Box is intact and all cable gland plates unused holes are sealed			
28	Check that pressure relief valve is correctly mounted			
29	Ensure unused secondary cores of Bushing CT's, if any, has been shorted			
30	Check CT star point has been formed properly and grounded at one end only as per scheme			
31	Check that permanent and adequate lighting arrangements are ready			
32	Check that labeling and identification is permanent and satisfactory			
33	Check that Buchholz Relay is correctly mounted with arrow pointing towards conservator			
34	Check cables are properly fixed and ensure cable entry at the bottom			
35	Ensure all Power and Control cable Terminals are tightened			
36	Check all cables and Ferrules are provided with Number as per Cable Schedule (Cross Ferruling to be checked)			
37	Check that all cables are correctly glanded			
38	Check external cabling from Junction Box to Relay / Control Panel completed			
39	Check that air has been released from the Radiators and their headers/ Buchholz relay/Main tank/tank/Bushing turrets etc			
40	Check Fire Protection System & Emulsifier systems is adequate & ready			
41	Check that CC-CL & G are shorted			
42	Check that all radiator bank valves on top and bottom headers are open			
43	Change over operation of ac supply from source- I to source-II checked			
44	Check the flanges of bushing for any crack after fixing			
45	Calibration of OTI & WTI performed as per procedure			
46	Ensure Remote OTI and WTI data transfer to control room is taking place			

Sl. No.	Description Of Activity	Status		Deficiencies, If Any
		Yes	No	
47	Ensure On-Line DGA is commissioned and kept "ON"			
48	Ensure On-Line Dry out system is commissioned and kept "ON"			
49	Check various interlocks provided with Fire Fighting as per the schematic Ref. Drg. No.___________________	Description of Interlocks		Checked

VI. MEASUREMENT OF EARTH RESISTANCE OF ELECTRODE

Location	Value
With Grid (Earth Pit -1)	
Without Grid (Earth Pit -1) (Neutral Earth)	
With Grid (Earth Pit -2)	
Without Grid (Earth Pit -2) (Neutral Earth)	

***Permissible limit with grid < 1 Ω**

VII. PRECOMMISSIONING TESTS AFTER READINESS OF THE REACTOR

A) Frequency Response Analysis (FRA)

Sl.No	Description	Yes	No	Remarks
1	Carried out after completion of all commissioning activities			
2	Factory FRA test report in soft form available at site			
3	Interpretation of test results carried out			
4	Test results matching with the factory results			

Note:-

a) Measurement to be carried out at Minimum, Maximum and Nominal Tap for all combination of HV & IV and Nomenclature to be made similar as mentioned in the procedure documents

B) Magnetization Current Test

Am bient temperature ______________________ Temperature of oil______________________

Voltage Applied (Volts)		Current Measured (mAmp)		Remark
R - N		R - PH		
Y - N		Y - PH		
B - N		B - PH		
NGR				

Note:

a. Excitation current < 50 milli-Amperes, then difference between two higher currents should be less than 10%.
b. Excitation current > 50 milli-Amperes, then difference between two higher currents should be less than 15 %.
c. Value of centre leg should not be more than either outside for a three phase reactor.
d. Results between similar single phase units should not vary more than 10%.

C) Tan δ And Capacitance Measurement

a) Tan δ And Capacitance Measurement of Bushing

BUSHING DETAILS

	R - Ø	Y - Ø	B - Ø	Neutral	NGR
Make					
Type					
Sl. No.					
STYLE NO / DRAWING NO					

Ambient temperature in ºC______________

i. Capacitance & **Tan δ** of bushing

Voltage Applied	Capacitance						Remarks
	R - Ø		Y - Ø		B - Ø		
	Site	Factory	Site	Factory	Site	Factory	
Measurement of C1							
2 K	V						
10 KV							
Measurement of C2							
1 K	V						
Voltage Applied	**Tan δ**						**Remarks**
	R - Ø		**Y - Ø**		**B - Ø**		
	Site	**Factory**	**Site**	**Factory**	**Site**	**Factory**	
Measurement of C1 Tan δ							
2 K	V						
10 KV							
Measurement of C2 Tan δ							
1 K	V						

b) Capacitance & Tan δ of NGR bushing

Voltage Applied	Capacitance		Tan δ	
	Site	Factory	Site	Factory
2 KV				
10 KV				

c) Tan δ And Capacitance Measurement Of Winding

Ambient temperature in ºC ______________________________

Voltage	Winding Combination	Test Mode	Capacitance		Tan δ *		Remark
			Site	Factory	Site	Factory	
2 KV	HV/Tank+Earh	GST					
10 KV							

Capacitance & **Tan δ** of NGR

Voltage	Winding Combination	Test Mode	Capacitance		Tan δ *		Remark
			Site	Factory	Site	Factory	
2 KV	HV/Tank+Earh	GST					
10 KV							

Note:

i. C2 values shall be only for record purpose.

ii. For bushing acceptable Limit for Tan δ1 should be comparable (+/- 0.001) with factory value subjected to max of 0.005 & Tan δ2:-0.01

iii. For winding acceptable Limit for Tan δ1 should be comparable (+/- 0.001) with factory value subjected to max of 0.005 & Tan δ2:-0.01

iv. Acceptable Limit for Capacitance -5% to + 10%

VIII. Insulation Resistance Measurement

a) Insulation Resistance Measurement of Cable and others (Using 500 Volt Megger)

Ambient temp in ºC ______________________

SL. NO.	DESCRIPTION	STATUS		REMARKS, IF ANY
		YES	NO	
A	Control wiring			
B	Cooling System			
	a) Motor Fan			
	b) Motor Pump			
	c) Control wiring			

*** Permissible limit of IR value should be > 50 M Ω**

b) Insulation Resistance Measurement in MΩ (Using 5000 V Megger)

Ambient temp in º C ________________________

Main Winding	Ir Value			Dielectric Absorption Coefficient(DAI) = 60 Sec / 15 Sec	Polarisation Index(PI) = 600 Sec / 60 Sec	Remarks
	15 Sec	60 Sec	600 Sec			
a) HV / E						
b)NGR WINDING						

***Permissible limit of IR value should be > 500 M Ω for 66kV & above at 30°C, DAI should be >1.3 and PI should be >1.25**

IX. Measurement Of Winding Resistance (In Ohm)

Ambient temperature in º C______ OTI Reading ______ WTI reading ______

i. **WINDING RESISTANCE OF REACTOR WINDING**

Winding Resistance(HV-N)			Resistance At 75º C			Factory Value At 75º C			% Deviation		
R	Y	B	R	Y	B	R	Y	B	R	Y	B

ii. **WINDING RESISTANCE OF NGR WINDING**

Winding Resistance(HV-N)			*Resistance At 75º C			*Factory Value At 75º C			% Deviation		
R	Y	B	R	Y	B	R	Y	B	R	Y	B

NOTE:

i. Formula for calculating the resistance at 75°C: R_{75} = RT (235+75)/ (235+T), where RT = Resistance Measured At Winding Temperature T.

ii. Permissible limit: ±5% variation between phases or from Factory test results

X. Core Insulation Test

Shorting link between CC, CL & G to be removed and IR value to be taken between CC-G, CL-G & CC-CL by applying 2 kV DC

Terminals	Insulation Value	Terminals	Insulation Value
CC-G		CC-CL	
CL-G		Semi-shield –G (if provided) at 1 kV	

Note:

i. Permissible value > 500 MΩ

ii. Ensure shorting of CC-CL & G after the completion of the testing

XI. Oil Characteristics

(Sample to be taken prior to charging to Reactor and it should fulfill the recommendations as per IS 1865 /IEC 60422)

DATE OF OIL SAMPLING	B.D.V.	MOISTURE	TAN δ	RESISTIVITY	INTERFACIAL TENSION
Permissible Limit →	**70KV(min)**	**5 PPM(Max)**	**0.01 at 90º C (Max)**	**6x 10 ^12 Ω - CM at 90º C (Min)**	**0.0 35 N/m at 27ºC (Min)**

DISSOLVE GAS ANALYSIS

Dissolve Gasses	H2	CH4	C2H4	C2H6	C2H2	CO	CO2	O2	N2	TCG

Note:-

i. TCG should be below 1%

ii. One fresh oil sample per lot (from drum) shall be sent to Lab for carrying out Oxidation Stability test

XII. Operational Test Of Other Equipments

i. Checking of cooling Equipments

SL.NO	DESCRIPTION	STATUS		
		OK	NOT OK	
1	Rotation direction of Fans			

XIII. Checks on Bushing CT's

a) Rated Data And Duty

	Core	Ratio	Class	Burden	Kvp	Protection / Metering
HV	Core-I					
	Core II					
	Core III					
	Core IV					
Neutral	Core-I					
	Core II					
	Core III					
	Core IV					

b) Insulation Resistance Measurement Of Bushing CT's(Using 500v Megger)

MEASUREMENT BETWEEN	UNIT	HV		
		R – Ø	Y - Ø	B - Ø
Earth - Core I	M Ω			
Earth - Core II	M Ω			
Earth - Core III	M Ω			
Earth - Core IV	M Ω			

i.

MEASUREMENT BETWEEN	UNIT	HV		
		R – Ø	Y - Ø	B - Ø
Core I – Core II	M Ω			
Core I – Core III	M Ω			
Core I – Core IV	M Ω			
Core II – Core III	M Ω			
Core II – Core IV	M Ω			
Core III – Core IV	M Ω			

c) Continuity Test Of Bushing Ct's (In Ω)

Continuity, Check between Terminals OK / NOT OK

CORE	BETWEEN TERMINAL	HV		
		R - Ø	Y - Ø	B - Ø
Core – I	1S1–1S2			
Core – II	2S1–2S2			
Core – III	3S1–3S2			
Core – IV	4S1–4S2			

d) Secondary Winding Resistance Of Bushing CT's (In Ω)

i. HV side

CORE	BETWEEN TERMINAL	UNIT	R - Ø		Y - Ø		B - Ø	
			FACTORY	SITE	FACTORY	SITE	FACTORY	SITE
Core I	1S1 – 1S2	Ω						
Core II	2S1 – 2S2	Ω						
Core III	3S1 – 3S2	Ω						
Core IV	4S1 – 4S2	Ω						

ii. Neutral Side

CORE	BETWEEN TERMINAL	UNIT	R - Ø	
			FACTORY	SITE
Core I	1S1 – 1S2	Ω		

iii. External Neutral CT

CORE	BETWEEN TERMINAL	UNIT	R - Ø	
			FACTORY	SITE
Core I	1S1 – 1S2	Ω		

e) Polarity Test Of Bushing CT'S

With 1.5 V DC supply (Connect +ve at P1 and –ve at P2)

CORE	BETWEEN		HV		
			R - Ø	Y - Ø	B - Ø
Core I	1S1 (+ve)	1S2 (-ve)			
Core II	2S1 (+ve)	2S2 (-ve)			
Core III	3S1 (+ve)	3S2 (-ve)			
Core IV	4S1 (+ve)	4S2 (-ve)			

f) Current Ratio Test

Primary Injection through Primary Injection Kit at Primary Terminal P1 – P2
Measure current on the secondary Terminals

i. HV side R – Phase side

CORE S1 - S2	PRIMARY %	CURRENT ACTUAL	SECONDARY CURRENT	THEORETICAL RATIO	ACTUAL RATIO	% OF ERROR
Core I (1S1 – 1S2)	20%					
	40%					
	80%					
Core II (2S1 – 2S2)	20%					
	40%					
	80%					
Core III (3S1 – 3S2)	20%					
	40%					
	80%					
Core IV (4S1 – 4S2)	20%					
	40%					
	80%					

ii. HV side Y – Phase

CORE S1 - S2	PRIMARY %	CURRENT ACTUAL	SECONDARY CURRENT	THEORETICAL RATIO	ACTUAL RATIO	% OF ERROR
Core I (1S1 – 1S2)	20%					
	40%					
	80%					
Core II (2S1 – 2S2)	20%					
	40%					
	80%					
Core III (3S1 – 3S2)	20%					
	40%					
	80%					
Core IV (4S1 – 4S2)	20%					
	40%					
	80%					

iii. HV side B – Phase

CORE S1 - S2	PRIMARY %	CURRENT ACTUAL	SECONDARY CURRENT	THEORETICAL RATIO	ACTUAL RATIO	% OF ERROR
Core I (1S1 – 1S2)	20%					
	40%					
	80%					
Core II (2S1 – 2S2)	20%					
	40%					
	80%					
Core III (3S1 – 3S2)	20%					
	40%					
	80%					
Core IV (4S1 – 4S2)	20%					
	40%					
	80%					

g) Magnetising Curves Performance

(Not to be done for metering Core)
Knee Point Voltage (KVp) = ………………..Volt

i. HV Side R – Phase

VOLTAGE		UNIT	CURRENT MEASUREMENT			
TO BE APPLIED	ACTUAL VALUE		CORE – I 1S1-1S2	CORE – II 2S1-2S2	CORE – III 3S1-3S2	CORE – IV 4S1-4S2
0.25 x KVp	mA					
0.50 x KVp	mA					
0.75 x KVp	mA					
1.00 x KVp	mA					
1.10 x KVp	mA					

ii. HV Side Y – Phase

VOLTAGE		UNIT	CURRENT MEASUREMENT			
TO BE APPLIED	ACTUAL VALUE		CORE – I 1S1-1S2	CORE – II 2S1-2S2	CORE – III 3S1-3S2	CORE – IV 4S1-4S2
0.25 x KVp	mA					
0.50 x KVp	mA					
0.75 x KVp	mA					
1.00 x KVp	mA					
1.10 x KVp	mA					

iii. HV Side B – Phase

VOLTAGE		UNIT	CURRENT MEASUREMENT			
TO BE APPLIED	ACTUAL VALUE		CORE – I 1S1-1S2	CORE – II 2S1-2S2	CORE – III 3S1-3S2	CORE – IV 4S1-4S2
0.25 x KVp	mA					
0.50 x KVp	mA					
0.75 x KVp	mA					
1.00 x KVp	mA					
1.10 x KVp	mA					

Note: 1.0 CT should not saturate at 110% of Knee Point Voltage (KVp)
2.0 If Knee Point Voltage is not mentioned then Knee Point Current may be taken into consideration.

XIV. Contact Resistance Measurement at 100 Amps

CONTACT RESISTANCE	UNITS	R - Ø	Y - Ø	B - Ø
Across HV Bushing Terminal Joint	μ Ω			
Across Neutral Bushing terminal joint	μ Ω			
NGR terminal connector	μ Ω			

The value of Contact Resistance should not be more than 10 Micro – ohms per Joint / Connector

XV. Protection And Alarms

i.

SL NO	DEVICE	SET FOR		PROVED	
		ALARM	TRIP	ALARM	TRIP
1	EXCESSIVE WINDING TEMPERATURE.				
2	EXCESSIVE OIL TEMPERATURE.				
3	PRESSURE RELIEF VALVE (MAIN TANK)	NA		NA	
4	PRESSURE RELIEF VALVE (NGR)	NA		NA	
5	MAIN TANK BUCHHOLZ RELAY				
6	NGR BUCHHOLZ RELAY				
7	FAN FAILURE\		NA		NA
8	LOW OIL LEVEL (MAIN TANK)		NA		NA
9	LOW OIL LEVEL (NGR)		NA		NA
10	HIGH OIL LEVEL (MAIN TANK)		NA		NA
11	OTI (MAIN TANK)	**90**	**100**		
12	OTI (NGR)				
13	WTI (MAIN TANK)	**100**	**110**		
14	DIFFERENTIAL	NA		NA	
15	BACKUP IMPEDENCE RELAY	NA		NA	
16	EARTH FAULT RELAY (REF)	NA		NA	
17	INTER TRIP , IF ANY	NA		NA	
18	TRIP FREE CHECK	NA		NA	
19	TEED PROTECTION				
20	On Line DGA alarm				

ii. Protection setting applied as per CC-Engg. approved settings

Yes	No	Remarks

iii. Stability test of differential and REF protection (at 10 kV)

Ok	Not Ok	Remarks

iv. Delta formation of single phase units and spare switching arrangement scheme checked

Yes	No	Remarks

NOTE : **Prove the tripping of associated breakers by actual operation of the various devices and relays as per the schemes.**

XVI. Final Documentation Review

i. Factory test results are available

Yes	No

ii. All electrical test results compared with factory test results & found to be in order

Yes	No

iii. Final documents of Pre- Commissioning checks reviewed and approved

Yes	No

iv. Document regarding spares equipment, O&M manuals etc available at site

Yes	No

Yes	No

XVII. Checks After Charging Of Reactor

Record the following after charging

i. Any abnormal sound emanating from the reactor

Yes	No	Remarks

ii. No load current at relay terminal

R - Ø	A
Y - Ø	A
B - Ø	A

iii. Temperature at the time of charging

OTI	° C
WTI	° C
AMBIENT	° C

iv. Maximum temperature after 24 hours____________ º C

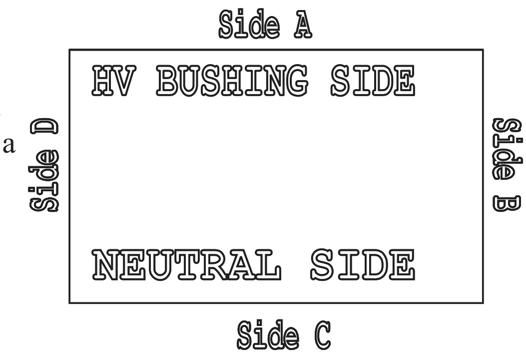
v. Thermo vision scanning done at least after 24 hours of loading & repeated one week.

Yes	No	Remarks

vi. **VIBRATION MEASUREMENT TEST**

a) Vibration measurements are to be carried out after energization of the reactor. This will be a reference data for future Measurements.

b) Various locations are to be shown in the diagram with x,y co-ordinates for easy identification.



SL. NO	DATE OF MEASUREMENT	LOCATION	VALUE	REMARKS

Signature:	Signature:	Signature:	Signature:
Name:	Name:	Name:	Name:
Desgn.:	Desgn.:	Desgn.:	Desgn.:
Organization: (Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commg. Team) Members: 1. 2. 3.

PRE-COMMISSIONING FORMATS FOR CIRCUIT BREAKER

I. General Details

DETAILS	
Region:	**Sub-Station:**
Feeder Name:	**LOA No. :**
Make:	**Year of Manufacture:**
Equipment Designation: **Ex: 452**	
Sr. No.:	**Type:**
Rating:	**Rated Breaking Capacity(kA):**
Operating Voltage:	**Control Voltage (DC) :**
Date of Receipt at site:	**Date of Erection:**
Date of energisation:	

II. Pre-Commissioning Checks:

Sl .No	Description	Status		Remarks
		Yes	No	
1	Equipment is free from dirt/dust/rust/ foreign materials etc.			
2	Equipment is free from all visible defects on physical inspection			
3	Support structures, marshalling box has been provided with double earth			
4	All nuts and bolts are tightened correctly as per specified torque			
5	Equipment erection is complete in all respect & erection completion certificate along with list of outstanding activities reviewed (attach remaining activities, if any)			
6	Permanent pole leveling and identification is done			

Sl .No	Description	Status		Remarks
		Yes	No	
7	Leveling and alignment of structure and base frame is checked			
8	Control box / marshalling kiosk is free from any physical defects			
9	Tightness of nuts bolts of terminal connectors are checked			
10	Auxiliary contacts and relays have been cleaned and free from rust / damage			
11	All spare wires to be kept with ferrules but not terminated at the terminal blocks			
12	Check all the valves in the SF6 pipe line are tightened, DILO coupling are tightened.			
13	Slow and power closing operation and opening done (wherever applicable)			

III. Operating System

Closing		Opening	
Hydraulic		Hydraulic	
Pneumatic		Pneumatic	
Spring		Spring	
Others		Others	

A. Hydraulic system

a) Accumulator

	R Ø	Y Ø	B Ø
Make			
Serial number			
Type			
Year of manufacture			

b) Pump details

Make		Volt	
Serial number		Amperes	
Type		Hp/ kW	
Year of manufacturer		O/L setting (Thermal Over load)	

c) Details of relays/contactors used

Schematic drawing no_______________________

Circuit Reference	Make	Type	No+Nc
Oil Pressure Switch			
Closing Lockout			
Auto Reclosing Lockout			
Operational Lockout			
Anti Pumping Contactor			
Pole Discrepancy Timer			
SF6 Alarm/Lockout			

d) **Operation checks**

Date of Hydraulic Oil filling______________________

Type of Hydraulic Oil ______________________

1. Venting of Hydraulic system

Sl .No	Item Description	Status		REMARKS
		Yes	No	
1	Pump			
2	Pilot Valve			
3	Main Valve			
4	Accumulator			
5	Hydraulic Mechanism			

2. Pressurising hydraulic system

Sl.No	Description	Factory Test Value	Site Test Value	Remark Record Deficiencies, If Any
1	Pre-filling pressure of N_2 in accumulator (bar / °C)			
2	Pump running time for charging hydraulic system from initial pressure to working pressure			
3	Checking safety valve (open/close)			
4	Hydraulic pressure drop for 1 hr			
	Breaker on position			
	Breaker off position			
5	Oil pressure monitor			
	Pump on / off bar			
	Pump running time			
6	Auto reclosing lockout (oil) Pressure contact ______________ make/break			
7	Closing lockout (oil) pressure Contact ___________make/break			
8	General lockout (oil) Pressure contact ___________ make/break			
9	Checking loss of nitrogen Pressure contact ___________make/break			

Factory test report ref no: ___________________________________

3. Oil pressure drop during operations and pump running time in seconds

Sl.No	Description	Factory Test Value	Site Test Value
(i)	Pressure before operation(Bar)		
	Pressure after closing operation(Bar)		
	Pump running time(Sec)		
(ii)	Pressure before operation(Bar)		
	Pressure after opening operation(Bar)		
	Pump running time(Sec)		
(iii)	Pressure before operation(Bar)		
	Pressure after close/open operation (Bar)		
	Pump running time in sec		
(iv)	Pressure before operation(Bar)		
	Pressure after open-close-open operation(Bar)		
	Pump running time(Sec)		

Factory test report ref no: ________________________________

B. Pneumatic System

a) Operating system details

	R - Ø	Y - Ø	B - Ø	Remarks
Air receiver no.				
Control block no.				
Pneumatic drive no.				
Magnetic ventil no.				

b) Motor details

Make		Volt	
Serial number		Amperes	
Type		Hp/ kW	
Year of manufacturer		O/L setting (Thermal Over load)	

c) ICU Details

Make	
Serial number	
Type	
Discharge	
Capacity	
Year of manufacturer	

d) Details of Relays / Contactors used

Schematic drawing no______________________

Circuit Reference	Make	Type	NO+NC
Air Pressure Monitor			
Closing Lockout			
Auto Reclosing Lockout			
General Lockout			
Pole Discrepancy Timer			
Auxiliary			
Power Contactor in ICU			
SF6 Alarm/Lockout			

e) Pressure Switch setting

Circuit Reference	Factory Setting Value		Site Setting Value		Make	Remarks	
	Block	De-block	Block	De-block			
Operation lockout -1							
Operation lockout -2							
Closing lockout							
Auto reclosing ckt							
Low/high pressure							
Alarm circuit							
Compressor start/stop setting							
Compressor safety valve							

Factory test report ref. no: ________________________________

f) Pressure drop during operation : (in kg/ sq.cm -bar)

Sl No	Description	Factory Setting Value	Site Setting Value
1	Tripping through TC-I		
2	Tripping through TC- II		
3	Closing circuit		
4	Close-open operation		
5	Open - close - open		

Factory test report ref no: ________________________________

g) **Air pressure drop in 24 hrs**

	Drop In Pressure In Kg/Sq.Cm Or Bar
Breaker "**On**"	
Breaker "**Off"**	

C. Spring Operating System

a) Motor details

Make		Volt	
Sl no		Amperes	
Type		Hp/kw	
Year of Manufacture		Setting (thermal overload)	
Current taken by motor for charging the spring (amp)		IR of spring charging motor	

b) Details of relays/contactors used : schematic drawing no

Circuit Reference	Make	Serial No.	Type	No+Nc
Closing lockout				
Auto reclosing lockout				
General lockout				
Pole discrepancy timer				

c) Spring operating time

<table>
<tr><th rowspan="2">Details</th><th colspan="4">R- Ø</th><th colspan="4">Y- Ø</th><th colspan="4">B- Ø</th></tr>
<tr><th colspan="2">Factory</th><th colspan="2">Site</th><th colspan="2">Factory</th><th colspan="2">Site</th><th colspan="2">Factory</th><th colspan="2">Site</th></tr>
<tr><td>Charging Time</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Factory test report ref no: ___________________________________

IV. SF6 DENSITY MONITOR DETAILS

A.

	R- Ø		Y- Ø		B- Ø	
	R1 Ø	R2 Ø	Y1 Ø	Y2 Ø	B1 Ø	B2 Ø
Make						
Model						
Sl.no						
Year of manufacture						
Final filling pressure						

B. SF6 density monitor settings

SF6 gas filled at ________ bar at _____ deg. C on ___/___/___

Phase (Ø)	Details	Blocking		De-blocking	
		Factory	Site	Factory	Site
R1 Ø (Bus side)	Low Pressure alarm				
	Lock out pressure				
R2 Ø (Line side)	Low Pressure alarm				
	Lock out pressure				
Y1 Ø (Bus side)	Low Pressure alarm				
	Lock out pressure				
Y2 Ø (Line side)	Low Pressure alarm				
	Lock out pressure				
B1 Ø (Bus side)	Low Pressure alarm				
	Lock out pressure				
B2 Ø (Line side)	Low Pressure alarm				
	Lock out pressure				

Factory test report ref no: ________________________________

C. Measurement of dew point of Sf6 gas

Sl. No	Measured Value	Measurement Pressure
1	R1 Ø (Bus side)	
2	R2 Ø (Line side)	
3	Y1 Ø (Bus side)	
4	Y2 Ø (Line side)	
5	B1 Ø (Bus side)	
6	B2 Ø (Line side)	

Note: Dew point measurement of SF6 gas needs to be done pole wise in close loop method without any wastage of SF6 gas

D. Leakage check

SL.NO	INTERVALS	UNIT	
A	Initial filling of SF6 gas at ____deg C (As per temp. Correction chart)	BAR	
B	Drop in sf6 gas pressure in 24 hrs :	BAR	
C	Final SF6 pressure at _____deg. C after all testing	-BAR	
D	Additional leakage test by covering individual joint with polythene	YES	NO

V. COIL RESISTANCE MEASUREMENT

COIL DETAILS	MEASURED IR VALUE IN Ω					
	R1- Ø	R2- Ø	Y1- Ø	Y2- Ø	B1- Ø	B2- Ø
TRIP COIL- I						
TRIP COIL-II						
CLOSE COIL						

VI. CIRCUITRY / OPERATIONAL CHECKS

Sl No	Circuit Reference	Circuitry Check		Operational Check	
		Local	Remote	Local	Remote
A	Tripping Through TC-I				
B	Tripping Through TC-II				
C	Closing Circuit				
D	Anti-hunting Feature				
	(Close Open Operation)				
E	Pole Discrepancy Feature				
F	Breaker Position Indication				
G	Heater In Switch Cubicle				
H	Heater In Control Cubicle				
I	Illum. In Switch Cubicle				
J	Illum. In Control Cubicle				

Note: In case wiring for remote operation is not ready, please indicate terminal number along with wire ferrule number in switch cubicle where remote cables shall be terminated. Remote operation can be checked from these terminals.

VII. OPERATING TIME (IN MILLI-SECONDS)

Phase (Ø)	Break	Close (Max 150ms)	Trip (Max 25ms 400kV& 765 kV,35ms 220kV, 40ms 132kV/66kV)		Close Trip (Min. 35 ms)	
			Trip - I	Trip - II	Trip - I	Trip - II
R- Ø main contact	Break -1					
R- Ø PIR						
Auxiliary contact						
R - Ø main contact	Break -2					
R - Ø PIR						
Auxiliary contact						
R - Ø main contact	Break -3					
R - Ø PIR						
Auxiliary contact						
R - Ø main contact	Break -4					
R - Ø PIR						
Auxiliary contact						

Phase (Ø)	Break	Close (Max 150ms)	Trip (Max 25ms 400kV& 765 kV,35ms 220kV, 40ms 132kV/66kV)		Close Trip (Min. 35 ms)	
			Trip - I	Trip - II	Trip - I	Trip - II
Y- Ø main contact	Break -1					
Y- Ø PIR						
Auxiliary contact						
Y - Ø main contact	Break -2					
Y - Ø PIR						
Auxiliary contact						
Y - Ø main contact	Break -3					
Y - Ø PIR						
Auxiliary contact						
Y - Ø main contact	Break -4					
Y - Ø PIR						
Auxiliary contact						
B - Ø main contact	Break -1					
B - Ø PIR						
Auxiliary contact						
B - Ø main contact	Break -2					
B - Ø PIR						
Auxiliary contact						
B - Ø main contact	Break -3					
B - Ø PIR						
Auxiliary contact						
B - Ø main contact	Break -4					
B - Ø PIR						
Auxiliary contact						

NOTE: for 765 kV, take measurements for four breaks

VIII. IR VALUE OF CONTROL CIRC UIT(USING 500 VOLT MEGGER)

Coil Details	Unit	Measurement Value	
		Pole - I	Pole - II
R – Ø TRIP COIL - I	MΩ		
R – Ø TRIP COIL - II	MΩ		
R – Ø CLOSE COIL	MΩ		
Y – Ø TRIP COIL - I	MΩ		
Y – Ø TRIP COIL - II	MΩ		
Y – Ø CLOSE COIL	MΩ		
B – Ø TRIP COIL - I	MΩ		
B – Ø TRIP COIL - II	MΩ		
B – Ø CLOSE COIL	MΩ		

CAUTION: Isolate necessary dc for trip coil-I and trip coil-II , closing coil before meggaring.

IX. IR VALUE WITH BREAKER OP EN(USING 5000 VOLT MEGGER)

PHASE	ACROSS OPEN CONTACT BREAK 1	ACROSS OPEN CONTACT BREAK 2	ACROSS OPEN CONTACT BREAK 3	ACROSS OPEN CONTACT BREAK 4
R				
Y				
B				

MINIMUM VALUE 1000 M Ω

X. IR VALUE WITH RESPECT TO EART H WITH BREAKER CLOSED, EARTH SWITCH AND ISOLATOR OPEN

MEASURED IR VALUE INMΩ					
R1 Ø -G	R2 Ø -G	Y1 Ø -G	Y2 Ø -G	B1Ø - G	B2Ø-G

MINIMUM VALUE 1000 M Ω

XI. MINIMUM PICKUP VOLTAGE OF COILS

COIL DETAILS	PICKUP VOLTAGE IN VOLTS					
	R1- Ø	R2- Ø	Y1- Ø	Y2- Ø	B1- Ø	B2- Ø
TRIP COIL-I						
TRIP COIL -II						
CLOSING COIL						

XII. GRADING CAPACITOR

i. Details

Details	Interrupter 1			Interrupter 2		
	R	Y	B	R	Y	B
MAKE						
SERIAL NO.						
CAPACITANCE VALUE						
FACTORY VALUE						
YEAR OF MANUFAC.						

ii. Capacitance And Tan Delta Measurement (To Be Done In UST Mode)

Capacitance	Interrupter 1			Interrupter 2		
	R	Y	B	R	Y	B
SITE						
-FACTORY						
% DEVIATION						
TAN DELTA						
SITE						
-FACTORY						
% DEVIATION						

Permissible Limits
a) Tan delta of grading capacitors 0.005 (max.)
b) Capacitance of grading capacitors within ±5% of the rated value

XIII. CONTACT RESISTANCE MEASUREMENT (MICRO Ω)

PHASE	ACROSS EACH POLE		PHASE	ACROSS EACH POLE	
	FACTORY	SITE		FACTORY	SITE
R 1 - Ø			Y 3 - Ø		
R 2 - Ø			Y 4 - Ø		
R 3 - Ø			B 1 - Ø		
R 4 - Ø			B 2 - Ø		
Y 1 - Ø			B 3 - Ø		
Y 2 - Ø			B 4 - Ø		

a) Contact Resistance of CB (in Micro-Ω)

765 kV	400kV	220kV	132kV
75 μΩ/ break	75 μΩ/ break	75 μΩ	100 μΩ

b) Contact Resistance of CB terminal connector 10 Micro-Ω per connector

Factory test report ref no :_______________________

XIV. BREAKER OPERATION COUNTER READING

Counter Type	Put √ Mark
ELECTRICAL	
MECHANICAL	

Sl.No	Phase	Reading	Date
A	R-Ø		
B	Y-Ø		
C	B-Ø		

XV. CHECK FOR ANNUNCIATION IN CONTROL ROOM AS PER THE FOLLOWING FORMATS AND RECORD THE READING

Sl No	Description Of Test	Source Of Initiation	Window Description	Result		Remark
				OK	NOT OK	
A	Switch off the dc switch in Control cubicle	Control cubicle dc Switch on/off	Source I/II dc fail / ac fail			
B	Switch off the ac Switch in control Cubicle	Control cubicle ac	Source I/II dc fail / ac fail			
		Switch on/off				
C	Short the alarm contacts of sf6 Gas density monitor (R-Ø)	Density monitor	Sf6 gas density low			
D	Short the alarm contacts of sf6 Gas density monitor (Y-Ø)	Density monitor	Sf6 gas density low			
E	Short the alarm contacts of sf6 Gas density monitor (B-Ø)	Density monitor	Sf6 gas density low			
F	Remove the cable connected to density monitor (R-Ø)	Density monitor	Operation/closing lockout			
G	Remove the cable connected to density monitor (Y-Ø)	Density monitor	Operation/closing lockout			
H	Remove the cable connected to density monitor (B-Ø)	Density monitor	Operation/closing lock out			
I	Give tripping command to R-ph only and check the operation of pole discrepancy relay	Pole discrepancy relay at breaker Cubicle	Breaker pole discrepancy			
J	Give tripping command to Y-Ø Only and check the operation of pole discrepancy relay	Pole discrepancy relay at breaker Cubicle	Breaker pole discrepancy			
K	Give tripping Command to B-ph only and check the operation of pole discrepancy relay	pole discrepancy relay at breaker cubicle	Breaker pole discrepancy			
L	Check other alarms as per plant Circuit diagram					
M	Close the breaker and trip through Protection which are applicable	protection relay as per scheme	Breaker auto trip			

NOTE : The tripping details are to be checked as per the Scheme approved by engineering.

XVI. DYNAMIC CONTACT RESISTANCE & TRAVEL MEASUREMENT

Phase (Ø)	Factory	Site	Remarks	Approval From CC/OS Obtained
R				
Y				
B				

XVII. OPERATION TIME MEASUREMENT OF POLE DISCREPANCY RELAY

Pole discrepancy relay	Setting	Actual

Note- 2.5 Sec for CBs with Auto Reclose Function & 0.5 Sec for CBs without Auto Reclose Function.

CONTROLLED SWITCHING RELAY (If provided)

Make: Model: Date of installation:

Application: Reactor/ Transformer

Settings	Trip Operation	Close Operation
R- Ø		
Y- Ø		
B- Ø		

XVIII. MECHANICAL CLOSE INTERLOCK CHECKED (WHEREVER APPLICABLE)

Yes	No

XIX. FINAL DOCUMENTATION REVIEW

i. Factory test results are available

Yes	No

ii. Final documents of Pre- Commissioning checks reviewed and approved

Yes	No

iii. Docum ent regarding spares equipment, O&M manuals etc available at sit for O&M purpose

Yes	No

iv. After modification, if any, "As built Drawings" are available at site

Yes	No

v. CC-OS approved DCRM signatures available

Yes	No

Signature:	Signature:	Signature:	Signature:
Name:	Name:	Name:	Name:
Designation:	Designation:	Designation:	Designation:
Organization: (Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commissioning. Team) Members: 1. 2. 3. 4.

PRE-COMMISSIONING FORMATS FOR CURRENT TRANSFORMER

I. General Details

DETAILS	
Region:	**Sub-Station:**
LOA No. :	**Make:**
Sr. No.: **R Ø:-** **YØ:-** **BØ:-**	**Type:**
Year of Manufacture: **R Ø:-** **YØ:-** **BØ:-**	**Rating:**
Date of Receipt at site: **R Ø:-** **YØ:-** **BØ:-**	**Date of Erection:** **R Ø:-** **YØ:-** **BØ:-**
Date of energisation	

II. Rated Data And Duty

Core	Ratio	Class	Burden	KVp	Protection / Metering
Winding I					
Winding II					
Winding III					
Winding IV					
Winding V					

KVp: Knee Point Voltage In Volts

III. Pre-Commissioning Checks:

Sl. No	Description	Status		Remark
		Yes	No	Record Deficiencies, If Any
1	Equipment is cleaned and free from dust / dirt foreign materials etc.			
2	Equipment is free from all visible defects on physical inspection			
3	Check ct tank has been provided with double earthing (dead tank CT's)			
4	Check that ct junction box is earthed.			
5	All nuts and bolts are tightened correctly as per specified torque			
6	Check tightness of terminal connector			
7	All fittings as per out line general arrangement drawing.			
8	Leveling and alignment of structure and base frame is checked			
9	Erection completion certificate along with list of outstanding activities reviewed			
10	Any paint removed / scratched in transit has been touched up			
11	Check primary polarity of CTs erected as per relevant drawing.			
12	Check hermetically sealing is intact			
13	Check the oil level and leakage through any joints / sec. Terminals			
14	Check oil drain valve is properly closed and locked.			
15	Oil level & oil sampling			
16	N2 pressure checked (wherever applicable)			
17	Oil level on top chamber gauge glass			
18	BDV of oil sample taken from tank bottom drain valve (only if Nitrogen pressure is measured zero)			
19	All the cable identification tags provided and all cores are provided with identification ferrules at MB.			
20	Check secondary cable end box is properly fixed and ensure cable entry at the bottom and unused holes sealed			
21	Ensure interpole cabling is completed and check the continuity.			
22	Check the ir value of secondary cable			
23	Check external cabling from junction- box to relay / control panel completed			
24	Ensure unused secondary cores, if any, has been shorted and earthed			
25	Check star point has been formed properly and grounded at one end only			
26	Check spark gap setting in p1 terminal (wherever provided/ possible) permanent Pole leveling and identification markings made			
27	Check tan delta test tap is properly earthed			
28	Check that lugs used in secondary circuit are of ring type			
29	Check direction of primary (P1/ P2) w.r.t. Bus/ line on erection			
30	Provision of bimetallic strips (cu +al) ensured wherever applicable			
31	Physically open the bellow cover and check the oil in bellow			
32	Ensure the proper sealing of the CT MB against moisture ingress			

IV. Insulation Resistance Measurement

a) Insulation Resistance Measurement (Using 5000Volt Megger)

Make & Sl. No of testing kit ____________________

Date of last calibration of the kit ____________________

Ambient temp in º C ____________________

Remove the connected earthing to system involving ct under test and disconnect the connected terminals of ct marshalling box.

Core	Unit	Phase		
		R	Y	B
PRIMARY - CORE I	M Ω			
PRIMARY - CORE II	M Ω			
PRIMARY - CORE III	M Ω			
PRIMARY - CORE IV	M Ω			
PRIMARY - CORE V	M Ω			
PRIMARY - CORE VI	M Ω			
PRIMARY - EARTH	M Ω			

*** Permissible limit of IR value should be > 1000 M Ω**

b) Insulation Resistance Measurement in MΩ (Using 500 V Megger)

Make & Sl. No of testing kit ____________________

Date of last calibration of the kit ____________________

Ambient temp in º C ____________________

Between	Unit	Phase		
		R Ø	Y Ø	B Ø
SECONDARY CORE I - EARTH	M Ω			
SECONDARY CORE II - EARTH	M Ω			
SECONDARY CORE III - EARTH	M Ω			
SECONDARY CORE IV - EARTH	M Ω			
SECONDARY CORE V - EARTH	M Ω			
SECONDARY CORE V - EARTH	M Ω			

***Permissible limit of IR value should be > 50 M Ω**

c)

Between	Unit	Phase		
		R Ø	Y Ø	B Ø
CORE I - CORE II	M Ω			
CORE I - CORE III	M Ω			
CORE I - CORE IV	M Ω			
CORE I - CORE V	M Ω			
CORE I - CORE VI	M Ω			
CORE II - CORE III	M Ω			
CORE II - CORE IV	M Ω			
CORE II - CORE V	M Ω			
CORE II - CORE V	M Ω			
CORE III - CORE IV	M Ω			
CORE III- CORE V	M Ω			
CORE III- CORE VI	M Ω			
CORE IV - CORE V	M Ω			
CORE IV - CORE VI	M Ω			
CORE V- CORE VI	M Ω			

d) **Check IR value between tan delta point and earth at 1 kv in secondary box**

R Ø	Y Ø	B Ø

V. Measurement Of Secondary Winding Resistance (In Ohm)

Make of testing kit ______________________________

Date of calibration________________________________

Ambient temperature ______________________________

Core	Terminal	Unit	R Ø		Y Ø		B Ø	
			Factory	Site	Factory	Site	Factory	Site
CORE I	1S1 - 1S2	Ω						
	1S1 - 1S3	Ω						
	1S1 - 1S4	Ω						
CORE II	2S1 - 2S2	Ω						
	2S1 - 2S3	Ω						
	2S1 - 2S4	Ω						
CORE III	3S1 - 3S2	Ω						
	3S1 - 3S3	Ω						
	3S1 - 3S4	Ω						
CORE IV	4S1 - 4S2	Ω						
	4S1 - 4S3	Ω						
	4S1 - 4S4	Ω						
CORE V	5S1 - 5S2	Ω						
	5S1 - 5S3	Ω						
	5S1 - 5S4	Ω						
CORE VI	6S1 - 6S2	Ω						
	6S1 - 6S3	Ω						
	6S1 - 6S4	Ω						

VI. POLARITY TEST

With 1.5 Volt connect +ve at P1 and –ve at P2

Core	Between		Phase		
			R Ø	Y Ø	B Ø
CORE I	1S1 (+VE)	1S2 (-VE)			
	1S1 (+VE)	1S3 (-VE)			
	1S1 (+VE)	1S4 (-VE)			
CORE II	2S1 (+VE)	2S2 (-VE)			
	2S1 (+VE)	2S3(-VE)			
	2S1 (+VE)	2S4 (-VE)			
CORE III	3S1 (+VE)	3S2(-VE)			
	3S1 (+VE)	3S3(-VE)			
	3S1 (+VE)	3S4(-VE)			
CORE IV	4S1 (+VE)	4S2(-VE)			
	4S1 (+VE)	4S3(-VE)			
	4S1 (+VE)	4S4(-VE)			

Core	Between		Phase		
			R Ø	Y Ø	B Ø
CORE V	5S1 (+VE)	5S2(-VE)			
	5S1 (+VE)	5S3(-VE)			
	5S1 (+VE)	5S4(-VE)			
CORE VI	6S1 (+VE)	6S2(-VE)			
	6S1 (+VE)	6S3(-VE)			
6S1	(+VE)	6S4(-VE)			

VII. Tan Delta And Capacitance Measurement

Make of testing kit ____________________________

Date of calibration ____________________________

Ambient temperature ____________________________

Capacitance

Across Stack	Pre Commissioning Values			Factory Values			% Deviation		
	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø
2kV									
10 kV									

Tan Delta

Across Stack	Pre Commissioning Values			Factory Values			% Deviation		
	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø
2kV									
10 kV									

Permissible Limits Tan δ 0.005 (max.) and Rate of rise in Tan Delta 0.001 per year (max)
Deviation of Capacitance value from factory value should be within ± 5% of the rated value

Factory Test Report Ref. No:____

VIII. Current Ratio Test

Make of testing kit ____________________________

Date of calibration ____________________________

Primary Injection through Primary Injection Kit at Primary Terminal P1 – P2
Measure the current on the secondary Terminals

R Phase-

Core	Primary Current		Secondary Current	Theoret-ical Ratio	Actual Ratio	% Of Error
	%	ACTUAL				
CORE I (1S1 - 1S2)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S2)	20 %					
	40 %					
	80 %					

Core	Primary Current		Secondary Current	Theoretical Ratio	Actual Ratio	% Of Error
	%	ACTUAL				
CORE III (3S1 - 3S2)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S2)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S2)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S2)	20 %					
	40 %					
	80 %					
CORE I (1S1 - 1S3)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S3)	20 %					
	40 %					
	80 %					
CORE III (3S1 - 3S3)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S3)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S3)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S3)	20 %					
	40 %					
	80 %					
CORE I (1S1 - 1S4)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S4)	20 %					
	40 %					
	80 %					
CORE III (3S1 - 3S4)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S4)	20 %					
	40 %					
	80 %					

Core	Primary Current %	Primary Current ACTUAL	Secondary Current	Theoret-ical Ratio	Actual Ratio	% Of Error
CORE V (5S1 - 5S4)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S4)	20 %					
	40 %					
	80 %					

Y Phase

Core	%	ACTUAL	Secondary Current	Theoret-ical Ratio	Actual Ratio	% Of Error
CORE I (1S1 - 1S2)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S2)	20 %					
	40 %					
	80 %					
CORE III (3S1 - 3S2)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S2)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S2)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S2)	20 %					
	40 %					
	80 %					
CORE I (1S1 - 1S3)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S3)	20 %					
	40 %					
	80 %					
CORE III (3S1 - 3S3)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S3)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S3)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S3)	20 %					
	40 %					
	80 %					

Core	Primary Current		Secondary Current	Theoretical Ratio	Actual Ratio	% Of Error
	%	ACTUAL				
CORE I (1S1 - 1S4)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S4)	20 %					
	40 %					
	80 %					
CORE III (3S1 - 3S4)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S4)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S4)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S4)	20 %					
	40 %					
	80 %					

B Phase

CORE I (1S1 - 1S2)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S2)	20 %					
	40 %					
	80 %					
CORE III (3S1 - 3S2)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S2)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S2)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S2)	20 %					
	40 %					
	80 %					
CORE I (1S1 - 1S3)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S3)	20 %					
	40 %					
	80 %					

Core	Primary Current		Secondary Current	Theoretical Ratio	Actual Ratio	% Of Error
	%	ACTUAL				
CORE III (3S1 - 3S3)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S3)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S3)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S3)	20 %					
	40 %					
	80 %					
CORE I (1S1 - 1S4)	20 %					
	40 %					
	80 %					
CORE II (2S1 - 2S4)	20 %					
	40 %					
	80 %					
CORE III (3S1 - 3S4)	20 %					
	40 %					
	80 %					
CORE IV (4S1 - 4S4)	20 %					
	40 %					
	80 %					
CORE V (5S1 - 5S4)	20 %					
	40 %					
	80 %					
CORE VI (6S1 - 6S4)	20 %					
	40 %					
	80 %					

Note: Primary current to be injected as per given % or 1500 Amps whichever is maximum

IX. Magnetising Curves Performance

Knee Point Voltage (KVp) = ………………..Volt

R – Phase

Voltage		Unit	Current Measurement			
To Be Applied	Actual Value		CORE – I 1S1-1S2	CORE – II 2S1-2S2	CORE – III 4S1-4S2	CORE – IV 5S1-5S2
0.25 x KVp		mA				
0.50 x KVp		mA				
0.75 x KVp		mA				
1.00 x KVp		mA				
1.10 x KVp		mA				

Y – Phase

Voltage		Unit	Current Measurement			
To Be Applied	Actual Value		CORE – I 1S1-1S2	CORE – II 2S1-2S2	CORE – III 4S1-4S2	CORE – IV 5S1-5S2
0.25 x KVp		mA				
0.50 x KVp		mA				
0.75 x KVp		mA				
1.00 x KVp		mA				
1.10 x KVp		mA				

B – Phase

Voltage		Unit	Current Measurement			
To Be Applied	Actual Value		CORE – I 1S1-1S2	CORE – II 2S1-2S2	CORE – III 4S1-4S2	CORE – IV 5S1-5S2
0.25 x KVp		mA				
0.50 x KVp		mA				
0.75 x KVp		mA				
1.00 x KVp		mA				
1.10 x KVp		mA				

X. Contact Resistance Measurement

Make of testing kit ____________________________

Date of calibration ____________________________

Contact Resistance	Units	R - Ø	Y - Ø	B - Ø
Across Terminal P1	μ Ω			
Across Terminal P2	μ Ω			

The value of Contact Resistance should not be more than 10 Micro – ohms per Joint / Connector

XI. Dissolve Gas Analysis

Duration	H2	CH4	C2H4	C2H6	C2H2	CO	CO2	O2	N2	TCG
After one month of charging										
Before completion of one year of charging										

XII. SF6 Gas and Density Monitor Test

In Case of SF6 gas filled CT

	Set Value			Measured		
	R	Y	B	R	Y	B
Loss of SF6 Alarm						
SF6 lockout/ trip						

a) **Measurement of dew point of sf6 gas**

Phase	Measured Value	Measurement Pressure
R Phase		
Y Phase		
B Phase		

XIII. Shock Indicator impact values (in G)

R Phase	
Y Phase	
B Phase	

Note : Shock recorder value to be filled in case digital recorder or in case of mechanical indicator type shock recorder OK/Not OK to be mentioned.

XIV. Check of SF6 gas purity

R Phase	
Y Phase	
B Phase	

XV. Final Documentation Review

i. Final documents of Pre- Commissioning checks reviewed and approved

Yes	No

ii. Document regarding spares equipment, O&M manuals etc available at site for O&M purpose

Yes	No

iii. After modification, if any, "As built Drawings" are available at site

Yes	No

Signature:	Signature:	Signature:	Signature:
Name:	Name:	Name:	Name:
Designation:	Designation:	Designation:	Designation:
Organization: (Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commissioning. Team) Members: 1. 2. 3. 4.

PRE-COMMISSIONING FORMATS FOR CAPACITIVE VOLTAGE TRANSFORMER

I. General Details

DETAILS	
Region:	**Sub-Station:**
Feeder name	**LOA No. :**
Make:	**Type:**
Sr. No.: **R Ø:-** **YØ:-** **BØ:-**	**Primary Voltage rating**
Secondary Voltage rating: **Winding-I** **Winding-II** **Winding III**	**Secondary Voltage Burden:** **Winding-I** **Winding-II** **Winding III**
Voltage Class: **Winding-I** **Winding-II** **Winding III**	**Purpose of** **Winding-I** **Winding-II** **Winding III**
Rating:	**Feeder name:**
Year of Manufacture: **R Ø:-** **YØ:-** **BØ:-**	**Date of Receipt at site:** **R Ø:-** **YØ:-** **BØ:-**
Date of Erection: **R Ø:-** **YØ:-** **BØ:-**	**Date of energisation**

II. Pre-Commissioning Checks:

Sl. No	Description	Status		Remarks Record Deficiencies, If Any
		YES	NO	
1	Equipment is cleaned and free from dust / dirt foreign materials etc.			
2	Equipment is free from all visible defects on physical inspection			
3	Check CVT tank has been provided with double earthing			
4	Check that CVT marshalling box is earthed correctly as per specified torque			
5	All nuts and bolts are tightened			
6	Check tightness of terminal connector			
7	All fittings as per outline general arrangement drawing.			
8	Labeling and identification marking is carried out			
9	Leveling and alignment of structure and base frame is checked			

Sl. No	Description	Status		Remarks Record Deficiencies, If Any
		YES	NO	
10	Erection completion certificate along with list of outstanding activities reviewed			
11	Any paint removed / scratched in transit has been touched up			
12	Sl. No of HV capacitor identical to the sl.no mentioned on rating & dig. Plate			
13	Ensure brass vent plug between stacks of CVT's is removed			
14	Check the oil level and leakage through any joints / sec. Terminals			
15	Check oil drain valve is properly closed and locked.			
16	Oil level on tank gauge glass			
17	BDV of oil sample taken from tank bottom drain valve			
18	Check secondary cable end box is properly fixed and ensure cable entry at the bottom.			
19	Ensure HF terminal of unused phases has been earthed and no load on HF terminal bushing			
20	Check rating / healthiness of fuses at CVT marshaling.b and CVT terminal box.			
21	Check that the neutral point is earthed			
22	Ensure interpole cabling is completed and check the continuity.			
23	Check the IR value of secondary cable (> 50 m ohms for control cables)			
24	Check external cabling from m.b to relay / control panel completed			
25	All the cable identification tags provided and all cores are provided with identification ferrules at m.b.			
26	Check all the fuse/ MCB			

III. Continuity Of Winding
(After removing Earth Link 1, 2 & 3)

i. Between terminals 1a - 1n

Yes	No

ii. Between terminals 2a - 1n

Yes	No

iii. Between terminals 3a - 1n

Yes	No

IV. Insulation Resistance Measurement

USING A MEGGER OF 5KV/ 10 KV

Between	Unit	Measured Value		
		R Ø	Y Ø	B Ø
Primary - secondary core 1	MΩ			
Primary - secondary core 2	MΩ			
Primary - secondary core 3	MΩ			
Primary - earth Ω	M			

Permissible Limit should be MIN 1000 MΩ

V. Secondary Winding Resistance

Phase	Core 1		Core 2		Core 3		Remarks
	Factory	Site	Factory	Site	Factory	Site	
R Ø							
Y Ø							
B Ø							

Factory test report ref. No: ________________________________

VI. INSULATION RESISTANCE MEASUREMENT

Using A Megger Of 500 Volt

Between	Unit	Measured Value		
		R Ø	Y Ø	B Ø
Secondary core 1 - earth	MΩ			
Secondary core 2 - earth	MΩ			
Secondary core 3 - earth	MΩ			
Core 1 - core 2	MΩ			
Core 1 - core 3	MΩ			
Core 2 - core 3	MΩ			

Permissible Limit should be MIN 50 MΩ

VII. VOLTAGE RATIO TEST

Phase	Primary Voltage	Secondary Voltage		Theoretical Ratio	Actual Ratio		%
		Between	Value		Factory	Site	Error
R		1a – 1 n					
		2a – 2 n					
		3a – 3 n					
Y		1a – 1 n					
		2a – 2 n					
		3a – 3 n					
B		1a – 1 n					
		2a – 2 n					
		3a – 3 n					

Permissible Limit should be min ± 5 % for protection cores and ± 0.5 % for metering cores

Note:-

a) Apply voltage of the order of 10 kV across line capacitor (top flange) to earth link
b) Ensure all earth links connected

VIII.

i. All terminal blocks closed in the secondary after all testing

Yes	No

ii. Phasing (phase relationship) of CVT by measuring voltage between R-phase, Y-phase and B-phase at incoming terminal in control cubicle, for one circuit of the checked CVT and output terninals R-phase, Y-phase and B-ph of a reference circuit (existing CVT) with known phasing

Reference Circuit	Measured Value		
	R Ø	Y Ø	B Ø
R Ø			
Y Ø			
B Ø			

IX. TAN δ AND CAPACITANCE MEASUREMENT

Make of testing kit ____________________________

Date of calibration ____________________________

Ambient temperature ____________________________

Capacitance

Across Stack	Pre Commissioning Values			Factory Values			% Deviation		
	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø
TOP									
MIDDLE 1									
MIDDLE 2									
MIDDLE 3									
BOTTOM									
TOTAL									

TAN δ

Across Stack	Pre Commissioning Values			Factory Values			% Deviation		
	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø	R Ø	Y Ø	B Ø
TOP									
MIDDLE 1									
MIDDLE 2									
MIDDLE 3									
BOTTOM									
TOTAL									

Permissible Limits Tan δ 0.005 (max.)
Deviation of Capacitance value from factory value should be within ± 5% of the rated value
For bottom stack, the measured values shall be considered as base value and may not match factory test results.

Factory Test Report Ref. No:____

X. Final Documentation Review

i. Final documents of Pre- Commissioning checks reviewed and approved

Yes	No

ii. Document regarding spares equipment, O&M manuals etc available at sit for O&M purpose

Yes	No

iii. After modification, if any, "As built Drawings" are available at site

Yes	No

Signature:	Signature:	Signature:	Signature:
Name:	Name:	Name:	Name:
Designation:	Designation:	Designation:	Designation:
Organization: (Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commissioning Team) Members: 1. 2. 3. 4.

PRE-COMMISSIONING FORMATS FOR BAY / FEEDER

I. GENERAL DETAILS

DETAILS	
Region	**Sub-Station**
Feeder Name	**Voltage Level**
Date of Starting of Erection	**Date of Completion of Erection and Oil filling**

II. DETAILS OF EQUIPMENT INVOLVED

EQUIPMENT	R - PHASE		Y - PHASE		B - PHASE		MAKE
	ID NO	SL NO	ID NO	SL NO	ID NO	SL NO	
CT							
CVT							
LA							
BREAKER							
TRANSFORMER							
REACTOR							
ISOLATOR							

EQUIPMENT	R - PHASE		Y - PHASE		B - PHASE		MAKE
	ID NO	SL NO	ID NO	SL NO	ID NO	SL NO	
EARTH SWITCH							
LINE TRAP							

III. DETAILS OF CR PANEL AND PLCC

PANEL DETAILS	IDENTIFICATION		IDENTIFICATION		IDENTIFICATION		MAKE
	NAME	NUMBER	NAME	NUMBER	NAME	NUMBER	
Control Panel							
Relay Panel							
PLCC Panel							
RTU Panel							

RECORDING INSTRUMENTS	IDENTIFICATION	
	NAME	NUMBER
Fault Locator		
Event Logger		
Disturbance Recorder		
Time Syncronisation		
Strip Chart Recorder		

IV. PROTOCOL DOCUMENTATION

EQUIPMENT	IDENTIFICATION NO	ALL PRE-COMM TESTS CARRIED OUT AS PER FQP YES/ NO	ALL TEST RESULTS ARE WITHIN THE LIMIT OF TOLERANCE YES/ NO	JOINT PROTOCOLS OF THE EQUIPMENT INVOLVED IN CHARGING ARE DOCUMENTED AND SIGNED BY ALL CONCERNED YES/NO	REMARKS
CT					
CVT					
LA					
BREAKER					

EQUIPMENT	IDENTIFI CATION NO	ALL PRE-COMM TESTS CARRIED OUT AS PER FQP YES/ NO	ALL TEST RESULTS ARE WITHIN THE LIMIT OF TOLERANCE YES/ NO	JOINT PROTOCOLS OF THE EQUIPMENT INVOLVED IN CHARGING ARE DOCUMENTED AND SIGNED BY ALL CONCERNED YES/NO	REMARKS
REACTOR					
ISOLATOR					
EARTH SWITCH					
LINE TRAP					
CONTROL PANEL					
RELAY PANEL					

EQUIPMENT	IDENTIFI CATION NO	ALL PRE-COMM TESTS CARRIED OUT AS PER FQP YES/ NO	ALL TEST RESULTS ARE WITHIN THE LIMIT OF TOLERANCE YES/ NO	JOINT PROTOCOLS OF THE EQUIPMENT INVOLVED IN CHARGING ARE DOCUMENTED AND SIGNED BY ALL CONCERNED YES/NO	REMARKS
PLCC					
RTU PANEL					

V. CHECK OF BAY MARSHALLING KIOSK
Identification No_____________

DETAILS	STATUS			REMARKS,IFANY
	OK/NOT OK	OK/NOT OK	OK/NOT OK	
ILLUMINATION AND HEATER				
5 /15 AMP SOCKET				
ALL SPECIFIED FUSES IN POSITION				
EARTHING AT 2 LOCATION				
ALL CABLES TIGHTNESS				
ALL CABLES ARE PROPERLY GLANDED				
ALL CABLES HAVE IDENTIFICATION NO				
ALL CORES HAVE IDENTIFICATION NO				
SHIELDING WIRES ARE EARTHED				
FREE FROM DUST AND DAMAGE				
DOOR HINGES AND LOCKING				
PAINTS				
UNUSED HOLES ARE SEALED				

VI. AVAILABILITY OF THE FOLLOWING

SL. NO.	DESCRIPTION OF ACTIVITY	STATUS		REMARK DEFICIENCIES/TEMPORARY ARRANAGEMENT IF ANY
		YES	NO	
1	Fire fighting system commissioned			
2	Fire protection including alarms			
3	Fire hydrant system			
4	Fire deluge (spinkler) system			
5	Portable fire extinguishers are in position			

SL. NO.	DESCRIPTION OF ACTIVITY	STATUS		REMARK DEFICIENCIES/TEMPORARY ARRANAGEMENT IF ANY
		YES	NO	
6	Fire tenders can be made available for any eventuality			
7	All equipment erection as per general arrangement drawing issued by engg.			
8	Equipment identification name plate are properly fixed			
9	All bus post insulators are cleaned and free from dust / dirt foreign materials etc.			
10	All earthing points have been earthed			
11	All nuts and bolts of bus bar are tightened correctly as per specified torque			
12	All clamps and connectors are as per the drawings issues by Engineering. department and correctly tightened as per specified torque			
13	Any paint removed / scratched in yard equipments have been touched up			
14	Bay identification and designation plate are on position with R,Y,B phase marking			
15	Gravel filling in the yard (if designed) has been done			
16	The ladders / tools / vehicles / work bench/ temporary earthing etc. Removed from the area which is to be energized			
17	DC emergency light in operation and in auto			
18	DG set is available and in operation			
19	Switching sequences with procedures are documented and available in the control room			
20	Regular operation in the control room is manned round the clock with regular operation staff			
21	All PTW issued earlier are cancelled and nothing are pending			
22	Operation data log sheets, PTW and other standard formats of Powergrid are available for regular operation			
23	Confirm color coding of all equipments and phase marking			
24	Check star points of CT & CVT secondary and associated links if any			
25	Check that treated earth pits are covered and numbered			
26	Check the tightness of the connecting links of treated earth pits			

SL. NO.	DESCRIPTION OF ACTIVITY	STATUS		REMARK DEFICIENCIES/TEMPORARY ARRANAGEMENT IF ANY
		YES	NO	
27	Core wise secondary injection test for both CTs and PTs inputs from secondary terminal box of CT/PT done to detect any mixing/ interchanging of cores/ phases			
28	Fuse fail protection checked for m1, m2, backup impedance etc			
29	Necessary clearances as applicable have been obtained			
30	Charging clearance is received from grid operation CPCC / IOCC / REB vide msg no :________ Time__________Dated__________			

VII. MEASUREMENT OF EARTH RESISTANCE

SL.NO	LOCATION DESCRIPTION	DISTANCE BETWEEN ELECTRODE	RESISTANCE
LOCATION – 1			
LOCATION - 2			
LOCATION - 3			
LOCATION - 4			
LOCATION - 5			
LOCATION - 6			

Permissible limit = 1.0 Ω (MAX)

VIII. CONTACT TIGHTNESS CHECK BY PRIMARY CURRENT INJECTION

CURRENT INJECTION AT	CURRENT MEASURED AT	CURRENT INJECTED	CURRENT MEASURED	REMARKS ON CONTACT HEALTHINESS

IX. MEASUREMENT OF SOIL RESISTIVITY DONE EARLIER PRIOR TO COMMISSIONING

DATE	DISTANCE BETWEEN ELECTRODE	SOIL RESISTIVITY	REMARK

X. CHECK THE MINIMUM CLEARANCE BETWEEN LIVE PARTS W.R.T GROUNG AND BETWEEN LIVE PARTS

VOLTAGE	PHASE TO GROUND	PHASE TO PHASE	REMARK , IF ANY
132 kV	1270 mm	1473 mm	
220 kV	2082 mm	2368 mm	
400 kV	3065 mm	5750 mm	
765 KV	6400 mm	9400 mm	

Note : All the clearance between phases & phase to ground are to be checked as per the drgs. issued by Engg. Dept.

XI. CHECKING OF INTERLOCKS

i. Please refer the relevant plant circuit diagram for checking the interlocks of various equipments to be energized.

ii. All isolators and ground switches Inter locking checked as per the Document no CF/ISO/08

Yes	No	Remarks

XII. TRIP TEST

All breakers are tested and all the trip test as per the required plant circuit diagrams are carried out as per the document No CF/CB/05

Yes	No	Remarks

XIII. STABILITY TEST FOR BUSBAR

Details of kit used:
To be done in line with approved scheme

i. Bus earth switch open

PHASE	PRIMARY INJECTION BETWEEN CTs	CURRENT VALUE	SPILL CURRENT VALUE	REMARKS
R				
Y				
B				
R				
Y				
B				
R				
Y				
B				

ii. Bus earth switch closed

PHASE	PRIMARY INJECTION BETWEEN CTs	CURRENT VALUE	SPILL CURRENT VALUE	REMARKS
R				
Y				
B				
R				
Y				
B				
R				
Y				
B				

XIV. FINAL TRIPM TEST

The trip test must be repeated prior to energization as per approved scheme.

Tripping operation to be checked for both the trip coils from local/ remote/ protection

i. DC source 1 off

SL. NO	PROTECTION TYPE	SIMULATION METHOD	CB TRIP RESPONSE		REMARK
			MAIN	TIE	
I	Main - I				
II	Main - II				
III	Over voltage				
IV	Carrier inter tripping				
V	LBB				
VI	Bus bar				
VII	Tee differential				
VIII	Differential				
IX	Restricted earth fault				
X	Back up o/c & e/f				
XI	Over fluxing				
XII	OTI trip				
XIII	WTI trip				
XIV	Buchholz trip (main)				
XV	Buchholz trip (OLTC)				
XVI	PRD				
XVII	Auto-reclose - R ø				
XVIII	Auto-reclose - Y ø				
XIX	Auto-reclose - B ø				

ii. DC source 2 off

SL. NO	PROTECTION TYPE	SIMULATION METHOD	CB TRIP RESPONSE		REMARK
			MAIN	TIE	
I	Main - I				
II	Main - II				
III	Over voltage				
IV	Carrier inter tripping				
V	LBB				
VI	Bus bar				
VII	Tee differential				
VIII	Differential				
IX	Restricted earth fault				
X	Back up o/c & e/f				
XI	Over fluxing				
XII	OTI trip				
XIII	WTI trip				
XIV	Buchholz trip (main)				
XV	Buchholz trip (OLTC)				
XVI	PRD				
XVII	Auto-reclose - R ø				
XVIII	Auto-reclose - Y ø				
XIX	Auto-reclose - B ø				

Operational Constraints if any

XV. FINAL DOCUMENTATION REVIEW

i. Final documents of Pre- Commissioning checks reviewed and approved

Yes	No

ii. Document regarding spares equipment, O&M manuals etc available at sit for O&M purpose

Yes	No

iii. After modification, if any, "As built Drawings" are available at site

Yes	No

iv. The above Bay/Feeder is cleared for high voltage energisation

Yes	No

Signature:	Signature:	Signature:	Signature:
Name:	Name:	Name:	Name:
Designation:	Designation:	Designation:	Designation:
Organization: (Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commissioning Team) Members: 1. 2. 3. 4.

PRE-COMMISSIONING FORMATS FOR ISOLATOR AND GROUNDING SWITCH

I. General Details

DETAILS	
Region:	**Sub-Station:**
Feeder name	**LOA No. :**
Make:	**Type:**
Sr. No.: **R Ø:-** **YØ:-** **BØ:-**	**Operating Voltage rating**
Control Volatge:	**Current Carrying capacit y:**
Year of Manufacture: **R Ø:-** **YØ:-** **BØ:-**	**Date of Receipt at site:** **R Ø:-** **YØ:-** **BØ:-**
Date of Erection: **R Ø:-** **YØ:-** **BØ:-**	**Date of energisation**

II. Pre-Commissioning Checks

Sl.No	Description	Status		Remark / Record Deficiencies, If Any
		YES	NO	
1	Equipment is free from dirt/dust foreign materials etc.			
2	Equipment is free from all visible defects on physical inspection			
3	Support structures, marshalling box has been provided with two earthing pads / points			
4	All nuts and bolts are tightened correctly as per specified torque			
5	Equipment erection is complete in all respect as per instruction Manual (attach remaining activities, if any)			
6	Permanent isolator lavelling and identification is done			
7	Leveling and alignment of structure and base frame is checked			
8	Control box / marshalling kiosk is free from any physical defects			
9	Tightness of nuts bolts of terminal connectors are checked			
10	Auxiliary contacts and relays have been cleaned and free from rust / damage			

Sl.No	Description	Status		Remark / Record Deficiencies, If Any
		YES	NO	
11	Corona rings are provided and properly fixed			
12	Cable termination and tightness checked and unused holes sealed			
13	External cabling is completed in all respect			
14	All the cable identification tags provided and all cores are provided with Identification ferrules at m.b.			
15	All moving parts are lubricated			
16	Alignment of isolator already made and locking bolt provided, if any			
17	Freeness of manual operation is ok			
18	Greasing has been made on the main contacts according to the manufacturers instruction			
19	Functional ckecking of auxiliary contacts for indications and interlocks			
20	Erection completion certificate along with list of Outstanding activities reviewed			
21	All spare wires to be kept with ferrules but not terminated at the terminal blocks			
22	Earth switch connected to earth through braided wires			
23	Interlocks checked as per approved scheme with all combinations			
24	Check that earth switch blade alignment in condition is at sufficient distant from isolator			
25	Check that operation and positioning of the limit switch & the auxiliary contacts assembly are ok			
26	Check that all three phase isolators are closing & opening at a time			
27	Check all 3 earth switches close at the same time			
28	Provision of bimetallic strips ensured wherever applicable			

III. Motor Details

	R - Ø	Y - Ø	B - Ø
Make			
Serial number			
Type			
Year of manufacturer			
Volt			
Amperes			
Hp/ kW			
O/L setting (Thermal Over load)			

IV. Insulation Resistance Measurement

Make of testing kit ______________________

Date of calibration ______________________

Ambient temperature ______________________

Using 500 volt megger measure resistance between the winding of motor and earth

Sl. No	Between	Phase		
		R Ø	Y Ø	B Ø
1	Winding to Earth			

PERMISSIVE VALUE > 50 M.OHM

V. Operational Checks

i. Operate the isolator and record the motor current

Isolator Operation	Motor Current					
	R - Ø		Y - Ø		B - Ø	
	Factory	Site	Factory	Site	Factory	Site
Close						
Open						

ii. Operation of isolator from local / remote Ok/Not Ok

Isolator Operation	Control Panel	
	Local	Remote
Close		
Open		

iii. Measurement of operating time

Operation	Unit	Phase		
		R - Ø	Y - Ø	B - Ø
Opening Time				
Closing Time				

iv. Auxillary Contacts Checking

ISOLATOR OPERATION	AUXILLARY RELAY TYPE	OPERATION TIME					
		R - Ø		Y - Ø		B - Ø	
		NO	NC	NO	NC	NO	NC
CLOSE							

ISOLATOR OPERATION	AUXILLARY RELAY TYPE	OPERATION TIME					
		R - Ø		Y - Ø		B - Ø	
		NO	NC	NO	NC	NO	NC
OPEN							

Reference drawing no:

v. Operation On Under Voltage Condition

Condition	Coil	Unit	Phase		
			R - Ø	Y - Ø	B - Ø
PICK UP VOLTAGE	CLOSING	VOLT DC			
	OPENING	VOLT DC			
	INTERLOCK	VOLT DC			
DROP VOLTAGE	CLOSING	VOLT DC			
	OPENING	VOLT DC			
	INTERLOCK				

VI. Insulation Resistance Measurement (By 5kV Megger)

Make of testing kit ______________________________

Date of calibration ______________________________

Ambient temperature ______________________________

Isolator open condition

Between	Phase		
	R Ø	Y Ø	B Ø
MALE SIDE TO GROUND			
FEMALE SIDE TO GROUND			
MALE SIDE TO FEMALE SIDE			

PERMISSIVE VALUE > 1000 M.OHM

VII. CONTACT RESISTANCE MEASUREMENT
(To be measured after 50 operations)

Make of testing kit ______________________________

Date of calibration ______________________________

i. Isolator Close condition

Contact Resistance	Units	R - Ø	Y - Ø	B - Ø
Connector 1	μ Ω			
Connector2	μ Ω			
Main Contact 1	μ Ω			
Main Contact 2	μ Ω			

The value of Contact Resistance should not be more than 10 Micro – ohms per / Connector
The value of Contact Resistance should not be more than 150 Micro – ohms per / break

ii. Isolator Open condition and grounding switch close condition

Contact Resistance	Units	R - Ø	Y - Ø	B - Ø
Main Contact(Male & Female) Ground Switch	μ Ω			

The value of Contact Resistance should not be more than 150 Micro – ohms per / break

VIII.

i. Resistance of open coil ________________________________

ii. Resistance of close coil ________________________________

iii. Resistance of interlocking coil________________________________

IX. Final Documentation Review

i. Final documents of Pre- Commissioning checks reviewed and approved

Yes	No

ii. Document regarding spares equipment, O&M manuals etc available at sit for O&M purpose

Yes	No

iii. After modification, if any, “As built Drawings” are available at site

Yes	No

Signature:	Signature:	Signature:	Signature:
Name:	Name:	Name:	Name:
Designation:	Designation:	Designation:	Designation:
Organization: (Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commissioning Team) Members: 1. 2. 3. 4.

PRE-COMMISSIONING FORMATS FOR SURGE ARRESTOR

I. General Details

DETAILS	
Region:	**Sub-Station:**
Feeder name	**LOA No. :**
Make:	**Type:**
Sr. No.: **R Ø:-** **YØ:-** **BØ:-**	**Voltage rating**
Rating:	**Feeder name:**
Year of Manufacture: **R Ø:-** **YØ:-** **BØ:-**	**Date of Receipt at site:** **R Ø:-** **YØ:-** **BØ:-**
Date of Erection: **R Ø:-** **YØ:-** **BØ:-**	**Date of energisation**

II. Pre-Commissioning Checks:

Sl.No	Description	Status		Remark Record Deficiencies, If Any
		Yes	No	
1	Equipment is free from dirt / dust foreign materials etc.			
2	Equipment is free from all visible defects on physical inspection			
3	Support structures have been provided with double earth			
4	All nuts and bolts are tightened correctly as per specified torque			
5	Equipment erection is complete in all respect (attach remaining activities, if any)			
6	Permanent la leveling and identification is done			
7	Leveling and alignment of structure and base frame is checked			
8	All insulators & surge counter are free from any physical defects			
9	Tightness of nuts bolts of terminal connectors are checked			
10	Erection completion certificate along with list of outstanding activities reviewed			

Sl.No	Description	Status		Remark Record Deficiencies, If Any
		Yes	No	
11	Check one end of surge counter is connected to the bottom of la stack and one end of surge counter has been earthed			
12	The direction of the exhaust vent ports away from the protected equipment and other arrester poles			
13	Clearance from the arrester to earthed objects and from the arrester pole to another arrester pole maintained as per outline drawing and all erection has been done as per drawing issued by engg. Dept.			
14	Operation of la counter checked by applying appropriate voltage			
15	Check the serial no. And sequence of la parts for erection in multi stack la			
16	Check the alignment of corona ring			
17	Check on charging, the surge counter pointer is in green zone			

III. Insulation Resistance Measurement : (Using 5kV Megger)

Sl. No	Between	Unit	Phase		
			R Ø	Y Ø	B Ø
1	1st stack	MΩ			
2	2nd stack	MΩ			
3	3rd stack	MΩ			
4	4th stack	MΩ			
5	5th stack	MΩ			
6	Total from top to earth	MΩ			

MIN VALUE > 1000 M OHMS

IV. Surge Counter Reading

Sl.No	Reading	R Ø	Y Ø	B Ø
1	Counter sr. No.			
2	Counter make			
3	Counter reading			

V. Capacitance & Tan Delta Measurement

Stack	Capacitance	Tan Delta	Remarks
Top			
Middle 1			
Middle 2			
Bottom			

The Tan delta and capacitance value shall be considered as base value for future monitoring. However, Tan delta value of different stack shall be comparable.

VI. Checking Of Healthiness Of Surge Monitor

Refer manufacturer's catalogue for detail checking of surge monitor

Yes	No

VII. Third Harmonic Resistive Current Measurement

Ambient Temperature ____________________________ System Voltage___________________________

Phase	Total Current	3rd Harmonic Resistive Current (I3 R) In A	Remarks
R Ø			
Y Ø			
B Ø			

The value of third harmonic current shall be less than 30 μA (for 400 kV & below) & 50 μA (for 765 kV).

VIII. Final Documentation Review

i. Final documents of Pre- Commissioning checks reviewed and approved

Yes	No

ii. Document regarding spares equipment, O&M manuals etc available at sit for O&M purpose

Yes	No

iii. After modification, if any, "As built Drawings" are available at site

Yes	No

Signature:	Signature:	Signature:	Signature:
Name:	Name:	Name:	Name:
Designation:	Designation:	Designation:	Designation:
Organization: (Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commissioning Team) Members: 1. 2. 3. 4.

PRE-COMMISSIONING FORMATS FOR WAVE TRAP

I. General Details

Details	
Region:	**Sub-Station:**
Feeder name	**LOA No. :**
Make:	**Type:**
Sr. No.: **R Ø:-** **YØ:-** **BØ:-**	**Voltage rating**
mH Rating:	**Current Rating:**
Band Width:	
Year of Manufacture: **R Ø:-** **YØ:-** **BØ:-**	**Date of Receipt at site:** **R Ø:-** **YØ:-** **BØ:-**
Date of Erection: **R Ø:-** **YØ:-** **BØ:-**	**Date of energisation**

II. Pre-Commissioning Checks

Sl No	Description	Status		Record Deficiencies, If Any
		Yes	No	
1	Equipment is free from dirt / dust foreign materials etc.			
2	Equipment is free from all visible defects on physical inspection			
3	Support structures has been provided with double earth			
4	All nuts and bolts are tightened correctly as per specified torque			
5	Permanent lavelling and identification is done			
6	Leveling and alignment of structure and base frame is checked			
7	All insulators & line matching unit are free from any physical defects			
8	Tightness of nuts / bolts of terminal connectors are checked			
9	Erection completion certificate along with list of outstanding Activities reviewed			
10	Check that the tuning unit and arrestor are properly tightened and free from any damage			
11	Tuning unit connection as per PLCC frequency			

III. Insulation Resistance Measurement

Make of testing kit ____________________________

Date of calibration ____________________________

Ambient temperature ____________________________

Sl. No	Between	Megger	Phase			Permissive Value
			R Ø	Y Ø	B Ø	
1	UPPER TEMINAL AND EARTH	5000 V				> 1000 M.OHM
2	LA OF THE WAVE TRAP	500 V				> 1 M.OHM

IV. Contact Resistance Measurement

Make of testing kit ____________________________

Date of calibration ____________________________

Contact Resistance	Units	R - Ø	Y - Ø	B - Ø
Across Terminal P1	μ Ω			
Across Terminal P2	μ Ω			

The value of Contact Resistance should not be more than 5 Micro – ohms per Joint / Connector

V. Final Documentation Review

i. Final documents of Pre- Commissioning checks reviewed and approved

Yes	No

ii. Document regarding spares equipment, O&M manuals etc available at sit for O&M purpose

Yes	No

iii. After modification, if any, "As built Drawings" are available at site

Yes	No

Signature:	Signature:	Signature:	Signature:
Name:	Name:	Name:	Name:
Designation:	Designation:	Designation:	Designation:
Organization: (Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commissioning Team) Members: 1. 2. 3. 4.

PRE-COMMISSIONING FORMATS FOR CONTROL & PROTECTION INCLUDING PLCC

LINE PROTECTION

General Details

Region:	**Sub-Station:**
Feeder Name:	**LOA No. :**
Date of testing:	**Date of Energisation:**

Main-I/II Protection Panel

1. **Main-I /II Distance relay: (separate for Main-I & II Relays)**

i		Check for proper programming of Input / Output contacts of the relay as per approved schematics		Ok/ Not Ok
ii	a	Check for proper programming of LED's(if applicable) of the relay and check that stickers are provided as per the configuration.		Ok/ Not Ok
	b	Check Configuration / Programmable Scheme Logic of relay according to scheme (applicable for numerical relays)		Ok/ Not Ok
	c	Get the print out of Configuration / PSL		Ok/ Not Ok
iii		Get a print of relay settings		Ok/ Not Ok
iv		Compare with the recommended setting		Ok/ Not Ok
v		Check for Reach Setting : Zone- I, II, III,IV		Ok/ Not Ok
vi		Check time of operation : Zone- I, II, III,IV		Ok/ Not Ok
vii		Test results of (iii) & (iv) enclosed		Yes/ No
viii		Check polarity of send & receive for PLCC command (If Digital Channel/ Under FET operation)		Ok/ Not Ok
ix		Check Permissive tripping by Carrier command receive and measure & record relay operation time for carrier aided trip. Also check Carrier Send command on relay tripping		Ok/ Not Ok
		Verify Respective Counter Advancement In Each Channel		
		Send	Recv	
	Main-I	CH….. Code………	CH….. Code………	Ok/ Not Ok
		CH….. Code………	CH….. Code………	Ok/ Not Ok
	Main-II	CH….. Code………	CH….. Code………	Ok/ Not Ok
		CH….. Code………	CH….. Code………	Ok/ Not Ok

x	Check Blocking scheme (if applicable) along with carrier command for both send & receive.			Ok/ Not Ok
	Verify Respective Counter Advancement In Each Channel			
	Send		Recv	
	Main-I	CH….. Code………	CH….. Code………	Ok/ Not Ok
		CH….. Code………	CH….. Code………	Ok/ Not Ok
	Main-II	CH….. Code………	CH….. Code………	Ok/ Not Ok
		CH….. Code………	CH….. Code………	Ok/ Not Ok
xi	Check SOTF Logic. Check Control switch(TCS) & wirings on Control panel to Relay Input for SOTF(if provided)			Ok/ Not Ok
xii	Check Weak-end in-feed logic			Ok/ Not Ok
xiii	Check Selective Phase tripping(R Ph fault to R-Ph Trip etc) for each phase separately			Ok/ Not Ok
xiv	Check Power swing blocking feature (if available)			Ok/ Not Ok
xv	Check trip Block in case of CVT Fuse Failure			Ok/ Not Ok
xvi		Check Auto Reclose Initiation Contacts for		
	a	Transient Single Phase Earth fault(Zone-1&Zone-2+CR)		Ok/ Not Ok
	b	Non initiation for 1 phase fault in Zone II		Ok/ Not Ok
	c	Transient Ph-Ph Fault		Ok/ Not Ok
	d	Transient 3 Phase Faults		Ok/ Not Ok
	e	Permanent Faults(Prepare 3Ph Trip)		Ok/ Not Ok
	f	Check for dead time and reclaim time setting		Ok/ Not Ok
	g	Check single phase auto reclosure for all three phases one by one.		Ok/ Not Ok
xvii	Check for tripping command directly to CB & correct operation of tripping relays and auxiliary relays			Ok/ Not Ok
xviii	Check Communication to PC keeping adjacent relay IN&OUT of service (If available)			Ok/ Not Ok
xix	Check PLCC carrier Switch Operation(In/Out).			Ok/ Not Ok
xx	Check Time synchronizing by altering Time Zone. Restore on confirmation			Ok/ Not Ok
xxi	Check Self-diagnostic feature of the relay (if provided)			Ok/ Not Ok
xxii	Check metering function of the relay (if provided)			Ok/ Not Ok
xxiii	Verify automatic downloading feature as per Tech spec.			Ok/ Not Ok
xxiv	Verify open delta voltage in DR channel			Ok/ Not Ok
xxv	Verify availability of configuration tool at site.			Ok/ Not Ok
xxvi	Verify Main & Tie CT circuits by primary injection			Ok/ Not Ok
xxvii	Check directionality of the relay after synchronization of the line			Ok/ Not Ok
xxviii	Check for DEF protection and its contacts (if applicable)			Ok/ Not Ok
xxix	Check all the contacts of relay for proper operation & rating			Ok/ Not Ok

2. Overvoltage Stage-I/II

i	Check Operate Value/Reset Value/Operate timing for all phases.	Ok/ Not Ok
ii	Check whether it trips Main/Tie CB & sends Direct trip to remote end	Yes/ No

3. Stub protection (4 CT scheme)

i	Check scheme logic	Ok/ Not Ok
ii	Check operation at set value	Ok/ Not Ok
iii	Check Direct Trip send & receive circuit with carrier command. Verify counter advancement in each channel	Ok/ Not Ok

4. TEE Differential-I/II (5 CT scheme)

i	Check Operate Value/Reset Value/Operate Timing for all phases	Ok/ Not Ok
ii	Check tripping of Main/Tie CB & send Direct trip to remote end	Ok/ Not Ok
iii	Check stability for out zone fault	Ok/ Not Ok
iv.	**If Biased differential,** check Biasing percentage for all phases	Ok/ Not Ok

5. Fault Locator

Feed FL & Distance relay with same Voltage & Current from test Kit. Simulate Zone-I/II, Single Ph/Ph-Ph/3Ph Fault to Main-I/II Distance relay.

i	Check initiation by Distance relay	Ok/ Not Ok
ii	Compare Fault location by calculating the Set Vale on test Kit	Ok/ Not Ok
iii	Repeat the above up to 99% in steps	Ok/ Not Ok
iv.	Check healthiness of mutual compensation circuit	Ok/ Not Ok

6. Disturbance Recorder

i	Check analog & digital channels are connected as per approved nomenclature	Ok/ Not Ok
ii	Check threshold value of analog triggering (including open delta voltage).	Ok/ Not Ok
iii	Check triggering on digital inputs	Ok/ Not Ok
iv	Check automatic downloading feature	Ok/ Not Ok
v	Check time synchronizing feature	Ok/ Not Ok
vi	Verify open delta voltage in DR channel	Ok/ Not Ok
vii	Check diagnostic feature(if provided)	Ok/ Not Ok

7. Final Documentation Review

S.No.	Description	Status (Yes/ No)	Remarks(Record deficiencies, if any)
1.	Final document of Pre-commissioning checks reviewed and approved		
2.	Documents regarding spares, equipment, factory reports, O&M manuals etc. available at site for O&M purpose		
3.	After modification, if any, "As built drawing are available at site		

Signature:	Signature:	Signature:	Signature:
Name:	Name:	Name:	Name:
Desgn.:	Desgn.:	Desgn.:	Desgn.:
Organization:			
(Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commg. Team) Members: 1, 2. 3. 4.

CIRCUIT-BREAKER PANEL

General Details

Region:	**Sub-Station:**
Feeder Name:	**LOA No. :**
Date of testing:	**Date of Energisation:**

1. **Auto-reclose Scheme:** (Checks applicable for distance protection scheme with auto re-closure function as well)

i		Check auto reclose initiation/Block contacts for	
	a	Transient Single Phase Earth fault	Ok/ Not Ok
	b	Non initiation for 1 phase fault in Zone II	Ok/ Not Ok
	c	Transient Ph-Ph Fault	Ok/ Not Ok
	d	Transient 3 Phase Faults	Ok/ Not Ok
	e	Permanent Faults	Ok/ Not Ok
ii		Simulate Zone-I ,Single Ph Transient E/F to Main-I/II Distance relay Check AR for all 3 Phases,one by One	Ok/ Not Ok
iii		Loop CS & CR, Simulate Zone-II ,Single Ph Transient E/F to Main-I/II Distance relay Check AR for all 3 Phases, one by One	Ok/ Not Ok
iv		Check settings & operation of Synchronizing/DLC relays	Ok/ Not Ok
v		Measure Dead Time setting ……………….ms	
vi		Measure Reclaim Timer setting	Ok/ Not Ok
vii		Check AR does not take place within reclaim time	Ok/ Not Ok
viii		Check AR does not take place in case of fault on Line Charging.	Ok/ Not Ok
ix		Check AR does not take place in case of Failure of PLCC Carriers	Ok/ Not Ok
x		Further, check AR Interlocking in case of	
	a	Pole discrepancy	Ok/ Not Ok
	b	Direct trip received	Ok/ Not Ok
	c	Over-voltage stage-I/II trips	Ok/ Not Ok
	d	Reactor protection trips	Ok/ Not Ok
	e	CB Troubles	Ok/ Not Ok
	f	Zone-2 & 3 time delayed faults	Ok/ Not Ok
xi		In a one & half / Two CB scheme, Check AR does not take place for any one of the CBs under S/D. Check Memory Circuit Contact status(CB Closed/Opened conditions). Check Memory Circuit Timer setting.	Ok/ Not Ok
xii		Check Logics of AR switch Operation (NA/1Ph/2Ph/3Ph).	Ok/ Not Ok
xiii		Check priority circuitry. Priority circuit of Tie CB should be bypassed is any of the main CB is kept in Non Auto mode due to shutdown or outages	Ok/ Not Ok
xiv		A/R should not take place in NON AUTO mode	Ok/ Not Ok

2. Local Breaker Back Up Protection:

i	Check Operate Value/Reset Value/Operate Timing for all phases	Ok/ Not Ok
ii	Check adjacent CB's as well as concerned Bus-Bar Trip relays operate during operation of LBB relay	Ok/ Not Ok
iii	Check Direct trip Transfer takes place only for feeder under testing during LBB operation	Ok/ Not Ok

3. Under-voltage Relay

i	Check Operate Value/Reset Value/Operate Timing for all phases	Ok/ Not Ok
ii	Check E/S interlock operation under relay energized condition & vice versa	Ok/ Not Ok

4. Direct Trip Transfer

a. Check Direct trip transfer in case of:

i	Over-voltage relay operations	Ok/ Not Ok
ii	Reactor trip operations.	Ok/ Not Ok
iii	Manual trip to One CB(Main/Tie) when another CB(Tie/Main) in same dia is under open condition	Ok/ Not Ok
iv	LBB relay Trip: for both the main & tie CB's	Ok/ Not Ok
v	Busbar Trip to One CB(Main/Tie) when another CB(Tie/Main) in same dia is under open condition	Ok/ Not Ok
vi	TEE Diff/ STUB Protection trip	Ok/ Not Ok
vii	Direct trip Transfer thr' 1st Chanel	Ok/ Not Ok
viii	Direct trip Transfer thr' 2nd Chanel	Ok/ Not Ok
ix	Check DT is not resulted by 1st Chanel permissive trip	Ok/ Not Ok
x	Check DT is not resulted by 2nd Chanel permissive trip	Ok/ Not Ok

b. Summary of Code Transfer for PLCC

Ch-1 Code-I……… Ch-1 Code-2 ……… Ch-2 Code-I ……… Ch-2 Code-2 ………

i	Check individual Code Transfer to be as per scheme	Ok/ Not Ok
ii	Ch-1 Code-I	Ok/ Not Ok
iii	Ch-1 Code-2	Ok/ Not Ok
iv	Ch-1 Code-3	Ok/ Not Ok
v	Ch-2 Code-I	Ok/ Not Ok
vi	Ch-2 Code-2	Ok/ Not Ok
vii	Ch-2 Code-3	Ok/ Not Ok
viii	Check if signal through One code is not transferred to another at Remote end	Ok/ Not Ok

5. CB Troubles

i	Check whether All relays are given elaborative nomenclatures. If not, Paste descriptions (CB LOW Air/Oil pressure, Pole discrepancy etc.)	Ok/ Not Ok
ii	Check Operations of individual Relays by actuating initiating Contacts from field	Ok/ Not Ok
iii	Check facia/Event Logger Input Contacts for the same	Ok/ Not Ok

6. Final Documentation Review

S.No.	Description	Status (Yes/ No)	Remarks(Record deficiencies, if any)
1.	Final document of Pre-commissioning checks reviewed and approved		
2.	Documents regarding spares, equipment, factory reports, O&M manuals etc. available at site for O&M purpose		
3.	After modification, if any, “As built drawing are available at site		

Signature:	Signature:	Signature:	Signature:
Name:	Name:	Name:	Name:
Desgn.:	Desgn.:	Desgn.:	Desgn.:
Organization:			
(Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commg. Team) Members: 1, 2. 3. 4.

LINE REACTOR PROTECTION

General Details

Region:	**Sub-Station:**
Feeder Name:	**LOA No. :**
Date of testing:	**Date of Energisation:**

1. Differential Protection

i	CT secondary Circuitry Checked & Diff current is Nil by Primary Injection for all Phases	Ok/ Value….
ii	Check connection of stabilizing resistance & metrosil (wherever applicable)	Ok/ Not Ok
iii	If fed from Turret CT's from both sides of Phase Windings. Check Operate Value/Reset Value/Operate Timing for all phases	Ok/ Not Ok
iv	Measure differential pick up current	Ok/ Not Ok
v	Carry out stability test by simulating external and internal faults and measure spill currents in Differential circuit	Ok/ Not Ok
vi	Check Biasing percentage, Operate Value/Reset Value/Operate including High set feature if applicable	Ok/ Not Ok
vii	Timing for all phases(if biased / percentage differential)	Ok/ Not Ok
viii	Check Blocking of tripping on Harmonic Restraints Feature (2^{nd} & 5^{th} harmonics)	Ok/ Not Ok
ix	Check DR feature (if available)	Ok/ Not Ok

2. Restricted Earth-Fault Protection:

i	Check Operate Value/Reset Value/Operate Timing for all phases	Ok/ Not Ok
ii	CT secondary Circuitry Checked & Diff current is Nil by Primary Injection for all Phases	Ok/ Value….
iii	Check connection of stabilizing resistance & metrosil (wherever applicable)	Ok/ Not Ok
iv	Check CT Circuits so that summation of same phases(R-R, Y-Y, B-B) is taking place (Sometimes R-B & B-R summations are observed due to wrong Wirings).	Ok/ Not Ok
v	If fed from Turret CT's from both sides of Phase Windings. Check Operate Value/Reset Value/Operate Timing for all phases	Ok/ Not Ok
vi	Measure differential pick up current	Ok/ Not Ok
vii	Carry out stability test by simulating external and internal faults by primary injection and measure spill currents in REF relay	Ok/ Not Ok

3. **Back-Up Impedance Relay** Type :…………

i	Get a print of relay settings(wherever applicable)	Ok/ Not Ok
ii	Compare with recommended setting	Ok/ Not Ok
iii	Check for Reach Setting	Ok/ Not Ok
iv	Check time of operation	Ok/ Not Ok
v	Test results of (iii) & (iv) enclosed	Yes/No
vi	Check Selective Phase tripping(R Ph fault to R-Ph Trip etc)	Ok/ Not Ok
vii	Check trip Block in case of CVT Fuse Failure.	Ok/ Not Ok
viii	Check Communication to PC(If available)	Ok/ Not Ok
ix	Check Time synchronizing by altering Time Zone. Restore on confirmation	Ok/ Not Ok
x	Check Self-diagnostic feature of the relay (if provided)	Ok/ Not Ok
xi	Check metering function of the relay (if provided)	Ok/ Not Ok
xii	Verification of Directionality	Ok/ Not Ok

4. **Electromechanical Relays** : Check operation of:

i	Buchholz Alarm & trip	Ok/ Not Ok
ii	WTI Alarm & trip	Alarm………Trip………..
iii	OTI Alarm & trip	Alarm………Trip………..
iv	PRD Trip	Ok/ Not Ok
v	MOG(LOL/Low Oil Level) Alarm	Ok/ Not Ok

5. **Direct Trip Transfer**

i	In all cases of above trippings, Direct trip to remote end is sent along with tripping of Main/Tie CB's	Ok/ Not Ok
ii	Direct trip **:** From line Reactor LBB in case of switchable reactor	Ok/ Not Ok

6. **Voltage selection for Protection & Metering**

i	Ensure Voltage inputs at specific terminals from		
	a	Line CVT	Ok/ Not Ok
	b	Bus-I CVT(say connected to CB-1)	Ok/ Not Ok
	c	Bus-II CVT(say connected to CB-2)	Ok/ Not Ok
ii	Check NO/NC Contacts from CB-1 & CB-2 for voltage selection		Ok/ Not Ok
		Open Line Isolator: Close CB-1 : Bus-I CVT supply will be selected. Check CVT Supply at selected CVT Terminals for Metering & Protection. Trip CB-1	Ok/ Not Ok
		Close CB-2 : Bus-II CVT supply will be selected. Check CVT Supply at selected CVT Terminals for Metering & Protection. Trip CB-2.	Ok/ Not Ok
		Close Line Isolator: Line CVT supply will be selected. Close CB-1 & 2, No change in status of Selection relays.	Ok/ Not Ok

7. Check RWTI on Control panel

i	RWTI checked on control panel	Ok/ Not Ok

8. Final Documentation Review

S.No	Description	Status (Yes/ No)	Remarks(Record Deficiencies, If Any)
1.	Final document of Pre-commissioning checks reviewed and approved		
2.	Documents regarding spares, equipment, factory reports, O&M manuals etc. available at site for O&M purpose		
3.	After modification, if any, “As built drawing are available at site		

Signature:	Signature:	Signature:	Signature:
Name:	Name:	Name:	Name:
Desgn.:	Desgn.:	Desgn.:	Desgn.:
Organization:			
(Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commg. Team) Members: 1, 2. 3. 4.

BUS REACTOR PROTECTION

General Details

Region:	**Sub-Station:**
Feeder Name:	**LOA No. :**
Date of testing:	**Date of Energisation:**

1. Differential Protection

i	CT secondary Circuitry Checked & Diff current is Nil by Primary Injection for all Phases	Ok/ Value….
ii	Check connection of stabilizing resistance & metrosil (wherever applicable)	Ok/ Not Ok
iii	Check CT Circuits so that summation of same phases(R-R, Y-Y, B-B) is taking place (Sometimes R-B & B-R summations are observed due to wrong Wirings)	
iv	If fed from Turret CT's from both sides of Phase Windings. Check Operate Value/Reset Value/Operate Timing for all phases	Ok/ Not Ok
v	Measure differential pick up current	Ok/ Not Ok
vi	Carry out stability test by simulating external and internal faults and measure spill currents in Differential circuit	Ok/ Not Ok
vii	Check Biasing percentage, Operate Value/Reset Value/Operate including High set feature if applicable	Ok/ Not Ok

2. Restricted Earth-Fault Protection:

i	Check Operate Value/Reset Value/Operate Timing for all phases	Ok/ Not Ok
ii	CT secondary Circuitry Checked & Diff current is Nil by Primary Injection for all Phases	Ok/ Value….
iii	Check connection of stabilizing resistance & metrosil (wherever applicable)	Ok/ Not Ok
iv	Check CT Circuits so that summation of same phases(R-R, Y-Y, B-B) is taking place (Sometimes R-B & B-R summations are observed due to wrong Wirings).	Ok/ Not Ok
v	If fed from Turret CT's from both sides of Phase Windings. Check Operate Value/Reset Value/Operate Timing for all phases	Ok/ Not Ok
vi	Measure differential pick up current	Ok/ Not Ok
vii	Carry out stability test by simulating external and internal faults by primary injection and measure spill currents in REF relay	Ok/ Not Ok

3. **Back-Up Impedance Relay** Type :…………

i	Get a print of relay settings(wherever applicable)	Ok/ Not Ok
ii	Compare with recommended setting	Ok/ Not Ok
iii	Check for Reach Setting	Ok/ Not Ok
iv	Check time of operation	Ok/ Not Ok
v	Test results of (iii) & (iv) enclosed	Yes/No
vi	Check trip Block in case of CVT Fuse Failure.	Ok/ Not Ok
vii	Check Communication to PC(If available)	Ok/ Not Ok
viii	Check Time synchronizing by altering Time Zone. Restore on confirmation	Ok/ Not Ok
ix	Check Self-diagnostic feature of the relay (if provided)	Ok/ Not Ok
x	Check metering function of the relay (if provided)	Ok/ Not Ok
xi	Verification of Directionality	Ok/ Not Ok

4. **Electromechanical Relays**

i	Buchholz Alarm & trip	Ok/ Not Ok
ii	WTI Alarm & trip	Alarm………Trip………..
iii	OTI Alarm & trip	Alarm………Trip………..
iv	PRD Trip	Ok/ Not Ok
v	MOG(LOL/Low Oil Level) Alarm	Ok/ Not Ok

5. **Direct Trip Transfer**

i	In all cases of above trippings, Direct trip to remote end is sent along with tripping of Main/Tie CB’s	Ok/ Not Ok
ii	Direct trip**:** From line Reactor LBB in case of switchable reactor	Ok/ Not Ok

6. **Voltage selection for Protection & Metering**

i	Ensure Voltage inputs at specific terminals from		
	a	Line CVT	Ok/ Not Ok
	b	Bus-I CVT(say connected to CB-1)	Ok/ Not Ok
	c	Bus-II CVT(say connected to CB-2)	Ok/ Not Ok
ii	Check NO/NC Contacts from CB-1 & CB-2 for voltage selection		Ok/ Not Ok
		Open Line Isolator: Close CB-1 : Bus-I CVT supply will be selected. Check CVT Supply at selected CVT Terminals for Metering & Protection. Trip CB-1	Ok/ Not Ok
		Close CB-2 : Bus-II CVT supply will be selected. Check CVT Supply at selected CVT Terminals for Metering & Protection. Trip CB-2.	Ok/ Not Ok
		Close Line Isolator: Line CVT supply will be selected. Close CB-1 & 2, No change in status of Selection relays.	Ok/ Not Ok

7. Check RWTI on Control panel

i	RWTI checked on control panel	Ok/ Not Ok

8. Final Documentation Review

S.No.	Description	Status (Yes/ No)	Remarks(Record deficiencies, if any)
1.	Final document of Pre-commissioning checks reviewed and approved		
2.	Documents regarding spares, equipment, factory reports, O&M manuals etc. available at site for O&M purpose		
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Signature:	**Signature:**	**Signature:**	**Signature:**
Name:	**Name:**	**Name:**	**Name:**
Desgn.:	**Desgn.:**	**Desgn.:**	**Desgn.:**
Organization:			
(Supplier Representative) (Wherever Applicable)	**(Erection Agency)**	**(POWERGRID Site I/C)**	**(POWERGRID Commg. Team) Members:** **1,** **2.** **3.** **4.**

AUTO-TRANSFORMER PROTECTION

General Details

Region:	**Sub-Station:**
Feeder Name:	**LOA No. :**
Date of testing:	**Date of Energisation:**

1. Differential Protection

i	CT secondary Circuitry Checked & Diff current is Nil by Primary Injection for all Phases	Ok/ Value….
ii	Check connection of stabilizing resistance & metrosil (wherever applicable)	Ok/ Not Ok
iii	Check CT Circuits so that summation of same phases(R-R, Y-Y, B-B) is taking place (Sometimes R-B & B-R summations are observed due to wrong Wirings)	Ok/ Not Ok
iv	If fed from Turret CT's from both sides of Phase Windings. Check Operate Value/Reset Value/Operate Timing for all phases	Ok/ Not Ok
v	Measure differential pick up current	Ok/ Not Ok
vi	Carry out stability test by simulating external and internal faults and measure spill currents in Differential circuit	Ok/ Not Ok
vii	Check Biasing percentage, Operate Value/Reset Value/Operate including High set feature if applicable	Ok/ Not Ok

2. Restricted Earth-Fault Protection

i	Check Operate Value/Reset Value/Operate Timing for all phases	Ok/ Not Ok
ii	CT secondary Circuitry Checked & Diff current is Nil by Primary Injection for all Phases	Ok/ Value….
iii	Check connection of stabilizing resistance & metrosil (wherever applicable)	Ok/ Not Ok
iv	Check CT Circuits so that summation of same phases(R-R, Y-Y, B-B) is taking place (Sometimes R-B & B-R summations are observed due to wrong Wirings).	Ok/ Not Ok
v	If fed from Turret CT's from both sides of Phase Windings. Check Operate Value/Reset Value/Operate Timing for all phases	Ok/ Not Ok
vi	Measure differential pick up current	Ok/ Not Ok
vii	Carry out stability test by simulating external and internal faults by primary injection and measure spill currents in REF relay	Ok/ Not Ok

3. Electromechanical Relays:

Check Operations of:

i	Buchholz Alarm & trip	Ok/ Not Ok
ii	WTI Alarm & trip	Alarm………Trip………..
iii	OTI Alarm & trip	Alarm………Trip………..
iv	PRD Trip	Ok/ Not Ok
v	MOG(LOL/Low Oil Level) Alarm	Ok/ Not Ok
vi	Oil surge relay	Ok/ Not Ok
vii	OLTC Protections	Ok/ Not Ok

4. Direct Trip Transfer

i	In all cases of above trippings, Direct trip to remote end is sent along with tripping of Main/Tie CB's	Ok/ Not Ok

5. Voltage selection for Protection & Metering

i	Ensure Voltage inputs at specific terminals from		
	a	Line CVT	Ok/ Not Ok
	b	Bus-I CVT(say connected to CB-1)	Ok/ Not Ok
	c	Bus-II CVT(say connected to CB-2)	Ok/ Not Ok
ii	Check NO/NC Contacts from CB-1 & CB-2 for voltage selection		Ok/ Not Ok
		Open Line Isolator: Close CB-1 : Bus-I CVT supply will be selected. Check CVT Supply at selected CVT Terminals for Metering & Protection. Trip CB-1	Ok/ Not Ok
		Close CB-2 : Bus-II CVT supply will be selected. Check CVT Supply at selected CVT Terminals for Metering & Protection. Trip CB-2.	Ok/ Not Ok
		Close Line Isolator: Line CVT supply will be selected. Close CB-1 & 2, No change in status of Selection relays.	Ok/ Not Ok

6. Check RWTI on Control panel

i	RWTI checked on control panel	Ok/ Not Ok

7. Over Flux Relay

i	Checking of Pick up drop off value(Alarm)	Ok/ Not Ok
ii	Checking of Pick up drop off value(Trip)	Ok/ Not Ok

8. Transformer Overload Relay

i	Check Operation of alarm Function	Ok/ Not Ok
ii	Operate Value of Current in secondary Terms	……………
iii	Check time of operations	Ok/ Not Ok
iv	Check if trip is provided on O/L Provided/ Not provided	

9. Directional Back-Up O/C & E/F Relay

i	Check Voltage-Current Circuit (Ir –V……., Iy - V……., Ib - V………)	
ii	Check Voltage/Current summation for E/F relay	Ok/ Not Ok
iii	Check Directional element Operation	Ok/ Not Ok
iv	Check time of operation with different operating current	Ok/ Not Ok
v	Attach Graph for IDMT operation for future ref.	Ok/ Not Ok

10. Final Documentation Review

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Name:	Name:	Name:	Name:
Desgn.:	Desgn.:	Desgn.:	Desgn.:
Organization:			
(Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commg. Team) Members: 1, 2. 3. 4.

CONTROL PANEL

General Details

Region:	**Sub-Station:**
Feeder Name:	**LOA No. :**
Date of testing:	**Date of Energisation:**

1. Check metering circuit along with transducers first by secondary injection and there by Primary injection with Standard Voltage & Currents(as per scheme)

i	With Voltmeter Selector switch at various positions R-Y Y-B B-R RN YN BN	Ok/ Not Ok
ii	With Ammeter selector switch at various positions R Y B	Ok/ Not Ok
iii	MW /MVAR Meters	Ok/ Not Ok
iv	Check metering circuits with Primary injection for each phase separately	Ok/ Not Ok
v	Check for frequency Meters	Ok/ Not Ok

2. Check Isolator Interlocks

i	Isolator Operation when Adjacent CB Open	Ok/ Not Ok
ii	Isolator Operation when Adjacent CB Close	Locked/ Unlocked
iii	Check for all Bay/Line/Transformer/reactor isolators with reference to interlock scheme	Ok/ Not Ok

3. Check for Bus isolator Interlock

i	Check Status of E/S interlock of Bus-I/II	Ok/ Not Ok
ii	Isolator Operation when Bus is earthed	Ok/ Not Ok
iii	Isolator Operation when Bus is Not earthed (Checking can be done with engaging/Disengaging Contact Multiplication relay.)	Locked/ Unlocked

4. Check for E/S Interlock(Line)

i	Check E/S Mech. interlock in case Line isolator is closed	Ok/ Not Ok
ii	U/V relay Operate/Reset Voltage	……………………
iii	E/S Operation when U/V relay de-energized	Ok/ Not Ok

5. Check for E/S Interlock(Bay)

i	Check E/S Mech. interlock in case isolator is closed	Ok/ Not Ok
ii	Check E/S interlock in case isolator in same bay is closed	………………
iii	Check E/S Aux. Contact for Local CB Close I/P	Ok/ Not Ok

6. Synchronization Check

i	Check DC supply at Specific Points on Synchro-Check Plug/Socket	Ok/ Not Ok
ii	Check CVT supply at incoming running & earth Points on Syncro-Check Plug/Socket	Ok/ Not Ok
iii	DC(+ve) to be extended to Closing Coil of CB by Synchro-Trolley	Ok/ Not Ok
iv	No close Operation of CB W/O connecting & putting on Synchro-Trolley	Ok/ Not Ok
v	Trip Operation is unbound	Ok/ Not Ok
vi	Check Incoming/running voltage selection and same phase must be selected for a particular sub-station	Ok/ Not Ok
vii	Synchronizing socket pin configuration must be same for trolly and control panel for all bays	Ok/ Not Ok
viii	Voltage selection: Verify operati ng as well as resetting logic (both logic should be mutually inverted)	Ok/ Not Ok

7. Checking of Isolator Indications

Isolator No…………..

i	Checking of Isolator Close Indication	Ok/ Not Ok
ii	Checking of Isolator Open Indication	Ok/ Not Ok
iii	Check Semaphore for E/S Close for Isolator	Ok/ Not Ok
iv	Check Semaphore for E/S Open for Isolator	Ok/ Not Ok
v	Check Operation if adjacent CB cleds	Ok/ Not Ok
vi	Check Operation if adjacent CB Opened	Ok/ Not Ok
vii	Check all NO/NC status as per scheme	Ok/ Not Ok
viii	Check all interlock status as per schem	Ok/ Not Ok

8. Checking of CB Indications

CB No…………..

i	Checking of CB Close Indication	Ok/ Not Ok
ii	Checking of CB Open Indication	Ok/ Not Ok
iii	Check DC healthy indication	Ok/ Not Ok
iv	Check Local Closing I/L as per schem	Ok/ Not Ok
v	Check Aux. Contact for CVT selection	Ok/ Not Ok
vi	Check Aux. Contact for Direct trip (In series with TCS of adjacent CB)	Ok/ Not Ok
vii	Check Aux. Contact for Sync circuit	Ok/ Not Ok
viii	Check all Annunciations Points for CB Troubles	Ok/ Not Ok
ix	Pole Discrepancy Timing set & Checked	Ok/ Not Ok
x	Pole Discrepancy Operation Checked	Ok/ Not Ok
xi	All Pressure switch settings/contacts checked	Ok/ Not Ok
xii	Check Anti-Hunting Operation	Ok/ Not Ok

9. Checking of Isolator Control Switch

Isolator No…………..

i	Wiring & Status of Contacts as per Scheme	Ok/ Not Ok

10. Checking of CB Control Switch

CB No…………..

i	Wiring & Status of Contacts as per Scheme	Ok/ Not Ok
ii	Annunciation & Facia All Working properly	Ok/ Not Ok

11. Control Panel

i	Check for control fuse failure	Ok/ Not Ok
ii	Check that the control fuse failure alarm is reported to station ser by removing one of the +ve/-ve fuse in control ckt.	Ok/ Not Ok
iii	Check that control DC is free from earthing	Ok/ Not Ok
iv	Check there is no mixing of source I & II	Ok/ Not Ok

12. Facia Checking

i	Checking for proper functioning of Annunciation Facia with individual elements of scheme	Ok/ Not Ok
ii	Indication for AC supply failure	Ok/ Not Ok

13. Final Documentation Review

S.No.	Description	Status (Yes/ No)	Remarks(Record deficiencies, if any)
1.	Final document of Pre-commissioning checks reviewed and approved		
2.	Documents regarding spares, equipment, factory reports, O&M manuals etc. available at site for O&M purpose		
3.	After modification, if any, “As built drawing are available at site		

Signature:	Signature:	Signature:	Signature:
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Desgn.:	Desgn.:	Desgn.:	Desgn.:
Organization: (Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commg. Team) Members: 1, 2. 3. 4.

BUSBAR PROTECTION

General Details

Region:	**Sub-Station:**
Feeder Name:	**LOA No. :**
Date of testing:	**Date of Energisation:**
Relay Name Zone-I………	Zone-II…… Check Zone…………..

i	Check Operate Value/Reset Value/Operate Timing for all phases	Ok/ Not Ok
	Zone-I	Ok/ Not Ok
	Zone-II	Ok/ Not Ok
	Check Zone	Ok/ Not Ok
	Block Auto-reclose for all CB's Connected Zone-I	Ok/ Not Ok
	Zone-II	Ok/ Not Ok
ii	If directional Element provided ,Relay tested & Direction found O.K	Ok/ Not Ok
iii	Test results enclosed & accepted	
iv	Zone-I Tripping extended to :	
	Trip relay Location ………… for CB No……… LBB Initiated	Yes/ No
	PLCC/D.T.	Yes/ No
	Trip relay Location ………… for CB No……… LBB Initiated	Yes/ No
	PLCC/D.T.	Yes/ No
v	Zone-II Tripping extended to :	
	Trip relay Location ………… for CB No……… LBB Initiated	Yes/ No
	PLCC/D.T.	Yes/ No
	Trip relay Location ………… for CB No……… LBB Initiated	Yes/ No
	PLCC/D.T.	Yes/ No
vi	LBB/BFR trip checked & extended to Zone-I	
	From CB No…………….	Ok/ Not Ok
	From CB No…………….	Ok/ Not Ok
	From CB No…………….	Ok/ Not Ok
vii	LBB/BFR trip checked & extended to Zone-II	
	From CB No…………….	Ok/ Not Ok
	From CB No…………….	Ok/ Not Ok
	From CB No…………….	Ok/ Not Ok
viii	Transfer Bus Trip Checked	Ok/ Not Ok
ix	Close Interlock in case of BB Trip Checked for all applicable CB's	
x	RESET Working properly	Yes/ No
xi	DC selection working properly for DC-I & II	Yes/ No
xii	Carry out stability test by simulating external and internal faults by primary injection and measure spill currents in Bus bar diff. relay	Ok/ Not Ok
xiii	Verify stabilizing resistor & Metrosil connection(wherever applicable)	Ok/ Not Ok
xiv	Check for CT switching relay operation, in case of DMT scheme by closing respective isolators. Also inject current at the relay panel entry point and measure current at Bus Bar protection relay terminals after operating respective CT switching relay	Ok/ Not Ok

OTHERS

Region:	**Sub-Station:**
Feeder Name:	**LOA No. :**
Date of testing:	**Date of Energisation:**
Relay Name Zone-I……… Zone-II………… Check Zone…………..	

1. Disturbance recorder

i	Check communication to PC/Terminals/Printers	Ok/ Not Ok
ii	Check All Analog Inputs (R-Y-B-residual Voltages & R-Y-B-Neutral currents)	Ok/ Not Ok
iii	Check Conversion(Primary to secondary ratio) settings are programmed as per scheme	Ok/ Not Ok
iv	Check contacts status of all digital inputs	Ok/ Not Ok
v	Normally six I/P's are from Two CB's. check Selective phase operation for RYB Poles for both the CB's. Ensure proper show of Phase/Pole	Ok/ Not Ok
vi	Check Analog threshold setting	Ok/ Not Ok
vii	Check whether all digital Inputs are programmed for initiation of recording Disturbance as well as right status(NO/NC). Also check the sequence of digital channels as per Technical specifications	Ok/ Not Ok
viii	Run self-diagnostic program & get a print for future reference. Otherwise, note down various Voltages at Monitoring points	Ok/ Not Ok
ix	Simulate a disturbance by shorting contacts of a Digital I/P. Check recording in progress. Print the same	Ok/ Not Ok
x	Repeat the above for all digital I/P Contacts	Ok/ Not Ok
xi	For analog threshold values (if provided), connect to Standard test kit to DR & test Threshold Value initiation of recording by Varying Voltages & Frequencies(Voltage Threshold, Frequency thresholds & DF/DT thresholds)	Ok/ Not Ok
xii	Check Time synchronizing by altering Time Zone in TSE. Restore on confirmation. Also check time stamping in the relays by externally triggering DR and record the error w.r.t. GPS time	Ok/ Not Ok
xiii	Check all analogue & digital inputs are configured as per power grid standard list	Ok/ Not Ok
xiv	Compare/Check analog value displayed on PC with the injected input analog value	Ok/ Not Ok
xv	Take a print out of DR settings & keep for future reference	Ok/ Not Ok
xvi	Check for availability of proper software	Ok/ Not Ok

2. Sequential Event Recorder

i	Check communication to PC/Terminals/Printers	Ok/ Not Ok
ii	Check contacts status of all digital inputs	Ok/ Not Ok
iii	Check whether all digital Inputs are programmed with right status(NO/NC)	Ok/ Not Ok
iv	Selective checking of each & every contacts is to be done in sequences. Print-Out/Display is to be compared	Ok/ Not Ok
v	Normally six I/P's are from Two CB's. check Selective Phase operation for RYB Poles for both the CB's. Ensure proper show of Phase/Pole.	Ok/ Not Ok
vi	Check Time synchronizing by altering Time Zone. Restore on confirmation	Ok/ Not Ok
vii	Take a print out of plant status (if available) and compare with the actual status	Ok/ Not Ok
viii	Check for availability of proper software & site programmability of event text	Ok/ Not Ok

3. OLTC/RTCC for Transformer

i	OLTC Operation checked from	
	Local Panel	Ok/ Not Ok
	Remote Panel	Ok/ Not Ok
	Super/Control Panel	Ok/ Not Ok
ii	Tap Position Display	Ok/ Not Ok
iii	Correct Tap position display at local panel & at remote display with respective OLTC indicator.	Ok/ Not Ok
iv	All Indicating lamps checked	Ok/ Not Ok
v	Tap Position Discrepancy Trip	Ok/ Not Ok
vi	Master/Follower scheme Checked for Master :Xformer-1	Ok/ Not Ok
	Master :Xformer-2	Ok/ Not Ok
	Master :Xformer-3	Ok/ Not Ok
vii	Check auto supply changeover feature for OTLC/Transformer (If available)	Ok/ Not Ok

4. General

i	Many a time, different Auxiliary voltages are used for drive power of DR & EL.For example, relay DC is 220 V, DR has it's isolated optical I/P , EL has 50 V drive DC. Conscious effort is to be put to keep all voltage contacts of relay, DR & EL isolated from each other	Ok/ Not Ok
ii	In case any changes are to be made in terminal designation, corresponding change in ferruling	Done/ Not done
iii	In each & every panel & Marshalling Boxes/Kiosks, CT & CVT Circuits must be provided with **Disconnecting stud** type terminals	Ok/ Not Ok
iv	20% spare TB's provided in all types	Ok/ Not Ok
v	Close Interlock of CB: In case trip relay is energized, Close command not forwarded. Normally, Manual Close command from CP must be in series with One set of NC contact of the Trip relay	Ok/ Not Ok

vi	CB in OFF Condition Selective checking of Trip-CKT Supervision relay of all CB's.by Opening wire from TC, one by One.Repeat the same with CB in On Condition	
vii	Permissive Tripping command thr' PLCC Main-I Main-II 1st CH. Return Time ………. mS ………. mS 2nd CH. Return Time ………. mS ………. mS	
viii	If substantial difference noted in above, reason for the difference	………………
ix	Any Prospect for reduction of Diff. in Time	Yes/ No
x	Hanging of RTU reported in Event logger	Yes/ No
xi	Reporting of communication failure of each channel in SER	Yes/ No
xii	Any data error encountered during isolator operation	Yes/ No
xiii	Suggestion for improvement………………………………………..	

5. **General**

i	Single point earthing must be ensured for CT&PT circuit	Yes/ No
ii	In case of four CT scheme ensure summation of Main/Tie/ Reactor CTs secondary to input of relay/ meters	Yes/ No

6. **Final Documentation Review**

S.No.	Description	Status (Yes/ No)	Remarks(Record deficiencies, if any)
1.	Final document of Pre-commissioning checks reviewed and approved		
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Signature:	Signature:	Signature:	Signature:
Name:	Name:	Name:	Name:
Desgn.:	Desgn.:	Desgn.:	Desgn.:
Organization:			
(Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commg. Team) Members: 1, 2. 3. 4.

CHECKS FOR PLCC

Region:	**Sub-Station:**
Feeder Name:	**LOA No. :**
Date of testing:	**Make:**
Direction:	**Frequency:**
Cabinet No.	**Eqpt Sr. No.**

1. General test

i	End to end Return Loss Measured (Attach separate sheet of results)	Yes/ No
ii	End to end attenuation Tests done (Attach separate sheet of results)	Yes/ No
iii	Composite loss (attenuation) measured for HF cable coupling device	Yes/ No
iv	Composite loss and return loss on coupling device using dummy load	Yes/ No
v	Measurement of AF frequency response (end to end) for the entire 4Khz bandwidth for speech and tele-protection channels	Yes/ No
vi	Measurement of Signal to Noise ratio with line energized condition.	Yes/ No
vii	Transmission time for tele-protection and other data channels	Yes/ No
viii	Observation of Tx/Rx levels (test tone) for each channel at both ends by sequential switching on/off parallel channels using dummy load and also with transmission line	Yes/ No
ix	Observation of end to end and trunk dialing performance	Yes/ No
x	Observation of unwarranted commands sent & received during switchyard operations	Yes/ No

2. Carrier SET Check List

a. Power Supply (Voltage as applicable)

i	48V POWER SUPPLY	Ok/ Not Ok
ii	60V POWER SUPPLY	Ok/ Not Ok
iii	+12V POWER SUPPLY	Ok/ Not Ok
iv	(-)12V POWER SUPPLY	Ok/ Not Ok
v	+5V POWER SUPPLY	Ok/ Not Ok

b. Ripple test

i	+12 V Ripplettes	Ok/ Not Ok
ii	(-) 12 V Ripple test	Ok/ Not Ok
iii	+5V Ripple test	Ok/ Not Ok

c. Freq generation check

i	System clock checked	Ok/ Not Ok
ii	Tx carrier Hz checked	Ok/ Not Ok
iii	Rx carrier Hz checked	Ok/ Not Ok
iv	Pilot freq. checked	Ok/ Not Ok

3. Transmitter

a.	**AF signal level**		
	i	Pilot	Ok/ Not Ok
	ii	Check Pressing test button	Ok/ Not Ok
	iii	Test tone checked	Ok/ Not Ok
b.		**Tx RF setting done**	Yes/ No
c.		Output Power/ Boosting checked	Ok/ Not Ok
d.		Tx alarm threshold checked	Ok/ Not Ok
e.		Tx alarm indication checked	Ok/ Not Ok

4. Receiver

i	Standard AGC setting done	Ok/ Not Ok
ii	Af rx level setting done	Ok/ Not Ok
iii	AGC test done	Ok/ Not Ok
iv	Remote Loop check done	Ok/ Not Ok
v	Rx alarm indication(interrupting RF Line)	Ok/ Not Ok

5. Telephony

i.	**TX Level Check**	Ok/ Not Ok
a.	4 wire IN Checked	Ok/ Not Ok
b.	2Wire in Checked	Ok/ Not Ok
ii.	**RX Level Check Feeding from Opposite Station**	Ok/ Not Ok
a.	4 wire Out Checked at 600Ohm	Ok/ Not Ok
b.	4 wire Out Checked at 600Ohm	Ok/ Not Ok
iii	Dialing Chanel Checked	Ok/ Not Ok
iv	Service Telephone checked	Ok/ Not Ok
v	Frequency Response across 600 Ohm (Attach separate sheet of results)	Ok/ Not Ok
vi	**Tele-operation:**	
a.	TX Level Check Done	Ok/ Not Ok
b.	Rx Level check done	Ok/ Not Ok

6. Protection Coupler Check

a. Measurements

i	All LED Indicator Checked	Ok/ Not Ok
ii	Transmit Level checked	Ok/ Not Ok
iii	Boost ratio Measured Boost ratio………………………	Ok/ Not Ok
iv	Muting of Speech Checked	Ok/ Not Ok

b. Command Transmission checking

i	RX Trip A	
	Command Transmission Time	……….ms
	Command Prolongation Time	……….ms

ii	Aux A Command Transmission Time	……….ms
iii	RX Trip B	
	Command Transmission Time	……….ms
	Command Prolongation Time	……….ms
iv	Aux B Command Transmission Time	……….ms
	Same for Trip C & D	
v	Trip Counters checked	Ok/ Not Ok
vi	All Alarms Checked	Ok/ Not Ok
vii	Loop test Done	Ok/ Not Ok
viii	End to End test Done	Ok/ Not Ok

7. Final Documentation Review

S.No.	Description	Status (Yes/ No)	Remarks(Record deficiencies, if any)
1.	Final document of Pre-commissioning checks reviewed and approved		
2.	Documents regarding spares, equipment, factory reports, O&M manuals etc. available at site for O&M purpose		
3.	After modification, if any, "As built drawing are available at site		

Signature:	Signature:	Signature:	Signature:
Name:	Name:	Name:	Name:
Desgn.:	Desgn.:	Desgn.:	Desgn.:
Organization:			
(Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commg. Team) Members: 1, 2. 3. 4.

SUB-STATION AUTOMATION SYSTEM (SAS)

Region:	**Sub-Station:**
Feeder Name:	**LOA No. :**
Date of testing:	**Make:**
Direction:	**Frequency:**
Cabinet No.	**Eqpt Sr. No.**

1. Availability of Items

i.	Check availability of all the IEDs, GPS Clock, Gateway, Computers & Servers, Periferals, Network Switches, Modems and various communication hardware etc. as per Scheme	Ok/ Not Ok
ii.	Check avaiability of all the orignal softwares for PC/ Servers (OS + Application Softwares), IEDs, Switches, Gateway etc. as per the scheme	Ok/ Not Ok
iii.	Check the originality/ authenticity of all the hardware & software items for POWERGRID approval.	Ok/ Not Ok
iv.	Check the validity of license of softwares/ hardware keys.	Ok/ Not Ok

2. Communication Setup

i	Check laying & termination of optical fiber as per approved scheme.	Ok/ Not Ok
ii	Check the proper tagging of optical fiber cable for identifying the origin and termination.	Ok/ Not Ok
iii	Check the LAN switches for proper installation & configuration as per scheme e.g. IP address is entered correctly, ports of Network switches are correctly configured as per requirement, satisfactory working of all the ports etc. Keep the records of all IP addresses.	Ok/ Not Ok
iv	Check dual DC power supply to all Network switches.	Ok/ Not Ok
v	Check all the PCs & printers are connected over Ethernet LAN and functioning properly.	Ok/ Not Ok
vi	Check the satisfactory working of dual LAN as per scheme	Ok/ Not Ok
vii	Check for the alarm if any link failure(fiber cut)	Ok/ Not Ok
viii	Check communication of all IEDs through Network switches as per the allocated IP address.	Ok/ Not Ok
ix	Check the functionality & running of original NMS software.	Ok/ Not Ok
x	Check the NMS software is monitoring the healthiness of Network switches/ IEDs.	Ok/ Not Ok
xi	Check communication between GATEWAY & SAS PC.	Ok/ Not Ok
xii	Check the communication between GATEWAY and PLCC data channel.	Ok/ Not Ok
xiii	Check the communication of each IED with Both SAS PCs individually.	Ok/ Not Ok
xiv	Check communication of each IED with DR PC.	Ok/ Not Ok
xv	Check the availability of spare cores in the armoured fiber optic cable as per specifications.	Ok/ Not Ok

3. Time Synchronization

i	Check proper installation and configuration of GPS and associated hardware like antenna etc	Ok/ Not Ok
ii	Check the availability of Time Synchronization Signal in the LAN through SNTP	Ok/ Not Ok
iii	Check the synchronizing of each IED /Server with GPS.	Ok/ Not Ok
iv	Check for alarm in case of failure of time synchronizing	Ok/ Not Ok

4. IED Setup

i	Check the availability of list of names of IEDs and their front/rear port address	Ok/ Not Ok
ii	Check IP address of all IEDs correctly entered.	Ok/ Not Ok
iii	Check the proper installation and configuration of all IEDs (as per their proprietary softwares) and Preparation of their ICD files for integration in the S/S SCD file.	Ok/ Not Ok
iv	Check the GOOSE function(Analog/Binary) for each IEDs and correctness of the same.	Ok/ Not Ok
v	Check SLD in IED HMI for correctness of same as per approved drawing.	Ok/ Not Ok
vi	Check each IED(for line/transformer/reactor/Bus-Bar/BCU) are correctly tested for every protection requirement of scheme.	Ok/ Not Ok
vii	Check loading of setting through local as well as remote.	Ok/ Not Ok
viii	Check availability of all setting address as per the relay setting received from CC-engg.	Ok/ Not Ok
ix	Check the operation of protection system and subsequent alarm at remote Local/HMI.	Ok/ Not Ok
x	Check the availabilty of alarms/events as per the POWERGRID requirement.	Ok/ Not Ok
xi	Check the Auto-downloading of DR Fault file in case of disturbance.	Ok/ Not Ok

5. Interlocking & Logic Setup (Through concerned BCUs)

i	Check configuration & working of all soft interlocks for CBs, Isolators, Earth Switches including Bus Isolators as per protection schemes.	Ok/ Not Ok
ii	Check configuration & working of all soft logics for Synchronization (DLDB, LLDB, LLLB, DLLB), Voltage Selection, Protection Transfer for DMT, Auto-sequencing etc. as per protection schemes.	Ok/ Not Ok

6. SCADA Setup

i	Check the proper integration of all IEDs and their ICD files in the S/S SCD file.	Ok/ Not Ok
ii	Check the building up of database as per approved point list	Ok/ Not Ok
iii	Check the correctness of HMI SLD for all bays/ feeders in both SAS PCs.	Ok/ Not Ok
iv	Check the correctness of operation of CB,Isolators &Tap changing operation through HMI SLD of both SAS PCs.	Ok/ Not Ok
v	Check that the status of CB,Isolators should change immediately in HMI after performing operation.	Ok/ Not Ok
vi	Check raising of audio alarm with SCADA alarm state for each breaker opening operation at HMI.	Ok/ Not Ok
vii	Check the PLCC,CB operation counters are correctly changing with operation.	Ok/ Not Ok
viii	Check the blocking of operation of bay equipments in case of issue of PTW through both SAS HMIs.	Ok/ Not Ok
ix	Check the availability of SLD of LT switchgear and operation of the same through local/remote.	Ok/ Not Ok
x	Check all measurement functions (Current,Voltage,MW,MVA) and their correctness in local/remote HMI.	Ok/ Not Ok
xi	Check the availability of OTI, WTI readings of ICTs on HMI & correctness of same.	Ok/ Not Ok
xii	Check the availability of voltage & current of both auxiliary DC systems sources .	Ok/ Not Ok
xiii	Check the DG alarm/trip & fire fightning signals are coming in SAS HMI.	Ok/ Not Ok
xiv	Check the monitoring of Kiosk AC/ kiosk temperature through both SAS HMI.	Ok/ Not Ok
xv	Check the colour coding of measurement parameters (Voltage,current,MW,MVAr,f etc.) if the values increases above a pre-set value with generation of audio/visual alarm.	Ok/ Not Ok
xvi	Check colour coding of SLD i.e. energized section will be in one colour and un-energized section will be in different colour.	Ok/ Not Ok
xvii	Check supervision of each IED on HMI of SAS PCs.	Ok/ Not Ok
xviii	Check Hot-stand by function availability between the SAS PCs.	Ok/ Not Ok
xix	Check after restoring of Master server, all the data must be transferred to Master server from slave server in a quick time as per HOT STAND By feature.	Ok/ Not Ok
xx	Check there should not be missing of any events during transfer from both Main to STANDBY and STANDBY to Main.	Ok/ Not Ok
xxi	Check provision of auto data backup & storage of monthly data backup.	Ok/ Not Ok
xxii	Check the correctness of alarm list and event list and proper sequencing of alarms/events.	Ok/ Not Ok
xxiii	Check weather all the events in event list are timely punched with milli second data.	Ok/ Not Ok
xxiv	Check the alarm/events of Auxiliary system are included in alarm/event list.	Ok/ Not Ok

xxv	Check that the SAS configuration tool should be password protected.	Ok/ Not Ok
xxvi	Check for any error signal while operating/running any software or performing any operation on SAS PC.	Ok/ Not Ok
xxvii	Check that basic training has been given to local operation staff so that in case of emergency they will be able to start the SAS PC in case of shut-down.	Ok/ Not Ok
xxviii	Check there should be no interruption in availability test.	Ok/ Not Ok
xxix	Check the Acknowledged alarms should shift to acknowledge window & persisting alarms should be in red colour with blinking of the same.	Ok/ Not Ok
xxx	Check the colour code of the acknowledged but persisting alarm.	Ok/ Not Ok
xxxi	Check the nomenclature of events and alarms for user friendliness.	Ok/ Not Ok
xxxii	Check the availability of backup of latest version configuration for ICD, SCD files, IED basic configuration, HMI server database etc.	Ok/ Not Ok
xxxiii	Ensure creation of appropriate restore points for each workstation in the substation after completion of commissioning.	Ok/ Not Ok

7. Trends & Reports Setup

i	Check all the operation formats are as per POWERGRID formats.	Ok/ Not Ok
ii	Check the reports generated by SAS PC are as per the requirement like max. & min. readings of voltage, MW, MVAR, MVA, Frequency, current etc. for a 24 hour period.	Ok/ Not Ok
iii	Check the reports/trends can be selected/filtered for any time period (datewise) specified by user.	Ok/ Not Ok
iv	Check the availability of measurements reports at desired interval of (15, 30,45 & 60 minutes) & correctness of the same.	Ok/ Not Ok
v	Check the trend display for each parameter(MW,MVA,MVAr,f,V,I etc.) at any time and at a interval selected by user.	Ok/ Not Ok

8. Remote Operation & RLDC reporting

i	Check that Gateway has been installed and configured properly and is working satisfactorily.	Ok/ Not Ok
ii	Check the Gateway Configuration as per approved interoperability profile of RLDC.	Ok/ Not Ok
iii	Check the healthiness of communication between Gateway and RLDC for both channels	Ok/ Not Ok
iv	Verify the data transfer to RLDC by point to point checking as well as at local level through Protocol Analyser	Ok/ Not Ok
v	Check that the online perameters on local/remote SLD like current,voltage,MW,MVAr,frequency etc are getting updated.	Ok/ Not Ok
vi	Check the operation of equipments/alarms/events for remote controlled ss.	Ok/ Not Ok
vii	Check the satus of CBs & Isolators should be available at RLDC and if any link fails then alarm should be generated.	Ok/ Not Ok
viii	If SAS S/S has to be remote controlled then check authenticity of operation from Local & remote end(i.e When control is in hand of	Ok/ Not Ok

	RCC, all local operation should be blocked and vice versa)	
ix	Check that in case of failure of one channel, changeover at remote end happens automatically and no interruption in data flow to Remote end occurs.	Ok/ Not Ok
x	Check for availability of final approved signal list for 101 communication with all details.	Ok/ Not Ok

9. Final Documentation Review

S.No.	Description	Status (Yes/ No)	Remarks(Record deficiencies, if any)
1.	Final document of Pre-commissioning checks reviewed and approved		
2.	Documents regarding spares, equipment, factory reports, O&M manuals etc. available at site for O&M purpose		
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Desgn.:	Desgn.:	Desgn.:	Desgn.:
Organization:			
(Supplier Representative) (Wherever Applicable)	(Erection Agency)	(POWERGRID Site I/C)	(POWERGRID Commg. Team) Members: 1, 2. 3. 4.

Employer has standardized its Specific Requirement for various equipment and works for different voltage levels. Items or clauses, which are not applicable for the scope of this package as per schedule of quantities described in BPS or as per scope defined elsewhere in Section Project, the technical specification/clauses for the items specified below should not be referred to.

S.No.	Clause No.	Amended As (As per Specific Requirement Rev 07)
A.	**Section: GTR Rev 15**	
1.	Section GTR, Rev-15 Clause 2.1 (a)	"All equipment/materials/items, as per **Annexure-K (Rev 01),** as applicable under present scope of works, shall be procured and supplied from domestic manufacturers only with Minimum Local Content for individual items as listed in the above annexure. Any imported equipment/material/item/parts/component (comprising of embedded systems) to be supplied under the contract shall be tested in the certified laboratories to check for any kind of embedded malware/trojans/cyber threats and for adherence to Indian Standards as per the directions issued by Ministry of Power/Govt. of India from time to time. In case of such import from specified "prior reference" countries, the requirement of prior permission from the Govt. of India including protocol for testing in certified and designated laboratories by Ministry of Power/Govt. of India shall also be complied with by the contractor. The bidder/contractor shall list out the products and components producing Toxic e-waste under the contract and shall furnish to the Employer the procedure of safe disposal at the time of closing of the contract."
2.	**New Clause No. 4.7**	**Planning and Designing in purview of Vulnerability Atlas of India** Vulnerability Atlas of India (VAI) is a comprehensive document which provides existing hazard scenario for the entire country and presents the digitized State/UT wise hazard, maps with respect to earthquakes, winds and floods for district wise identification of vulnerable areas. It also includes additional digitized maps for thunderstorms, cyclones and landslides. The main purpose of this Atlas is its use for disaster preparedness and mitigation at policy planning and project formulation stage. This Atlas is one of its kind single point source for the various stakeholders including policy makers, administrators, municipal commissioners, urban managers, engineers, architects, planners, public etc. to ascertain proneness of any city/ location/ site to multi-hazard which includes earthquakes, winds, floods thunderstorms, cyclones and landslides. While project formulation, approvals and implementation of various urban housing, buildings and infrastructures schemes, this Atlas provides necessary information for risk analysis and hazard assessment. The Vulnerability Atlas of India has been prepared by Building Materials and Technology Promotion Council under Ministry of Housing and Urban Affairs, Government of India and available at their website https://www.bmtpc.org/. It is mandatory for the bidders to refer Vulnerability Atlas of India for multi-hazard risk assessment and include the relevant hazard proneness specific to project location while planning and designing the project in terms of: i) Seismic zone for earthquakes, ii) Wind velocity iii) Area liable to floods and Probable max. surge height iv) Thunderstorms history v) Number of cyclonic storms/ severe cyclonic storms and max sustained wind specific to coastal Region vi) Landslides incidences with Annual rainfall normal vii) District wise Probable Max. Precipitation

3.	**New Para under Clause no. 8.3.2**	Wherever references to SFQP is made in Technical Specifications, it shall be the latest edition/revision of the same uploaded up to seven (7) days prior to the actual date of bid opening.
4.	Section GTR Rev 15 Clause No 24.1	Technical requirements for 765/400/220/132kV* Air Insulated Switchgear (AIS) Equipment*: **A)** Circuit Breaker (i) The manufacturer(s) whose 765/400/220/132kV* Circuit Breaker(s) are offered, must have, manufactured, type tested (as per IEC/IS or equivalent standard) and supplied 715/345/220/132kV* or higher voltage class Circuit Breaker(s), which are in satisfactory operation# for atleast two (2) years as on the date of NOA. (ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India for the offered Circuit Breaker and not meeting the requirement stipulated in (i) above, can also be considered provided that a) 715/345/220/132kV* or higher Voltage class Circuit Breaker(s) must have been manufactured in the above Indian works & type tested (as per IEC/IS standard) and supplied as on the date of NOA. b) In case manufacturer meets the technical requirement through clause (ii) above, warranty obligations for additional warranty of two (2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of the offered Circuit Breaker(s) to be supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 3% of the ex-works cost of the Circuit Breaker(s)* for the additional warranty period in addition to the contract performance guarantee to be submitted by the contractor. **B)** Isolator, Current Transformer, Capacitive Voltage transformer, Inductive Voltage transformer, Surge Arrester and Wave Trap) (i) The manufacturer whose 765/400/220/132kV* equipment(s) are offered, must have manufactured, type tested (as per IS/IEC or equivalent standard) and supplied 715/345/220/132kV* or higher voltage class equipment(s), which are in satisfactory operation# for at least two (2) years as on the date of NOA. OR (ii) The manufacturer, who have established manufacturing and testing facilities in India for the offered equipment(s) and not meeting the requirement stipulated in (i) above, can also be considered provided that: a) 715/345/220/132kV* or higher Voltage class equipment(s) must have been manufactured in the above Indian works & type

		tested (as per IS/IEC standard) as on the date of NOA b) Manufacturer has manufactured, type tested (as per IS/IEC or equivalent standard) and supplied equipment(s) of 345kV or above voltage class (applicable for 765kV* Equipment)/220kV or above voltage class (applicable for 400kV* equipment) /132kV or above voltage class (applicable for 220kV* equipment) / 66kV or higher voltage class (applicable for 132kV* equipment), which are in satisfactory operation# for at least two (2) years as on the date of NOA. c) Warranty obligations for additional warranty of two (2) years over & above the warranty period as specified in the bidding documents shall be applicable for the entire quantity of the offered equipment(s) to be supplied under the contract. Further, contractor shall furnish performance guarantee for an amount of 3% of the ex-works cost of the equipment(s)* for the additional warranty period in addition to the contract Performance guarantee to be submitted by the contractor. OR (iii) The manufacturer, who have established manufacturing and testing facilities in India for the offered equipment(s) based on technological support of a parent company or collaborator and not meeting the requirement stipulated in (i) above, can also be considered provided that: a) 715/345/220/132kV* or higher Voltage class equipment(s) must have been manufactured in the above Indian works & type tested (as per IS/IEC standard) as on the date of NOA. b) The parent company or collaborator meets the qualifying requirements stipulated under (i) given above. A valid collaboration agreement for technology transfer / license to design, manufacture, test and supply the 765/400/220/132kV* Air Insulated Switchgear (AIS) Equipment(s)* in India, shall be submitted. c) The parent company/collaborator shall furnish performance guarantee for an amount of 3% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to contract performance guarantee to be submitted by the contractor Legends: * : voltage class of respective equipment as applicable. # : satisfactory operation means certificate issued by the Employer/Utility certifying the operation without any adverse remark.

<table>
<tr><td></td><td></td><td>NOA: Notification Of Award</td></tr>
<tr><td>5.</td><td>Clause No. 24.16(ii)(b)</td><td>Contractor shall furnish performance guarantee for an amount of 3% of the ex-works cost of the equipment (s)* and this performance guarantee shall be in addition to the contract performance guarantee to be submitted by the contractor.</td></tr>
<tr><td>6.</td><td>New Clause Clause No. 24.21</td><td><u>Technical Requirement for 220/132/66 kV* level GIS/Hybrid GIS/MTS Equipment:</u>

(i) The manufacturer whose 220/132/66 kV* level GIS/Hybrid GIS/MTS bays are offered must have designed, manufactured, type tested** (as per IEC or equivalent standard), supplied and supervised erection & commissioning of at least two (2) nos. Gas Insulated Switchgear (GIS) circuit breaker bays@ of 220/110/66kV* or above voltage class in one (1) Substation or Switchyard during the last seven (7) years and these bays must be in satisfactory operation# for at least two (2) years as on the date of NOA.

(ii) Alternatively, the manufacturer, who have established manufacturing and testing facilities in India and not meeting the requirement stipulated in (i) above, can also be considered provided that

a) Atleast one no. 220/110/66kV* or above voltage level GIS Circuit Breaker bay@ must have been manufactured in the above Indian works based on the technological support of the Collaborator(s) and either supplied or type tested the above GIS bay (as per IEC or equivalent standard) as on the date of NOA.

b) The collaborator(s) meets the requirements stipulated in (i) above. A valid collaboration agreement for technology transfer/license to design, manufacture, test and supply 220/110/66*kV or above voltage level GIS equipment in India shall be submitted.

c) The Collaborator(s) shall furnish performance guarantee for an amount of 3% of the ex-works cost of such equipment(s) and this performance guarantee shall be in addition to Contract Performance Guarantee to be submitted by the bidder.

Note:
1. (*) voltage class of respective equipment as applicable

2. (@) For the purpose of technical requirement, one no. of circuit breaker bay shall be considered as a bay used for controlling a line or a transformer or a reactor or a bus section or a bus coupler and comprising of at least one circuit breaker, one disconnector and three nos. of single phase CTs / Bushing CTs. GIS means SF6 Gas insulated Switchgear.

3. Experience with combination of GIS CB bay/Hybrid GIS CB Bay/MTS CB Bay is also acceptable if supply of only Hybrid/MTS equipment is envisaged. Hybrid GIS means outdoor SF6 Gas insulated switchgear connected to outdoor Air insulated bus-bar System (AIS bus-bars System), MTS means outdoor SF6 Gas insulated Mixed Technology Switchgear connected to outdoor AIS bus bar system.</td></tr>
</table>

		4. (**) Type test reports of the collaborator/ parent company/ subsidiary company/ group company shall also be acceptable
B.	**Section GIS Rev 5A**	
1.	**New Para under Clause no.1**	GIS of all voltage levels above 52kV class envisaged under a single package, shall be supplied from one GIS manufacturer who shall be responsible for design, manufacturing, erection, testing and commissioning of complete GIS switchyard under the Contract and any other responsibilities stipulated in the contract with respect to GIS portion
2.	**New Clause no. 5.41(10)**	The price of Bus-duct inside the GIS hall shall be integral part of the respective bay module and it will not be paid separately. However, the payment of bus-duct for outside the GIS hall along with support structure shall be paid as per running meters in line with provision of Bid Price schedule.
3.	**Clause no. 6.8.2**	The CSD shall be provided in following circuit breakers: a) 765kV • Main and Tie bay for Auto Transformer • Main and Tie bay of Bus Reactor • Switchable Line Reactor bay b) 400kV • Main and Tie bay for 765/400kV Auto Transformer • Main and Tie bay of Bus Reactor • Switchable Line Reactor bay c) 220 & 132kV • Bay for operation of Shunt reactor The requirement of CSD shall be explicitly specified in price schedule.
4.	**New Clause 6.8.3 (n)**	For Circuit breaker with CSD controlling a Transformer following is applicable "The limit for inrush current for switching of Transformer by CSD shall be 1.0 p.u. of rated current of transformer after fine tuning of CSD settings during pre-commissioning checks. For site acceptance of CSD, during online CSD test after fine tuning inrush current should be less than 1.0 P.U. of rated current in five consecutive operations".
5.	**New Clause no. 10.1.3(n)**	For 400kV & above voltage class GIS bay module, CT cores shall be duly distributed on both side of circuit breaker. For 220 kV and below voltage level GIS bay module, CT on one side of the circuit breaker is also acceptable.
6.	**New Clause no. 15.2.14**	All 765kV & 400kV Circuit Breaker control schematics shall be finalized in such a way, that it may operate with or without CSD by using a suitable selector switch irrespective of whether circuit breakers to be supplied are envisaged along with CSD or not as per bid price schedules.
7.	**New Para added under Clause no. 20**	During detailed engineering, the type test reports of GIS equipment of the parent company/subsidiary company/group company shall also be acceptable provided that the design of offered GIS is same as that of type tested GIS equipment.
8.	Clause no 20, Sl. no. 14 of Table	14 — Reactor current switching test for Inductive Current switching capability as per IEC 62271-110. Further, the manufacturer whose circuit breakers tested with smaller current w.r.t current limits specified for Reactor current switching test duty-2, 3 & 4 in IEC 62271-110 shall also be acceptable.

<table>
<tr><td>9.</td><td>Annexure-1
S.No. 20 (i)</td><td>
<table>
<tr><th>Parameter</th><th>765kV system</th><th>400kV system</th><th>220kV system</th><th>132 kV system</th></tr>
<tr><td>Pre-insertion resistor requirement</td><td>As per BPS</td><td>As per BPS</td><td>NA</td><td>NA</td></tr>
<tr><td>Rating (ohms)</td><td>Approx. 450 with tolerance as applicable</td><td>Approx. 400 with tolerance as applicable</td><td>NA</td><td>NA</td></tr>
</table>
</td></tr>
<tr><td>10.</td><td>New Para under Clause no 26.</td><td>Requirement for Mandatory spares for GIS
a. Any equipment which is not supplied as main equipment or part of main equipment, mandatory spare for that is not applicable.
b. It is recognized that the GIS manufacturer may have standardized the GIS design/equipment rating based on the manufacturer's standard practice. Alternate proposals, offering higher rating equipment (without additional cost implication), will also be considered provided such equipment meets the specified minimum designs rating, standard and performance requirements.
c. In case contractor offers circuit breaker, dis-connector, current transformer, SF6/Air Bushing etc. under main equipment of higher rating than equipment rating specified in the specifications, the mandatory spare of same higher rating offered by contractor identical to main equipment offered in the package shall be required to be supplied against spares without any cost implication to POWERGRID.</td></tr>
<tr><td>11.</td><td>Annexure-10
Rev-1</td><td>Annexure-10 Rev-1 (Standard Mandatory Spares for Gas Insulated Switchgear) of stands deleted.</td></tr>
<tr><td>C.</td><td colspan="2">Section Switchgear – CB Rev 11</td></tr>
<tr><td>1.</td><td>Clause no. 2.6
Para 2</td><td>The CSD shall be provided in following circuit breakers:
d) 765kV
• Main and Tie bay for Auto Transformer
• Main and Tie bay of Bus Reactor
• Switchable Line Reactor bay
e) 400kV
• Main and Tie bay for 765/400kV Auto Transformer
• Main and Tie bay of Bus Reactor
• Switchable Line Reactor bay
f) 220 & 132kV
• Bay for operation of Shunt reactor
The requirement of CSD shall be explicitly specified in price schedule.</td></tr>
<tr><td>2.</td><td>New Clause no. 2.6.1(n)</td><td>For Circuit breaker with CSD controlling a Transformer following is applicable

"The limit for inrush current for switching of Transformer by CSD shall be 1.0 p.u. of rated current of transformer after fine tuning of CSD settings during pre-commissioning checks. For site acceptance of CSD, during online CSD test after fine tuning inrush current should be less than 1.0 P.U. of rated current in five consecutive operations".</td></tr>
<tr><td>3.</td><td>Clause No. 11.4</td><td>Separate cables shall be used for AC, DC-I, DC-II and selected DC. Each control cable shall include minimum 10% spare cores (subject to minimum 1 no. of spare core).</td></tr>
<tr><td>4.</td><td>Clause No. 11.5</td><td>Requirement of Plug-In type connector for Inter-pole cabling is deleted</td></tr>
<tr><td>5.</td><td>Clause No. 11.6</td><td>Vertical run of cables to the operating mechanism box shall be properly supported by providing the perforated closed type galvanized cable tray (Cable tray also to be supplied along with the Circuit Breaker) to be fixed as an integral part of the</td></tr>
</table>

		structures. The load of the cable shall not be transferred to the mechanism box/terminal arrangement in any circumstances. Hanging or loose run of cable is not permitted. The drawing of cable tray including fixing arrangement shall be incorporated in the GA drawing of CB also.
6.	**Clause No. 16.0 S.No. 20 (i)**	<table><tr><th>Parameter</th><th>765kV system</th><th>400kV system</th><th>220kV system</th><th>132 kV system</th><th>66kV System</th></tr><tr><td>Pre-insertion resistor requirement</td><td>As per BPS</td><td>As per BPS</td><td>NA</td><td>NA</td><td>NA</td></tr><tr><td>Rating (ohms)</td><td>Approx. 450 with tolerance as applicable</td><td>Approx. 400 with tolerance as applicable</td><td>NA</td><td>NA</td><td>NA</td></tr></table>
D.	**Section Switchgear-INST Rev 11**	
1.	**Clause No. 6.2 (a)(iii)**	Seismic withstand test as per Annexure-B of Section-GTR or IEC62271-2 (with Seismic acceleration requirement as per Annexure-I of this specification/Section-Project) for 400kV and above voltage rating.
2.	**Clause No. 6.2 (b)(iii) & (c)(iii)**	Seismic withstand test (as per Annexure-B of Section-GTR) or IEC-62271-2 (with Seismic acceleration requirement as per Annexure-II of this specification/Section-Project) for 400kV and above voltage class.
3.	**Clause No. 9.2 Para 3 & 4**	CTs must have adequate provision for taking oil samples from the bottom of the CT without exposure to atmosphere. Manufacturer shall recommend the frequency at which oil samples should be taken and norms for various gases in oil after being in operation for different durations. Manufacturer should also indicate the total quantity of oil which can be withdrawn from CT for gas analysis before refilling or further treatment of CT becomes necessary. Manufacturer/Contractor shall supply 2 nos. of oil sampling device for every 20 nos. of oil filled CT supplied with a minimum of 2 nos. of oil sampling device for each substation. The price of the above sampling bottles is deemed to be included in cost of equipment.
4.	**Clause No. 9.3**	**Voltage Transformers** a) Insulation Resistance test for primary (if applicable) and secondary winding b) Polarity test c) Ratio test d) Dielectric test of oil (wherever applicable) e) Tan delta and capacitance measurement of individual capacitor stacks f) Secondary winding resistance measurement g) DGA of oil (for IVT/PT) Dissolved Gas Analysis (DGA) shall be carried out twice within the first year of service, first within the first month of commissioning/charging and second between six months to one year from the date of commissioning/charging. IVTs/PTs must have adequate provision for taking oil samples from the bottom of the IVT/PT without exposure to atmosphere. Manufacturer shall recommend the frequency at which oil samples should be taken and norms for various gases in oil after being in operation for different durations. Manufacturer should also indicate the total quantity of oil which can be withdrawn from IVT/PT for gas analysis before refilling or further treatment of IVT becomes necessary.

		Manufacturer/Contractor shall supply 2 nos. of oil sampling device for every 20 nos. of oil filled IVT/PT supplied with a minimum of 2 nos. of oil sampling device for each substation. The price of the above sampling bottles is deemed to be included in cost of equipment.
5.	**Clause No. 10.0**	**Defect Liability** The actions required to be taken by contractor in case of defects observed in CT/CVT/**IVT/PT** of ratings 145kV & above during the warranty period (defect liability period) shall be as per enclosed **Annexure-V (Revised)** of this specification. Further, the replaced/repaired/refurbished equipment (or part of equipment) shall have Two (2) years warranty without prejudice to contractual warranty period (defect liability period).
E.	**Section Switchgear-Surge Arrester Rev 12**	
1.	**New Clause No. 4.5**	The Surge Arresters shall be provided with a common Junction box suitably for a set of three (3) Surge Arresters of each bay for extending the contact information of surge counter to SAS
F.	**Section: Lighting System Rev 07**	
1.	**New Para under Clause No. 2.1**	Wherever, Indoor Illumination of building is specified as LS/Lot/SET item in BPS, illumination shall be provided using fixture types as specified in Annexure-I of Section: Lighting System. However, contractor shall submit lighting design calculation for deciding the number of fixtures in each building/room. Following Average lux (at working plane of height 1.2 Mtrs from floor level) levels to be maintained for design of illumination system:

S.No.	Building/Room Type	Average Lux Level to be maintained
1	Control Room /Station-In charge Room /Administrative Room/Conference Room / Switchyard Panel Room/ GIS Relay Panel Room	300 Lux
2	Electronic Test Lab	250 Lux
3	GIS Hall/ Battery Room/ACDC & DCDB Room	200 Lux
4	AHU Room/GIS Store Room/ Pantry /Reception/ FFPH Building	150 Lux
5	Corridor/ Toilets	100 Lux
6	Periphery of the Building	50 Lux
7	Any other room/building	200 Lux

The minimum lux level to average lux level ratio should not be less than 0.6 (i.e Emin/Eav> 0.6). The maintenance factor for indoor illumination design shall be considered as 0.8.

		All required items /equipment /fixtures/ panels/ receptacles/ switches/ switchboards/ fans etc. for Illumination of Control Room Building, GIS Building, FFPH, SPR, Security Hut etc. (as applicable) are deemed to be included under corresponding LS/Lot/SET item of BPS.
2.	**Clause no. 6.2.1(ii)**	All Outdoor Lighting Panels shall be Stainless sheet steel of Grade 304 and shall be dust, weather and vermin proof. Panels shall be of thickness not less than 1.5 mm smoothly finished, leveled and free from flaws. Stiffeners shall be provided wherever necessary. **Alternatively, outdoor lighting panels of Aluminum shall also be acceptable as per provisions stipulated in Section GTR.**
3.	**Clause no. 6.6(i) (b)**	The outdoor junction boxes shall be complete with conduit knockouts/threaded nuts and provided with terminal strips. The junction boxes shall be suitable for termination of Cable glands of required size. The junction boxes shall be provided with 4 way knockouts suitable for street lighting/switchyard lighting terminals suitable for 2 numbers 4C x 16 Sq.mm Al. cable or as per requirement. All Outdoor Junction boxes shall be of Stainless Steel of thickness 1.5mm of grade 304. Outdoor Junction Boxes shall be suitable for mounting on columns, structures etc for Outdoor Lighting. The outdoor Junction shall have IP 55 protection. **Alternatively, outdoor junction boxes of Aluminum shall also be acceptable as per provisions stipulated in Section GTR.**
G.	**Section: LT Switchgear Rev 05**	
1.	**Clause no. 1.21.2**	Contractor shall submit type test reports for the Lighting transformers as per IS:2026 for which test conducted once are acceptable (i.e. The requirement of test conducted within last ten years shall not be applicable)
2.	**Clause no. 1.6.1**	MCCB shall in general conform to IS: 13947 Part-2. All MCCB offered shall have Ics = 100% Icu rating.
H.	**Section DG Set Rev 05**	
1.	**New para added under Clause no. 7.1(a)**	Alternatively, AMF Panel for DG Set may be installed outside the acoustic enclosure near the DG Set. In such cases, AMF panel with or without additional enclosure shall meet IP-55 degree of protection.
I.	**Section: Battery and Battery Charger Rev 06**	
1.	**Clause no. 1.2.12**	The battery shall be capable of giving 1200 or more charge/discharge cycles at 80% Depth of discharge (DOD) at an average temperature of 27º Celsius. DOD (Depth of Discharge) is defined as the ratio of the quantity of electricity (in Ampere-hour) removed from a cell or battery on discharge to its rated capacity.
2.	Clause no 1.1.4 table -2 (48V)	Bidder shall select number of cells, float and Boost voltage to achieve following system requirement:- ………… …………
J.	**Section Fire Protection Rev 06**	
1.	**New para added at Clause no.2.03.00**	Fire detection and alarm system shall also be provided in the GIS Hall using beam type smoke detectors to be installed at suitable mounting height, and in the Relay Panel room with ionization/optical type smoke detectors to be installed on the

Nested table within item I.2:

	Load	**Duration**	**Type Of Loads**
220V DC system	…..	…..	……
	…..	……	……
	…….	…….	……
48V DC System	Continuous Load	10 hours Continuous	load associated with PLCs.(when speech is not working)
	Momentary Load	15 minute	Loads associated with PLCs (when speech is working)

<table>
<tr><td></td><td></td><td>ceiling.</td></tr>
<tr><td>2.</td><td>New Clause no.2.01.02</td><td>Hydrant posts and Fire extinguishers (CO2 and DCP type) shall also be provided for GIS Building also.</td></tr>
<tr><td>3.</td><td>Clause No. 2.04.02 & 10.00.00</td><td>Mechanical foam type fire extinguishers wherever specified as 50 litre capacity, conforming to IS:13386, shall be read as 60 litre capacity conforming to IS 16018

Further in case of non-availability of any type of fire extinguisher (i.e. water, CO2, DPC, foam type) of a particular size as specified in BPS or technical specification, next available higher size conforming to IS shall be supplied.</td></tr>
<tr><td>4.</td><td>New Clause No. 2.06.05</td><td>For new substation, Fire Fighting LT Boards (AC & DC) and Annunciation panels (for FFPH & Control Room Building), shall have number of feeders, annunciation windows, zone-alarm modules (as applicable) required for entire present & specified future scope of the substation.</td></tr>
<tr><td>5.</td><td>Clause No.9.01.00(c) & Appendix-V</td><td>Deleted</td></tr>
<tr><td>6.</td><td>Appendix-I</td><td>Appendix-I (Rev 4) stand replaced by following <u>Appendix-I (Rev 5)</u></td></tr>
<tr><td>7.</td><td>Appendix-IV</td><td>Revised Appendix-IV Page1 of 13 is replaced by <u>Annexure-IV rev 01</u> Page1 of 13.</td></tr>
<tr><td>K.</td><td colspan="2">Section: Power & Control Cable Rev 06</td></tr>
<tr><td>1.</td><td>Section: Power & Control Cable Rev 06

Clause No. 4.2</td><td>Standard lengths for each size of power and control cables shall be 500/1000 meters. However, to avoid cable wastage and cable jointing at site, non-standard lengths of each size of Power & Control cable may also be acceptable subject to maximum length of 1000meters (+ 5% tolerance)</td></tr>
<tr><td>2.</td><td>Clause no 1.1.4</td><td>Refer <u>Annexure-S1</u> for METHODOLOGY FOR SUPPLY, INSTALLATION & SIZING OF CABLES</td></tr>
<tr><td>L.</td><td colspan="2">Section-Air Conditioning Rev-04</td></tr>
<tr><td>1.</td><td>Clause No. 2.3.2.3</td><td>Cooling capacity of 3TR AC units shall not be less than 36000btu/hr. and shall have energy efficiency rating of 5 star as on the date of NOA.</td></tr>
<tr><td>2.</td><td>Clause No. 2.3.3.4</td><td>Cooling capacity of 2TR AC units shall not be less than 22000btu/hr. and shall have energy efficiency rating of 5 star as on the date of NOA</td></tr>
<tr><td>3.</td><td>Clause no. 2.4</td><td>Clause no. 2.4 of Section-Air Conditioning Rev-04 of Technical Specification Void</td></tr>
<tr><td>4.</td><td>New Annexure-S2</td><td><u>Annexure S2</u> – Air Conditioning & Ventilation System for GIS Building</td></tr>
<tr><td>M.</td><td colspan="2">Section Switchyard Erection Rev 10</td></tr>
<tr><td>1.</td><td>New Clause No. 2.5</td><td>Transmission line side insulator string along with hardware for line termination shall be in the scope of substation contractor. The erection of same shall be done by associated TL contactor.</td></tr>
<tr><td>2.</td><td>Clause No. 9.4(j) & (k)</td><td><table>
<tr><th>S.No</th><th>Item</th><th>Size</th><th>Material</th></tr>
<tr><td>j)</td><td>Isolator MOM Box</td><td>50X6 mm GS flat & Flexible copper braid</td><td>Galvanised steel and copper Braid</td></tr>
<tr><td>k)</td><td>Insulator Guy Arrangement</td><td>75x12mm G.S. flat</td><td>Galvanised Steel</td></tr>
</table></td></tr>
<tr><td>3.</td><td>New Clause No. 9.5.8</td><td>For estimation of riser of new substation/switchyard, maximum spacing of Main Earthmat shall be considered as 30 M x 30 M, 24 M x 24 M, 16 M x 16 M & 12 M x 12 M for 765kV, 400kV, 220kV & 132kV switchyard respectively.

Actual spacing for main earthmat shall be finalized during detailed engineering</td></tr>
</table>

<table>
<tr><td></td><td></td><td>based on soil resistivity data and payment shall be made as per actual executed quantity at site. However, no cost compensation shall be considered in case of actual spacing of main earthmat finalized during detailed engineering is less than that mentioned above.

For switchyard extensions, main earthmat spacing shall be considered same as that in the existing switchyard.</td></tr>
<tr><td>4.</td><td>Clause no 9.10.3</td><td>Auxiliary earthing mat comprising of minimum 32mm dia M.S. rods closely spaced (300 mm x 300 mm) conductors shall be provided at depth of 300mm from ground level below the operating handles of the M.O.M. Box of the isolators. M.O.M. boxes shall be directly connected to the auxiliary earthing mat. Flexible copper
braid connection to be provided between MOM box and GI flat to take care of soil sagging. The size of auxiliary earthing mat shall be of 1500mmx1500mm size for 220kV and above voltage class isolators and 900mmx900mm size for 132kV and below voltage class isolators. Factory welded auxiliary earthmat is preferable</td></tr>
<tr><td>5.</td><td>New Clause No. 10.2</td><td>Following type of conductor for Flexible or Rigid Bus bars/Switchyard Equipment Jumpers/Interconnections shall be provided subject to suitability of conductor as per specified/applicable current ratings:

<table>
<tr><th>Voltage Level</th><th>Conductor / Al .Tube Type</th></tr>
<tr><td>Voltage Level: 765kV</td><td>AAC Bull / 4.5'' IPS Al. Tube</td></tr>
<tr><td>Voltage Level: 400kV</td><td>ACSR Bersimis / 4.5'' IPS Al. Tube</td></tr>
<tr><td>Voltage Level: 220kV</td><td>ACSR Moose / 4.0'' IPS Al. Tube</td></tr>
<tr><td>Voltage Level: 132kV</td><td>ACSR Moose / 3.0'' IPS Al. Tube</td></tr>
</table>

For substation extension works, suitable clamps & connectors for interconnection with existing buses as per drawings shall be provided by the contractor under present scope.

Conductor type with higher current rating than that specified above shall also be acceptable without any additional price implication.
Note: - For existing Substation, existing conductor configuration may preferably be adopted in extn. S/s package.</td></tr>
<tr><td>6.</td><td>New
Clause no. 20.1</td><td><u>Neutral formation for Transformer(s), DELTA formation and making connection arrangement to connect spare unit in place of any unit of the bank without physical shifting and Earthing Arrangement :</u>

For Spare Unit connection to form 3-ph bank of 765kV Class Transformers with isolator based switching arrangement without physical shifting of spare unit along with necessary Neutral Formation, Earthing Arrangement & Tertiary (DELTA) formation for 3-ph bank formation with 1-ph units shall be under present scope as per the details mentioned below:

i. <u>Neutral Formation including Neutral auxiliary bus and Earthing Arrangement</u>

The contractor shall connect the neutrals of three (3) 1-phase transformers by overhead connection using 3" IPS Al tube. The neutral formation shall be such that neutral winding of single-phase spare transformer can be disconnected or connected to the three phase banks. The connection from the neutral bushing to neutral bus shall be through 3" IPS Al tube and wherever flexible jumper needs to be provided, same shall be through twin conductor. All material like Bus post insulator, Aluminium tube, conductor, clamps & connectors, earthing materials, support structure, foundation bolts, hardware etc. required for neutral formation and connection with neutral CT and earthing of neutral shall be provided by</td></tr>
</table>

		contractor. **ii. <u>Tertiary Delta Formation including Tertiary auxiliary bus(Insulation level 52 kV) .</u>** The contractor shall connect 33kV tertiary of single-phase auto-transformers in DELTA configuration by overhead connection to operate in 3-Ph Bank. The Delta shall be formed by 3" IPS Al tube, which shall be insulated with heat shrinkage insulating sleeve of at least 52kV class and shall be supported by structure mounted bus post insulators at suitable intervals. Jumpers (twin conductors) wherever provided shall also be insulated using suitable insulation tape or sleeve at least 52kV class at site. The minimum phase to phase horizontal spacing for delta formation shall be 1.5meter. All associated materials like bus post insulators, Aluminium tube, conductor, clamps & connectors, support structures, **foundation bolts,** hardware, earthing materials etc. required for tertiary delta formation shall be provided by the contractor. **iii. <u>HV & IV Auxiliary Buses (Applicable for AIS Substation)</u>** Formation of HV & IV auxiliary buses for connection of transformer 3-Phase bank with 1-Phase Spare transformer unit is under the present scope of the bidder. All associated materials like Bus post insulators, Aluminium tube, conductors, clamps & connectors, insulator strings, hardware, earthing materials, support structures, **foundation bolts,** required for the above-mentioned arrangement shall be provided by the contractor.
7.	**New Clause no. 20.2**	**<u>Neutral formation for Reactor banks, connection to neutral grounding reactor through 132kV Surge arrester, connection to ground through neutral CTs and connection arrangement to connect spare reactor unit in place of any other units of the bank without physical shifting and Earthing Arrangement :</u>** For Spare Unit connection to 3-ph bank of 765kV Class Reactors with isolator based switching arrangement without physical shifting of spare unit along with necessary Neutral Formation, Earthing Arrangement for 3-ph bank formation with 1-ph units shall be under present scope as per the details mentioned below: **i. <u>Neutral Formation including Neutral auxiliary bus and Earthing Arrangement</u>** The contractor shall connect the neutrals of three (3) 1-phase reactors by overhead connection using 3" IPS Al tube. The neutral formation shall be such that neutral winding of single-phase spare reactor can be disconnected or connected to the three phase banks. Neutral Connections of spare unit shall be extended upto the other unit(s) by forming Neutral auxiliary bus. The connection from the neutral bushing to neutral bus shall be through 3" IPS Al tube and wherever flexible jumper needs to be provided, same shall be through twin conductor. All material like Bus post insulator, Aluminum tube, conductor, clamps & connectors, earthing materials, support structure, **foundation bolts,** hardware etc. required for neutral formation and connection with neutral CT and earthing of neutral shall be provided by contractor. Required Insulation level is 145 kV from individual reactor neutral to point of neutral formation. However after neutral formation, the insulation level is 36kV. Connection of each Line reactor bank formed under present scope to Neutral grounding reactor through 132kV Surge Arrester including NGR by passing arrangement is also under present scope.

		ii. <u>HV Auxiliary Bus (Applicable for AIS Substation)</u> Formation of HV auxiliary bus for connection of reactor 3-Phase bank with 1-Phase Spare reactor unit is under the present scope of the bidder. All associated materials like Bus post insulators, Aluminium tube, conductors, clamps & connectors, insulator strings, hardware, earthing materials, support structures, **foundation bolts** , etc. required for the above-mentioned arrangement shall be provided by the contractor.
8.	**New Clause no. 20.3**	Supply & Laying of Power, Control Cables & Special Cables (if any) (including all cabling works for spare unit of transformer/reactor) along with accessories for power supply, alarm, trip, control & indication, status and monitoring signals & contacts made available at MB/CMB of Transformers/Reactors upto Control & Relay Panels and BCUs located in the Switchyard Panel Room/Control Room and successful integration of same with Station Control, Protection & SAS System is in the scope of the contractor.
9.	**New Clause no. 20.4**	3½Cx300 Sq. mm XLPE power cable for oil filtration units of reactors & transformers shall be provided. The cable shall be terminated at 250A receptacle near Reactor & Transformer in the switchyard. XLPE Power cables shall be looped in & out for 250A Power receptacles.
10.	**New Clause no. 20.5**	Neutral of spare transformer/reactor is to be connected to station grounding system through a jumper/copper flat. This shall be applicable for single phase transformer/reactor wherever spare unit have been provided.
11.	**New Clause no. 20.6**	Tertiary connections made for tertiary loading of LT Transformer shall be insulated using suitable insulation tape or sleeve of at least 52kV class at site
12.	**New Clause no. 20.7**	The earthing risers from terminal of Neutral Current Transformer (NCT) of bank of 1-Phase Transformer/Reactor (as applicable) shall be brought down for connection with pipe electrodes by providing suitable insulators mounted on NCT support structure (minimum 2 nos. per support). Necessary provisions on NCT support structure for mounting of insulator shall be provided. These insulators shall deemed to be included in corresponding Erection Hardware item for Transformer/Reactor bay (as applicable) of BPS
13.	**New Clause No. 21**	Connection arrangement of 765kV equipment's shall be done as per the conceptual drawing (Drawing No. C/ENGG/SS/CONCEPTUAL 765KV BAY CONNECTIONS, Rev-01) enclosed as **<u>Annexure-S3</u>** of this Section.
14.	**New Clause No. 22**	For connection to HV bushing of tertiary loaded LT Transformer, insulated copper rod/strip of at least 75 sq.mm cross sectional area shall be used.
15.	New annexure	Refer **<u>Annexure-S4</u>** for SHORT CIRCUIT FORCES & SPACER SPAN FOR 765kV & 400kV GANTRY STRUCTURE
N.	**Section: Structure Rev 06**	
1.	**New Clause No. 3.2.4 Added**	POWERGRID will issue the fabrication drawings of the standard structures to the successful bidder. The contractor shall do the proto assembly of the structures as per the issued fabricated drawings. Employer may opt to witness such proto assembly. The bidder shall follow the fabrication drawing for preparing the proto assembly and do the minor adjustments if necessary, without affecting the strength of the structure. In case of equipment support structure the attachment of stool and fixing of MOM box etc. shall be taken care by the contractor as per the requirement of the equipment. The proto to be witnessed and Proto corrected drawings along with BOM shall be certified by the contractor. Certified drawings and BOM shall be submitted to POWERGRID for information only. The arrangement shall however not

		absolve the contractor from the responsibility of supply and erection of safe sound and durable structure.
2.	**New Clause no. 3.4**	Nuts, Bolts and washers for all non standard structures shall be payable as per BPS.
O.	**Section Civil Works Rev 11A**	
1.	**New Clause No. 21.0**	The dewatering pump shall be Portable, Self Priming, Non clog, horizontal type monobloc pump. The Pump shall be driven by electric motor suitable for outdoor application with IP-55 degree of protection. Following are the major technical parameters for the pumps to be supplied as per BPS: (A) Pump Rating : 2 HP Flow Rate : 200-400 LPM Minimum Total Head : 12 Mtrs Voltage Range : 415 ± 10% Volts (Three Phase) (B) Pump Rating : 5 HP Flow Rate : 1000-1400 LPM Minimum Total Head : 10 Mtrs Voltage Range : 415 ± 10% Volts (Three Phase)
2.	**Clause 10.5.3 of Section-Civil works Rev 11A & Clause 2.8 (b) of Section-Structures Rev 06**	**Factor of safety for design of tower and equipment structures and foundations:** a. Factor of safety for design of tower, equipment structures shall be 1.5 under normal condition and 1.2 under short-circuit condition. b. Factor of safety for design of tower, equipment foundation shall be 1.5 in both normal and short circuit condition as per IS 456. c. Factor of safety for stability of tower, equipment foundation like overturning shall be 2 (without wind or seismic), 1.5 (with wind or seismic) for normal and short circuit condition as per IS 1904.
3.	**New Clause No. 22.0**	**Slope Protection Works & Retaining Walls**: Design & Drawings pertaining to slope protection works & retaining walls (if required) shall be developed by the contractor during detailed engineering for Employer's approval. The work shall be measured under respective line items of BPS.
4.	New Clause of Copy right in Civil Rev 11A & Structure Rev 06	a. The copyright in all drawings, documents and other materials containing data and information for such design(s) to be developed by the Contractor or through any third party under this Contract shall remain vested in the Employer for a period of 5 years from the date of Completion of the Contract. In case the Contractor intends to use these design(s) for any purpose other than for project(s) to be executed by POWERGRID prior to the period of 5 years as above, the Contractor shall obtain a written permission from POWERGRID to this effect. The permission shall be granted or otherwise by POWERGRID keeping in view the specifics of the case and POWERGRID shall be sole judge in this regard. In case any breach of the aforesaid provisions of copyright during the copyright retention period comes to the notice, POWERGRID shall take the action as deemed fit keeping inter-alia under the provisions of the Integrity Pact.

		b. The Contractor may also use previous structure designs and associated foundation designs meeting specification requirements, which have been designed by them for any other project of POWERGRID, having copyright retained thereof with POWERGRID, without any financial implication and without any written permission from POWERGRID as per para (a) above. c. In case the Contractor uses previously designed structure and associated foundation designs meeting specification requirements, developed by the Contractor for any other utility/developer, POWERGRID shall be free to use designs and reproduce all drawings, documents and other material for the purpose of the Contract including, if required, in its any other project and for operation and maintenance, without any financial implication. The contractor shall ensure to submit only those documents for which they hold copyright. d. Also, all the drawings indicated at (a) & (b) above shall carry the following statement and shall be displayed conspicuously on the drawing: "WARNING: THIS IS PROPRIETORY ITEM AND DESIGN RIGHT IS STRICTLY RESERVED WITH POWERGRID UNDER NO CIRCUMSTANCES THIS DRAWING SHALL BE USED BY ANYBODY WITHOUT PRIOR PERMISSION FROM POWERGRID IN WRITING"
P.	**Section CRP Rev 09**	
1.	**New Para added under Clause No.5.1**	Requirement of Shrouding shall not be applicable to TB's where live parts are concealed.
2.	**New para added under Clause no.18.8**	Line Differential relays used as both Main –I & Main-II protection of a line, shall be of either different make & model or shall be on different hardware platform.
3.	**New para added under Clause no.18.9(s)**	Directional Earth Fault Relay/Function provided shall have Carrier Aided scheme feature which shall be suitable for single phase auto re-closure schemes
4.	Clause no. 19.1. (a), (b) and (d)	(a) have single phase & 3 phase reclosing facilities. (b) have a continuously variable dead time range of 0.1-2 seconds. (d) Auto reclose scheme shall have provision of selection of the following modes:- i. Single phase. ii. Three Phase. iii. Single & three phase. iv. Non-Auto The necessary provision in the scheme shall be provided to select the A/R mode from both **local and remote**.
5.	**New Para added under Clause No. 20.4**	Wherever, scope for NGR by passing is envisaged, necessary equipment, wiring etc. required for control & monitoring of 145kV Circuit Breaker for NGR by-passing arrangement shall be under contractor's scope of work. The same may be located in respective line/reactor protection panel.
6.	**Clause No. 21.1 (e)**	be suitable for individual input from associated CTs with rated CT secondary current of 1 Amp.
7.	**New Clause No. 21.8**	Back-up Impedance protection function shall be provided for 765kV & 400kV sides of 765/400/33kV ICT and for 400kV side of 400kV class ICT. This protection function can be clubbed with any other protection IED's except of Differential Protection IDC.
8.		The equipment offered shall have six (6) output ports. Various combinations of

<table>
<tr><td></td><td>Clause No. 32.9</td><td>output ports shall be selected by the customer, during detailed engineering, from the following :
• Potential free contact (Minimum pulse duration of 50 milli seconds.)
• IRIG-B
• RS232C
• SNTP Port (at least 4 ports)
• IEEE 1588 PTP (Applicable only for Process bus automation station)</td></tr>
<tr><td>9.</td><td>Clause no 37. IV Breaker Relay Panel</td><td>BREAKER RELAY PANEL: The breaker relay panel shall consist of the following:
<table>
<tr><th>Sl. No.</th><th>Description</th><th>Qty</th></tr>
<tr><td>1.</td><td>Breaker failure Protection Scheme*</td><td>1no.</td></tr>
<tr><td>2.</td><td>DC supply Supervision relay</td><td>2nos.</td></tr>
<tr><td>3.</td><td>Trip Circuit supervision relays#</td><td>6nos.</td></tr>
<tr><td>4.</td><td>Auto-reclose scheme (##)</td><td>1No.</td></tr>
<tr><td>5.</td><td>Flag relays, aux relays, timers, trip relays as per scheme requirements</td><td>As required</td></tr>
<tr><td>Note-1)</td><td colspan="2"># Trip supervision relays shall be 2 or 6 numbers as per no. of trip coils for each 132KV Circuit breaker</td></tr>
<tr><td>Note- 2)</td><td colspan="2">Equipment/relays to be provided under CB Relay Panel may be accommodated in the Protection Panels to be provided for Transmission Line/Transformer/Reactor as applicable</td></tr>
<tr><td>Note- 3)</td><td colspan="2">* In case of bay extension in existing half diameter, breaker failure relay for main CB / Tie CB shall be supplied only if BFR built-in Bus Bar protection bay unit is not available or Tie CB standalone BFR relay is not available in the existing protection scheme.</td></tr>
<tr><td>Note-4)</td><td colspan="2">## Auto reclose scheme shall also be acceptable as a part of BCU. All Circuit Breaker Relay Panel shall be provided with Auto-reclose function. However, during execution stage Auto-reclose function shall be enabled/ disabled based on requirement.</td></tr>
</table></td></tr>
<tr><td>Q.</td><td colspan="2">Section SAS Rev 04</td></tr>
<tr><td>1.</td><td>Typical Architectural Drawing of SAS (Without Process Bus)</td><td>TYPICAL ARCHITECTURAL DRAWING OF SUBSTATION AUTOMATION SYSTEM (Without Process Bus) stands replaced by <u>Annexure-S5</u></td></tr>
<tr><td>2.</td><td>Para 2 under Clause No. 3.3.1</td><td>The Substation Automation System shall have communication ports on each gateway (two gateways per station) as follows:

(a) Three ports for Remote Control Centres on Secure IEC60870-5-104 protocol.
(b) Two port on IEC 60870-5-104 for Regional System Coordination Centre (RSCC)</td></tr>
<tr><td>3.</td><td>New Para Added Under Clause No.4.1.5</td><td>The bidder shall also provide 2 Nos. managed Ethernet switches with at least 16 copper RJ45 ports on each switch to form managed "Redundant System LAN" for connecting different NTAMC sub-systems devices (SCADA Gateways, VMS, VOIP etc.) as per revised system architecture <u>(attached as Annexure S5)</u>. The specification of the switches is enclosed at <u>Annexure-S6.</u></td></tr>
<tr><td>4.</td><td>Para 2 Under Clause No.4.1.6</td><td>Contractor shall provide 2 nos. Next Generation Firewalls (NGFW); one No. Main & one No. Standby having electrical ethernet interfaces/ports and placed between FOTE & SAS gateways, NTAMC switch etc. at the substation. All ethernet based applications (e.g. PMU, AMR, VOIP, SAS/SCADA etc.) shall be terminated in the firewall ports directly. Each port of firewall shall work as a separate zone. Firewall shall be hardware based with functionality of Block/Allow/drop and IPSec VPN (network encryption). Minimum 16 Nos. of ports/interfaces shall be provided in</td></tr>
</table>

		each firewall (i.e. Main & Standby) Contractor can use either single firewall or multiple firewalls to meet this interfaces requirement, each for main as well as standby firewall. Minimum throughput of firewall shall be 300 Mbps. The Firewall shall be managed/ configured as standalone at present and shall also have compatibility to manage/configure through Centralized Management Console (CMC) remotely in future. OEM Support on 24x7 basis for 7 years shall be provided for all the functions & features of the Firewall. Firewall shall be tested and certified for ISO15408 Common Criteria for least EAL4+. Further, the OEM must certify that it conforms to Secure Product Development Life Cycle requirements as per IEC62443-4-1. The firewall shall generate reports for NERC-CIP Compliance. The specifications for the firewalls are attached at **Annexure-S7.**
5.	**Para 3 Under Clause No.4.1.6**	The substation routers shall have the following features: - Routing protocols such as OSPF and support for IPv4 and IPv6 **- 8 Ethernet interfaces of 10/100 Mbps** - 2 E1 interfaces - Hot standby operation with a similar router - Support IEEE 802.3u, 802.1p, 802.1Q, 802.1d, 802.1w, - Traffic prioritization for routed IP flows/ports
6.	**Bullet no.4 under Clause No. 4.2.1**	Each BCU shall be equipped with Local HMI (display) facilities, enabling control of each particular bay from BCU whenever required. The Local HMI facilities shall be accomplished by means of Graphical LCD display embedded into the front panel of the BCU. Display will show the SLD (with device identification number) showing status of bay switching equipment (such as circuit breaker, isolators, earth switches) and enabling issuance of switching controls. Other display type will be multiple displays of analog values readings / reports, displays for controls other than switching, Alarm panel displays, Diagnostic/ online configuration displays etc. **Bay control unit shall have inbuilt metering CVT supervision function. It shall have feature to give alarm in case of CVT/PT metering core fuse fail.**
7.	Clause 4.2.2 New bullet	Bay Control Units for Main System and Auxiliary system at a station shall be classified as below based on it's application and Contractor shall supply following types of BCU applicable under the subject package: Bay control Unit (IED) of Main System (a). Main Bay BCU (b). Tie Bay BCU (c). Switchable Line Reactor Bay BCU Bay control Unit (IED) of Auxiliary System (a) Auxiliary BCU
8.	**New Clause 15.4**	Mandatory spares: a. Mandatory Spares for Substation Automation shall be supplied as per BPS. b. The offered "Bay control Unit (IED) of Main System" as spare, shall be sufficient to replace all types of Bay control Units supplied under Main system without addition of any hardware/module etc. Further any additional I/O module and/or hardware supplied under Main system to meet the functional requirement of Bay control Unit in any bay, shall be considered part of Bay control Unit (IED) of Main System. The offered "Bay control Unit (IED) of Auxiliary System" as spare, shall be sufficient to replace all types of Auxiliary BCU supplied under Auxiliary system without addition of any hardware/module etc.

		Further any additional I/O module and/or hardware supplied under Auxiliary system to meet the functional requirement of Bay control Unit shall be considered part of Bay control Unit (IED) of Auxiliary System
9.	**Clause No. 16.0 (v)**	**<u>LIST OF EQUIPMENTS</u>** v) **Two nos. Disturbance Recorder/Engineering Work Station where atleast one workstation shall have Linux based operating system.**
R.	**Section PLCC Rev 05**	
1.	**New Clause No. 6.12.4**	For 765 kV Wave Trap, cantilever strength of BPIs used for Wave Trap shall be 10kN.
2.	**New Clause no. 10.4.13**	All protection couplers (Analog protection coupler, digital protection coupler) shall be equipped with direct reading type counter facility for all the codes (Tx & Rx).
3.	**New Clause no.10.5**	Digital protection coupler (DPC) shall be used as one of the two tele-protection channel on the lines between the stations having Optical Fiber link alongwith SDH Equipment. Specification of digital protection coupler is enclosed as **<u>Annexure-S8.</u>** The DPC can be housed either in offered Control & Protection Panel / PLCC Panel or in separate panel. Generally SDH Equipment are placed in communication room of Control room where as DPC is placed in panel room. The connection between SDH equipment and each DPC shall be through Optical fiber. Necessary cables, converter(s) for converting E1 signal to optical fiber at both ends (at Panel Room as well as at Control room) along with FODP shall be in the scope of the contractor. Further sharing of additional spare ports of converter for DPC placed in other Panel Room or in same Panel Room is also permitted. Necessary optical fiber for interconnection of DPC is to be provided by the contractor. Further any copper wiring for ensuring the protection signaling/data/speech shall be in the scope of the contractor.
S.	**VISUAL MONITORING SYSTEM** (if specified in BPS)	
1.		Technical Specification for Visual Monitoring System for watch and ward of substation premises is attached at **<u>Annexure-S9</u>**
T.	**Section –400KV Transformer Rev 13**	
1.	Clause 4(b)	The concentration of any fault gas is more than respective values as per Table-1 of IEEE-C57.104-2019, which are as detailed below.

FAULT GAS	**O2/N2 Ratio ≤ 0.2**	**O2/N2 Ratio > 0.2**
Hydrogen (H2)	75	40
Methane (CH4)	45	20
Ethene (C2H6)	30	15
Ethylene (C2H4)	20	25
Acetylene (C2H2)	01	02
Carbon monoxide (CO)	900	500
Carbon dioxide (CO2)	5000	3500

2.	**Clause No. 6.5.1**	Conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. Conservator Protection Relay (CPR)/Air cell puncture detection relay shall be installed to give alarm in the event of lowering of oil in the conservator due to puncture of air cell in service. Conservator shall be fitted with magnetic oil level gauge (Plug & socket type arrangement) with potential free high and low oil level alarm contacts and prismatic oil level gauge and Conservator Protection Relay.

		Plug & socket type arrangement with factory fitted cable of adequate length shall be supplied by OEM. Connection of plug and socket with cable at site is not acceptable.
3.	Annexure-H	**ANNEXURE - H** **1.1 KV GRADE POWER & CONTROL CABLES** **…** **…** **STANDARD TECHNICAL DATA SHEET (1.1kV GRADE XLPE POWER CABLES) – VOID (Parameters of Standard Technical Data Sheet shall not be referred to)** **STANDARD TECHNICAL DATA SHEET (1.1kV GRADE PVC POWER CABLES) – VOID (Parameters of Standard Technical Data Sheet shall not be referred to)** **STANDARD TECHNICAL DATA SHEET (1.1kV GRADE PVC CONTROL CABLES) – VOID (Parameters of Standard Technical Data Sheet shall not be referred to)**
4.	Clause 9.1	**Particles in the oil** The particle analysis shall be carried out in an oil sample taken before carrying out FAT at manufacturer's works and after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17- "Effect of particles on transformer dielectric strength". Particle limit as shown below shall be ensured by manufacturer, implying low contamination, as per CIGRE Brochure 157, Table 8. Limiting value for the particle count are 1000 particle/100 ml with size ≥ 5 µm; 130 particle/100 ml with size ≥ 15 µm.
U.	**Section 400kV Shunt Reactor Rev. 11**	
1.	Clause No. 7.5.1	Conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. Conservator Protection Relay (CPR)/Air cell puncture detection relay shall be installed to give alarm in the event of lowering of oil in the conservator due to puncture of air cell in service. Conservator shall be fitted with magnetic oil level gauge (Plug & socket type arrangement) with potential free high and low oil level alarm contacts and prismatic oil level gauge and Conservator Protection Relay. **Plug & socket type arrangement with factory fitted cable of adequate length shall be supplied by OEM. Connection of plug and socket with cable at site is not acceptable.**
2.	Clause 5(b)	The concentration of any fault gas is more than respective values as per Table-1 of IEEE-C57.104-2019, which are as detailed below.

FAULT GAS	**O2/N2 Ratio ≤ 0.2**	**O2/N2 Ratio > 0.2**
Hydrogen (H2)	75	40
Methane (CH4)	45	20
Ethene (C2H6)	30	15
Ethylene (C2H4)	20	25
Acetylene (C2H2)	01	02
Carbon monoxide (CO)	900	500
Carbon dioxide (CO2)	5000	3500

<table>
<tr><td>3.</td><td>Annexure-I</td><td>ANNEXURE - I
1.1 KV GRADE POWER & CONTROL CABLES
…
…
STANDARD TECHNICAL DATA SHEET (1.1kV GRADE XLPE POWER CABLES) – VOID (Parameters of Standard Technical Data Sheet shall not be referred to)

STANDARD TECHNICAL DATA SHEET (1.1kV GRADE PVC POWER CABLES) – VOID (Parameters of Standard Technical Data Sheet shall not be referred to)

STANDARD TECHNICAL DATA SHEET (1.1kV GRADE PVC CONTROL CABLES) – VOID (Parameters of Standard Technical Data Sheet shall not be referred to)</td></tr>
<tr><td>4.</td><td>Clause 9.1</td><td>Particles in the oil

The particle analysis shall be carried out in an oil sample taken before carrying out FAT at manufacturer's works and after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17- "Effect of particles on transformer dielectric strength". Particle limit as shown below shall be ensured by manufacturer, implying low contamination, as per CIGRE Brochure 157, Table 8.

Limiting value for the particle count are 1000 particle/100 ml with size ≥ 5 μm; 130 particle/100 ml with size ≥ 15 μm.</td></tr>
<tr><td>V.</td><td colspan="2">Section- 765kV Auto-transformer Rev 08</td></tr>
<tr><td>1.</td><td>Clause 4(b)</td><td>The concentration of any fault gas is more than respective values as per Table-1 of IEEE-C57.104-2019, which are as detailed below.
<table>
<tr><th>FAULT GAS</th><th>O2/N2 Ratio ≤ 0.2</th><th>O2/N2 Ratio > 0.2</th></tr>
<tr><td>Hydrogen (H2)</td><td>75</td><td>40</td></tr>
<tr><td>Methane (CH4)</td><td>45</td><td>20</td></tr>
<tr><td>Ethene (C2H6)</td><td>30</td><td>15</td></tr>
<tr><td>Ethylene (C2H4)</td><td>20</td><td>25</td></tr>
<tr><td>Acetylene (C2H2)</td><td>01</td><td>02</td></tr>
<tr><td>Carbon monoxide (CO)</td><td>900</td><td>500</td></tr>
<tr><td>Carbon dioxide (CO2)</td><td>5000</td><td>3500</td></tr>
</table></td></tr>
<tr><td>2.</td><td>Clause 6.5.1</td><td>Conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture.
Conservator Protection Relay (CPR)/Air cell puncture detection relay shall be installed to give alarm in the event of lowering of oil in the conservator due to puncture of air cell in service.

Conservator shall be fitted with magnetic oil level gauge (Plug & socket type arrangement) with potential free high and low oil level alarm contacts and prismatic oil level gauge and Conservator Protection Relay.

Plug & socket type arrangement with factory fitted cable of adequate length shall be supplied by OEM. Connection of plug and socket with cable at site is not acceptable.</td></tr>
</table>

3.	Annexure-H	**ANNEXURE - H** **1.1 KV GRADE POWER & CONTROL CABLES** **…** **…** **STANDARD TECHNICAL DATA SHEET (1.1kV GRADE XLPE POWER CABLES) – VOID (Parameters of Standard Technical Data Sheet shall not be referred to)** **STANDARD TECHNICAL DATA SHEET (1.1kV GRADE PVC POWER CABLES) – VOID (Parameters of Standard Technical Data Sheet shall not be referred to)** **STANDARD TECHNICAL DATA SHEET (1.1kV GRADE PVC CONTROL CABLES) – VOID (Parameters of Standard Technical Data Sheet shall not be referred to)**
4.	Clause 8.1	**Particles in the oil** The particle analysis shall be carried out in an oil sample taken before carrying out FAT at manufacturer's works and after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17- "Effect of particles on transformer dielectric strength". Particle limit as shown below shall be ensured by manufacturer, implying low contamination, as per CIGRE Brochure 157, Table 8. Limiting value for the particle count are 1000 particle/100 ml with size ≥ 5 µm; 130 particle/100 ml with size ≥ 15 µm.
W.	**Section-765kV Shunt Reactor, Rev. 08**	
1.	Clause 5(b)	The concentration of any fault gas is more than respective values as per Table-1 of IEEE-C57.104-2019, which are as detailed below.

FAULT GAS	O2/N2 Ratio ≤ 0.2	O2/N2 Ratio > 0.2
Hydrogen (H2)	75	40
Methane (CH4)	45	20
Ethene (C2H6)	30	15
Ethylene (C2H4)	20	25
Acetylene (C2H2)	01	02
Carbon monoxide (CO)	900	500
Carbon dioxide (CO2)	5000	3500

2.	Clause No. 7.5.1	Conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. Conservator Protection Relay (CPR)/Air cell puncture detection relay shall be installed to give alarm in the event of lowering of oil in the conservator due to puncture of air cell in service. Conservator shall be fitted with magnetic oil level gauge (Plug & socket type arrangement) with potential free high and low oil level alarm contacts and prismatic oil level gauge and Conservator Protection Relay. **Plug & socket type arrangement with factory fitted cable of adequate length shall be supplied by OEM. Connection of plug and socket with cable at site is not acceptable.**
3.	Annexure-I	**ANNEXURE - I** **1.1 KV GRADE POWER & CONTROL CABLES** **…** **…** **STANDARD TECHNICAL DATA SHEET (1.1kV GRADE XLPE POWER CABLES)**

		– VOID (Parameters of Standard Technical Data Sheet shall not be referred to) **STANDARD TECHNICAL DATA SHEET (1.1kV GRADE PVC POWER CABLES)** **– VOID (Parameters of Standard Technical Data Sheet shall not be referred to)** **STANDARD TECHNICAL DATA SHEET (1.1kV GRADE PVC CONTROL CABLES)** **– VOID (Parameters of Standard Technical Data Sheet shall not be referred to)**
4.	Clause 9.1	**Particles in the oil** The particle analysis shall be carried out in an oil sample taken before carrying out FAT at manufacturer's works and after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17- "Effect of particles on transformer dielectric strength". Particle limit as shown below shall be ensured by manufacturer, implying low contamination, as per CIGRE Brochure 157, Table 8. Limiting value for the particle count are 1000 particle/100 ml with size ≥ 5 µm; 130 particle/100 ml with size ≥ 15 µm.
X.	**LT transformer Rev-5**	
1.	Clause no 5.2.5 b)	**Clause no 5.2.5 b) Stand Deleted.**

Sl. No.	**Power System Equipment**	**Minimum Local Content (%)**
1	Power Transformers (up to 765 kV, including Generator Transformers)	60
2	Instrument Transformer (up to 765 kV)	60
3	Transformer Oil Dry Out System (TODOS)	60
4	Reactors up to 765 kV	60
5	Oil Impregnated Bushing (Up to 400kV)	60
6	Resin Insulated Paper (RIP) bushings (up to 145 kV)	50
7	Circuit Breakers (up to 765kV AC-Alternating Current)	60
8	Disconnectors, Isolators (up to 765kV AC)	60
9	Wave Trap (up to 765kV AC)	60
10	Oil Filled Distribution Transformers up to & including 33kV [Cold Rolled Grain Oriented (CRGO)/Amorphous, Aluminium/Copper wound]	60
11	Dry type Distribution Transformers up to & including 33kV (CRGO/Amorphous, Aluminium/Copper wound)	60
12	Conventional conductor	60
13	Accessories for conventional conductors	60
14	High Temperature/High Temperature Low Sag (HTLS) conductors (such as Composite core, GAP, ACSS, INVAR, AL59) and accessories	60
15	Optical ground wire (OPGW)- all designs	60
16	Fiber Optic Terminal Equipment (FOTE) for OPGW	50
17	OPGW related Hardware and accessories	60
18	Remote Terminal Unit (RTU)	50
19	Power Cables and accessories up to 33kV	60
20	Control cables including accessories	60
21	XLPE cables up to 220kV	60
22	Substation Structures	60
23	Transmission Line Towers	60
24	Porcelain (Disc/Long Rod) Insulators	60
25	Bus Post Insulators (Porcelain)	60
26	Porcelain Disc Insulators with Room Temperature Vulcanisation (RTV) coating	50
27	Porcelain Long Rod Insulators with Room temperature Vulcanisation (RTV) coating	50
28	Hardware Fittings for porcelain Insulators	60
29	Composite/Polymeric Long Rod Insulators	60
30	Hardware Fittings for Polymer Insulators	60
31	Bird Flight Diverter (BFD)	60
32	Power Line Carrier Communication (PLCC) system (up to 800kV)	60
33	Gas Insulated Switchgear (up to 400kV AC)	60
34	Gas Insulated Switchgear (above 400kV AC)	50
35	Surge/Lightning Arrester (up to 765kV AC)	60
36	Power Capacitors	60
37	Packaged Sub-station (6.6kV to 33kV)	60
38	Ring Main Unit (RMU) (up to 33kV)	60

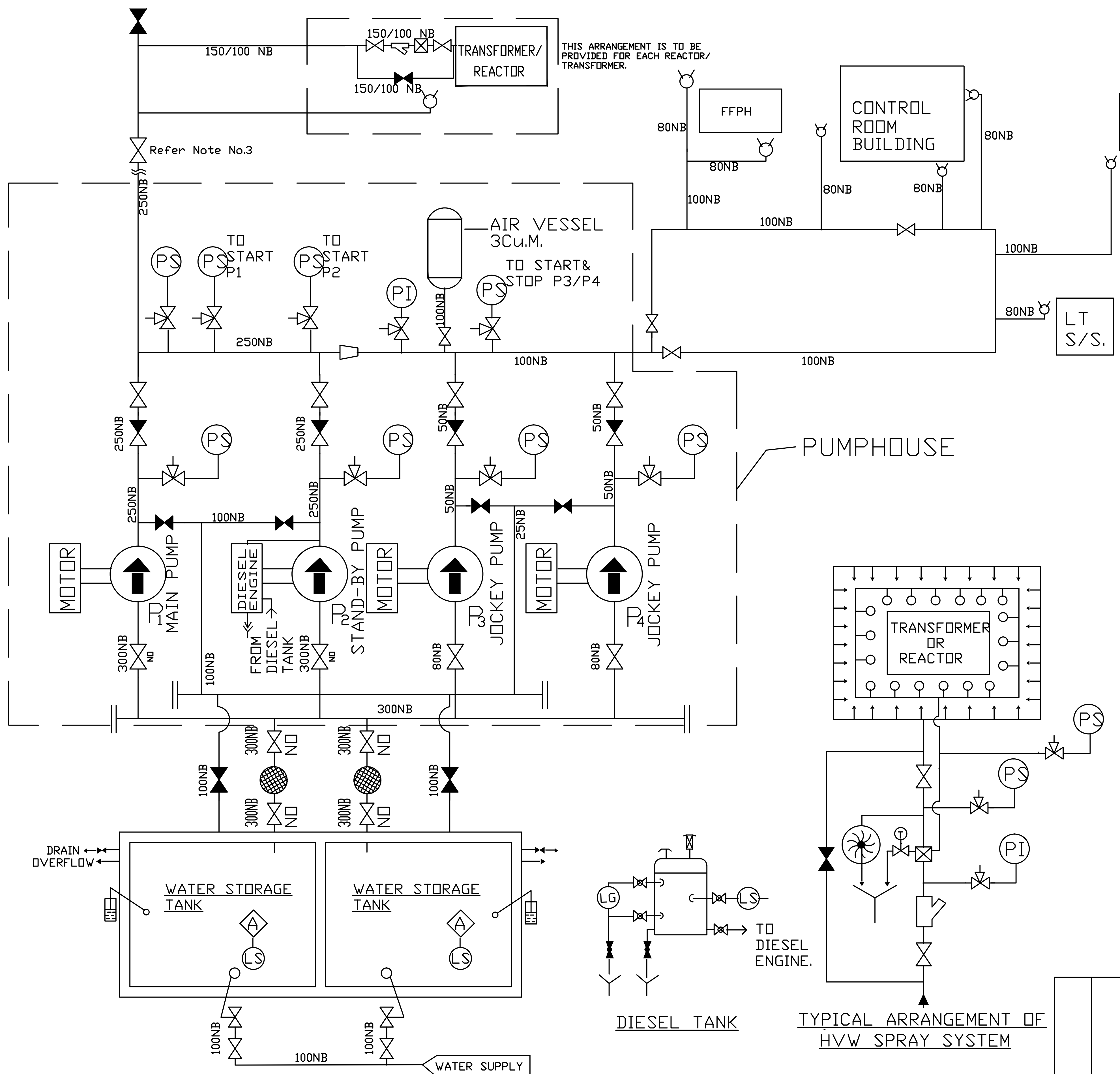
39	Medium Voltage (MV) GIS panels (up to 33kV)	60
40	Automation and Control system/Supervisory Control and Data Acquisition (SCADA) system in Power system	50
41	Control and Relay panel (including Digital/Numerical relays)	50
42	Electrical motors 0.37kW to 1MW	60
43	Energy meters excluding smart meters	50
44	Control and Power cables and accessories (up to 1.1kV)	60
45	Diesel Generating (DG) set	60
46	DC system (DC Battery & Battery Charger)	60
47	AC and DC Distribution board	60
48	Indoor Air Insulated Switchgear (AIS) up to 33kV	60
49	Poles (PCC, PSCC, Rolled Steel Joist, Rail Pole, Spun, Steel Tubular)	60
50	Material for Grounding/earthing system	60
51	Illumination system	60
52	Overhead Fault Sensing Indicator (FSI)	50
53	Power Quality Meters	50
54	Auxiliary Relays	50
55	Load Break Switch	50
56	Cranes, EOT cranes, gantry crane & chain pulley blocks, etc	60
57	Elevator	60
Fire Protection and Detection system		
58	Motor driven fire water pumps	60
59	Diesel engine driven fire water pumps	60
60	Hydrant system	60
61	High velocity water spray system	60
62	Medium velocity water spray system	60
63	Foam Protection system	60
64	Inert gas flooding system	60
65	Fire tenders	60
66	Portable fire-extinguishers	60

Annexure-V (Revised): Actions required in case of defects observed during warrantee period

Equipment	Nature of problem	Corrective measures to be taken by contractor
CT/**IVT/PT** (Oil filled)	**DGA Violation** $H_2 > 300$ ppm $C_2H_2 > 2$ ppm	Refurbished or replaced
CT/**IVT/PT** (SF_6 filled)	a) SF6 gas leakage b) High Dew point of SF6 gas (> -36 deg C at atm press)	a)Repair/ replacement b)Re-processing of gas and replacement of Gas in case of no improvement
CT/**IVT/PT** (Oil filled)	**Violation of Tan delta** Tan Delta: >0.5%(during pre-commisioning) >0.7% (in operation) or change w.r.t. to previous **year** value > 0.1%	Replacement
CT, **IVT/PT** & CVT	- Oil leakage - Low Oil level -Sec winding problem leading to open/ short circuit, saturation etc	Replacement or repair as per repair procedure approved by QA.
CVT	Secondary voltage drift: Upto ± 0.5 volts Healthy a) ± 0.5 **or beyond**	a) CVT to be replaced

***Replaced/Repaired/Refurbished Equipment (or part of equipment) shall have 2 years warranty without prejudice to contractual warranty period.**

APPENDIX-I
TO TECHNICAL SPECIFICATION
FOR FIRE PROTECTION SYSTEM REV.-6



LEGEND

- ALARM
- GATE VALVE NORMALLY OPEN
- GATE VALVE NORMALLY CLOSED
- NON-RETURN VALVE
- GLOBE VALVE NORMALLY OPEN
- GLOBE VALVE NORMALLY CLOSED
- FLOAT OPERATED GATE VALVE
- TEST VALVE
- PRESSURE GAUGE
- PRESSURE SWITCH
- LEVEL GAUGE
- LEVEL SWITCH
- BASKET STRAINER
- FLOAT OPERATED LEVEL GAUGE
- Y-TYPE STRAINER
- WATER MOTOR GONG
- REDUCER
- THREE WAY COCK/ VALVE
- VENT
- DRAIN
- OUT DOOR HYDRANT
- QUARTZOID BULB DETECTOR
- HVW SPRAY NOZZLE
- PUMP
- WATER LINE
- DELUGE VALVE

NOTES:
1. THE HYDRANT POINTS FOR TRANSFORMER/ REACTOR SHALL BE LOCATED AT LEAST 20M AWAY FROM THEM.
2. AS SAFETY MEASURE, A WARNING PLATE SHALL BE PLACED NEAR HYDRANT POINTS FOR TRANSFORMER/ REACTOR TO CLEARLY INDICATE THAT WATER SHALL BE SPRAYED ONLY AFTER ENSURING THAT THE POWER TO THE TRANSFORMER/ REACTOR WHICH IS ON FIRE IS SWITCHED OFF AND THERE ARE NO LIVE PART WITHIN 20 M. DISTANCE OF THE PERSONNEL USING THE HYDRANT.
3. FIRE HYDRANT PIPE LINE OUTSIDE THE PUMP HOUSE SHALL BE SUITABLY SECTIONALIZED AS PER LAYOUT REQUIREMENT. MINIMUM ONE(1) GATE VALVE TO BE PROVIDED FOR EVERY 200 METER OF MAIN HYDRANT PIPE FOR PURPOSE OF MAINTENANCE.

FOR TENDER PURPOSE ONLY

POWER GRID CORPORATION OF INDIA LIMITED
(A GOVERNMENT OF INDIA ENTERPRISE)

DATE	DRAWN	CHKD.	APPD.
17.07.2019	HIMANSHU	S K THAKUR	

APPD.

RECOMMENDED

PROJECT: 765kV AND 400kV SUBSTATION

TITLE: PIPING & INSTRUMENTATION DIAGRAM FOR HYDRANT & HVW SPRAY SYSTEM.

NTS | DRG.NO. C/ENGG/STD/FP/1 | REV. 5

Sheet 1 of 1

TECHNICAL DATA SHEETS

DATA SHEET FOR DELUGE VALVE

1.0	Manufacturer	POWERGRID Approved make
2.0	Number & size	As per approved system drawings.
3.0	Type	Differential Diaphragm type
4.0	Rating	
4.1	Flow in M^3/hr. 1. 150 mm ø 2. 100 mm ø	170 to 650 50 to 225
4.2	Pressure	Working Pressure – 12.3 kg/cm^2 Test Pressure - 25 kg/cm^2
4.3	Pressure drop in equivalent length 1. 150 mm ø 2. 100 mm ø	19M 11M
5.0	**Material of construction**	
5.1	Body	CI IS:210 Gr. FG 260
5.2	Valve internal	Cast Bronze – IS:318-LTB 2 / Ductile Iron ASTM A536 65-45-12
5.3	Seat Seal	EPDM/ Neoprene Rubber
5.4	Diaphragm	EPDM/ Neoprene Rubber
6.0	Differential pressure required for operation	Differential Ratio – 50%
7.0	Water Motor Gong provided	Yes
7.1	Type	Hydraulic type
7.2	**Material of Construction:**	
7.2.1	Housing	Al. Alloy-IS:617
7.2.2	Cover/Rotor./Gong	Aluminium to IS:737
7.2.3	Manual actuation lever provided?	Yes
8.0	Remote actuation with Solenoid Valve provided?	Yes
9.0	Resetting type	Manual resetting type
10.0	Deluge valve complete with test and drain valves, manual operation arrangement, supporting structures and all necessary accessories	Yes
11.0	Approval of Deluge Valve.	FM of USA, UL of USA, LPCB of U.K. or VDS of Germany

METHODOLOGY FOR SUPPLY, INSTALLATION & SIZING OF CABLES

Supply of 1.1kV grade Cables:

- The quantities of various type of 1.1kV grade power and control cables shall be assessed by POWERGRID. The Sizes of 1.1 kV grade Control cables to be adopted for installation is enclosed at Appendix I . For Sizes of Power Cable, Clause 1.1.4 of Section Power and control Cable rev 06 is amended at Appendix-II

  For Applications in addition to those specified, appropriate cable size shall be considered by the contractor with prior approval of Employer during execution stage

- Supply of 1.1kV grade power and control cables of various sizes shall be as per unit quantities mentioned in BPS.

- The Cables from Control Room/SPR/ACDB/DCDB/BMK to Equipment Marshalling box (MB)/Local control Cubical (LCC) shall be considered under the BPS item for supply of cables.

- The Interpole cables between AIS Instrument Transformer (CT/CVT), Surge Arrester and associated Junction Box shall be as per unit quantities mentioned in BPS.

- The Interpole cables between Circuit Breaker, Isolator and associated Marshalling box shall be deemed to be included in price of Equipment.

Installation of 1.1kV grade Cables:

- The quantity of Installation of cables is to be assessed by the contractor for the complete scope of work specified in Section project.

- The installation of 1.1kV grade power and control cables (including interpole cable of Equipment & illumination cables) shall be quoted in “LOT” basis.

- Supply and installation of Cable accessories like lugs, glands etc. for entire cabling work shall be deemed to be included in Installation charges of cables quoted by contractor in Bid price schedule.

- No variation shall be admissible on account of Installation of Cables/supply and installation of associated accessories, irrespective of variation (either positive or negative) in supply quantity of Cable specified in BPS.

Extra Consumption of 1.1 kV Power and control cables.

The Contractor shall make every effort to minimise wastage of the cables during installation. The Permitted Overall scarp/wastage shall be limited to 0.50% of actual supplied quantity for each size of cables. Any wastage more than the above limit shall be recovered from the contractor. All balance unused cables shall be returned to the employer by rewinding in separate drums for each size with discrete markings on drums.

Cut pieces of Cables having length less than following shall be considered for Scrap. The Contractor shall dispose of the scrap (if any), at their own cost :

1.) **Length less than 20 M**
   - **a)** Control Cable (3C, 5C, 7C & 10 Core)
   - **b)** Power Cable(2CX 6Sqmm,4CX6Sqmm, 4CX16Sqmm)

2.) **Length less than 50 M**
   - **a)** Control Cable having more than 10 Cores
   - **b)** Power Cable of sizes above 16 Sq mm

For Illumination purpose, ACP’s shall be supplied as per BPS. From ACP to luminous all the required cables, accessories(including lugs and gland for cables between MLDB & ACP) , SLP/JB etc as required shall be assessed and supplied by the contractor. The price of these items shall be deemed to be included in price of luminaries.

Appendix-I: Control Cable Sizes

S.No.	From	To	Proposed Cable size
1.	CB MB	CRP panels	i) 10CX2.5Sq mm ii) 19CX1.5 Sq mm iii) 27CX 1.5 Sq mm
2.	CB MB	Earth switch MB	i) 3CX 2.5 Sqmm ii) 5C X2.5 Sq mm
3.	Isolator MB	Earth switch MB	10CX2.5Sq mm
4.	Isolator MB	CRP panels	19CX1.5 Sq mm
5.	CT	CT JB	i) 5C X2.5 Sq mm ii) 10C X2.5 Sq mm
6.	CT JB	CRP panels	i) 5C X2.5 Sq mm ii) 10C X2.5 Sq mm
7.	CVT	CVT JB	i) 5C X2.5 Sq mm ii) 10C X2.5 Sq mm
8.	CVT JB	CRP panels	i) 5C X2.5 Sq mm ii) 10C X2.5 Sq mm
9.	LA	LA JB	3C X2.5 Sq mm
10.	LA JB	CRP panels	5C X2.5 Sq mm
11.	Reactor MB/CMB (for 1-Ph)	CRP panels	i) 3CX2.5Sq mm ii) 5CX2.5 Sq mm iii) 19CX 1.5 Sq mm iv) 27CX 1.5 Sq mm v) Paired Cables
12.	ICT MB/CMB (for 1-Ph)	CRP panels	i) 3CX2.5Sq mm ii) 5CX2.5 Sq mm iii) 19CX 1.5 Sq mm iv) 27CX 1.5 Sq mm v) Paired Cables

Note:

i) For Applications in addition to those specified, appropriate cable size shall be considered by the contractor with prior approval of Employer during execution stage.

ii) GTP of 1.5 Sq mm Cable shall be submitted during detailed engineering stage for employers approval.

iii) In case, more nos. of runs or larger sizes of cables are required between two points based on design calculations, same shall deemed to be included in the scope of bidder.

Appendix-II Power cable sizes.

S.No.	From	To	Existing Cable size	Cable type
1.	Main Switch Board	LT Transformer	2-1C X 630 mm^2 :For each phase 1-1C X 630 mm^2 : for neutral	XLPE
2.	Main Switch Board	AC Distribution Board	2-3½C X 300 mm^2	XLPE
3.	Main Switch Board	Oil Filtration Unit	1-3½C X 300 mm^2	XLPE
4.	Main Switch Board	Colony Lighting	1-3½C X 300 mm2	XLPE
5.	Main Switch Board	HVW pump LCP	1-3½C X 300 mm2	XLPE
6.	Main Switch Board	Main Lighting distribution board	2-3½C X 300 mm2	XLPE
7.	AC Distribution Board	D.G. Set AMF Panel	For 500 kVA DG set: 2-3½C X 300 mm2 For 250 kVA DG set: 1-3½C X 300 mm2	XLPE
8.	AC Distribution Board	Emergency Lighting distribution board	3½C X 70mm2 :For 765/400kV S/s 3½C X 35mm2 :For 400/220kV S/s	PVC
9.	AC Distribution Board	ICT MB	3½C X 70mm2 :For 765/400kV S/s 3½C X 35mm2 :For 400/220kV S/s	PVC
10.	AC Distribution Board	Bay MB	3½C X 70mm2 :For 765/400kV S/s 3½C X 35mm2 For 400/220kV S/s	PVC
11.	Bay MB	AC Kiosk	1-4C X 16 mm2	PVC
12.	AC Distribution Board	Battery Charger 220 V	1-3½C X 70 mm2	PVC

13.	AC Distribution Board	Battery Charger 48 V	1-3½C X 35 mm	PVC
14.	DCDB	Battery	2-1C X 150 mm2	PVC
15.	DCDB	Battery Charger	2-1C X 150 mm2	PVC
16.	DCDB	Protection/PLCC panel	1-4C X 16 mm2 : 765/400kV S/s 1-4C X 6 mm2: 400/220kV S/s	PVC
17.	Main Lighting DB	Lighting panels(Indoor)	1-3½C X 35 mm2	PVC
18.	Main Lighting DB	Lighting panels (outdoor)	1-3½C X 70 mm2	PVC
19.	Main Lighting DB	Receptacles (Indoor)	1-3½C X 35 mm2	PVC
20.	Main Lighting DB	Receptacles (Outdoor)	1-3½C X 70 mm2	PVC
21.	Lighting Panel	Sub lighting panels	These Cables shall be included in Price of item for Lighting fixture	PVC
22.	Lighting Panel	Street Lighting Poles	These Cables shall be included in Price of item for Lighting fixture	PVC
23.	Lighting Panel/ Sub lighting panels	Lighting Fixtures (Outdoor)	These Cables shall be included in Price of item for Lighting fixture	PVC
24.	Bay MB	Equipment	1-4C X 16 mm^2 : For CB 1-4C X 6 mm$^{2:}$ For Isolator/earths switch 1-2C X 6 : For CT/CVT	PVC
25.	ELDB	Lighting panel	3½C X 70mm^2 :For 765/400kV S/s 3½C X 35mm2 :For 400/220kV S/s	

AIR CONDITIONING & VENTILATION SYSTEM FOR GIS BUILDING

AIR CONDITIONING SYSTEM FOR GIS

1 GENERAL

1.1 This specification covers supply, installation, testing and commissioning and handing over to POWERGRID of Air conditioning system for the Local Control rooms & Maintenance Room in the GIS halls.

1.2 Air conditioning system shall be designed to maintain the inside DBT below 24^{o}C. Bidder shall submit necessary design calculations for employer's approval.

1.3 At least 50% spare Air-Conditioning capacity shall be provided for Local Control rooms in the GIS halls.

1.4 Controllers shall be provided in Local Control room inside GIS hall for controlling and monitoring the AC units in these rooms as detailed in clause no.2.6

1.5 Each Local Control room inside GIS hall shall be provided with temperature transducer to monitor the temperature of the Local Control rooms in the GIS halls. The Temperature transducer shall have the following specification:

Sensor	:	Air temperature sensor (indoor use)
Output	:	4 to 20mA
Temperature range	:	-5^{o}C to 60^{o}C
Resolution	:	0.1^{o}C
Accuracy	:	0.5^{o}C or better.

2 AIR CONDITIONING SYSTEM REQUIREMENTS.

2.1 Air conditioning requirement of the buildings shall be met using a combination of following types Air Conditioning units as required.

a) Cassette type split AC units of 3TR.
b) High wall type split AC units of 2TR.

2.2 Type & Capacity of air conditioners shall be so chosen such that quantity of air conditioners in the room is optimized keeping the necessary air flow.

2.3 **Scope**

The scope of the equipment to be furnished and services to be provided under the contract are outlined hereinafter and the same is to be read in conjunction with the provision contained in other sections/ clauses. The scope of the work under the contract shall be deemed to include all such items, which although are not specifically mentioned in the bid documents and/or in Bidder's proposal, but are required to make the equipment/system complete for its safe, efficient, reliable and trouble free operation.

2.3.1 Required number of Cassette type split AC units of 3TR capacity each complete with air cooled outdoor condensing unit having hermetically sealed compressor unit with cordless remote controller.

2.3.2 Required number of High wall type split AC units of 2TR capacity each complete with air cooled outdoor condensing unit having hermetically sealed compressor and high wall type indoor evaporator unit with cordless remote controller.

2.3.3 Copper refrigerant piping complete with insulation between the indoor and outdoor units as required.

2.3.4 First charge of refrigerant and oil shall be supplied with the unit.

2.3.5 GSS/Aluminium sheet air distribution ducting for distributing conditioned dehumidified air along with supply air diffusers and return air grilles with volume control dampers and necessary splitters etc., suitable fixtures for grilles/diffusers and supports for ducting complete with insulation.

2.3.6 Local start/stop facility for local starting/ stopping of all electrical equipment/ drives.

2.3.7 All instruments and local control panels alongwith controls and interlock arrangements and accessories as required for safe and trouble free operation of the units.

2.3.8 PVC drain piping from the indoor units upto the nearest drain point.

2.3.9 Supply and erection of Power and control cable and earthing.

2.3.10 MS Brackets for outdoor condensing units, condensers as required.

2.4 **Technical specifications.**

2.4.1 **Cassette type split AC units**.

The Cassette type AC units shall be complete with indoor evaporator unit,

outdoor condensing units and cordless remote control units.

2.4.1.1 Outdoor unit shall comprise of hermetically/ semi hermetically sealed compressors mounted on vibration isolators, fans and copper tube aluminium finned coils all assembled in a sheet metal casing. The casing and the total unit shall be properly treated and shall be weatherproof type. They shall be compact in size and shall have horizontal discharge of air.

2.4.1.2 Indoor units shall be of 4-way, ceiling mounted cassette type. The indoor unit shall be compact and shall have elegant appearance. They shall have low noise centrifugal blowers driven by suitable motors and copper tube aluminium finned cooling coils. Removable and washable polypropylene filters shall be provided. They shall be complete with multi function cordless remote control unit with special features like programmable timer, sleep mode etc.

2.4.1.3 Cooling capacity of 3TR AC units shall not be less than 36000btu/hr. and shall have energy efficiency rating of 5 star as on the date of NOA.

2.4.2 **High wall type split AC units**

2.4.2.1 The split AC units shall be complete with indoor evaporator unit, outdoor condensing units and cordless remote control units.

2.4.2.2 Outdoor unit shall comprise of hermetically/semi hermetically sealed compressors mounted on vibration isolators, propeller type axial flow fans and copper tube aluminium finned coils all assembled in a sheet metal casing. The casing and the total unit shall be properly treated and shall be weatherproof type. They shall be compact in size and shall have horizontal discharge of air.

2.4.2.3 The indoor units shall be high wall type. The indoor unit shall be compact and shall have elegant appearance. They shall have low noise centrifugal blowers driven by suitable motors and copper tube aluminium finned cooling coils. Removable and washable polypropylene filters shall be provided. They shall be complete with multi function cordless remote control unit with special features like programmable timer, sleep mode and soft dry mode etc.

2.4.2.4 Cooling capacity of 2TR AC units shall not be less than 22000btu/hr. and shall have energy efficiency rating of 5 star as on the date of NOA.

2.5 Controllers shall be provided in Local Control room inside GIS hall, one controller for each room, to control and monitoring of AC units and shall have the following facilities;

- Standby units shall come in to operation automatically when the running main unit fails
- Main and standby units shall be changed over periodically which shall be finalised during detailed engineering.
- Following alarms shall be provided:

  a. Compressor On/OFF condition of each unit
  b. Compressor failure of each unit
  c. Power OFF to AC unit
  d. High temperature in room.

2.6 **Warranty**

All compressors shall have minimum 5 years Warranty from the date of commissioning.

Ventilation system for GIS Hall

Each GIS Hall shall have an independent ventilation system. Each Ventilation system shall consist of two 100% capacity systems, one operating and one stand-by.

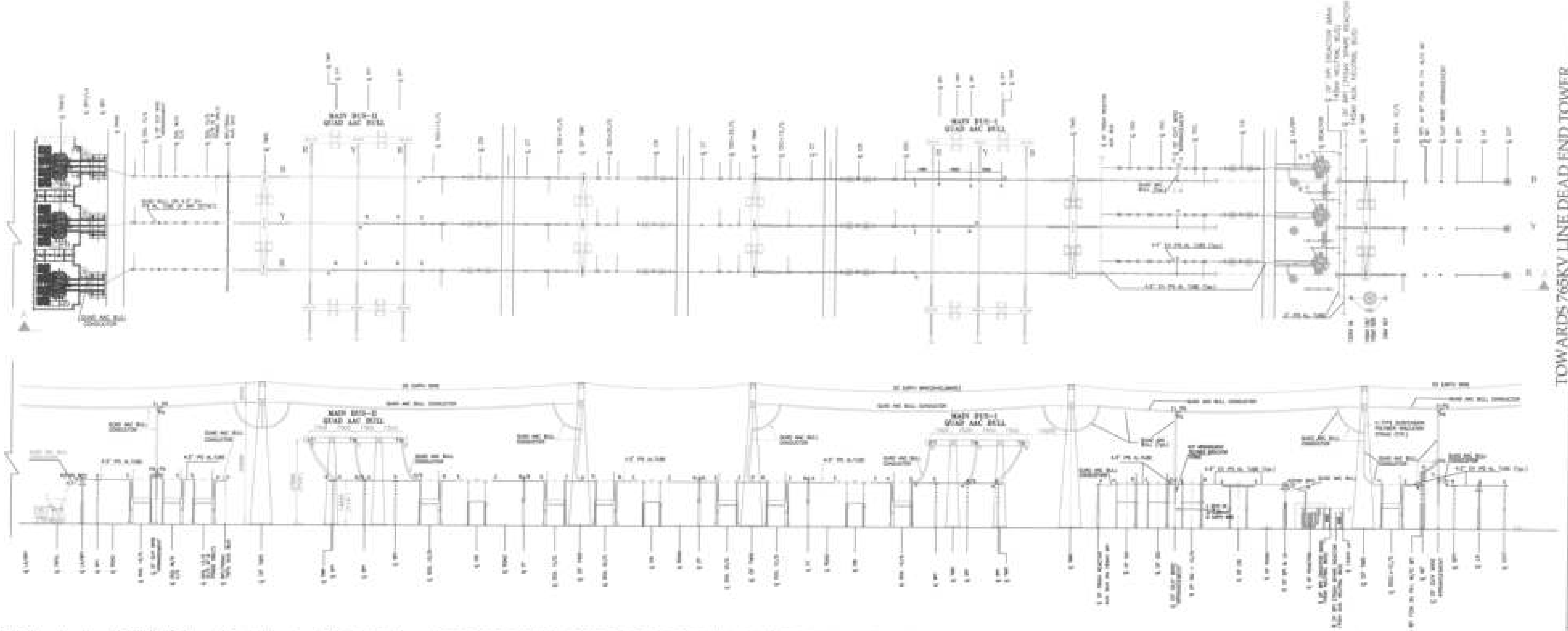
To ensure that the air being supplied to the GIS hall is free from dust particles, a minimum two stage dust filtration process shall be supplied. This shall consist of at least the following:

1. Pre Filters: To remove dust particles down to 10 micron in size with at least 95% efficiency.

2. Fine Filters: To remove dust particles down to 5 microns in size with at least 99% efficiency.

All the filters shall be panel type. Easy access should be available to the filters for replacement/cleaning.

The ventilation of the GIS hall shall be of a positive pressure type with minimum 2 air changes per hour. The pressure inside the GIS hall shall be maintained 5 mm of water above the atmospheric pressure. Fresh outdoor air shall be filtered before being blown into the GIS hall by the air fans to avoid dust accumulation on components present in the GIS hall. GIS hall shall be provided with motorized exhaust dampers with local control.



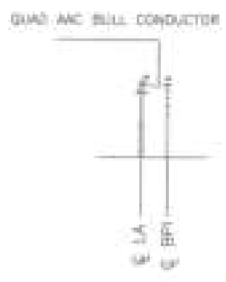
SECTION A–A (TYPICAL PLAN & SECTION FOR 765kV SIDE OF 765/400/33kV ICT –TIE–765kV LINE WITH LINE REACTOR BAY)

LEGENDS:

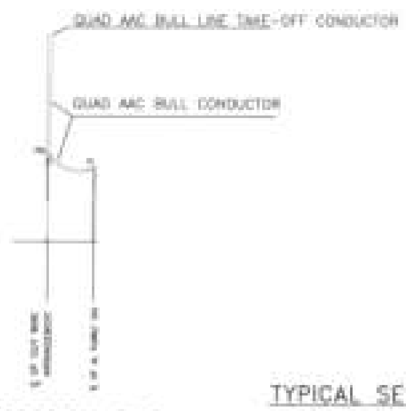
R– RIGID CONNECTION
E– EXPANSION TYPE CONNECTION
S– SLIDING TYPE CONNECTION
PG–PARALLEL GROOVE CONNECTION
T1– T1 TYPE CONNECTION (EACH T CONNECTOR SHALL BE OF TWIN TO TWIN CONDUCTOR TYPE FOR QUAD TO QUAD CONNECTION)
H– HORIZONTAL TYPE CONNECTION

NOTES:

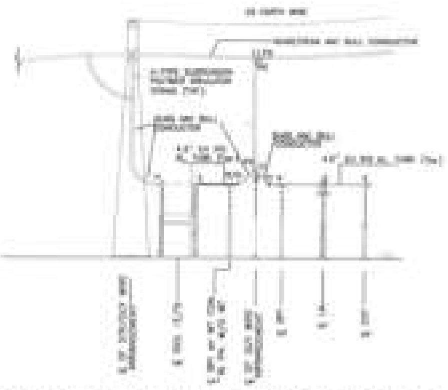
1) TWIN–TWIN CONNECTOR SHALL BE USED FOR QUAD–QUAD DROPPER CONNECTION.
2) AUXILIARY BUS ARRANGEMENT FOR 765kV TRANSFORMERS & REACTOR NEUTRALS, SPARE TRANSFORMER/REACTOR CONNECTION, TERTIARY ARRANGEMENT OF TRANSFORMERS ARE NOT SHOWN COMPLETELY.
3) CANTILEVER STRENGTH OF 765KV INSULATORS/BPI USED FOR 765KV ISOLATORS/WT SHALL BE OF 10KN AND FOR OTHER BPI IN SWITCHYARD SHALL BE OF 8KN MINIMUM.
4) HORIZONTAL TAKE–OFF OF JUMPERS AT EQUIPMENT LEVELS WITH ADEQUATE SAG SHALL BE PROVIDED



SECTION B–B



SECTION C–C



TYPICAL SECTION FOR 765KV LINE SIDE EUIPMENT CONNECTION ARRANGEMENT IN PHASE WITHOUT WT

GAUTAM SHARMA CDE (ENGG–S/S)	D.OJHA DGM (ENGG–S/S)	A.SAMBAIAH DGM (ENGG–S/S)	ABHAY KUMAR Sr. GM (ENGG–S/S)	P.K. DAS Sr.GM (ENGG–S/S)	RAJIL SRIVASTAVA CGM (ENGG–S/S)	R.N. SINGH ED (ENGG.–S/S,T/L & Civil)
PREPARED BY			REVIEWED BY			APPROVED BY

POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)

TITLE: CONCEPTUAL CONNECTION ARRANGEMENT OF 765KV TRANSFORMER BAY–TIE BAY– LINE WITH LINE REACTOR BAYS

DRAWING NO. C/ENGG/SS/CONCEPTUAL 765KV BAY CONNECTIONS

REV.1

SHORT CIRCUIT FORCES & SPACER SPAN FOR 765kV & 400kV GANTRY STRUCTURE

For new 765kV and 400 kV AIS switchyard with one & a half breaker switching scheme, three gantry type arrangement (i.e. arrangement having single gantry in Tie bay) shall be considered. Further, Short-Circuit Forces (SCF) for the design of Gantry Structure and spacer spans shall be as mentioned below:

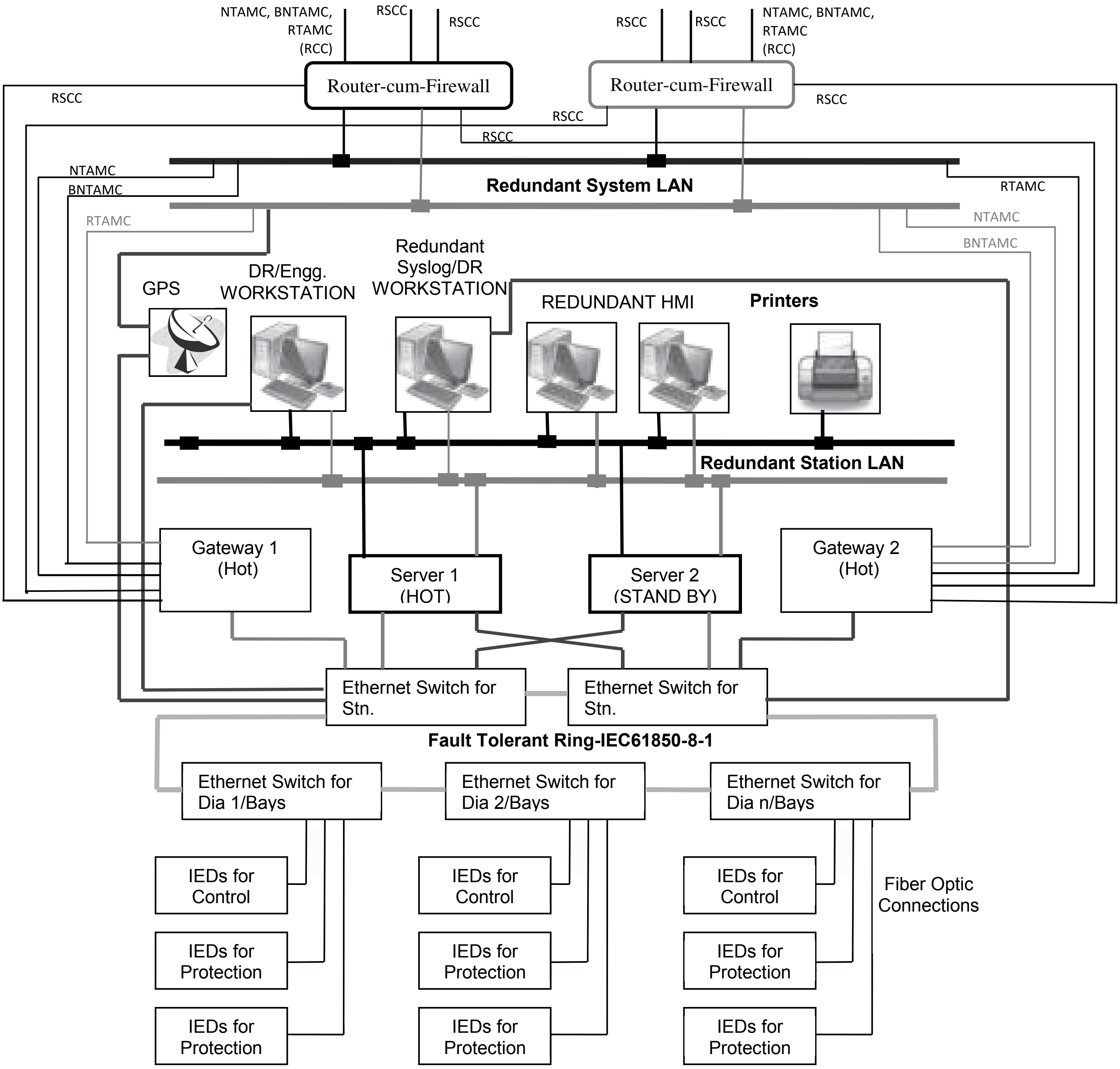
Voltage Level: 765kV, Fault Level: up to 50kA for 1 sec								
Bus Type	**Height of Bus (from FGL)**	**Max Span**	**Bus Conductor Configuration**	**Ph-Ph Spacing**	**Normal Tension per phase**	**SCF per phase**	**Spacer Span**	**Applicable Wind Speed**
Main Bus	27 Mtr	108 Mtr	Quad Bull	15Mtr	8T	9.75T	6Mtr	Upto 50m/s
Jack Bus	40 Mtr	140 Mtr		15Mtr	9.5T	11.26T	6Mtr	Upto 50m/s
Jack Bus	40 Mtr	114 Mtr		15Mtr	9.5T	11.10T	6Mtr	Upto 50m/s
Voltage Level: 400kV, Fault Level: up to 63kA for 1 sec, Bay Width : 24 Mtr								
Bus Type	**Height of Bus (from FGL)**	**Max Span**	**Bus Conductor Configuration**	**Ph-Ph Spacing**	**Normal Tension per phase**	**SCF per phase**	**Spacer Span**	**Applicable Wind Speed**
Main Bus	15mtr	72.0Mtr	Quad Bersimis	6.5mtr	5T	7.32T	4Mtr	Upto 50m/s
Jack Bus	23Mtr	75.0Mtr		6.5mtr	5T	7.36T	4Mtr	Upto 47m/s
Jack Bus	23Mtr	75.0Mtr		6.5mtr	5T	7.36T	3.5Mtr	Upto 50m/s
Jack Bus	23Mtr	59.0Mtr		6.5mtr	5T	7.12T	4Mtr	Upto 50m/s
Jack Bus	23Mtr	46.0Mtr		6.5mtr	4T	6.20T	4Mtr	Upto 50m/s

Above shall also be applicable for following cases unless otherwise specified elsewhere:

(i) Extension of 765kV switchyard with existing three gantry type arrangement
(ii) Extension of 400kV switchyard with existing three gantry type arrangement and having bus heights matching with above.

For design of gantry structures with spans, wind speed or conductor configurations other than that mentioned above, conductor tension shall be considered based on actual requirement of present & future scope of work. Relevant design calculations for such cases shall be submitted by the contractor for employer’s approval.

TYPICAL ARCHITECTURAL DRAWING OF SUBSTATION AUTOMATION SYSTEM (Without Process Bus) for New Substation



Note:

1. The redundant managed bus (station LAN) shall be realized by high speed optical bus using industrial grade components and shall be as per IEC 61850.
2. Inside the sub-station, all connections shall be realized as per IEC 61850 protocol.
3. For gateway, it shall communicate with Remote Supervisory Control Centre (RSCC) on IEC 60870-104 protocol. The number of ports required shall be as per clause no. 1.1 and 3.3 of this specification.
4. The printer as required shall be connected to station bus directly and can be managed either from station HMI, HMI view node or disturbance recorder work stations.
5. The above layout is typical. However if any contractor offers slightly modified architecture based on their standard practice without compromising the working, the same shall be subject to approval during detailed engineering.
6. RCC means NTAMC/RTAMC. Similarly, RSCC could be SLDC for state owned substations/bays.
7. Syslog server to be Linux based. However DR/Engg. PC workstation can be other Operating System.

SPECIFICATION FOR SWITCHES

Substation System LAN:

2 (two) nos. managed Ethernet switches with 16 copper 10/100 Mbps RJ45 ports on each switch shall be supplied to form redundant system LAN as shown in typical architecture drawing. These switches shall be different from IEC 61850 LAN and specifically used for the purpose of connecting various devices of different sub-systems (SCADA, VMS, VOIP etc.) for integration with NTAMC/RTAMC. These switches shall be suitable for substation environment and shall comply with the requirements of IEC 61850-3 standard for EMI/EMC.

These LAN switches shall have the following compliance and functional features:

(a) Compliance as per NERC-CIP-3, NERC-CIP-5. NERC-CIP-7 standard for cyber security
(b) Support SNMPv3 (Full SNMP support including Traps)
(c) Web based GUI or CLI based with HTTPS/HTTP and SSH/ Telnet support
(d) Support for IPv4 and IPv6 switching simultaneously
(e) Layer 3 Static routing functionality
(f) Syslog facility for local as well as remote server
(g) Support for remote management
(h) LED indication for port status/supply etc.
(i) Shall support VLAN IEEE 802.1Q
(j) IGMP snooping
(k) Spanning tree protocol IEEE 802.1d or RSTP IEEE 802.1w
(l) Shall support SNTP
(m) Port based Network Access Control (IEEE 802.1x)
(n) Quality of Service (IEEE 802.1p)
(o) Shall support unicast as well as multicast IP traffic
(p) SNTP time synchronization
(q) Shall support Mac Binding
(r) Fanless design

Annexure-S7

Technical Specification for Next Generation Firewalls (NGFW)

1. NGFW shall have following features including but not limited to:
   Encryption through IPSec VPN (Virtual Private Network), Deep Packet Inspection (DPI), Denial of service (DoS) & Distributed Denial of Service (DDoS) prevention, Port Block/ Allow, rules/ policies for block/allow, IP (Internet Protocol) & Media Access Control (MAC) spoofing protection, threat detection, Intrusion Prevention System (IPS), Anti-Virus, Anti-Spyware, Man In The Middle (MITM) attack prevention.

2. The proposed firewall shall be able to handle (alert, block or allow) unknown /unidentified applications e.g. unknown TCP & UDP packets. It shall have the provision to define application control list based on application group and/or list.

3. Firewall shall have feature and also have capability to update the definition/ Signatures of Anti-Virus online as well as offline. Firewall shall also be compatible to update the definitions/signatures through CMC. There shall be a defined process for security patching and firmware up-gradation. There shall be a feature to field validate firmware checksum. The same shall also be validated before using the OEM provided file/binary in the process of firmware up-gradation and security patching

4. Firewall shall have Management Console port to configure remotely.

5. Firewall shall be EMI/EMC compliant in Substation environment as per IEC 61850-3.

6. Firewall shall be rack mounted in existing standard equipment cabinets.

7. Firewall shall have support of SCADA applications (IEC-60870-5-104), ICCP, PMU (IEEE C37.118), Sub-Station Automation System (IEC 61850), Ethernet and other substation environment protocols.

8. Client based Encryption/ VPN must support different Operating System platforms e.g. Windows, Linux & Mac.

9. The solution must have content and comprehensive file detection policies, blocking the files as function of their types, protocols and directions.

10. Firewall shall have logging facility as per standard logs/events format. Firewall shall have features to export the generated/stored logs/events in csv (Comma Separated Value) and also any other standard formats for offline usage, analysis and compliance. Firewall shall have suitable memory architecture and solution to store and be enable to export all logs/events for a period of last 90 days at any given time.

11. Firewall shall have features and be compatible with local as well as central authentication system (RADIUS, LDAP, or TACACS+) for user account and access right management. It shall also have Role Based User management feature.

12. Firewall shall have the capability to configure sufficient number of VLANs.

13. Firewall shall have the capability to support sufficient number of sessions.

14. Firewall shall have provision to configure multiple IP Sec VPNs, at least 100 nos., (one-to-many or many-to-one). Shall support redundant operation with a similar router after creation of all the IP Sec VPN. IPSec VPN shall be with encryption protocols as AES128, AES256 and hashing algorithms as MD5 and SHA1. IPSec VPN throughput shall be at least 300 Mbps.

15. Firewall shall be capable of SNMP v3 for monitoring from Network Management system. It shall also have SNMPv3 encrypted authentication and access security.

16. Firewall shall operate in Active/Passive or Active-Active mode with High Availability features like load balancing, failover for firewall and IPsec VPN without losing the session connectivity.

17. Firewall should have integrated traffic shaping (bandwidth, allocation, prioritisation, etc.) functionality.

18. Shall support simultaneous operation with both IPv4 and IPv6 traffic.

19. Firewall shall be compatible with SNTP/NTP or any other standards for clock synchronization.

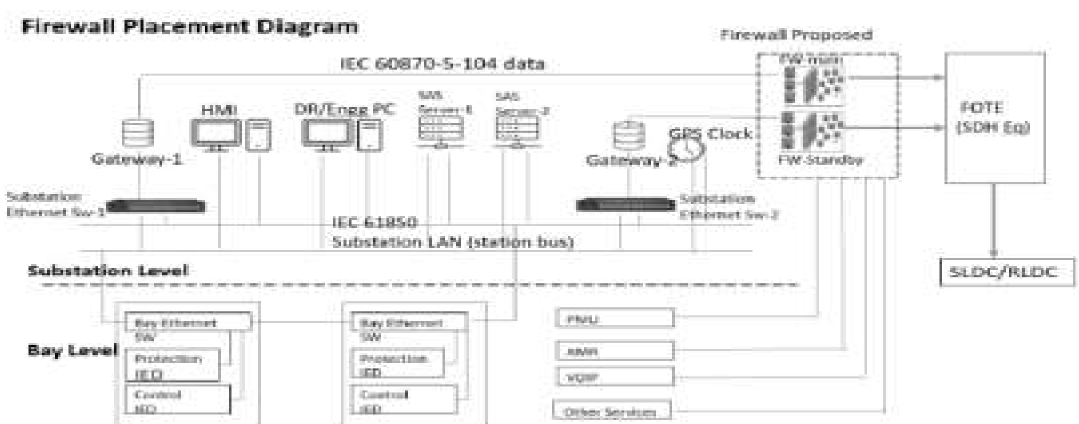
20. Firewall shall have the features of port as well as MAC based security.

21. Firewall shall support exporting of logs to a centralized log management system (e.g. syslog) for security event and information management.

22. Firewall time shall be kept synchronised to official Indian Timekeeping agency, time.nplindia.org.

23. Firewall product shall be provided with all applicable updates at least until 36 months since the applicable date of product shipping to the concerned utility.

Figure-I



SPECIFICATION FOR DIGITIAL PROTECTION COUPLER

1.0 Digital protection coupler for protection signalling through optical fibre cablesystem

1.1 The Digital protection signalling equipment is required to transfer the trip commands from one end of the line to the other end in the shortest possible time with adequate security and dependability. It shall also monitor the healthiness of the link from one end to the other and give alarms in case of any abnormality. The protection signalling equipment shall have a proven operating record in similar application over EHV systems and shall operate on 48V DC (+15%/-20%). It shall provide minimum four commands. These commands shall be suitable for Direct tripping, Intertripping and Blocking protection schemes of EHV lines.

The protection signalling equipment shall communicate to the remote end interfacing with SDH terminal equipment at its 2Mbps port. It shall provide suitable interfaces for protective relays, which operate at 220V DC. Power supply points shall be immune to electromagnetic interface

1.2 Principle of operation

During normal operation, protection signalling equipment shall transmit a guard signal/code. In case Protection signalling equipment is actuated by protective relays for transmission of commands, it shall interrupt the guard signal/code and shall transmit the command code to the remote end. The receiver shall recognize the command code and absence of the guard code and will generate the command to the protective relays.

All signal processing i.e. generation of tripping signal and the evaluation of the signals being received shall be performed completely digital using Digital Signal Processing techniques.

1.3 Loop testing

An automatic loop testing routine shall check the teleprotection channel.

It shall also be possible to initiate a loop test manually at any station by pressing a buttonon the front of the equipment.

Internal test routine shall continuously monitor the availability of the protection signaling equipment.

Proper tripping signal shall always take the priority over the test procedure.

The high speed digital protection signalling equipment shall be designed and provided with following feature.

- Shall work in conjunction with SDH terminal equipment.
- It shall communicate on G 703 (E1,2 Mbps)
- Full Duplex operation
- Auto loop facility shall be provided
- Shall meet IEC 60834-1 standard
- Shall be able to transmit upto 4 commands with trip counter simultaneouslyor sequentially in one 2Mbps channel

Bidder shall quote for protection signalling equipment suitable for 4 commands with separate trip counters for transmit and receive. With regard to trip counters alternate arrangement .i.e. Laptop along with software & all accessories to download eventsincluding carrier receipt and transmit shall be acceptable. Laptop for the above shall be supplied at each substation under substation package.

High security and dependability shall be ensured by the manufacturer. Probability of false tripping and failure to trip shall be minimum. Statistical curves/figures indicating above mentioned measures shall be submitted along with the bid.

The DPC can be either housed in offered Control & Protection Panel / PLCC Panel or in separate panel.

Reports of the following tests as per clause 9.2 of Section-GTR shall be submitted for approval for protection signalling equipment and relays associated with the protection signalling equipment and interface unit with protective relay units, if any.

i) **General equipment interface tests:-**

a) Insulated voltage withstand tests
b) Damped oscillatory waves disturbance test
c) Fast transient bursts disturbance test
d) Electrostatic discharge disturbance test
e) Radiated electromagnetic field test
f) RF Disturbance emission test

ii) **Specific power supply test**

a) Specific power supply test
b) Power supply variations
c) Interruptions
d) LF disturbance emission
e) Reverse polarity

iii) **Tele-protection system performance test:-**

a) Security
b) Dependability
c) Jitter
d) Recovery time
e) Transmission time
f) Alarm functions
g) Temperature and Humidity tests (As per IEC 68-2)
- Dry heat test (50°C for 8 hours
- Low temperature test (-5°C for 8 hours)
- Damp heat test (40°C/95%RH for 8 hours

All the above tests at i, ii & iii (except temperature & humidity tests) shall be as per IEC

60834-1 and the standards mentioned therein.

iv) **Relays**

a) Impulse voltage withstand test as per clause 6.1 of IS:8686 (for a test voltage appropriate to clause III as per clause 3.2 of IS:8686

b) High frequency disturbance test as per clause 5.2 of IS:8686 (for a test voltage appropriate to clause III as per clause 3.2 of IS:8686).

The protection signalling equipment shall be of modular construction and preferably mounted in the Relay panels. Cabling between the protection signalling equipment & Protection relays and between protection signalling equipment & Communication equipment shall be in the scope of bidder.

The input/output interface to the protection equipment shall be achieved by means of relays and the input/output rack wiring shall be carefully segregated from other shelf/cubicle wiring.

The isolation requirements of the protection interface shall be for 2kV rms.

1.4 Major technical Particulars

The major technical particulars of protection signalling equipment shall be as follow.

i) Power supply 48V DC +15% /-20%

ii) Number of commands 4 (four)

iii) Operating time <7 ms

iv) Back to back operate time without propagation delay ≤ 8 ms

v) Interface to Protection relays

Input: Contact Rating:

Rated voltage : 250
volts DCMaximum current rating: 5
amps

Output: Contact Rating:

Rated voltage : 250 volts DC
Rated current : 0.1 A DC
Other parameters : As per IEC-255-0-20

vi) Alarm contact

Rated voltage : 250 volts DC
Rated current : 0.1 A DC
Other parameters : As per IEC-255- 0-20

vii) Digital communication interface: G 703(E1

Technical Specification for Visual monitoring system for watch and ward of Substation premises:

Visual monitoring system (VMS) for effective watch and ward of sub station premises covering the areas of entire switchyard, Control Room cum Administrative building, Fire fighting pump house, stores and main gate, shall be provided. The contractor shall design, supply, erect, test and commission the complete system including cameras, Digital video recorder system, mounting arrangement for cameras, cables, LAN Switches, UPS and any other items/accessories required to complete the system. To provide all the necessary licenses to run the system successfully shall be in the scope of contractor.

System with Color IP Cameras for VMS surveillance would be located at various locations including indoor areas and outdoor switchyard and as per the direction of Engineer-In-Charge. The VMS data partly/completely shall be recorded (minimum for 15 days) and stored on network video recorder.

The number of cameras and their locations shall be decided in such a way that any location covered in the area can be scanned. The cameras shall be located in such a way to monitor at least:

1. The operation of each and every isolator pole of the complete yard in case of AIS Sub-station.

2. The Operation of each bay(s) of GIS Hall as Applicable.

3. All the Transformer and Reactors All the Entrance doors of Control Room Building and Fire-fighting Pump House, GIS Hall and Switchyard Panel room as applicable.

4. All the gates of switchyard.

5. Main entrance Gate

6. All other Major AIS Equipment (such as CB, CT, CVT, SA etc. as applicable)

   The cameras can be mounted on structures, buildings or any other suitable mounting arrangement to be provided by the contractor.

1.1 Technical requirements of major equipment of Visual Monitoring System.

1.1.1 The Video Monitoring system shall be an integrated system with IP network centric functional and management architecture aimed at providing high-speed manual/automatic operation for best performance.

1.1.2 The system should facilitate viewing of live and recorded images and controlling of all cameras by the authorized users.

1.1.3 The system shall use video signals from various types of indoor/outdoor CCD colour cameras installed at different locations, process them for viewing on workstations/monitors in the control Room and simultaneously record all the cameras after compression using **H 264/**MPEG 4 or better standard. Mouse/Joystick-Keyboard controllers shall be used for Pan, Tilt, Zoom, and other functions of desired cameras.

1.1.4 The System shall provide sufficient storage of all the camera recordings for a period of 15 days or more

@ 25 FPS, at 4 CIF or better quality using necessary compression techniques for all cameras. It shall be ensured that data once recorded shall not be altered by any means. The recording resolution and frame rate for each camera shall be user programmable.

1.1.5 The surveillance VMS System shall operate on 230 V, 50 Hz single-phase power supply. System shall have back up UPS power supply meeting the power supply need of all the cameras in the stations including those which are installed at gate for a period of 2 hours. The bidder shall submit the sizing calculation for the UPS considering the total load requirement of Video Monitoring System.

1.2 System requirements:

a) System must provide built-in facility of watermarking or Digital certificate to ensure tamperproof recording.

b) All cameras may be connected through a suitable LAN which shall be able to perform in 765kV class sub-station environment without fail.

c) All camera recordings shall have Camera ID & location/area of recording as well as date/time stamp. Camera ID, Location/Area of recording & date/time shall be programmable by the system administrator with User ID & Password.

d) Facility of camera recording in real-time mode (25 FPS)/15/12.5/10 or lower FPS as well as in any desired combination must be available in the system.

e) Facility of Camera recording in HD (1280X720p), D1 , 4CIF , CIF, VGA, as well as in any combination i.e. any camera can be recorded in any quality.

f) System to have facility of **100%** additional camera installation beyond the originally planned capacity.

g) In order to optimize the memory, while recording, video shall be compressed using H **264/**MPEG-4 or better standard and streamed over the IP network.

h) System shall be triplex i.e. it should provide facility of Viewing, Recording & Replay simultaneously.

i) The offered system shall have facility to export the desired portion of clipping (from a specific date/time to another specific date/time) on CD or DVD. Viewing of this recording shall be possible on standard PC using standard software like windows media player etc.

j) System shall have provision of WAN connectivity for remote monitoring.

k) The equipment should generally conform to Electro magnetic compatibility requirements for outdoor equipment in EHV switchyards. The major EMC required for Cameras and other equipment shall be as under:

1. Electrical Fast Transient (Level 4) – As per IEC 61000-4-4
2. Damped Oscillatory (1 MHz and 100 KHz) (level 3) – As per IEC 61000-4-18
3. AC Voltage Dips & Interruption/Variation (class 3) – As per IEC 61000-4-11
4. Electrostatic Discharge (Level 4) – As per IEC 61000-4-2
5. Power Frequency Magnetic Field (level 4) – As per IEC 61000-4-8
6. Ripple on DC input Power Supply Port immunity test(level 4) - As per IEC 61000-4-17

Type test reports to establish compliance with the above requirement shall be submitted during detailed engineering.

1.2.1 VIDEO SURVEILLANCE APPLICATION SOFTWARE

a) Digital video surveillance control software should be capable to display and manage the entire surveillance system. It should be capable of supporting variety of devices such as cameras, video encoder, Servers, NAS boxes/Raid backup device etc.

b) The software should have inbuilt facility to store configuration of encoders and cameras.

c) The software should Support flexible 1/2/4/8/16/32 Windows Split screen display mode and scroll mode on the PC monitor.

d) The software should be able to control all cameras i.e. PTZ control, Iris control, auto / manual focus, and color balance of camera, Selection of presets, Video tour selection etc.

e) The software should have user access authority configurable on per device or per device group basis. The system shall provide user activity log with user ID, time stamp, action performed, etc.

f) The users should be on a hierarchical basis as assigned by the administrator. The higher priority person can take control of cameras, which are already being controlled by a lower priority user.

g) It should have recording modes viz. continuous, manual, or programmed modes on date, time and camera-wise. All modes should be disabled and enabled using scheduled configuration. It should also be possible to search and replay the recorded images on date, time and camera-wise. It should provide onscreen controls for remote operation of PTZ cameras. It should have the facility for scheduled recording. Different recording speeds (fps) and resolution for each recording mode for each camera should be possible.

h) The software for clients should also be working on a browser based system for remote users. This will allow any authorized user to display the video of any desired camera on the monitor with full PTZ and associated controls.

i) Retrieval: The VMS application should allow retrieval of data instantaneously or any date / time interval chosen through search functionality of the application software. In case data is older than 15 days and available, the retrieval should be possible. The system should also allow for backup of specific data on any drives like DVD's or any other device in a format which can be replayed through a standard PC based software. Log of any such activity should be maintained by the system.

j) VMS shall provide the full functionality reporting tool which can provide reports for user login/logoff, camera accessibility report, server health check reports etc.

1.2.2 Network video recorder

The Network Video recorder shall include at least Server (min 3.0 GHZ, 4GB RAM, 3000GB HDD(min)), RAID 5 ,with suitable configuration along with Colored TFT 22" High resolution monitor, and Internal DVD writer. Windows XP/Vista/7 Prof. or VMS compatible operating system latest version with hardware like graphic cards, licensed Anti-virus etc.

Further the digital video recorder shall conform to the following requirements:

1.	Server Spec	Intel Quad Core (or better) 3.0 Ghz (min.) , 8 MB Cache , 4 GB memory , with suitable NVIDIA graphics card,3 TB HDD , Raid 5
2.	Recording and Display Frame Rate	Real-time 25 frames per second per channel , manual select

3.	Recording Resolution	(PAL): 1280X720 , 704(H) x 586(V) It should be possible to select lower resolutions
4.	Compression Method	H.264/MPEG-4 or better and latest
5.	Video Motion Detection Capable	Standard and built-in (selectable in menu)
6.	Monitoring Options	Split screen 1, 2, 4 , 8, 16, 32 or more cameras
7.	Playback Options	Search, still image capture
8.	Alarm/Event Recording Capable	To be provided with built-in external alarm input/ output ports minimum(8 in, 2 out)
9.	Network Operation Capable	To be provided by using WAN or LAN router
10.	Remote Internet Viewing Capable	Using WAN or LAN router
11.	HDD Storage Consumption	1GB ~ per hour / channel variable based on frame speed and resolution settings, as well as compression
12.	Operation	Triplex operation (simultaneous recording, playback, network operation)
13.	Number of Video Channel	32
14.	Audio Recording Capable	32
15.	Input Voltage	230V AC or equivalent with UPS as a back up for 30 minutes.

1.2.3 VMS Camera

a) The color IP camera for substation shall have PAN, TILT and ZOOM facilities so that it can be focused to the required location from the remote station through a controller. Whereas wireless IP cameras with PTZ controls are required for installation at gates of the POWERGRID premises as per the direction of Engineer-In-Charge

b) The IP Camera at the main gate can be fixed or PTZ based and shall be used for monitoring entry and exit

c) It should have sufficient range for viewing all the poles of isolators and other equipments with high degree of clarity.

d) The VMS camera shall be suitable for wall mounting, ceiling mounting and switchyard structure mounting.

e) It shall be possible to define at 128 selectable preset locations so that the camera gets automatically focused on selection of the location for viewing a predefined location.

f) The camera should be able to detect motion in day & night environments having light intensity of Color: 0.5 Lux; B&W:0.05 Lux

g) Housing of cameras meant for indoor use shall be of IP 42 or better rating whereas outdoor camera housing shall be of IP 66 or better rating. Housing shall be robust and not have the effect of electromagnetic induction in 765/400KV switchyard.

h) All camera recordings shall have Camera ID & location/area of recording as well as date/time stamp. Camera ID, Location/Area of recording & date/time shall be programmable by the system administrator with User ID & Password

i) Facility of camera recording in real-time mode (25 FPS)/15/12.5/10 or lower FPS as well as in any desired combination must be available in the system.

A. Outdoor IP Fixed Megapixel Camera Specifications (For Main Gate)

1.	Image Sensor	2-megapixel Progressive ,1 / 3" CMOS/CCD sensor, Minimum illumination 0.1 Lux
2.	Min Luminous	0.5LUX(Color) 0.05Lux(Black)
3.	Camera Enclosure Type	IP66 Grade
4.	Iris/Focus	Auto/Manual
5.	Video Compression	Dual Stream H.264 and MPEG 4 user selectable
6.	Support Dual-stream	primary/secondary stream, H.264/MPEG 4 optional
7.	Video Definition	Primary stream:1600x1200,1280x960,1280x720, Secondary stream:800x600,400x288,192x144
8.	Video Parameters	Brightness, hue, contrast, saturation and image quality
9.	Video Frame Rate	PAL: 1-25frames/second NTSC:1-30frames/second
10.	Video Compression BR	32Kbit/S - 6Mbit/S
11.	Video Output	One channel composite Streaming
12.	Supported Protocols	TCP, UDP, IP, HTTP, FTP, SMTP, DHCP, DNS,ARP, ICMP, POP3, NTP, IPsec, UpnP, RTP, RTCP
13.	Operating Temperature	-5 ~ +50℃
14.	Operating Humidity	10 ~ 90%

B. Outdoor IP66 PTZ HD Camera Specifications (For Switch Yards)

1.	Image sensor	1/3 type Solid State Progressive Scan CCD,WDR(High Definition)
2.	Security	Multiple user access with password protection
3.	Effective Pixels	**(PAL): Main Stream：1280x720** Sub Stream：640x360、320x280 selectable
4.	Compression	Dual Stream H.264 and MPEG 4 user selectable
5.	Signal System	50 Hz
6.	S/N (signal to noise) Ratio	Better than 50 dB
7.	Electronic Shutter	1/60 ~ 1/10,000 sec. automatic or better
8.	Scanning System	Progressive/interlace
9.	Low Light Sensitivity (lux)	Color: 0.5 Lux; B&W:0.02 Lux
10.	Lens	Minimum 10x (minimum) optical in High Definition (**The system shall be able to zoom the images on the monitor without any distortion to the maximum level of optical zoom)**
11.	Lens Size	Minimum 4.1~73.8 mm
12.	Lens Aperture	F1.6(wide)~F2.8(tele), f=4.1~41.0mm, 10X Zoom, Video Auto Focus Angle of View Horizontal : 52°(wide) , 2.8°(tele)
13.	PTZ Data Transfer Baud/Bit Rates Supported	Selectable 2400 bps / 4800 bps / 9600 bps

14.	Panning Range	Complete 360 degrees (horizontal)
15.	Pan Speed	Adjustable, 0.1 degrees / second ~ 250 degrees / second
16.	Tilting Range	Minimum 180° Tilt Rotation
17.	Tilt Speed	Adjustable, 0.1 degrees / second ~ 150 degrees / second
18.	In Built Storage	Camera should have inbuilt storage TF or SD format for recording and storing Pictures
19.	IP Class	IP66 Standard
20.	Working temperature	-0℃ ~ +50℃
21.	Working Humidity	10 ~ 90%

1.2.4 PTZ-Keyboards

The features of PTZ shall include:

- Fully functional dynamic keyboard/joystick controllers
- Controls all pan, tilt, zoom, iris, preset functions
- Control up to 255 units from a single keyboard
- Many preset options and advanced tour programming
- Compatible with all connected cameras

1.	Key Application	wired keyboard control operation of PTZ functions for weatherproof dome cameras
2.	Pan / Tilt / Zoom Protocol Languages Supported	Selectable
3.	PTZ Data Transfer Baud Rates Supported	selectable 1200 bps / 2400 bps / 4800 bps / 9600 bps
4.	Additional Features	dynamic joystick for smooth camera movements, preset location option for quick access to frequently monitored areas

TECHNICAL SPECIFICATION
SECTION: SWITCHGEAR-CB
REVISION-11

<u>Summary of major changes made in this revision w.r.t earlier Technical Specification, Section: Switchgear, Chapter-CB, Rev.10A</u> & <u>Section: Switchgear, Chapter 765kV CB, Rev.02</u>

1) Technical specification, Section: Switchgear, Chapter 765kV CB, Rev.02 and Section: Switchgear, Chapter CB, Rev.10A are merged to prepare this combined technical specification section up to 765kV CB.

2) All 765kV & 400kV Circuit Breaker control schematics shall be finalized in such a way, that it may operate with or without CSD (refer clause 1.6)

3) Some duty requirements parameters added/modified (refer clause 2.0)

4) SF6 gas for main CBs shall be supplied in returnable cylinders (refer clause 5.0)

5) Insulators for Circuit breakers can be of Porcelain/polymer type (refer clause 6.0)

6) Included Indicative platform & ladder drawing for 400kV&765kV CB (refer clause 9.0)

7) Included Plug-in type arrangement for termination of inter pole cables (refer clause 11.0)

8) Included Technical parameters for 72.5kV CB (refer clause 16.0)

9) Some parameters like dielectric, creepage, seismic requirement etc w.r.t CBs are included (refer clause 16.0)

10) Included Actions required for defects observed during defect liability period (refer clause 18.0)

Note:

Changes made in this document are shown with bold letters, further major changes are listed above; however for complete details of changes, please refer the complete technical specification, Section: Switchgear-CB, REV.11

SECTION: SWITCHGEAR–CB (CIRCUIT BREAKER)

CONTENTS

SECTION: SWITCHGEAR–CB (CIRCUIT BREAKER)

1.0 GENERAL

1.1 The circuit breakers and accessories shall conform to IEC: 62271-100, IEC: 62271-1 and other relevant IEC standards except to the extent explicitly modified in the specification and shall also be in accordance with requirements specified in Section-GTR.

1.2 800/420/245/145/**72.5**kV circuit breakers offered would be of sulphur hexafluoride (SF6) type and of class C2-M2 as per IEC. The bidder may offer circuit breakers of either live tank type or dead tank type of proven design.

1.3 The circuit breaker shall be complete with operating mechanism, **common marshalling box**, piping, inter-pole cables, cable accessories like glands, terminal blocks, marking ferrules, lugs, pressure gauges, density monitors (with graduated scale), galvanised support structure, **platform with ladder** for CB, their foundation bolts and all other accessories required for carrying out all the functions of the CB.

All necessary parts to provide a complete and operable circuit breaker installation such as terminal pads, control parts and other devices shall be provided.

1.4 Painting shall be done in line with Section – GTR. **Paint shade RAL-7032** or similar shades can be used for painting. The support structure, **platform & ladder** of circuit breaker shall be hot dip galvanised. Exposed hardware items shall be hot dip galvanised or Electro-galvanised.

1.5 The circuit breakers shall be designed for use in the geographic and meteorological conditions as given in Section-**Project**.

1.6 **All 765kV & 400kV Circuit Breaker control schematics shall be finalized in such a way, that it may operate with or without CSD by using a suitable selector switch irrespective of whether circuit breakers to be supplied are envisaged along with CSD or not as per bid price schedules.**

2.0 DUTY REQUIREMENTS

2.1 The circuit breakers shall be capable of performing their duties without opening resistors.

2.2 The circuit breaker shall meet the duty requirements for any type of fault or fault location **and** also for line switching when used on effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.

2.2.1 PRE-INSERTION RESISTER

800kV & 420kV circuit breakers shall be provided with single step pre-insertion closing resistors **(wherever the requirement of PIR is explicitly specified in bid price schedules)** to limit the switching surges. The resistance value of pre-insertion resistor and the duration of pre-insertion time **is** given in clause **16.0** of this section. The resistor shall have thermal rating for the following duties:

i) TERMINAL FAULT

Close .... 1 Min .... Open Close Open…..2 min ..... Close ..... 1 Min .... Open Close Open.

ii) RECLOSING AGAINST TRAPPED CHARGES

Duty shall be the same as under (i) above. The first, third and fourth closures are to be on de - energised line while second closing is to be made with lines against trapped charge of 1.2 p.u. of opposite polarity.

iii) OUT OF PHASE CLOSING

One closing operation under phase opposition, that is with twice the voltage across the terminals.

iv) No allowance shall be made for heat dissipation of resistor during time interval between successive closing operations. The resistors and resistor supports shall perform all these duties without deterioration. Test reports of resistors proving thermal rating for duties specified above shall be furnished during detailed engineering. The calculations shall be provided to take care of the effect of tolerances on resistance values and-insertion time.

2.3 The breaker shall be capable of:

i) Interrupting the steady and transient magnetizing current corresponding to Power transformers as follows:

Voltage rating of CB	Type of Transformer	Rating (in MVA)
800kV	765/400kV	250 to 1500
420kV	765/400kV	250 to 1500
	400/220kV	250 to 630
	400/132kV	160 to 315
245kV	400/220kV	200 to 630
	220/132kV	50 to 200

	220/66kV	**50 to 200**
145kV	**220/132kV**	**50 to 200**
	132/33kV	**10 to 50**

ii) Interrupting line/cable charging current as per IEC without use of opening resistors. **The breaker shall be able to interrupt the rated line charging current as per IEC-62271-100 with test voltage immediately before opening equal to the product of U/√3 and 1.4**

iii) Clearing short line fault (kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.

iii) Breaking 25% of the rated fault current at twice rated voltage under phase opposition condition.

iv) Withstanding all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. shall be designed for 2 p.u. across the breaker continuously, for validation of which a power frequency withstand test conducted for a duration of at least 15 minutes is acceptable).

v) Circuit breakers shall be able to switch in and out the shunt reactor as detailed below:

Voltage rating of CB	**Reactor Rating (in MVAR)**	**Max. rise of over voltage (in p.u.)**
800kV	**150 to 330**	**1.9**
420kV	**50 to 150**	**2.3**
245kV	**25 to 50**	**2.3**

a. Capability of 400 kV circuit breakers to interrupt inductive current below 100 A without giving rise to overvoltage more than 2.3 p.u. (As specified in IEC-62271-110) shall be validated by carrying out the simulation study/analysis (EMTP/PSCAD) by modeling an equivalent circuit comprising all circuit component i.e. Inductance of Shunt Reactor, Stray capacitance of Shunt Reactor, Circuit Breaker, Stray capacitance of Bus Connection, Capacitance of grading Capacitor, inductance of neutral grounding reactor, Network Thevenin's equivalent, any other series/parallel inductance/capacitance connected to simulate the actual inductive load switching.

b. **Current chopping capability (chopping number) of circuit breaker as per IEC-62271-306 to be figured out from actual Laboratory test and / or field test report and same Current chopping capability (chopping number) shall be used in above said simulation study/analysis.**

c. **To validate the results of above said simulation study/analysis report, the same study shall be carried out for capability of tested circuit breaker and the study/analysis results shall be comparable with actual Laboratory test and / or field test reports.**

d. **Laboratory test/ field test reports shall be submitted for 400 kV CBs in case there is change in design including change in following:**
   i. **Different short circuit current capability**
   ii. **Different model/type**

vi) The breakers shall also withstand the voltages specified under clause **16.0** of this section.

2.6 CONTROLLED SWITCHING DEVICE (CSD) :

Circuit Breakers shall be equipped with controlled switching **device** with consequent optimization of switching behavior, when used in:

- Switching of transformer **(from 765kV and 400kV side circuit breakers only)**
- Switching of shunt Reactor

The CSD shall be provided in Circuit breaker of switchable line reactor **bay** and in Main & Tie **bay** circuit breakers of Transformers, line with non-switchable line reactors and Bus reactors. **The CSD shall be supplied as per bid price schedules.**

2.6.1 Technical Requirement for controlled switching device:

a) The CSD shall be designed to operate correctly and satisfactorily with the excursion of auxiliary A/C & DC voltages and frequency as specified in section - GTR.

b) The CSD shall meet the requirements **of IEC-61000-4-16 class IV** for HF disturbance test **(for short and long durations both)** and fast transient test shall be as per **IEC-61000-4-4 level IV** and insulation test as per IEC 60255–5.

c) The CSD shall have functions for switching ON & OFF the circuit breakers.

d) The CSD shall get command to operate the breakers manually. The controller shall be able to analyze the current and voltage waves available through the signals from secondaries of CTs & CVTs for the purpose of calculation of optimum moment of the switching the circuit breaker and issue command to circuit breaker to operate.

e) The CSD shall also have an adaptive control feature to consider the next operating time of the breaker in calculation of optimum time of issuing the switching command. In calculation of next operating time of the breaker, the CSD must consider all factors that may affect the operating time of the breaker such as, but not limited to, ambient temperature, control voltage variation, SF6 gas density variations etc. Schematic drawing for this purpose shall be provided by the contractor. The accuracy of the operating time estimation by the controller shall be better than **± 0.5 ms.**

f) The CSD should have display facility at the front for the display of settings and measured values.

g) The CSD shall be PC compatible for the setting of various parameters and down loading of the settings and measured values, date, time of switching etc. Window based software for this purpose shall be supplied by the contractor to be used on the owner's PC.

h) The controller shall be suitable for current input of 1 ampere from the secondary of the CTs. and 110 V (Ph to Ph) from the CVTs. The CSD shall **withstand** transient and dynamic state values of the current from the secondary of the CTs and CVTs.

i) The CSD shall have time setting resolution of 0.1 ms or better.

j) The CSD shall have sufficient number of output/input potential free contacts for connecting the monitoring equipment and annunciation system available in the control room. Necessary details shall be worked out during engineering of the scheme.

k) The CSD shall also record and monitor the switching operations and make adjustments to the switching instants to optimize the switching behavior as necessary. It shall provide self-diagnostic facilities, signaling of alarms and enable downloading of data captured from the switching events.

l) The provision for bypassing the Controlled switching device shall be provided through BCU and SCADA both **so that whenever, the CSD is not healthy due to any reason (including auxiliary supply failure), uncontrolled trip/close command can be extended to the circuit**

Breaker. Alternatively, in case of any non-operation of the CSD after receiving a close/trip command after a pre-determined time delay, the CSD should automatically be bypassed so as to ensure that the trip and close commands are extended to the Trip/Close coils **through subsequent command.**

m) **The CSD shall be provided with a communication port to facilitate online communication of the CSD with Substation automation system directly on IEC 61850 protocols. If the CSD does not meet the protocols of IEC 61850, suitable gateway shall be provided to enable the communication of CSD as per IEC 61850.**

3.0 TOTAL BREAK TIME

3.1 The total break time as specified under this section shall not be exceeded under any of the following duties:

i) Test duties T10, T30, T60, T100a, and T100s (with TRV as per IEC: 62271-100)

ii) Short line fault L75, L90 (with TRV as per IEC: 62271-100)

3.2 The total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage (70-110%), arc extinguishing medium pressure etc. While furnishing the proof of the total break time of complete circuit breaker, the effect of non-simultaneity between contacts within a pole or between poles **shall be brought out to establish** guaranteed total break time.

3.3 The values guaranteed shall be supported with the type test reports.

4.0 CONSTRUCTIONAL FEATURES

The features and constructional details of circuit breakers shall be in accordance with requirements stated hereunder:

4.1 Contacts

4.1.1 The gap between the open contacts shall be such that it can withstand at least the rated phase to ground voltage for 8 hours at zero gauge pressure of SF6 gas due to the leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. 2 p.u. across the breaker continuously, for validation of which a power frequency dielectric with stand test conducted for a duration of at least 15 minutes is acceptable).

4.2 If multi-break interrupters are used, these shall be so designed and augmented that a uniform voltage distribution is developed across them. Calculations/

test reports in support of the same shall be furnished. The thermal and voltage withstand rating of the grading elements shall be adequate for the service conditions and duty specified.

4.3 The SF6 Circuit Breaker shall meet the following additional requirements:

a) The circuit breaker shall be single pressure type. The design and construction of the circuit breaker shall be such that there is a minimum possibility of gas leakage and entry of moisture. There should not be any condensation of SF6 gas on the internal insulating surfaces of the circuit breaker.

b) All gasketted surfaces shall be smooth, straight and reinforced, if necessary, to minimise distortion and to make a tight seal, the operating rod connecting the operating mechanism to the arc chamber (SF6 media) shall have adequate seals. The SF6 gas leakage should not exceed 0.5% per year and the leakage rate shall be guaranteed **during the warrantee period**. In case the leakage under the specified conditions is found to be greater than 0.5% **per** year **after** commissioning of circuit breaker **during the warrantee period**, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during **the warrantee period**.

c) In the interrupter assembly there shall be an absorbing product box to minimise the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be fully compatible with SF6 gas decomposition products.

d) Each pole shall form an enclosure filled with SF6 gas independent of two other poles (for 800, 420 & 245 kV CBs) and the SF6 density of each pole shall be monitored individually. For CBs of voltage class of 145 kV or less, a common SF6 scheme/density monitor shall be acceptable.

e) The dial type SF6 density monitor shall be adequately temperature compensated to model the pressure changes due to variations in ambient temperature within the body of circuit breaker as a whole. **Separate density monitor and dial type temperature compensated pressure guage is also acceptable.** The density monitor shall have graduated scale and it shall be possible to dismantle the density monitor for checking/replacement without draining the SF6 gas by providing suitable interlocked non return valve coupling.

f) Circuit Breaker shall be capable of withstanding a vacuum of minimum 8 millibars without distortion or failure of any part.

g) Sufficient SF6 gas **(including that will be required for gas analysis during filling)** shall be provided to fill all the circuit breakers **being supplied.** Spare gas shall be supplied in separate unused cylinders as per requirement specified in **BPS.**

4.4 Provisions shall be made for attaching an operational analyser to record contact travel, speed and making measurement of operating timings, pre insertion timings of closing resisters if used, synchronisation of contacts in one pole.

4.5 **The CO (Close-open) operation and its timing shall be such as to ensure complete travel/insertion of the contact during closing operation and then follow the opening operation.**

5.0 SULPHUR HEXAFLUORIDE GAS (SF6 GAS)

a) The SF6 gas shall comply with IEC 60376 and shall be suitable in all respects for use in the switchgear under the operating conditions.

b) The high pressure cylinders in which the SF6 gas is shipped and stored at site shall comply with requirements of the relevant standards and regulations. **SF6 gas shall be supplied (in returnable cylinders) for all circuit breakers. However, SF6 gas for spare circuit breakers and mandatory spare quantity of SF6 gas shall be supplied in non-returnable cylinders.**

c) Test: SF6 gas shall be tested for purity, dew point, air, **hydro-soluble** fluorides and water content as per IEC 60376 and test certificates shall be furnished to Employer indicating all the tests as per IEC 60376 for each lot of SF6 gas and Material safety datasheet shall be provided. Gas bottles should be checked for leakage during receipt at site.

6.0 INSULATORS

a) The porcelain**/polymer** of the insulators shall conform to the requirements stipulated under Section-GTR.

b) The mechanical characteristics of insulators shall match with the requirements specified under this section.

c) All **porcelain & polymer** hollow **column** insulators shall conform to IEC-62155 & **IEC-61462 respectively.**

d) Hollow Porcelain**/polymer** for pressurised columns/chambers should be in one integral piece in green and fired stage.

7.0 SPARE PARTS AND MAINTENANCE EQUIPMENT

The bidder shall include in his proposal, spare parts and maintenance equipment in accordance with BPS. Calibration certificates of each maintenance equipment shall be supplied along with the equipment.

8.0 OPERATING MECHANISM AND CONTROL

8.1 General Requirements

8.1.1 **Circuit breaker shall be operated by spring charged mechanism. The mechanism box shall meet the requirements of IP-55.**

8.1.2 The operating mechanism **box** shall be strong, rigid, **rebound free and shall be readily accessible for maintenance**.

8.1.3 The mechanism shall be anti-pumping and trip free under every method of closing.

8.1.4 The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause **unwanted** trip or closing operation of the Circuit Breaker

8.1.5 A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided in the **common marshalling box**.

8.1.6 Working parts of the mechanism shall be of corrosion resisting material, bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing adjustment with repeated operation of the breaker.

8.1.7 The **contractor** shall furnish detailed operation and maintenance manual of the mechanism alongwith the operation manual for the circuit breaker. The instruction manuals shall contain exploded diagrams with complete storage, handling, erection, commissioning, troubleshooting, servicing and overhauling instructions.

8.1.8 Size of common marshalling Box shall be such that adequate space is available for working in the panel and all wiring shall be routed through non-inflammable wire troughs with covers.

8.1.9 Space shall be available in 765kV CB common marshalling box to mount monitoring device, of about 300x300x150mm size and of approximately 7kg weight, by the owner in future.

8.1.10 Operating mechanism and Marshalling box should be provided with space heater with thermostat, CFL/LED lamp and AC point /Socket.

8.2 **Control:**

8.2.1 The close and trip circuits shall be designed to permit use of momentary contact switches and push buttons.

8.2.2 Each breaker shall be provided with two (2) independent tripping circuits, pressure switches and coils each to be fed from separate DC sources.

8.2.3 The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose a local/remote selector switch and close and trip control switch/push buttons shall be provided in the Breaker **common marshalling box**.

8.2.4 The trip coils shall be suitable for trip circuit supervision during both open and close position of breaker.

8.2.5 Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip coil and associated circuits shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage. However, even at 50% of rated voltage the breaker shall be able to open. If additional elements are introduced in the trip coil circuit their successful operation and reliability for similar applications on outdoor circuit breakers shall be clearly brought out during detailed engineering.

8.2.6 The 765kV kV, 3-Phase circuit breakers suitable for single phase switching shall be suitable for taking a spare pole into service in case of any operational requirement and their marshalling box shall be suitable for accommodating the additional relays etc. required for changeover arrangement of all contacts, alarms, signals, indications, interlocks and lockouts.

8.2.7 In trip and closing circuits, relays/relay contacts shall preferably be used instead of contactors.

8.2.8 Controlled switching scheme/device, wherever required shall be considered as integral part of CB and shall be commissioned along with CB.

8.2.9 Density Monitor contacts and pressure switch contacts shall be **preferably** suitable for direct use as permissive in closing and tripping circuits. **The devices shall provide continuous & automatic monitoring of the state of the gas as follows:**

a) 'Gas Refill' level

This contact will be used for remote indication/ to annunciate the need for gas refilling.

b) 'SF6 gas density Low' Alarm level - 1
This contact will be used for remote indication/ to annunciate the need for the urgent gas refilling.

c) 'SF6 gas density Low' Alarm level - 2
This contact will be used to annunciate the need for gas refilling under emergency or trip the Circuit Breaker.

d) 'Breaker Block' level
This is the minimum gas density at which the manufacturer will guarantee the rated fault interrupting capability of the breaker. At this level the breaker block contact shall operate & the tripping & closing circuit shall be blocked.

It shall be possible to test all gas monitoring relays/devices without de-energizing the primary equipment & without reducing pressure in the main section. Plugs & sockets shall be used for test purposes. It shall also damp the pressure pulsation while filling the gas in service, so that flickering of the pressure switch contacts does not take place.

The density monitor shall be placed suitably inclined in such a way so that the readings are visible from ground level with or without using binoculars. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail safe logic/schemes are to be employed. DC supplies for all auxiliary circuits shall be monitored and provision shall be made for remote annunciations and operation lockout in case of D.C. failures. Density monitors are to be so mounted that the contacts do not change on vibration during operation of circuit Breaker.

8.2.10 The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

8.3 **Spring operated mechanism:**

a) Spring operated mechanism shall be complete with motor **as per manufacturer practice**. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.

b) As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.

c) After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.

d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it requires not more than 30 seconds for full charging of the closing spring.

e) Closing action of circuit breaker shall compress the opening spring ready for tripping.

f) When closing springs are discharged after closing a breaker, closing springs shall be automatically charged for the next operation and an indication of this shall be provided in the local and remote control cabinet.

g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition. Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is already in the closed position.

h) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

i) **The spring charging failure alarm shall be provided with a time delay relay having setting range from 0-1minute.**

j) **Separate MCBs shall be provided for each spring charging motor and the rating of MCBs shall be suitably selected to match the starting, running and stalling time.**

k) **An overload relay shall be provided for protection of the spring charging motor.**

9.0 SUPPORT STRUCTURE

a) The structure design shall be such that during operation of circuit breaker vibrations are reduced to minimum.

b) **Ladder and Maintenance platform for 400kV and 765kV Circuit breaker:**

A suitable ladder with the safety cage and a free standing maintenance platform with railing for each pole of the circuit breaker shall be supplied along with the equipment and it's support structure. The platform shall be suitable for maintenance personnel to stand and carryout the activities along with the tools and plant. The ladder cum maintenance platform shall be designed as a free standing structure without taking any support from the main circuit breaker structure. The ladder having height more than 3.0m shall have at least 15 degree slope and is to be provided with safety guard above 2.0m level. All structural steel for the platform shall be as per IS: 2062 and to be galvanized. An indicative drawing of ladder and platform (Drg.Ref.: C-ENGG-IND.DWG-PLATFORM-CB, Rev.0) is added at page 27 of 27 with this specification for guidance which may be modified to suit the requirement of CB by CB manufacturer. However, the minimum size of the structural members shall be maintained as mentioned in the drawing.

c) **For 220kV, 132kV & 66kV circuit breakers a suitable platform cum ladder shall be provided as per manufacturer design.**

10.0 TERMINAL CONNECTOR PAD

The circuit breaker terminal pads shall be made up of high quality electrolytic copper or aluminium and shall be conforming to Australian Standard AS-2935 **or equivalent standard** for rated current. The terminal pad shall have protective covers which shall be removed before interconnections.

11.0 INTER-POLE CABLING

11.1 All cables to be used by contractor shall be armoured and shall be as per IS – 1554/ IEC-60502 (1100 Volts Grade). All cables within & between circuit breaker poles and its marshaling box and up to the controlled switching device is included in the scope of work. Special cables like screened cable if required for Circuit Breaker, **temperature Transducer/CB Status Signals for CSD** and its associated C&R panel shall be laid in 50mm diameter PVC pipe. Suitable supports for PVC pipe shall be included in the scope of Supply.

11.2 Only stranded conductor shall be used. Minimum size of the conductor for inter-pole control wiring shall be 1.5 sq.mm. Copper.

11.3 The cables shall be with oxygen index Minimum 29 and temperature index as $250^{O}C$ as per relevant standards.

11.4 **Separate cables shall be used for AC, DC-I, DC-II and selected DC.**

11.5 **All inter-pole cabling of Circuit breakers and up to common marshalling box shall be done by plug-in type arrangement. Suitable removable type**

encasing cover shall be provided in case plug-in type connection arrangement is provided exterior side of LCC/MB. The plug-in type cable termination shall be conforming to IP-67 as per IEC60529. Cable sealing arrangement shall be provided (as per requirement) to avoid entry of moisture etc.

11.6 **Vertical run of cables to the operating mechanism box shall be properly supported by providing the perforated closed type galvanized cable tray (Cable tray also to be supplied along with the Circuit Breaker) to be fixed as an integral part of the structures. The load of the cable shall not be transferred to the mechanism box/plug-in type terminal arrangement in any circumstances. Hanging or loose run of cable is not permitted. The drawing of cable tray including fixing arrangement shall be incorporated in the GA drawing of CB also.**

11.7 **Wiring** shall be done with stud type terminals and ring type lugs. More than two wires shall not be connected on each side of terminal.

12.0 FITTINGS AND ACCESSORIES

12.1 Following is **list of** some of the major fittings and accessories to be furnished by Contractor in the **common marshalling box**. Number and exact location of these parts shall be indicated **in the drawing**.

i) Cable glands (Double compression type), Lugs, Ferrules etc.

ii) Local/remote changeover switch.

iii) Operation counter

iv) Control switches to cut off control power supply.

v) Fuses**/MCBs** as required.

vi) The number of terminals provided shall be adequate enough to wire out all contacts and control circuits plus 24 terminals spare for future use.

vii) Anti-pumping relay.

viii) Pole discrepancy relay (for electrically ganged CBs).

ix) D.C. Supervision relays.

x) Rating plate description in accordance with IEC incorporating year of manufacture.

xi) Controlled switching **accessories** like sensors, timers, relays etc.(as applicable)

xii) **Transducers/Fixtures required for travel measurement shall be supplied by CB manufacturer. The complete set of Transducers/Fixtures for measurement of complete 3-phase CB shall be supplied for each station. Further, one set of gas filling adopter (Including coupling, regulator, connecting hose pipe up to ground level) shall be supplied as per BPS.**

13.0 ADDITIONAL DATA TO BE FURNISHED

a) Drawing, showing contacts in close, arc initiation, full arcing, arc extinction and open position.

b) The temperature v/s pressure curves for each setting of density monitor along with details of density monitor.

c) Method of checking the healthiness of voltage distribution devices (condensers) provided across the breaks at site.

d) Data on capabilities of circuit breakers in terms of time and number of operations at duties ranging from 100% fault currents to load currents of the lowest possible value without requiring any maintenance or checks.

e) **Maximum** non-simultaneity between contacts, between poles and **effect of the same on the** guaranteed total break time.

f) Sectional view of non-return couplings used for SF6 pipes.

g) Details & type of filters used in interrupter assembly and also the operating experience with such filters.

h) Details of SF6 gas:

   i) The test methods used in controlling the quality of gas used in the circuit breakers particularly purity and moisture content.

   ii) Proposed tests to assess the conditions of the SF6 within a circuit breaker after a period of service particularly with regard to moisture contents of the gas.

j) Shall furnish curves supported by test data indicating the opening time under close open operation with combined variation of trip coil voltage.

k) Detailed literature and schematic diagrams of switching mechanism for closing resistor showing the duration of insertion shall also be furnished alongwith the calculations in respect of thermal rating of resistors for the duties specified under clause **2.2.1** of this section in case of 420 kV **& 800kV** circuit breakers.

l) All duty requirements as applicable to 800 kV, 420 kV, 245 kV, 145 kV & 72.5kV CBs specified under Clause **2.0** of this section shall be provided with the support of adequate test reports.

14.0 DEAD TANK TYPE CIRCUIT BREAKER

14.1 In case dead tank type circuit breaker is offered, the Bidder shall offer bushing type CTs (whose secondary parameters are given in under **Section: Switchgear-Instrument Transformer** and in case of 765kV and 400kV these secondaries shall be provided in sets of 3 cores, i.e., 2 cores of PX class and one core of metering, on both sides of dead tank circuit breaker instead of conventional outdoor CTs.

14.2 The enclosure shall be made of either Al/Al Alloy or mild steel (suitably hot dip galvanized). The enclosure shall be designed for the mechanical and thermal loads to which it is subjected in service. The enclosure shall be manufactured and tested according to the pressure vessel codes {i.e., latest edition of the ASME code for pressure vessel - Section VIII of BS-5179, IS4379, IS-7311 (as applicable) and also shall meet Indian Boiler Regulations}.

The maximum temperature of enclosure with CB breaker carrying full load current shall not exceed the ambient by more than 20 deg C.

14.3 The enclosure has to be tested as a routine test at 1.5 times the design pressure for one minute. A bursting pressure test shall be carried out at 5 times the design pressure as type test on the enclosure.

15.0 TESTS

15.1 In accordance with the requirements stipulated under Section-GTR the circuit breaker alongwith its operating mechanism shall conform to **the type tests as per** IEC: 62271-100.

15.2 The type test reports **as per IEC** and the following additional type test reports shall also be submitted for purchaser's/**employer's** review:

i) Corona extinction voltage test (**procedure** as per Annexure-A of Section-GTR).

ii) Out of phase closing test as per IEC: 62271-100.

iii) Line charging interrupting current for proving parameters as per clause no. **16.0** of this section.

iv) Test to demonstrate the Power Frequency withstand capability of breaker in open condition at Zero Gauge pressure and at lockout pressure (Ref. Clause 4.1.1).

v) Seismic withstand test (**procedure** as per Annexure-B of Section-GTR) in unpressurised condition.

vi) Verification of the degree of protection.

vii) Low temperature test (applicable only for minimum ambient temperatures of less than (-) 10 deg.C application purpose) and High temperature test. Contractor can also submit the field performance report in line with IEC stipulations.

viii) Static Terminal Load test.

ix) Critical Currents test (if applicable).

x) Switching of Shunt Reactors. **Test reports shall be submitted as per IEC. Calculations shall be submitted for meeting the requirements of clause 2.3(v) of this section.**

xi) Circuit breakers meant for controlled switching shall conform to requirements of IEC/TR-62271 – 302. The contractor shall submit test reports to demonstrate that the offered CB conforms to the requirements of performance verification tests and parameter definition tests as per IEC/TR 62271-302. The contractor shall also furnish the report for the re-ignition free arcing window for switching 3-phase shunt reactor as demonstrated in the shunt reactor switching test.

15.3 **Routine Tests**

Routine tests as per IEC:62271-100 shall be performed on all circuit breakers.

In addition to the mechanical and electrical tests specified by IEC, the following tests shall also be performed.

i) Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto reclosing and trip free operation under normal as well as limiting operating **control voltage conditions**. The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation etc. This test shall also be performed at site for which the necessary operation analyzer along with necessary transducers, cables, console etc. shall be **arranged by the contractor at his own cost**.

ii) **During testing of CB, dynamic contact resistance measurement (DCRM) shall be carried out for close-open (CO) operations with delay of 300ms between close and trip operations. Minimum 100A**

current shall be injected for DCRM test. Travel characteristics, injected current, trip/close coil current shall also be recorded along with DCRM test.

iii) **Routine tests on Circuit breakers with Controlled switching device as per IEC/TR 62271-302.**

iv) **Tan delta and Capacitance measurement for grading capacitors at rated voltage and also at 10kV (for reference).**

16.0 TECHNICAL PARAMETERS FOR CIRCUIT BREAKER

(In addition to those indicated in section-GTR)

Sl. no.	Parameter	765kV system	400kV system	220kV system	132 kV system	66 kV system
1.	Rated voltage (Umax) kV (rms)	800	420	245	145	72.5
2.	Rated frequency (Hz)	50	50	50	50	50
3.	No. of poles	3	3	3	3	3
4.	Type of circuit breaker	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated
5.	Rated continuous current (A) at an ambient temperature of 50^0C	3150/4000	2000/3150/ 4000 (as applicable)	1600/2500 (as applicable)	1250	1250
6.	Rated short circuit capacity with percentage of DC component as per IEC-62271-100 corresponding to minimum opening time under operating conditions specified.	50kA (As applicable)	40/50/63kA (As applicable)	40/50 kA (As applicable)	31.5kA	25kA
7.	Symmetrical interrupting capability kA (rms)	50	40/50/63 (As applicable)	40/50 (As applicable)	31.5	25
8.	Rated short circuit making current kAp	125	100/125/ 157.5 (As applicable)	100/125 (As applicable)	80	63
9.	Short time current carrying capability kA (rms)	50 for one second	40/50/63 As applicable for one second	40/50 As applicable for one second	31.5 for one second	25 for three second
10.	Out of phase breaking current carrying capability kA (rms)	12.5	10/12.5/15.75 (As applicable)	**As per IEC**	**As per IEC**	**As per IEC**
11.	Rated line charging interrupting current at 90 deg. Leading power factor angle (A rms) (The breaker shall be able to interrupt the rated line charging current with test voltage immediately before	900	600	As per IEC	As per IEC	As per IEC

	opening equal to the product of U/√3 and 1.4 as per IEC-62271-100					
12.	First pole to clear factor	1.3	1.3	1.3	1.3	1.5
13.	Temperature rise over an ambient temperature of 50^0C	As per IEC: 62271-100	As per IEC: 62271-100	As per IEC: 62271-100	As per IEC: 62271-100	As per IEC: 62271-100
14.	Rated break time as IEC (ms)	40	40	60	60	Less than 75
15.	Total break time (ms)	45	45	65	65	Less than 80
16.	Total closing time (ms)	Not more than 150	Not more than 150	Not more than **150**	Not more than **150**	Not more than **150**
17.	Operating mechanism or a combination of these	Spring	Spring	Spring	Spring	Spring
18.	Rated operating duty cycle	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO
19.	Reclosing	Single phase &Three phase auto reclosing.	Single phase &Three phase auto reclosing.	Single phase &Three phase auto reclosing.	Three phase auto reclosing. (Single phase auto reclosing if specified in section-project)	Three phase auto reclosing.
20.	Pre-insertion resistor requirement	As per BPS	As per BPS	NA	NA	NA
i)	Rating (ohms)	450(max.) with tolerance as applicable	400(max.) with tolerance as applicable	NA	NA	NA
ii)	Minimum electrical (mechanical insertion time +pre-arcing time) pre-insertion time (ms)	9	8	NA	NA	NA
iii)	Opening of PIR contacts	PIR contacts should open immediately after closing of main contacts OR At least 5 ms prior to opening of main contacts at rated air/gas pressure where the	PIR contacts should open immediately after closing of main contacts OR At least 5 ms prior to opening of main contacts at rated air/gas pressure where the	NA	NA	NA

		PIR contacts remain closed	PIR contacts remain closed			
21.	Max. difference in the instants of closing/opening of contacts (ms) between poles at rated control voltage and rated operating & quenching media pressures	2.5(within a pole) 3.3(opening) 5.0(closing)	2.5(within a pole) 3.3(opening) 5.0(closing)	3.3(opening) 5.0(closing)	3.3(opening) 3.3(closing)	As per IEC
22.	Maximum allowable switching over voltage under any switching condition	1.9 p.u.	2.3 p.u.	As per IEC	As per IEC	As per IEC
23.	Trip coil and closing coil voltage with variation as specified	220V DC	220V DC	220V DC	220V DC or 110V DC	220V DC or 110V DC
24.	Noise level at base and up to 50 m distance from base of circuit breaker	As per IEC	140dB (max.)	140dB (max.)	140dB (max.)	140dB (max.)
25.	Rating of Auxiliary contacts	10A at 220V DC	10A at 220V DC	10A at 220V DC	10A at 220V DC	10A at 220V DC
26.	Breaking capacity of Aux. Contacts	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms
27.	**Rated insulation levels**					
i)	Full wave impulse withstand (1.2 /50 µs) between line terminals and ground	±2100kVp	±1425 kVp	±1050 kVp	±650 kVp	±325 kVp
ii)	Full wave impulse withstand (1.2 /50 µs) between terminals with circuit breaker open	2100kVp impulse on one terminal & 455 kVp power frequency voltage of opposite polarity on the other terminal	1425 kVp impulse on one terminal & 240 kVp power frequency voltage of opposite polarity on the other terminal	±1050 kVp	+ 650kVp	±325 kVp
iii)	Rated switching impulse withstand voltage (250/2500 µs) Dry & wet between line terminals and ground	+ 1550kVp	+1050 kVp .	NA	NA	NA
iv)	Rated switching impulse withstand voltage (250/2500 µs) Dry &wet Between terminals with circuit breaker open	1175kVp impulse on one terminal & 650 kVp power frequency	900 kVp impulse on one terminal & 345 kVp power frequency	NA	NA	NA

		voltage of opposite polarity on the other terminal	voltage of opposite polarity on the other terminal			
v)	One minute power frequency dry withstand voltage between line terminals and ground	830kV rms	520 kV rms.	460 kV rms.	275 kV rms	140 kV rms
vi)	One minute power frequency dry withstand voltage between terminals with circuit breaker open	1150kV rms	610 kV rms.	460 kV rms.	275 kV rms	160 kV rms
28.	Minimum corona extinction voltage with CB in all positions	508 kV rms	320kV rms	156 kV rms	92 kV rms	NA
29.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz (Micro volts)	2500 µV (at 508kV rms)	1000 µV (at 266kV rms)	1000 µV (at 156kV rms)	500µV (at 92kV rms)	NA
30.	Minimum Creepage distance*					
i)	Phase to ground (25mm/kV)	20000mm	10500mm	6125mm	3625mm	1813mm
ii)	Between CB terminals	18000mm	10500mm	6125mm	3625mm	1813mm
31.	System neutral earthing	Effectively earthed				
32.	Rated terminal load	As per IEC or as per the value calculated based on specific switchyard layout requirement, whichever is higher.				
33.	Auxiliary contacts	Besides requirement of technical specification, the manufacturer/contractor shall wire up 10 NO + 10 NC contacts exclusively for purchaser's use and wired up to common marshalling box.				
34.	No. of terminals in common marshalling box	All contacts & control circuits to be wired out up to common marshalling box + minimum 24 terminals exclusively for purchaser's future use				
35.	Seismic level	0.5g horizontal for the site location under the Zone-V as per IS-1893 0.3g horizontal for the site location under other than the Zone-V as per IS-1893				

*** The values indicated are for specific creepage of 25mm/kV. In case of specific creepage of 31mm/kV specified, the Minimum Creepage distance values shall be concidered proportionately.**

17.0 PRE-COMMISSIONING TESTS

17.1 An indicative list of tests is given below. All routine tests except power frequency voltage dry withstand test on main circuit breaker shall be repeated on the completely assembled breaker at site. For Pre-commissioning tests, procedures and formats for circuit breakers, POWERGRID document no. CF/CB/03/R-4 dated 01/04/2013 of document no. D-2-01-03-01-04 dated 01-04-2013 will be the reference document. This document will be available at respective sites and shall be referred by the contractor. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Employer for approval.

(a) Insulation resistance of each pole.

(b) Check adjustments, if any suggested by manufacturer.

(c) Breaker closing and opening time.

(d) Slow and Power closing operation and opening.

(e) Trip free and anti pumping operation.

(f) Minimum pick-up voltage of coils.

(g) Dynamic Contact resistance measurement.

(h) Functional checking of control circuits interlocks, tripping through protective relays and auto reclose operation.

(i) Insulation resistance of control circuits, motor etc.

(j) Resistance of closing and tripping coils.

(k) SF6 gas leakage check.

(l) Dew Point Measurement

(m) Operation check of pressure switches and gas density monitor during gas filling.

(n) Checking of mechanical 'CLOSE' interlock, wherever applicable.

(o) Testing of grading capacitor.

(p) Resistance measurement of main circuit.

(q) Checking of operating mechanisms

(r) Check for annunciations in control room.

(s) Point of wave switching test (wherever applicable)

17.2 The contractor shall ensure that erection, testing and commissioning of circuit breaker shall be carried out under the supervision of the circuit breaker manufacturer's representative. The commissioning report shall be signed by the manufacturer's representative.

18.0 ACTIONS REQUIRED FOR DEFECTS OBSERVED DURING DEFECT LIABILITY PERIOD

The actions required to be taken by contractor in case of defects observed in AIS type Circuit Breakers of ratings 132kV & above during the warranty period (defect liability period) shall be as per following. Further, the replaced/repaired/ refurbished equipment (or part of equipment) shall have warranty in line with the GCC clause 22 in SCC.

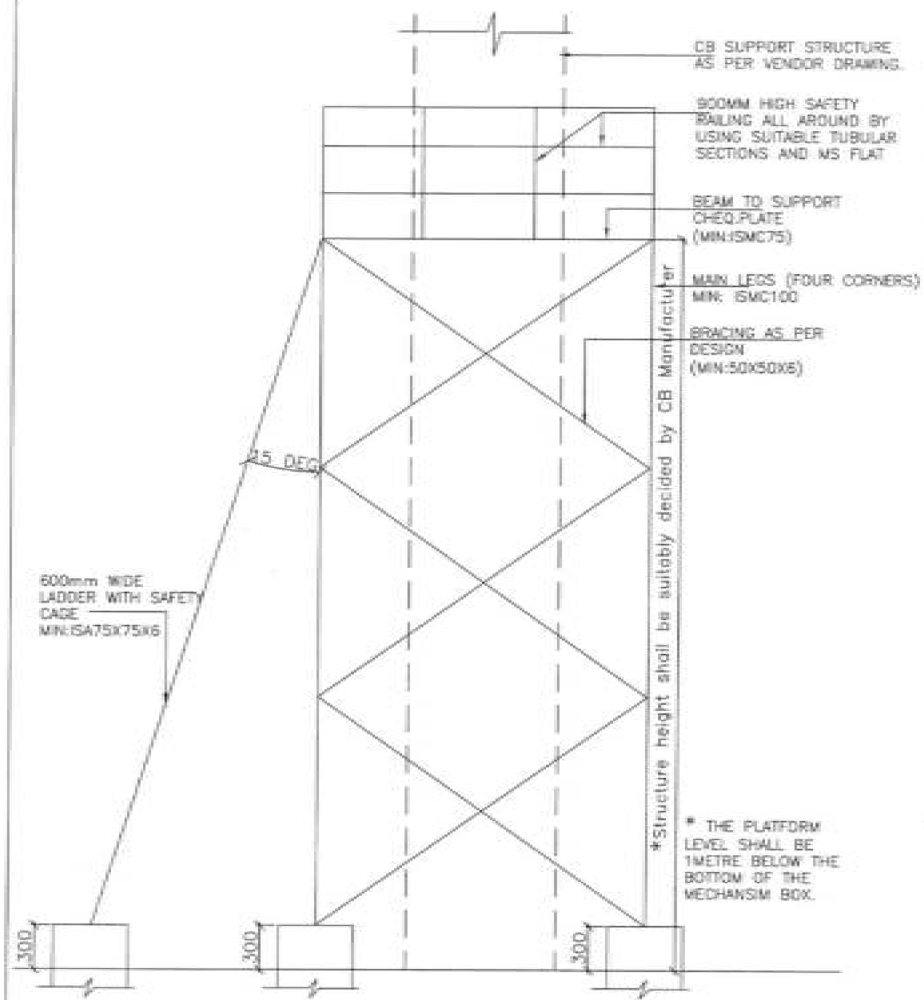
Sl.no.	Nature of problem	Corrective measures to be taken by contractor
1.	Blasting of interrupter, PIR, pole column,	Replacement of compete CB pole Including SF6 gas
	a. Abnormal DCRM and Travel Measurement b. Contact assembly and internal component damage, misalignment not leading to complete failure of interrupter/ PIR	Repair/replacement of affected assembly/ component based on repair procedure approved by QA
2.	Crack in insulator, cementing joint of interrupter , PIR , pole column	Replacement of affected part
3.	SF6 gas leakage from sealing and bolted joints. SF6 gas leakage detectable by any Leakage Detection Method	Rectification by replacement of gasket, O-ring, sealing, Interrupter or affected part to be replaced etc If unable to arrest the leakage in 02 attempts, replacement of interrupter/ column
4.	SF6 gas low dew point: > (-)35 deg C at atmospheric pressure.	Re-conditioning of gas. If does not improve, complete evacuation of CB, replacement filter material and gas
5.	Oil leakage of grading capacitor Change in Capacitance value beyond +/- 5 % w.r.t. to value of Capacitance obtained at site during pre-commissioning test.	Replacement or Refurbishment of grading capacitor
6.	Pole/ break discrepancy (during O&M) Limits: Break to Break (Opening/Closing) : max. 2.5 ms Phase to Phase (Opening) : max. 3.33 ms Phase to Phase (Closing) : max 5 ms	Rectification/replacement of affected parts
7.	Static Contact Resistance: increase >50% from factory/ pre-commissioning value or >75 micro-ohm/ break whichever is lower	Rectification/Replacement of pole
8.	Drive mechanism assembly failure	Rectification/ Replacement of affected part
9.	Trip/ close coil, density monitor, relays and contactors and components of common MB	Replacement of affected part

Note: 1) Replaced/Repaired/Refurbished Equipment (or part of equipment) shall have 2 years warranty without prejudice to contractual warranty period.

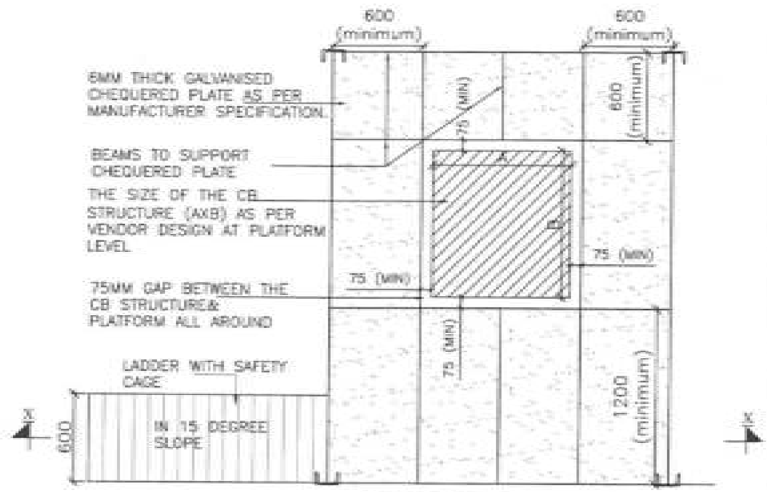
2) The measurement at site shall be carried out as per POWERGRID standard Pre-commissioning procedures as indicated in Technical Specification.

GENERAL NOTES

1. ALL DIMENSIONS ARE IN MM.
2. ALL STRUCTURAL STEEL SHALL BE AS PER IS:2062 & FABRICATION SHALL BE AS PER IS:802.
3. BOLTS, NUTS SHALL BE AS PER IS:1367 (PROPERTY CLASS 5.6)
4. ALL MEMBERS, BOLTS, NUTS, WASHERS SHALL BE HOT DIP GALVANISED AS PER IS 2614.
5. THE MINIMUM THICKNESS OF GALVANISATION SHALL BE SAME AS THAT OF THE CB SUPPORT STRUCTURE.
6. SPRING WASHERS SHALL BE AS PER IS: 1573 AND MAY BE HOT DIP/ ELECTRO GALVANISED AS PER MANUFCATURER SPECIFICATION.
7. ALL HOLES 17.5MM DIA FOR 16MM DIA. BOLT UNLESS NOTED OTHERWISE.
8. WELDING SHALL BE DONE AS PER I.S. : 816.
9. ALL ITEMS TO BE PREFIXED WITH "PCB" THAT IS PCB-1, PCB-2, SO ON.
10. POSITION OF LADDER SHOWN IS INDICATIVE AND THE SAME SHALL BE SUITABLY POSITIONED BY CB MANUFACTURER DURING DETAILED ENGINEERING.
11. ORIENTATION OF PLATFORM CUM LADDER SHALL BE SUITABLY SHOWN ON DGA OF CIRCUIT BREAKER DURING DETAILED ENGINEERING BY CB MANUFACTURER ALONG WITH CB MAIN SUPPORT STRUCTURE.
12. THE AXB DIMENSION SHALL BE THE OVERALL LENGTH AND WIDTH OF THE CB STRUCTURE INCLUDING THE MECHANISM BOX OF CB AT PLATFORM LEVEL.
13. THE MEMBER SIZES SHOWN FOR PLATFORM SUPPORT STRUCTURE AND BRACINGS ARE INDICATIVE. THE SAME MAY BE VARY AS PER DURING DETAILED ENGINEERING. HOWEVER, THE MEMBER SIZES SHALL NOT BE LESS THAN THE MINIMUM SECTION SIZES SHOWN IN THIS DRAWING.



SECTION X-X



PLAN AT PLATFORM LEVEL

ACDE ENGG-CVL	CDE ENGG-CVL	ENGG-SS	AGM ENGG-SS	AGM ENGG-CVL	GM ENGG-SS	GM ENGG-CVL	DATE

POWER GRID CORPORATION OF INDIA LIMITED

(A Government of India Enterprise)

TITLE : INDICATIVE DRAWING FOR PLATFORM DETAILS OF 400Kv & 765kV CIRCUIT BREAKER

DRAWING NO. C-ENGG-IND.DWG-PLATFORM-CB SHEET 01 OF 01

SCALE NTS | REV. 0

MODEL TECHNICAL SPECIFICATION

SECTION-SWITCHGEAR - ISOLATOR

(REV. NO. 12)

Following are the major changes made in the Technical specification, Section-Switchgear - ISOLATOR, Rev. 12:

Clause No.	Major Modification
3.1 f)	Minimum thickness of silver plating specified for contact points of male and female contact.
3.6	New Clause added for Locking Device
5.0 i)	Blocked rotor test of motor deleted.
6.0 g)	Type test to verify the proper functioning of the position-indicating device as per IEC added.
9.1	Mechanical endurance test requirement of E/s during routine testing modified.
12.1 (g)	Requirement of measurement of operating torque for isolator and earth switch as pre-commissioning test has been deleted

<u>Notes:</u> The above is the list of major changes with respect to previous revision (Rev.11B). However, the bidders are advised to read the entire section for other changes and quote accordingly.

SWITCHGEAR – ISOLATOR

CONTENTS

SWITCHGEAR - ISOLATOR

1.0 GENERAL:

1.1 The Isolators and accessories shall conform in general to **IS/IEC: 62271-102 latest edition** except to the extent explicitly modified in specification and shall be in accordance with requirement of Section-GTR.

1.2 Complete isolator with all the necessary items for successful operation shall be supplied including but not limited to the following:

1.2.1 Isolator with complete Support Insulators, operating rod insulator, base frame, linkages, operating mechanism, control cabinet, interlock etc.

1.2.2 All necessary parts to provide a complete and operable isolator installation, control parts and other devices whether specifically called for herein or not.

1.2.3 The isolator shall be designed for use in the geographic and meteorological conditions as given in Section-GTR and Section-Project.

2.0 DUTY REQUIREMENTS:

a) Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the rated short circuit current of the systems in their closed position. They shall be constructed such that they do not open under influence of short circuit current.

b) The earth switches, wherever provided, shall be constructionally interlocked so that the earth switches can be operated only when the isolator is open and vice versa. The constructional interlocks shall be built in construction of isolator and shall be in addition to the electrical interlocks. Suitable mechanical arrangement shall also be provided for delinking electrical drive for manual operation.

c) In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of failsafe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from station DC supply and within a variation range as stipulated in Section-GTR.

d) The earthing switches shall be capable of discharging trapped charges of the associated lines.

e) The isolator shall be capable of making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of isolator on account of make/break operation.

3.0 CONSTRUCTIONAL FEATURES:

Isolators shall be outdoor, off-load type. Earth switches shall be provided on isolators wherever called for, with possibility of being mounted on any side of the isolator. 800kV isolator design shall be double break or vertical break or knee-type. 420kV & below rated isolators shall be double break type, unless specified otherwise. Isolator design shall be such as to permit addition of earth switches at a future date. The features and constructional details of isolators, earth switches and accessories shall be in accordance with requirements stated hereunder:

3.1 Contacts:

a) The contacts shall be self aligning and self cleaning type and shall be so designed that binding cannot occur after remaining in closed position for prolonged period in a heavily polluted atmosphere.

b) No undue wear or scuffing shall be evident during the mechanical endurance tests. Contacts and spring shall be designed so that readjustments in contact pressure shall not be necessary throughout the life of the isolator or earthing switch. Each contact or pair of contacts shall be independently sprung so that full pressure is maintained on all contacts at all time.

c) Contact springs shall not carry any current and shall not loose their characteristics due to heating effects.

d) The moving contact of double break isolator shall have preferably turn-and-twist type or other suitable type of locking arrangement to ensure adequate contact pressure.

e) Flexible braided copper, where used, shall have corrosion resistant coating such as tinning or silvering.

f) Minimum thickness of silver plating on all contact points of male and female contact shall be 25 microns.

3.2 Base :

Each single pole of the isolator shall be provided with a complete galvanised steel base provided with holes and designed for mounting on a standard supporting structure. Common base frame shall be provided for 400/220/132kV isolators suitable for mounting on pipe structures.

3.3 Blades :

a) All metal parts shall be of non-rusting and non-corroding material. All current carrying parts shall be made from high conductivity electrolytic copper/aluminium. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities if provided on current carrying parts shall be made of copper silicon alloy or stainless steel or equivalent. The bolts or pins used in current carrying parts shall be made of non-corroding material. Ferrous parts, other than stainless steel shall not be used in close proximity of main current path. All ferrous castings, if used elsewhere shall be made of malleable cast iron or cast-steel. No grey iron shall be used in the manufacture of any part of the isolator.

b) The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces, where this is impracticable, adequate corona rings shall be provided. Corona shields are not acceptable. Corona rings shall be made up of aluminum/aluminum alloy.

c) Isolators and earthing switches including their operating parts shall be such that they cannot be dislodged from their open or closed positions by short circuit forces, gravity, wind pressure, vibrations, shocks, or accidental touching of the connecting rods of the operating mechanism.

d) The isolator and earth switch shall be designed such that no lubrication of any part is required except at very infrequent intervals i.e. after every 1000 operations or after 5 years whichever is earlier.

3.4 **Insulator:**

a) The insulator shall conform to IS: 2544, IEC-60168 and IEC-60815. The porcelain of the insulator shall conform to the requirements stipulated under Section-GTR.

b) Pressure due to the contact shall not be transferred to the insulators after the main blades are fully closed.

c) Insulator shall be type and routine tested as per IEC-60168. Besides following additional routine/acceptance tests shall also be conducted:

(i) Bending load test in four directions at 50% of minimum bending load guaranteed on all insulators, as a routine test.

(ii) Bending load test in four directions at 100% of minimum bending load as a sample test on each lot.

(iii) Torsional test on sample insulators of a lot.

(iv) Ultrasonic test as a routine test.

d) Requirement of Insulators of Isolators shall be as follows:

i) **For 800 kV Insulator**:

Cantilever strength (min.)	=	**10 kN**
Top PCD	=	225 mm
No. of holes	=	4 x M16
Bottom PCD	=	356 mm
No. of holes	=	8 x 18mm dia.

ii) **<u>For 420 kV Insulator</u>**:

Cantilever strength (min.)	=	**10 kN**
Top PCD	=	127 mm
No. of holes	=	4 x M16
Bottom PCD	=	325 mm
No. of holes	=	8 x 18mm dia

iii) **<u>For 245 kV Insulator</u>**:

Cantilever strength (min.)	=	**10 kN**
Top PCD	=	127 mm
No. of holes	=	4 x M16
Bottom PCD	=	275 mm
No. of holes	=	8 x 18mm dia

iv) **<u>For 145 kV Insulator</u>**:

Cantilever strength (min.)	=	**6 kN**
Top PCD	=	127 mm
No. of holes	=	4 x M16
Bottom PCD	=	254 mm
No. of holes	=	8 x 18mm dia

3.5 **Name Plate:**

The name plate shall conform to the requirements of IEC incorporating year of manufacture.

3.6 Locking device (applicable for 132kV and above):

a) Locking device between Disconnectors and earth switches (wherever applicable) are to be provided and shall be designed to meet the requirement as per latest edition of IS/IEC 62271:102.
For this, mechanical arrangements must be there to stop any forceful act (like push button operation of motor, handle operation etc) to operate earth switch (while main isolator is in closed position) or vice versa. Mechanical arrangements to be provided to hold operating pipe connected to motor shaft. Trapped Key Interlocking solution between Isolator and Earth switch is to be provided in such a way that each Isolator shall be connected with a mechanism with Key trapped in it. Once Isolator is completely open (Locally or Remote) the key will be released and blocks the isolator rotating pipe for any movement and same key shall be utilized to make Earth switch to operate.

The earth switch shall be locked at two positions:

(i) In normal condition the earth switch is blocked mechanically so that it cannot be rotated until trapped key from key exchange box (in case of bus isolator)/isolator is released.

(ii) Once connected to earth, rotating shaft shall be blocked at that position with key out and can only be operated once key is again placed in E/S.

b) The Locks used for earth switch shall be of electromechanical type lock. Lock and mechanical arrangement to hold rotating shaft must be suitable for long term outdoor operation and accordingly, stainless-steel material is to be used and enclosure of lock shall be such that ingression of dust and moisture inside is prevented.

c) In case of new substation, for interlock between bus isolators and bus earth switch, locks along with key is to be provided for present and future bays. In such case, key exchange box (IP 55 Class) is also to be provided (with provision of spares as per envisaged future) for each bus. The key exchange box will have arrangement of N Key IN and one key OUT, where N is the number of bus isolators of particular bus (present+future). In case of substation extension (where above system has been implemented), bus isolators are to be provided with mechanical arrangement at shaft compatible with existing locks.

d) Strength of mechanical interlock/shaft blocking must be designed as per IEC 62271-102 in such a way that it can withstand during motor-operation, the strain produced by the motor starting torque at the maximum motor supply voltage.

e) The locking device must be type tested as per IS/IEC 62271 102.

4.0 EARTHING SWITCHES:

a) Where earthing switches are specified these shall include the complete operating mechanism and auxiliary contacts.

b) The earthing switches shall form an integral part of the isolator and shall be mounted on the base frame of the isolator.

c) Earthing switches shall be only locally operated.

d) Each earth switch shall be provided with flexible copper/aluminum braids for connection to earth terminal. These braids shall have the same short time current carrying capacity as the earth blade. The transfer of fault current through swivel connection will not be accepted.

e) The plane of movement and final position of the earth blades shall be such that adequate electrical clearances are obtained from adjacent live parts in the course of its movement between ON and OFF position.

f) The frame of each isolator and earthing switches shall be provided with two reliable earth terminals for connection to the earth mat.

g) The earth switch should be able to carry the same fault current as the main blades of the Isolators and shall withstand dynamic stresses.

h) 800kV, 420 kV & 245 kV earth switches shall also comply with the requirements of IEC-62271-102, in respect of induced current switching duty as defined for Class-B and short circuit making capability class E-0 for earthing switches.

i) Earth switch blade in open condition shall not project (from the centre line of Insulator) by more than 4200mm for 400kV and 2810mm for 220kV respectively.

5.0 OPERATING MECHANISM:

a) The bidder shall offer motor operated Isolators and earth switches. Isolators of 36 kV and below and earth switches of 72.5 kV and below rating shall be manual operated.

b) Control cabinet/operating mechanism box shall conform to the requirement stipulated in Section-GTR and shall be made of cast aluminium/aluminum sheet of adequate thickness (minimum 3 mm) or stainless steel (grade-304) of minimum thickness 2mm.

c) A “Local/Remote” selector switch and a set of open/ close push buttons shall be provided on the control cabinet of the isolator to permit its operation through local or remote push buttons.

d) Provision shall be made in the control cabinet to disconnect power supply to prevent local/remote power operation.

e) Motor shall be an AC motor and conform to the requirements of Section-GTR.

f) Suitable reduction gearing shall be provided between the motor and the drive shaft of the isolator. The mechanism shall stop immediately when motor supply is switched off. If necessary a quick electro-mechanical brake shall be fitted on the higher speed shaft to effect rapid braking.

g) Manual operation facility (with handle) should be provided with necessary interlock to disconnect motor.

h) Gear should be of forged material suitably chosen to avoid bending/jamming on operation after a prolonged period of non-operation. Also all gear and connected material should be so chosen/surface treated to avoid rusting.

i) Only stranded conductor shall be used for wiring. Minimum size of the conductor for control circuit wiring shall be 1.5 sq.mm. (Copper).

j) The operating mechanism shall be located such that it can be directly mounted on any one of the support structure.

k) Snap type limit/auxiliary switches shall be used with Factory set values. No adjustment shall be required at site during commissioning.

6.0 OPERATION:

a) The main Isolator and earth switches shall be individual pole operated for 800/420 kV and gang operated in case of 245 kV & 145 kV. However, 245 kV Tandem Isolators shall be individual-pole operated. The operating mechanism of all the three poles shall be well synchronized and interlocked.

b) The design shall be such as to provide maximum reliability under all service conditions. All operating linkages carrying mechanical loads shall be designed for negligible deflection and strain less than 1%. The length of inter insulator and interpole operating rods shall be capable of adjustments, by means of screw thread which can be locked with a lock-nut after an adjustment has been made. The isolator and earth switches shall be provided with “over dead center” device in the operating mechanism at open and close position to prevent accidental opening by wind, vibration, short circuit forces or movement of the support structures.

c) Each isolator/pole of isolator and earth switch shall be provided with a manual operating handle enabling one man to open or close the isolator with ease while standing at ground level. Non-detachable type manual operating handle shall have provision for padlocking. For detachable type manual operating handles, suitable provision shall be made inside the operating mechanism box for parking the detached handles. The provision of manual operation shall be located at a convenient operating height from the base of isolator support structure.

d) The isolator contacts shall be positively driven by the operating mechanism continuous control throughout the entire cycle of operation. The operating pipes and rods shall be sufficiently rigid to maintain positive control under the most adverse conditions and when operated in tension or compression for isolator closing / opening operation. They shall also be capable of withstanding all torsional and bending stresses due to operation of the isolator. Wherever supported, the operating rods shall be provided with bearings on each support and at the ~~either~~ ends. The operating rods/ pipes shall be provided with suitable universal couplings to account for any angular misalignment.

e) All rotating parts shall be provided with grease packed roller or ball bearings in sealed housings designed to prevent the ingress of moisture, dirt or other foreign matter. Bearings pressure shall be kept low to ensure long life and ease of operation. Locking pins wherever used shall be rust-proof.

f) Signaling of closed position shall not take place unless it is certain that the movable contacts, have reached a position in which rated normal current, peak withstand current and short time withstand current can be carried safely. Signaling of open position shall not take place unless movable contacts have reached a position such that clearance between contacts is atleast 80% of the isolating distance.

g) The position of movable contact system (main blades) of each of the Isolators and earthing switches shall be indicated by a mechanical indicator at the lower end of the vertical rod of shaft for the Isolators and earthing switch. The indicator shall be of metal and shall be visible from operating level. **Type test to verify the proper functioning of the position-indicating device shall be carried out as per requirement of latest edition of IS/IEC 62271 102.**

h) The contractor shall furnish the following details alongwith quality norms, during detailed engineering stage:

(i) Current transfer arrangement from main blades of isolator alongwith milli volt drop immediately across transfer point.

(ii) Details to demonstrate smooth transfer of rotary motion from motor shaft to the insulator alongwith stoppers to prevent over travel.

7.0 TERMINAL CONNECTOR STUD/PAD:

The isolator terminal pads/studs shall be made of high quality copper or aluminum. The terminal pad shall have protective covers which shall be removed before interconnections. Only terminal pads shall be used for current ratings above 1250A. Terminal pads shall be mounted below the current transfer contacts so that the cantilever pull from the terminal connector is not transferred through the current transfer point to the support insulator. The terminal pad shall be suitable for horizontal plane connection with terminal connector. The terminal pads for all isolators with 3150A & above rating shall have six holes for terminal pad.

8.0 SUPPORT STRUCTURE:

800 kV/420 kV/245 kV/145 kV Isolators along with Earth switches shall be suitable for mounting on standard support structures.

9.0 TESTS:

9.1 In continuation to the requirements stipulated under Section-GTR the isolator alongwith its earthing switch and operating mechanism should have been type tested as per IEC/IS and shall be subjected to routine tests in accordance with **latest edition** of IEC-62271-102. Minimum 1000 Nos. mechanical operations in line with mechanical endurance test, M0 duty, shall be carried out on 1 (one) isolator **(not applicable for earth switch)** out of every lot of Isolators, assembled completely with all accessories including insulators, as acceptance test for the lot. **For Earth Switch, 100 operations in acceptance test shall be carried out in each lot.** The travel characteristics measured at a suitable location in the base of insulator along with motor current/power drawn, during the entire travel duration are to be recorded at the start and completion and shall not vary by more than (+/-) 10% after completion of 1000 cycles of operation. After completion of test, mechanical interlock operation to be checked.

9.2 The test reports of the type tests as per **latest** IS/IEC 62271-102 and the following additional type tests shall also be submitted for the Employer's review.

(i) **RIV (for ≥ 245kV)** and Corona Extinction Voltage test as per Annexure-A of Section-GTR

(ii) Seismic withstand test on isolator mounted on Support structure as per Annexure-B of Section-GTR. The test shall be performed in the following position:

Isolator open	E/S Closed
Isolator open	E/S Open
Isolator Closed	E/S Open

10.0 MANDATORY SPARES:

Bidder shall include in his proposal mandatory spares as mentioned in the Bidding Documents.

11.0 TECHNICAL PARAMETERS: As per table given at **Annexure-I**:

12.0 PRE-COMMISSIONING TESTS

12.1 Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment manufacturer or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates at his own cost.

An indicative list of tests on isolator and earth switch is given below. For pre-commissioning procedures and formats for Isolators and Grounding switch, Doc No. **CF/ISO/08/R-5** under POWERGRID standard pre-commissioning document **Doc. No. D-2-01-03-01-05** will be the reference document. This document will be available at respective sites and shall be referred by the contractor.

(a) Insulation resistance of each pole

(b) Manual and electrical operation and interlocks

(c) Insulation resistance of control circuits and motors

(d) Ground connections

(e) Contact resistance measurement

(f) Proper alignment so as to minimize vibration during operation

(g) Resistance of operating and interlocks coils

(i) Functional check of the control schematic and electrical & mechanical interlocks

(j) 50 operations test on isolator and earth switch

12. 2 The Contractor shall ensure that erection, testing and commissioning of Isolators above 72.5 kV class shall be carried out under the supervision of the Isolator manufacturer's representative and the cost of the same shall be included in the erection price of the respective equipment.

Annexure-I

1. Technical Parameters for 765kV, 400kV, 220kV and 132kV Isolators

Sl. No.	Description	Unit	800kV ISO	420kV ISO	245kV ISO	145kV ISO
1	Rated voltage	kVrms	800	420	245	145
2	Rated frequency	Hz	50	50	50	50
3	No. of poles	Nos.	3	3	3	3
4	Design ambient temperature	℃	50	50	50	50
5	Type		Outdoor	Outdoor	Outdoor	Outdoor
6	Rated current at $50^{o}C$ ambient temperature	A	3150	3150	1600A / 2500 A (as applicable)	1250
7	Rated short time withstand current of isolator and earth switch	kA	40 / 50 for 1 sec (as applicable)	40 /50 /63 for 1 sec (as applicable)	40 / 50 for 1 sec (as applicable)	31.5 for 1 sec
8	Rated dynamic short time withstand current of isolator and earth switch	kAp	**100 kAp / 125 kAp** (as applicable)	100 kAp / 125 kAp / 157.5 kAp (as applicable)	100 kAp / 125 kAp (as applicable)	80kAp
9	Temperature rise over design ambient temperature	As per **Table-14** of IEC-62271-1				
10	Rated mechanical terminal load	N	As per **Table 4** of IEC-62271-102			
11	Mechanical Endurance Class	Isolator-M2 E/S-M0				
12	Operating mechanism of isolator/erathswitch	A.C. Motor operated				
13	No. of auxiliary contacts on each isolator	Besides requirement of this spec., 5 NO + 5 NC contacts wired on each isolator to terminal block exclusively for Employer's use in future.				
14	No. of auxiliary contacts on each earthing switch	Besides requirement of this spec., 3 NO + 3 NC contacts wired on each **earth switch** to terminal block exclusively for Employer's use in				

Sl. No.	Description	Unit	800kV ISO	420kV ISO	245kV ISO	145kV ISO
15	Max. Operating time	secs	20 sec. for Isolator and 25 seconds for earth switch	20 secs	12 secs	12 secs
16	Number of terminal in control cabinet	All contacts & control circuits are to be wired up to control cabinet plus 24 spare terminals evenly distributed.				
17	Rated Insulation levels					
a)	Full wave impulse withstand voltage (1.2/50 microsec.)					
i)	between line terminals and ground	kVpeak	±2100	±1425	±1050	±650
ii)	between terminals with isolator open	kVpeak	±2100 kVp impulse on one terminal and 455 kVp power frequency voltage of opposite polarity on other terminal	±1425 kVp impulse on one terminal and 240 kVp power frequency voltage of opposite polarity on other terminal	±1200	±750
b)	Switching impulse withstand voltage (250/2500 micro-second) dry and wet					
i)	between line terminals and ground	kV peak	± 1550	± 1050	-NA-	-NA-
ii)	between terminals with Isolator open	kV peak	1175 kVp impulse on one terminal and 650 kVp power frequency voltage of opposite polarity on other terminal	900 kVp impulse on one terminal and 345 kVp power frequency voltage of opposite polarity on other terminal	-NA-	-NA-
c)	One minute power frequency dry withstand voltage					
i)	between line terminals and ground	kV rms	830	520	460	275
ii)	between terminals with isolator open	kV rms	1150	610	530	315
18	Minimum Corona extinction voltage	KV rms	508	320	156	92

Sl. No.	Description	Unit	800kV ISO	420kV ISO	245kV ISO	145kV ISO
	with Isolator in all positions					
19	Max. radio interference voltage for frequency between0.5 MHz and 2 MHz. in all positions	micro volts	2500 at 508 kVrms	1000 at 266 kVrms	1000 at 156 kVrms	500 at 92 kVrms
20	Minimum Creepage distance					
i)	Phase to ground	mm	As per Section-GTR	As per Section-GTR	As per Section-GTR	As per Section-GTR
21	Seismic acceleration		As per IS:1893	As per IS:1893	As per IS:1893	As per IS:1893
22	Thermal Rating of Auxiliary Contacts	A	10 A at 220 V DC	10 A at 220 V DC	10 A at 220 V DC	10 A at 220 V DC
23	Breaking Capacity of auxiliary contacts		2 A DC with circuit time constant not less than 20 ms	2 A DC with circuit time constant not less than 20 ms	2 A DC with circuit time constant not less than 20 ms	2 A DC with circuit time constant not less than 20 ms
24	Distance between support structures foundations (within same phase)	m	6.0	4.0	2.5	-
25	System neutral earthing		Effectively Earthed	Effectively Earthed	Effectively Earthed	Effectively Earthed

Note: The above insulation levels are applicable for altitude up to 1000 meters above M.S.L. For higher altitudes, suitable correction factor as per relevant IEC shall be applied.

2. Technical Parameters for 72.5 kV, 36 kV and 11 kV Isolator

Sl. No.	Description	Unit	72.5kV ISO	36kV ISO	12kV ISO
1	Rated voltage	kVrms	72.5	36	11
2	Rated frequency	Hz	50	50	50
3	No. of poles	Nos.	3	3	3
4	Design ambient temperature	°C	50	50	50
5	Type		Outdoor, Mechanically gang operated	Outdoor, Mechanically gang operated	Outdoor, Mechanically gang operated
6	Rated current at 50°C ambient temperature	A	As per requirement	As per requirement	As per requirement
7	Rated short time withstand current of isolator and earth switch	kA	25 kA for 3 sec	25 kA for 3 sec	25 kA for 3 sec
8	Rated dynamic short time withstand current of isolator and earth switch	kAp	62.5kAp	62.5kAp	62.5kAp
9	Temperature rise over design ambient temperature	As per **Table-14** of IEC-62271-1			
10	Rated mechanical terminal load	N	As per **Table 4 of IEC-62271-102**		
11	Mechanical Endurance Class		Isolator-M1 E/S-M0		
12	Operating mechanism of isolator/erathswitch		Isolator - A.C. Motor operated E/S – Manual operated	Isolator - Manual operated E/S – Manual operated	Isolator - Manual operated E/S – Manual operated
13	No. of auxiliary contacts on each isolator	Besides requirement of this spec., 5 NO + 5 NC contacts wired on each isolator to terminal block exclusively for Employer's use in future.			
14	No. of auxiliary contacts on each earthing switch	Besides requirement of this spec., 3 NO + 3 NC contacts wired on each **earth switch** to terminal block exclusively for Employer's use in future.			
15	Max. Operating time	sec	12 sec.	NA for manual	NA for manual operation

Sl. No.	Description	Unit	72.5kV ISO	36kV ISO	12kV ISO
16	Number of terminal in control cabinet	All contacts & control circuits are to be wired up to control cabinet plus 24 spare terminals evenly distributed.			
17	Rated Insulation levels				
a)	Full wave impulse withstand voltage (1.2/50 microsec.)				
i)	between line terminals and ground	kVpeak	±325	±170	-
ii)	between terminals with isolator open	kVpeak	±375 kVp	±180 kVp	-
b)	One minute power frequency dry withstand voltage				
i)	between line terminals and ground	kV rms	140	70	-
ii)	between terminals with isolator open	kV rms	160	80	-
18	Minimum Creepage distance				
i)	Phase to ground	mm	As per Section-GTR	As per Section-GTR	As per Section-GTR
19	Seismic acceleration		As per IS:1893	As per IS:1893	As per IS:1893
20	Thermal Rating of Auxiliary Contacts	A	10 A at 220V/110V DC	10 A at 220V/110V DC	10 A at 220V/110V DC
21	Breaking Capacity of auxiliary contacts		2 A DC with circuit time constant not less than 20 ms	2 A DC with circuit time constant not less than 20 ms	2 A DC with circuit time constant not less than 20 ms
22	Distance between support structures foundations (within same phase)	m	As per layout		
23	System neutral earthing		Effectively Earthed	Effectively Earthed	Effectively Earthed

Note: The above insulation levels are applicable for altitude up to 1000 meters above M.S.L. For higher altitudes, suitable correction factor as per relevant IEC shall be applied.

MODEL TECHNICAL SPECIFICATION

SECTION-SWITCHGEAR-INST

(INSTRUMENT TRANSFORMERS)

(REV. NO. 11)

Following are the major changes made in the Technical specification, Section-Switchgear-INST, Rev. 11:

Clause No.	Major Modification
1.	**New IEC-61869 referred. IEC-60044 is superseded by IEC-61869**
2.	**245kV and above rating CT are acceptable with Polymer Insulator**
3.	**Cantilever strength for 72.5kV Instrument Transformer specified**
4.	**Live Tank CT shall be preferably of Bar primary design with SS Bellow**
5.	**Type test & Special test requirements mentioned in line with IEC-61869**
6.	**DGA sampling after commissioning elaborated**
7.	**Requirement of Oil sampling device added**
8.	**Defect liability clause added for actions required in case of defects observed during warrantee period**
9.	**Protection class of CT mentioned as "PX class" in line with IEC-61869**

<u>**Note:**</u> The above is the list of major changes with respect to previous revision (Rev. 10). However, the bidders are advised to read the entire section/chapter for other changes and quote accordingly.

SECTION-SWITCHGEAR–INST

INSTRUMENT TRANSFORMERS

CONTENTS

SECTION-SWITCHGEAR-INST

INSTRUMENT TRANSFORMERS

1.0 GENERAL:

1.1 The instrument transformers and accessories shall conform to the latest version of the standards specified below except to the extent explicitly modified in this specification and shall be in accordance with the requirements in Section-GTR.

Current Transformers (CT): IEC: ***61869-1 & 61869-2*** or IS: 2705 ***Part-1 to 4***

Capacitive Voltage Transformers (CVT): IEC: ***61869-1, 61869-5*** & IEC-60358 ***or IS-3156 Part-1 to 4***

Inductive Voltage Transformers (IVT): IEC: ***61869-1 & 61869-3 or IS-3156 Part-1 to 3***

1.2 The instrument transformers shall be designed for use in geographic and meteorological conditions as given in Section-GTR **and Section-Project.**

2.0 CONSTRUCTION FEATURES:

The features and constructional details of instrument transformers shall be in accordance with requirements stipulated hereunder:

a) Instrument transformers of **800kV/420kV/245kV/145kV/72.5** kV class, shall be oil filled/SF_6 gas filled, suitable for outdoor service and upright mounting on steel structures. **245kV, 420kV and** 800kV CT shall be with polymer insulator.

b) Bushings/Insulators shall conform to requirements stipulated in Section-GTR. The bushing/insulator for CT shall be one piece without any metallic flange joint.

c) Oil filling and drain plugs, oil sight glass shall be provided for CT & IVT. Oil sight glass shall be provided for electromagnetic unit of CVT. ***The Instrument transformer shall have cantilever strength of not less than 500 kg, 500 kg, 350 kg, 350 kg and 250 kg respectively for 800kV, 420kV, 245kV, 145kV and 72.5kV Instrument Transformers.*** For CVT/IVT with polymer housing, the cantilever strength shall not be less than 150kg. Oil filling and drain plugs are not required for SF_6 gas filled CT/IVT.

d) Instruments transformers shall be hermetically sealed units. The details of the arrangements made for the sealing of instrument transformers shall be furnish during detailed engineering.

e) Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

f) SF_6 gas filled CT/IVT shall be provided with a suitable SF_6 gas density monitoring device, with NO/NC contacts to facilitate the remote annunciation and tripping in case of SF_6 gas leakage. Provisions shall be made for online gas filling. Suitable rupture disc shall be provided to prevent explosion.

g) The instrument transformers shall be complete with its terminal box and a common marshalling box for a set of 3 instrument transformers.

h) The external surface of instrument transformer, if made of steel, shall be hot dip galvanized or painted as per Section-GTR. External surface of aluminum can have natural finish.

i) The impregnation details alongwith tests/checks to ensure successful completion of impregnation cycle shall be furnished for approval.

2.2 **Terminal box/Marshalling Box:**

Terminal box**/Marshalling Box** shall conform to the requirements of Section-GTR.

2.3 **Insulating Oil/Gas:**

a) Insulating oil to be used for instrument transformers shall be of EHV grade and shall conform to IS-335/IEC-60296 (required for first filling). Non–PCB based synthetic insulating oil conforming to IEC 60867 **shall** be used in the capacitor units of CVT.

b) The SF_6 gas shall comply with IEC-60376, 60376A, 60376B **& IEC-60480** and shall be suitable in all respects for use in the switchgear under operating conditions.

2.4 **Name Plate:**

Name plate shall conform to the requirements of IEC incorporating the year of manufacture. The rated current **&** extended current rating in case of current transformers and rated voltage, voltage factor **& intermediate voltage** in case of voltage transformers shall be clearly indicated on the name plate.

3.0 CURRENT TRANSFORMERS:

a) Current transformers shall have single primary either ring type or hair pin type and suitably designed for bringing out the secondary terminals in a weather proof (IP-55) terminal box at the bottom. PF **(Tan delta)** terminal for measurement of tan delta and capacitance of the unit shall be provided. These secondary terminals shall be terminated to stud type non disconnecting terminal blocks inside the terminal box.

In case of inverted type **(Live Tank)** current transformers, the manufacturer shall meet following additional requirements:

(i) **The primary conductor shall preferably be of bar type meeting the desired characteristics.**

(ii) The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

(ii) The lowest part of the insulation assembly **i.e. insulation at neck** shall be properly secured to avoid any risk of damage due to transportation stresses.

(iii) The upper part of insulation assembly resting on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly & top dome.

(iv) **Bellows made of stainless steel shall be used at the top for hermetic sealing of CT.**

(v) Bidder/Manufacturer shall recommend whether any special storage facility is required for spare CT.

b) Different ratios specified shall be achieved by secondary taps only and primary reconnection shall not be accepted.

c) Core lamination shall be of cold rolled grain oriented silicon steel or other equivalent alloys. μ metal or nano-crystalline core can also be used for metering cores.

d) The expansion chamber at the top of the porcelain insulators should be suitable for expansion of oil.

e) Facilities shall be provided at terminal blocks in the marshalling box for star delta formation, short circuiting and grounding of CT secondary terminals.

f) Current Transformer's guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

g) The rated extended currents for 800kV and 420kV class Current transformers shall be as given below:

Tap Ratio	800kV, 3000A	400kV, 3000A
	Rated extended currents in % of rated current	
500/1	200	200
1000/1	---	---
2000/1	180	180
3000/1	120 (200 for 15 min)	120

h) The secondary winding shall be rated for 2A continuously.

Further, the intermediate tapping at 3000-2000 of metering core of 3000 A rated 400kV and 800kV CTs shall be suitable for using as 1000/1 ratio **also**. The Auxiliary reactor, **if used,** as referred at wiring diagram No.0000-000-T-E-L-028 shall be suitable for connecting to the selected taps. The requirements of 3000A CTs are given at TABLE II-A.

For 245/145**/72.5**kV class CTs, the rated extended primary current shall be 120% (or 150% if applicable) on all cores of the CTs.

h) For 800/420/245/145**/72.5**kV Current Transformer, characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 5% to 120% (or specified rated extended current whichever is higher) of rated current in case of metering CTs and up to the accuracy limit factor/knee point voltage in case of relaying CTs.

i) The current transformer shall be suitable for horizontal transportation. It shall be ensured that the CT is able to withstand all the stresses imposed on it while transporting and there shall be no damage in transit. The Contractor shall submit the details of packing **and transportation** design to the Employer for review.

j) For 800kV CTs, the instrument security factor at all ratios shall be less than ten (10) for metering core. For 420/245/145**/72.5**kV CTs, the instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably wired upto the terminal blocks.

k) The wiring diagram plate for the interconnections of the three single phase CTs shall be provided inside the marshalling box. A typical wiring diagram no. 0000-000-T-E-L-028 (Sh.1 & 2) is enclosed herewith at Annexure-III **of this specification**.

l) The Current Transformers should be suitable for mounting on lattice structure (for 800 kV) or pipe structure (for 420 kV and below) to be provided by the Contractor in accordance with stipulations of Section-Project/**Section-Structures.**

m) The CT shall be designed so as to achieve the minimum risks of explosion in service. Bidder/Manufacturer shall bring out in his offer, the measures taken to achieve this.

n) 800/420/245/145kV Current Transformers shall be suitable for high speed auto reclosing.

4.0 VOLTAGE TRANSFORMERS:

a) 800/420/245/145kV Voltage Transformers shall be capacitor voltage divider type with electromagnetic units and shall be suitable for carrier coupling.

b) Voltage transformers secondaries shall be protected by HRC cartridge type fuses or MCBs for all the windings. In addition, fuses/MCBs shall be provided for the protection and metering windings for fuse monitoring scheme. The secondary terminals of the VTs shall be terminated to the stud type non-disconnecting terminal blocks in the individual phase secondary boxes via the fuse/MCBs.

c) CVTs shall be suitable for high frequency (HF) coupling required for power line carrier communication. Carrier signal must be prevented from flowing into potential transformer (EMU) circuit by means of a RF choke/reactor suitable for effectively blocking the carrier signals over the entire carrier frequency range i.e. 40 to 500 KHz. H.F. terminal of the CVT shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment, when utilized. Further, earthing link with fastener to be provided for HF terminal.

d) The electromagnetic unit comprising compensating reactor, intermediate transformer and protective and damping devices should have separate terminal box with all the secondary terminals brought out.

e) The damping device, which should be permanently connected to one of the secondary windings, should be capable of suppressing the ferroresonance oscillations.

f) The accuracy of 0.2 on secondary III for all CVTs/IVTs should be maintained through out the entire burden range upto 50 VA on all the windings without any adjustments during operation.

g) **The Voltage Transformers shall be suitable for mounting on lattice structure (for 800kV) or Pipe structure (for 420kV and below) to be provided by the Contractor in accordance with stipulations of Section-Project/Section-Structures.**

h) It should be ensured that access to secondary terminals is without any danger of access to high voltage circuit.

i) A protective surge arrester shall be provided, if required, to prevent breakdown of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor/primary winding, tuning reactor/RF choke etc. due to short circuit in transformer secondaries. **Alternate arrangement shall also be acceptable**.

j) The wiring diagram for the interconnection of the three single phase CVTs/IVTs shall be provided inside the marshalling box in such a manner that it does not deteriorate with time. Wiring diagram no.: 0000-000-T-E-L-029 enclosed herewith at Annexure-IV **of this specification shall be** followed.

5.0 TERMINAL CONNECTORS:

The terminal connectors shall meet the requirements as given in Section-GTR **and technical parameters for the respective equipment as per Annexure-I and Annexure-II of this specification.**

6.0 TESTS:

6.1 In accordance with the requirements in Section-GTR, Current Transformer and Voltage Transformer should have been type tested and shall be subjected to routine tests in accordance with **relevant IEC**.

6.2 The test reports of type tests**, as applicable, as per IEC-61869-2 for CT, IEC-61869-5/IEC-60358 for CVT, and IEC-61869-3 for IVT** and following additional tests shall be submitted for the Employer's review. **The type tests for which the procedure is under consideration as per abovesaid IEC is not required to be considered.**

a) Current Transformers (CT):

i) Corona test as per Annexure-A of Section-GTR **for 420kV and above voltage rating.**

ii) RIV test as per IEC-61869 or as per Annexure-A of Section-GTR for 145kV and above voltage rating. However, RIV level shall be as specified at Annexure-II of this specification.

iii) Seismic withstand test as per Annexure-B of Section-GTR **or IEC-62271-2 (with Seismic acceleration requirement as per Annexure-I of this specification/Section-Project) for 145kV and above voltage rating.**

iv) Thermal stability test, i.e. application of rated voltage and rated extended thermal current simultaneously by synthetic test circuit **for 145kV and above voltage rating** (not applicable for SF_6 filled CT).

v) Thermal co-efficient test i.e. measurement of tan-delta as a function of temperature (at ambient and between $80^{O}C$ & $90^{O}C$) and voltage (at 0.3, 0.7, 1.0 and 1.1 Um/√3) **for 145kV and above voltage rating** (not applicable for SF_6 filled CT).

vi) Multiple chopped impulse test (not applicable for SF_6 filled CT) with the application of 600 chopped impulses **for 145kV and above voltage rating**.

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vii) Transmitted over voltage test for 145kV and above voltage rating

viii) Mechanical test (with minimum Cantilever load as per clause no. 2.1.c) for 145kV and above voltage rating

ix) Internal Arc fault test for 145kV and above voltage rating (not applicable for CT with Polymer Insulator)

x) Enclosure tightness test at low & high temperature for SF_6 filled CT of 145kV and above voltage rating

xi) Gas dew point test for SF_6 filled CT

xii) Corrosion test for 145kV and above voltage rating

b) Capacitive Voltage Transformers (CVT):

i) High frequency capacitance and equivalent series resistance measurement (as per IEC-60358)

ii) Seismic withstand test (as per Annexure-B of Section-GTR) ***or IEC-62271-2*** **(with Seismic acceleration requirement as per Annexure-II of this specification/Section-Project) for 145kV and above voltage class.**

iii) Stray capacitance and stray conductance measurement of the low voltage terminal (as per IEC-60358)

iv) Corona test as per Annexure-A of Section-GTR **for 420kV and above voltage rating**.

v) **RIV test as per IEC-61869 or as per Annexure-A of Section-GTR for 145kV and above voltage rating. However, RIV level shall be as specified at Annexure-II of this specification.**

vi) **Transmitted over voltage test for 145kV and above voltage rating**

vii) **Mechanical test (with minimum Cantilever load as per clause no. 2.1.c) for 72.5kV and above voltage rating**

viii) **Determination of Temperature coefficient for 145kV and above voltage rating**

ix) **Tightness design test of capacitor units for 145kV and above voltage rating**

x) **Corrosion test for 145kV and above voltage rating**

c) **Inductive Voltage Transformers (IVT):**

i) Seismic withstand test (as per Annexure-B of Section-GTR) ***or IEC-62271-2*** **(with Seismic acceleration requirement as per Annexure-II of this specification/Section-Project) for 145kV and above voltage rating.**

ii) Corona test as per Annexure-A of Section-GTR **for 420kV and above voltage rating**.

ii) **RIV test as per IEC-61869 or as per Annexure-A of Section-GTR for 145kV and above voltage rating. However, RIV level shall be as specified at Annexure-II of this specification.**

iii) **Multiple chopped impulse test with application of 600 chopped impulses for 145kV and above voltage rating** (not applicable for SF_6 filled CT).

iv) **Transmitted over voltage test for 145kV and above voltage rating**

v) **Mechanical test (with minimum Cantilever load as per clause no. 2.1.c) for 72.5kV and above voltage rating**

vi) **Enclosure tightness test at low & high temperature for SF_6 filled CT of 145kV and above voltage rating**

vii) **Gas dew point test for SF_6 filled CT**

viii) Corrosion test for 145kV and above voltage rating

ix) Measurement of Capacitance and Dielectric dissipation factor for 145kV and above voltage rating

6.3 The current and voltage transformer shall be subjected to the following routine tests in addition to routine tests as per ***relevant*** IEC~~.~~

a) CURRENT TRANSFORMERS:

ROUTINE TESTS:

For Oil filled CT:

i) Measurement of Capacitance.

ii) Oil leakage test.

iii) Measurement of tan delta at 0.3, 0.7, 1.0 and 1.1 Um/√3.

For SF_6 filled CT:

i) Dew point measurement

ii) SF_6 alarm/ lockout check.

iii) SF_6 gas leakage test: Gas leakage rate shall be maintained within 0.2% per annum.

b) VOLTAGE TRANSFORMERS:

Routine tests on CVT/IVT shall be done in line with IEC-61869-3/61869-5.

7.0 MANDATORY SPARES:

Bidder shall include in his proposal mandatory spares as mentioned in the Bidding Documents.

8.0 MAJOR TECHNICAL PARAMETERS:

Major technical parameters for 800kV/420kV/245kV/145kV/72.5kV Instrument Transformers are enclosed at Annexure-I and Annexure-II to this specification.

9.0 PRE-COMMISSIONING TESTS

9.1 An indicative list of tests is given below. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment Supplier or Employer without any extra cost to the Employer. **The Contractor shall arrange all instruments**

required for conducting these tests alongwith calibration certificates at his own cost.

9.2 **Current Transformers**

(a) Insulation Resistance Test for primary and secondary

(b) Polarity test

(c) Ratio identification test - checking of all ratios on all cores by primary injection of current

(d) Dielectric test of oil (wherever applicable)

(e) Magnetizing characteristics test

(f) Tan delta and capacitance measurement

(g) Secondary winding resistance measurement

(h) Contact resistance measurement (wherever possible/accessible)

(i) Test for SF_6 (for SF_6 filled CTs) – Dew point measurement, SF_6 alarm/ lockout check

(j) DGA test of oil

Dissolved Gas Analysis (DGA) shall be carried out twice within the first year of service, first within the first month of commissioning/charging and second between six months to one year from the date of commissioning/charging.

CTs/IVTs must have adequate provision for taking oil samples from the bottom of the CT/IVT without exposure to atmosphere. Manufacturer shall recommend the frequency at which oil samples should be taken and norms for various gases in oil after being in operation for different durations. ~~Bidder/~~Manufacturer should also indicate the total quantity of oil which can be withdrawn from CT for gas analysis before refilling or further treatment of CT becomes necessary.

Bidder shall supply 2 nos. oil sampling device for every 20 nos. oil filled CT supplied with a minimum of 2 nos. oil sampling device for each substation.

9.3 **Inductive Voltage Transformers/Capacitive Voltage Transformers**

(a) Insulation Resistance test for primary (if applicable) and secondary winding
(b) Polarity test
(c) Ratio test
(d) Dielectric test of oil (wherever applicable)

(e) Tan delta and capacitance measurement of individual capacitor stacks
(f) Secondary winding resistance measurement

For pre-commissioning procedures and formats for Current Transformers, Doc.No.: CF/CT/04/R-4 dtd-01.04.2013 and for Voltage Transformers, CF/CVT/05/R-4 dtd-01.04.2011 under POWERGRID document no. D-2-01-03-01-04 will be the reference document. **This document will be available at respective sites and shall be referred by the contractor.**

10.0 Defect Liability

The actions required to be taken by contractor in case of defects observed in CT/CVT of ratings 145kV & above during the warranty period (defect liability period) shall be as per enclosed Annexure-V of this specification. Further, the replaced/repaired/refurbished equipment (or part of equipment) shall have Two (2) years warranty without prejudice to contractual warranty period (defect liability period).

TABLE - IA

REQUIREMENTS OF 800 KV CAPACITIVE VOLTAGE TRANSFORMER

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	800		
2.	Type	Single phase Capacitor VT		
3.	No. of secondaries	3		
4.	Rated voltage factor	1.2 continuous 1.5 - 30 seconds		
5.	Phase angle error	**± 10 minutes** (For metering core)		
6.	Capacitance (pf)	4400/8800* (+10% /- 5%)		
7.	Core details	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	$\frac{765}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{765}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{765}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$
	b) Application	Protection	Protection	Metering
	c) Accuracy	0.5&3P	0.5&3P	0.2
	d) Min. Output burden (VA)	50	50	50

* Capacitance value shall be as specified in BPS.

TABLE - IB

REQUIREMENTS OF 420 KV VOLTAGE TRANSFORMER

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	420		
2.	Type	Single phase Electromagnetic or Capacitor VT		
3.	No. of secondaries	3		
4.	Rated voltage factor	1.2 continuous 1.5 - 30 seconds		
5.	Phase angle error	$\pm$ 10 minutes (For metering core)		
6.	Capacitance (pf) (for CVT)	4400/8800* (+10% / - 5%)		
7.	Core details	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	$\frac{400}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{400}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{400}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$
	b) Application	Protection	Protection	Metering
	c) Accuracy	0.5&3P	0.5&3P	0.2
	d) Min. Output burden (VA)	50	50	50

* Capacitance value shall be as specified in BPS.

TABLE - IC

REQUIREMENTS OF 245 KV VOLTAGE TRANSFORMER

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	245		
2.	Type	Single phase Electromagnetic or Capacitor VT		
3.	No. of secondaries	3 cores		
4.	Rated voltage factor	1.2 continuous 1.5 - 30 seconds		
5.	Phase angle error	$\pm$ 10 minutes (For metering core)		
6.	Capacitance (pf) (for CVT)	4400/8800* (+10% / - 5%)		
7.	Core details	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	$\frac{220}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{220}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$	$\frac{220}{\sqrt{3}}/\frac{0.11}{\sqrt{3}}$
	b) Application	Protection	Protection	Metering
	c) Accuracy	3P	3P	0.2
	d) Min. Output burden (VA)	50	50	50

* Capacitance value shall be as specified in BPS.

TABLE - ID

REQUIREMENTS OF 145 KV VOLTAGE TRANSFORMER

S.No.	PARTICULAR			
1.	Rated primary voltage (kV rms)	145		
2.	Type	Single phase Electromagnetic or Capacitor VT		
3.	No. of secondaries	3 cores		
4.	Rated voltage factor	1.2 continuous 1.5 - 30 seconds		
5.	Phase angle error	$\pm$ 10 minutes (For metering core)		
6.	Capacitance (pf) (for CVT)	8800 (+ 10% / -5%)		
7.	Core details	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	$\frac{132}{\sqrt{3}} / \frac{0.11}{\sqrt{3}}$	$\frac{132}{\sqrt{3}} / \frac{0.11}{\sqrt{3}}$	$\frac{132}{\sqrt{3}} / \frac{0.11}{\sqrt{3}}$
	b) Application	Protec-tion	Protec-tion	Meter-ing
	c) Accuracy	3P	3P	0.2
	d) Min. Output burden (VA)	50	50	50

TABLE - IE

REQUIREMENTS OF 72.5 KV VOLTAGE TRANSFORMER

S.No.	PARTICULAR		
1.	Rated primary voltage (kV rms)	72.5	
2.	Type	Single phase Electro-magnetic or Capacitive VT	
3.	No. of secondaries	2 cores	
4.	Rated Voltage Factor	1.2 continuous 1.5 – 30 seconds	
5.	Phase angle error	+ 20 minutes (For metering core)	
6.	Core details	**Core-1**	**Core-2**
	a) Voltage ratio	**For 66 kV feeder application**	
		66/√3 /0.11/√3	66/√3 /0.11/√3
		For tertiary loading (of ICT) application	
		33/√3 /0.11/√3	33/√3 /0.11/√3
	b) Application	Protection	Metering
	c) Accuracy	3P	0.5
	d) Output Burden (VA) (minimum)	10	10

TABLE-IIA

REQUIREMENTS FOR 800 KV CURRENT TRANSFORMER

No. of Cores.	Core No.	Application	Current Ratio	Output Burden (VA)	Accuracy Class	Min. Knee Pt. Voltage (Vk)	Max. CT Sec. wdg. Resistance (in Ω)	Max. Excit. Current at Vk (in mA)
6	1	BUS DIFF. CHECK	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	2.	BUS DIFF. MAIN	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	3.	METERING	3000/ 2000/ 500/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	4.	METERING	3000/ 2000/ 500/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	5.	TRANSF DIFF./ LINE PROTN.	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	6	LINE PROTN/LBB PROTN.	3000- 2000- 500/1	-	**PX**	3000/ 2000 500	15/10/2.5	20 on 3000/1 Tap,30 on 2000/1 Tap,120 on 500/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE-IIB

REQUIREMENTS FOR 420 KV CURRENT TRANSFORMER

No. of cores	Core No.	Application	Ratio	Output Burden	Accuracy Class	Min. Knee Pt. Voltage (Vk)	Max. CT Sec. wdg. Resistance (in Ω)	Max. Excit. Current at Vk (in mA)
6	1	BUS DIFF. CHECK	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	2.	BUS DIFF. MAIN	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	3.	METERING	3000/ 2000/ 500/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	4.	METERING	3000/ 2000/ 500/1	20 20 20	0.2S 0.2S 0.2S	- - -		- - -
	5.	TRANS. BACK UP/LINE PROTN.	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap
	6.	TRANS. DIFF. /LINE PROTN.	3000/ 2000/ 500/1	-	**PX**	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1; 120 on 500/1 tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE - IIC

REQUIREMENTS FOR 245 KV CURRENT TRANSFORMER

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt.volt-age (Vk)	Max. CT sec.wdg. resist-ance(ohms)	Max. Excit-ation cur-rent at Vk (in mA)
5	1	BUS DIFF CHECK	1600-800/1	-	**PX**	1600/800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	2	BUS DIFF MAIN	1600-800/1	-	**PX**	1600/800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	3	METERING	1600-800/1	20	0.2S	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	1600-800/1	-	**PX**	1600/800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap
	5	TRANS. DIFF/LINE PROTN	1600-800/1	-	**PX**	1600/800	8/4	25 on 1600/1 Tap; 50 on 800/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE - IID

REQUIREMENTS FOR 145 KV CURRENT TRANSFORMER

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt.volt-age Vk	Max. CT sec.wdg. resist-ance(ohms)	Max. Excit-ation cur-rent at Vk (in mA)
5	1	BUS DIFF CHECK	800-400/1	-	PX	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap
	2	BUS DIFF MAIN	800-400/1	-	PX	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap
	3	METERING	800-400/1	20	**0.2S**	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	800-400/1	-	PX	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap
	5	TRANS. DIFF/LINE PROTN	800-400/1	-	PX	800/400	8/4	25 on 800/1 Tap; 50 on 400/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE – IIE

REQUIREMENTS FOR 145 kV CURRENT TRANSFORMER

No.of Cores	Core No.	Appli-cation	Current ratio	Output burden (VA)	Accuracy class	Min. knee pt.volt-age Vk	Max. CT sec.wdg. resist-ance(ohms)	Max. Excit-ation cur-rent at Vk (in mA)
5	1	BUS DIFF CHECK	600-300/1	-	PX	600/300	6/3	30 on 600/1 Tap; 60 on 300/1 Tap
	2	BUS DIFF MAIN	600-300/1	-	PX	600/300	6/3	30 on 600/1 Tap; on 300/1 Tap
	3	METERING	300-150/1	20	0.2S	-	-	-
	4	TRANS. BACK UP/LINE PROTN.	600-300/1	-	PX	600/300	6/3	30 on 600/1 Tap; 60 on 300/1 Tap
	5	TRANS. DIFF/LINE PROTN	600-300/1	-	PX	600/300	6/3	30 on 600/1 Tap; 60 on 300/1 Tap

Note: 1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE – IIF

REQUIREMENTS FOR 72.5 kV CURRENT TRANSFORMER (FOR TERTIARY LOADING OF ICT)

No. of Cores	Core No.	Application	Current Ratio	Output burden (VA)	Accuracy class & ALF
2	1	O/C & E/F	50/1	10	5P10
	2	Metering	50/1	10	0.5

Annexure-I

MAJOR TECHNICAL PARAMETERS FOR CT

S. No.	Description	765kV system	400kV system	220kV system	132 kV system	66 kV System (for Tertiary loading)
1	Rated voltage, U_m (kVrms)	800	420	245	145	72.5
2	Rated frequency (Hz)	50	50	50	50	50
3	No. of Poles	1	1	1	1	1
4	Design ambient temperature (°C)	50	50	50	50	50
5	Rated Primary Current (A)	3000	3000	1600	800/600	50
6	Rated extended primary current	120%	120%	120%/150%	120%/150 %	120%
7	Rated short time thermal withstand current	40kA/50kA (as applicable) for 1 sec	40kA/50kA/63kA (as applicable) for 1 sec	40kA/50kA (as applicable) for 1 sec	31.5kA for 1sec	25kA for 3sec
8	Rated dynamic current	100kAp/125kAp (as applicable)	100kAp/125kAp/ 157.5kAp (as applicable)	100kAp/125kAp (as applicable)	80kAp	63kAp
9	Temperature rise over design ambient temperature	As per IEC				
10	Rated Insulation levels					
a)	Full wave impulse withstand voltage (1.2/50 microsecond)					
i)	between line terminals and ground(kVpeak)	±2100	±1425	±1050	±650	±325
b)	Switching impulse withstand voltage (250/2500 microsecond) (dry and wet)					
i)	between line terminals and ground (kVpeak)	± 1550	± 1050	-NA-	-NA-	-NA-
c)	One minute power frequency dry withstand voltage (dry and wet)					
i)	between line terminals and ground (kVrms)	975 (dry only)	630 (dry only)	460	275	140
d)	One minute power frequency withstand voltage between secondary terminals & earth (kVrms)	5kV				

S. No.	Description	765kV system	400kV system	220kV system	132 kV system	66 kV System (for Tertiary loading)
11	Max. radio interference voltage for frequency between0.5 MHz and 2 MHz at (microvolts)	2500 at 508 kV rms	1000 at 266kV rms	1000 at 156kV rms	500 at 92kV rms	-NA-
12	Minimum Corona extinction voltage (kVrms)	508	320	-NA-	-NA-	-NA-
13	Seismic acceleration (Horizontal)	0.3g	0.3g	0.3g	0.3g	-NA-
14	Partial Discharge	As per IEC	As per IEC	As per IEC	As per IEC	As per IEC
15	Number of terminals	All terminals of control circuits are to be wired up to marshaling box plus 20% spare terminals evenly distributed on all TBs.				
16	Minimum Creepage distance (mm) *	20000	10500	6125	3625	1813
17	System neutral earthing	Effectively Earthed				

*The values indicated are for specific creepage of 25mm/kV. In case of specific creepage of 31mm/kV is specified, the Minimum Creepage distance values shall be considered proportionately.

For other parameters, refer respective Table for the applicable voltage class of CTs.

Annexure-II

MAJOR TECHNICAL PARAMETERS FOR CVT/IVT

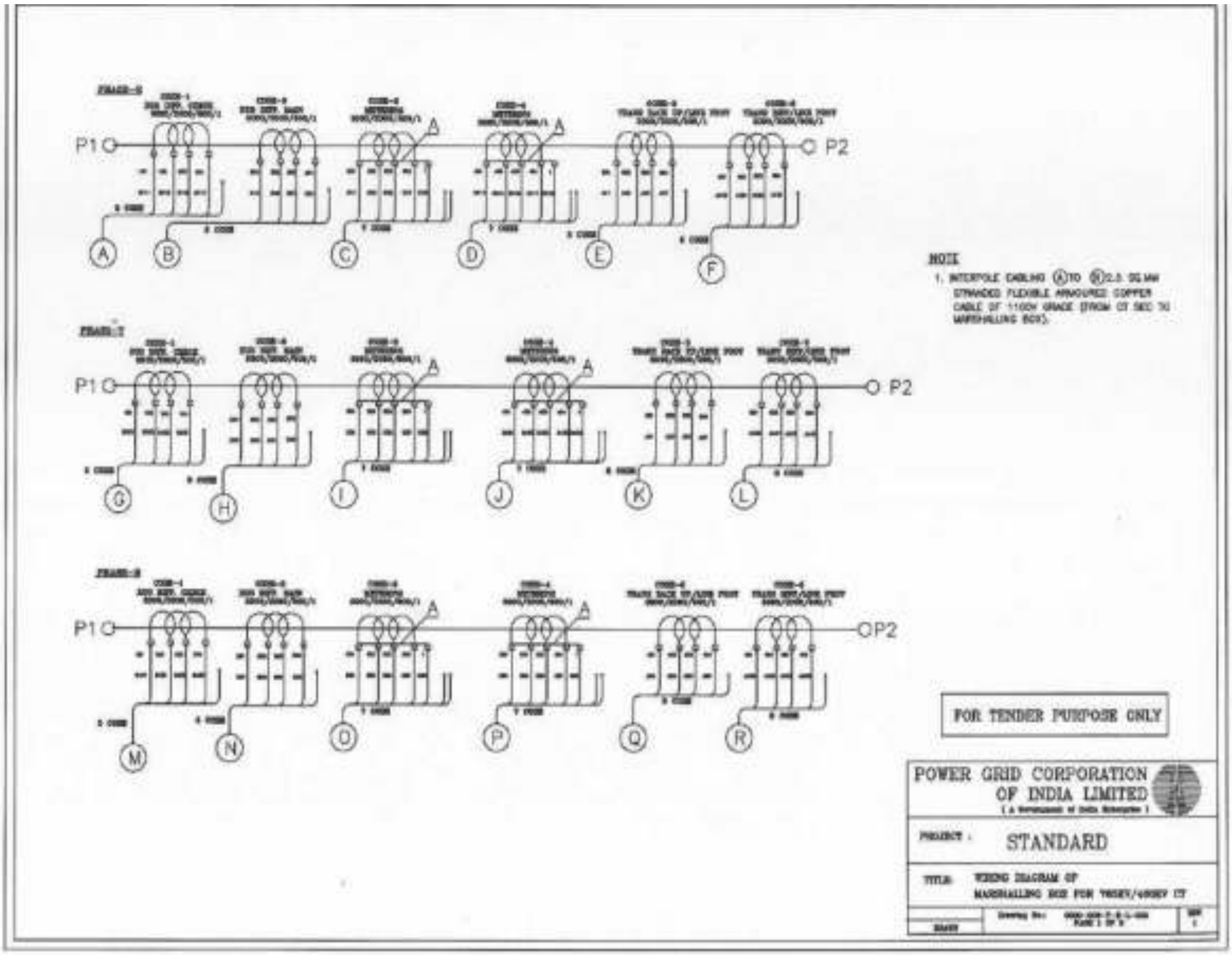
S. No.	Description	765kV system	400kV system	220kV system	132 kV system	66 kV System (for tertiary loading)
1	Type (CVT/IVT)	**CVT**	**CVT/IVT**	**CVT/IVT**	**CVT/IVT**	**CVT/IVT**
2	Rated voltage, U_m (kVrms)	800	420	245	145	72.5
3	Rated frequency (Hz)	50	50	50	50	50
4	No. of Poles	1	1	1	1	1
5	Design ambient temperature (°C)	50	50	50	50	50
6	System fault level (kA)	40kA/50kA (as applicable) for 1 sec	40kA/50kA/63kA (as applicable) for 1 sec	40kA/50kA (as applicable) for 1 sec	31.5kA for 1sec	25kA for 3sec
6	Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement				
7	High frequency capacitance for entire carrier frequency range (for CVT only)	Within 80% to 150% of rated capacitance				-
8	Equivalent series resistance over entire carrier frequency range (for CVT)	Less than 40 Ohms				-
9	Stray capacitance and stray conductance of HF terminal over entire carrier frequency range (for CVT)	As per IEC-60358				-
10	Temperature rise over design ambient temperature	As per IEC				
11	Rated Insulation levels					
a)	Full wave impulse withstand voltage (1.2/50 microsecond)					
i)	between line terminals and ground (kVpeak)	±2100	±1425	±1050	±650	±325
b)	Switching impulse withstand voltage (250/2500 microsecond) (dry and wet)					

S. No.	Description	765kV system	400kV system	220kV system	132 kV system	66 kV System (for tertiary loading)
i)	between line terminals and ground (kVpeak)	± 1550	± 1050	-NA-	-NA-	-NA-
c)	One minute power frequency dry withstand voltage (dry and wet)					
i)	between line terminals and ground (kVrms)	975 (dry only)	630 (dry only)	460	275	140
d)	One minute power frequency withstand voltage between secondary terminals & earth					
i)	between LV (HF) terminal and earth terminal (kVrms)	10kVrms for exposed terminals and 4kVrms for terminals enclosed in a weather proof box				
ii)	For secondary winding	3kVrms				
11	Max. radio interference voltage for frequency between0.5 MHz and 2 MHz at (microvolts)	2500 at 508 kV rms	1000 at 266kV rms	1000 at 156kV rms	500 at 92kV rms	-NA-
12	Minimum Corona extinction voltage (kVrms)	508	320	-NA-	-NA-	-NA-
13	Seismic acceleration (Horizontal)	0.3g	0.3g	0.3g	0.3g	-NA-
14	Partial Discharge	As per IEC	As per IEC	As per IEC	As per IEC	As per IEC
15	Number of terminals	All terminals of control circuits are to be wired up to marshaling box plus 20% spare terminals evenly distributed on all TBs.				
16	Rated Total Thermal Burden (VA)	300 VA (100VA/winding)				20VA
17	System neutral earthing	Effectively Earthed				
	Minimum Creepage distance (mm) *	20000	10500	6125	3625	1813

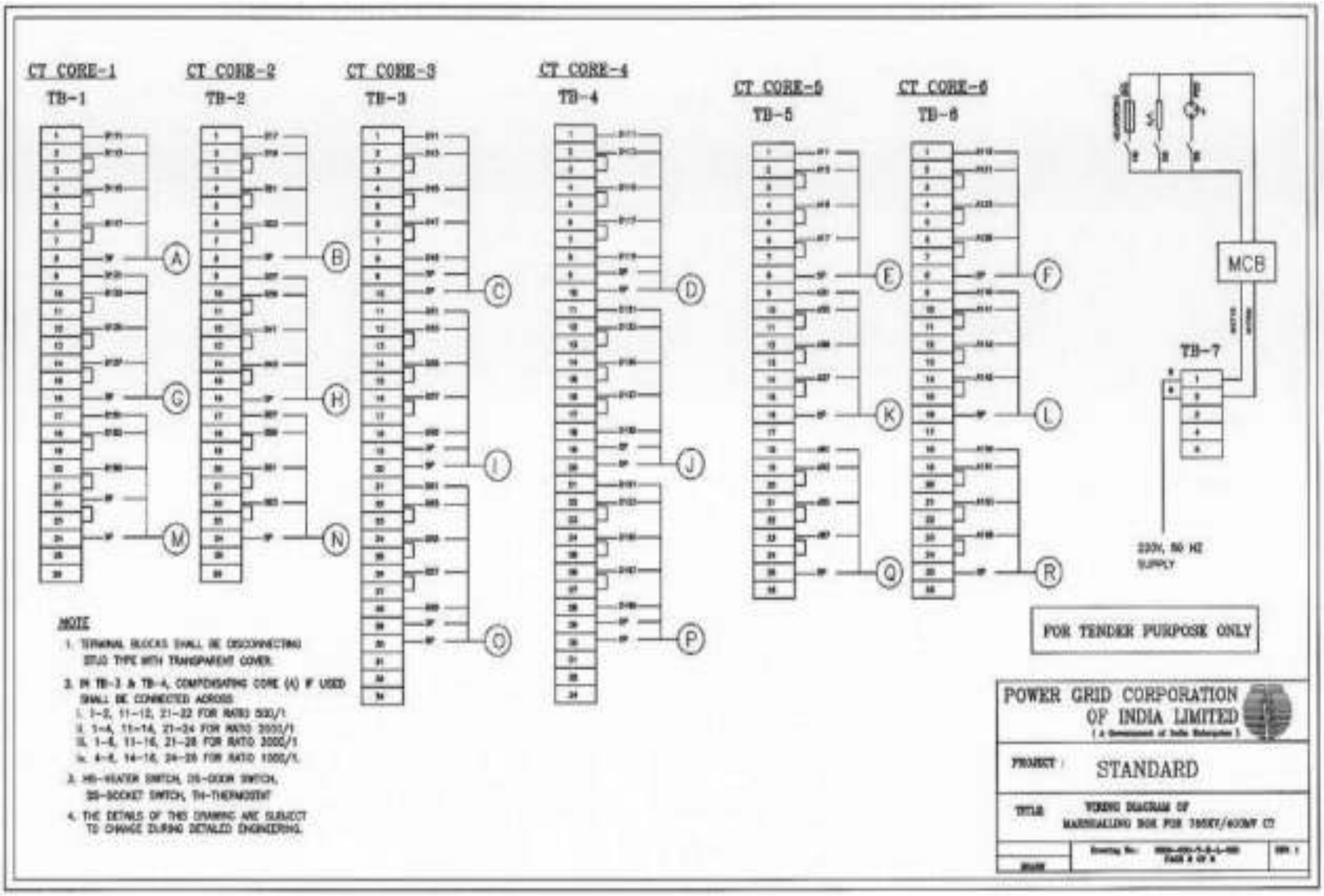
*The values indicated are for specific creepage of 25mm/kV. In case of specific creepage of 31mm/kV is specified, the Minimum Creepage distance values shall be considered proportionately.

For other parameters, refer respective Table for the applicable voltage class of CVTs/IVTs.

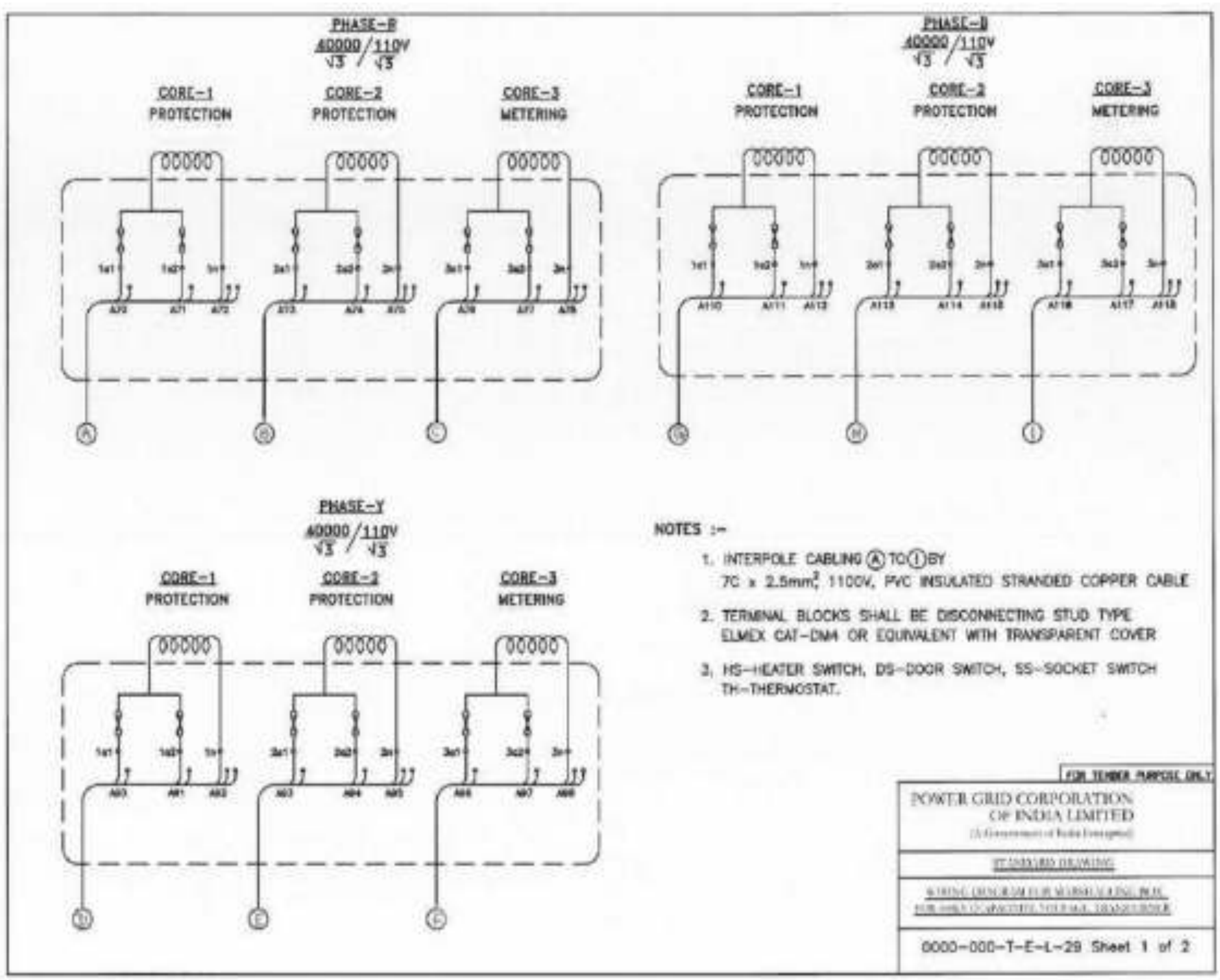
Annexure-III: Wiring Diagram of CT



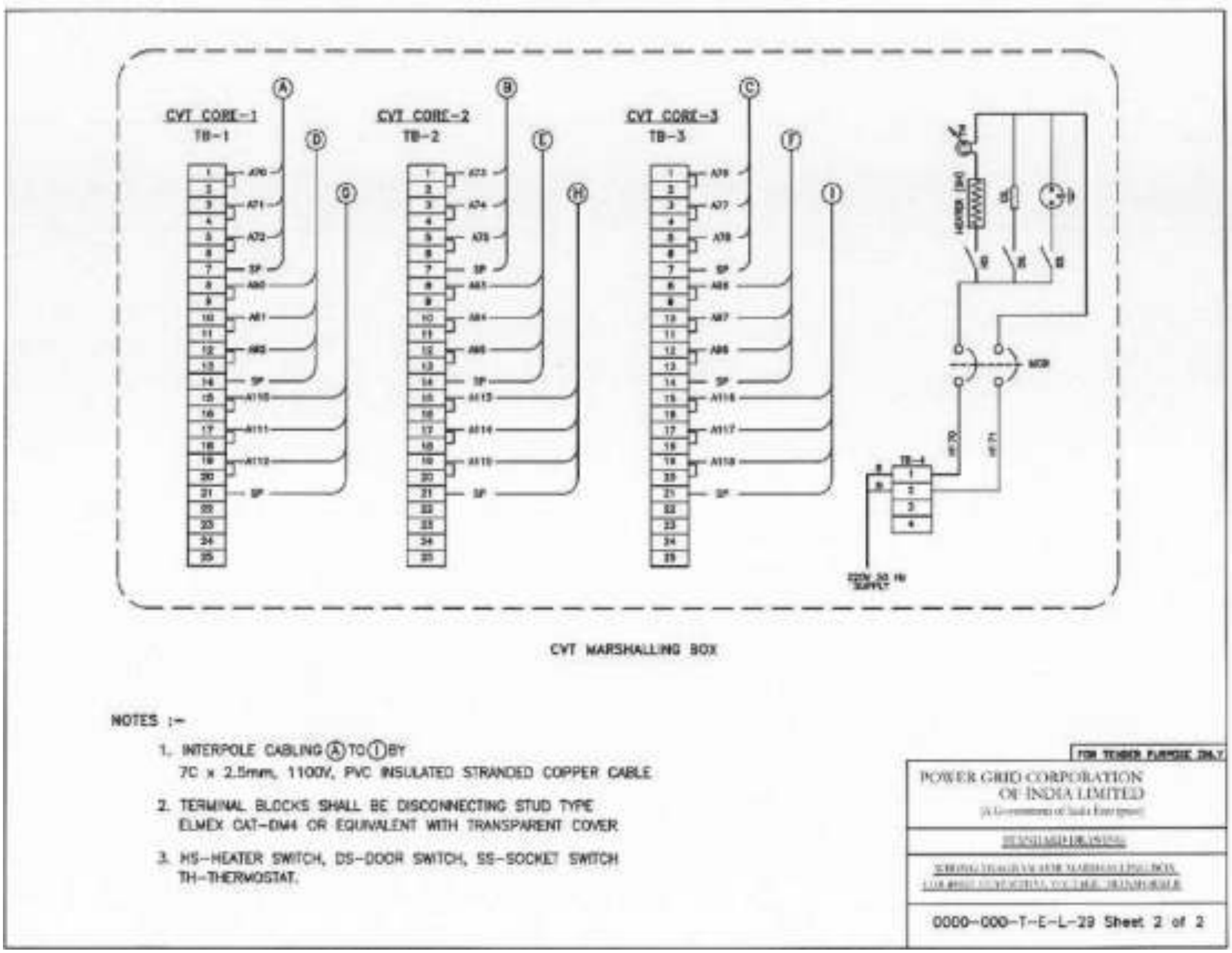
Annexure-III: Wiring Diagram of CT



Annexure-IV: Wiring Diagram of VT



Annexure-IV: Wiring Diagram of VT



Annexure-V: Actions required in case of defects observed during warrantee period

Equipment	Nature of problem	Corrective measures to be taken by contractor
CT (Oil filled)	**DGA Violation** H2 > 300 ppm C2H2> 2 ppm	CT to be **refurbished** or replaced
CT (SF_6 filled)	a) SF6 gas leakage b) High Dew point of SF6 gas (> -36 deg C at atm press)	a)Repair/ replacement b)Re-processing of gas and replacement of Gas in case of no improvement
CT (Oil filled)	**Violation of Tan delta** Tan Delta: >0.5%(during pre-commisioning) >0.7% (in operation) or change w.r.t. to previous **year** value > 0.1%	Replacement of CT
CT & CVT	- Oil leakage - Low Oil level -Sec winding problem leading to open/ short circuit, saturation etc	Replacement or repair as per repair procedure approved by QA.
CVT	Secondary voltage drift: Upto ± 0.5 volts Healthy a) ± 0.5 **or beyond**	a) CVT to be replaced

***Replaced/Repaired/Refurbished Equipment (or part of equipment) shall have 2 years warranty without prejudice to contractual warranty period.**

MODEL TECHNICAL SPECIFICATION
SECTION: SWITCHGEAR - SURGE ARRESTER
(REV. NO. 12)

Following are the major changes made in the Technical specification, Section-Switchgear - SA, Rev. 12:

Clause No.	Major Modification
1.1, 2.1, 2.4, 2.5 and Annexure-I	As per latest IS 15086 part 4/ IEC 60099-4:2014, new classification of Surge Arresters added. A new concept of arrester classification and energy withstand testing is introduced in line with IEC : line discharge classification is replaced by a classification based on repetitive charge transfer rating (Qrs) as well as on thermal energy rating (Wth) and thermal charge transfer rating (Qth), respectively.
Clause 3	1) Construction features of SA classified into Design A and Design B as per IEC. Design A for 336kV and above SA and Design A/Design B for <336kV SA. 2) Outer insulator of SA shall be either Polymer/Porcelain.
Clause 4.3	Option of PVC insulated flexible copper cable included for Surge monitor connection.
Clause 5.2	Special type tests not specified in IEC 60099-4 /IS are specified and other type tests to be carried out as per latest IEC/IS.
Annexure-I	1) LDC replaced with new arrester classification as per IEC, Minimum discharge capacity replaced with Thermal energy rating, Wth and repetitive charge transfer, Qrs added as new parameter. 2) Insulation withstand data shall be as per IEC 60099-4: 2014 latest edition. 3) Allowable deflection values changed as per cantilever strength. 4) Steep front residual voltage value for 624kV LA updated.

<u>Notes:</u> The above is the list of major changes with respect to previous revision (Rev. 11). However, bidders are advised to read the entire section for other changes and quote accordingly.

Table of Contents

1. GENERAL

1.1. The Surge arresters shall conform to **IS 15086 part 4/IEC: 60099-4 (latest edition)** except to the extent modified in the specification and shall also be in accordance with requirements under Section -GTR.

1.2. The Surge Arrestors shall be designed for use in the geographic and meteorological conditions as given in Section-GTR and Section- Project.

2. DUTY REQUIREMENTS

2.1. The surge arresters shall be of **Station High Duty (SH) / Station Medium Duty (SM) / Station Low Duty (SL) as per requirement** and gapless type without any series or shunt gaps.

2.2. The surge arresters shall be capable of discharging over-voltages occurring during switching of unloaded transformers, reactors and long lines.

2.3. 420 kV class Surge arresters shall be capable of discharging of severe re-energisation switching surges on a 400kV, 450km long line with Surge impedance of 300 ohms and capacitance of 11.986nF/km and over voltage factor of 2.3 p.u. Similarly, 800kV class Surge arresters shall be capable of discharging of severe re-energisation switching surges on a 765kV, 450km line with Surge impedance of 270 ohms and capacitance of 13 nF/km.

2.4. 420kV class arrester shall be capable of discharging energy equivalent to **Station High Duty (SH) class of IEC with thermal energy (Wth) of 12 kJ/kV for a 420kV system** followed immediately by 50 Hz energisation with a sequential voltage profile as specified below:

650 kVp for 3 peaks

575 kVp for 0.1 second

550 kVp for 1 second

475 kVp for 10 seconds

800kV class arrester shall be capable of discharging energy equivalent to **Station High Duty (SH) class of IEC with thermal energy (Wth) of 13 kJ/kV for an 800kV system** followed immediately by 50 Hz energisation with a sequential voltage profile as specified below:

1000 kVp for 3 peaks

910 kVp for 0.1 second

885 kVp for 1 second

866 kVp for 10 seconds

2.5. 245/145 kV class arrester shall be capable for discharging energy equivalent **to Station Medium Duty (SM) class of IEC with thermal energy (Wth) of minimum 7 kJ/kV for 245/145 kV system** followed by procedure as per IEC.

2.6. The surge arresters shall be suitable for withstanding forces as defined in Section-GTR.

2.7. The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

2.8. The surge arresters are being provided to protect the following equipment whose insulation levels are indicated in the table given below: -

Equipment to be protected	Lightning Impulse (kVp) for 800 kV system	Switching surge(kV) for 800 kV system	Lightning impulse(kVp) for 420 kV system	Switching surge(kV) for 420 kV system	Lightning impulse (kVp) for 245 kV system	Lightning Surge (kVp) for 145 kV system
Power transformer	± 1950	± 1550	±1300	±1050	±950	± 550
Reactor	± 1950	± 1550	± 1300	±1050	± 950	± 550
Instrument Transformer	± 2100	±1550	±1425	±1050	± 1050	±650
CB/Isolator Phase to ground	± 2100	± 1550	±1425	±1050	± 1050	± 650
CB/Isolator Across open contacts	± 2100 (-/+457)	± 1140 (-/+653)	±1425 (-/+240)	± 900 (-/+345)	±1050 (for CB) ± 1200 (for Isolator)	± 750 (for Isolator)

2.9. The duty cycle of CB installed in 800/420/245/145 kV System of the Employer shall be O-0.3 sec-CO-3 min-CO. The Surge Arrester shall be suitable for such circuit breaker duties in the system.

3. CONSTRUCTIONAL FEATURES

The features and constructional details of surge arresters shall be in accordance with requirement stipulated hereunder:

3.1. The non-linear blocks shall be of sintered metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent mechanical and electrical properties even after repeated operations.

3.2. **The surge arrester offered shall be of Design A (for 336kV and above SA) and Design A/Design B for <336kV SA.**

a. **Design A type arresters must be** fitted with pressure relief devices suitable for preventing violent failure of insulator housing and providing path for flow of rated fault currents in the event of arrester failure.

b. **Design B arrester should be embedded, all the components free of bubbles and gaps thus preventing partial discharge and moisture ingress. This type of design must have ability to control the cracking or tearing open of housing due to arc action and thereby avoiding violent shattering.**

3.3. **Outer insulator of surge arrester shall be porcelain/polymer conforming to requirements stipulated in Section-GTR.** Terminal connectors shall conform to requirements stipulated under Section-GTR. The outer insulator housing shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage upto the maximum design value for arrester. **Arresters shall not fail due to arrester insulator contamination.**

3.4. Seals **(for design A arresters)** shall be provided in such a way that these are always effectively maintained even when discharging rated lightning current.

3.5. The end fittings shall be made of corrosion proof material and preferably be nonmagnetic.

3.6. The name plate shall conform to the requirements of IEC incorporating the year of manufacture.

3.7. The following details shall be furnished for quality checks:

a. The heat treatment cycle details along with necessary quality checks used for individual blocks and insulation layer formed across each block.

b. Metalizing coating thickness for reduced resistance between adjacent discs.

3.8. The manufacturer will submit Data for rejection rate of ZnO blocks during manufacturing/operation for the past three years.

3.9. The sealing arrangement **(for design A arresters)** of the Surge Arrester stacks shall be done incorporating grooved flanges with the O-rings/elliptical cross-section gaskets of Neoprene or Butyl rubber.

3.10. Arresters shall be of hermetically sealed units, self-supporting construction, suitable for mounting on tubular support structures. However, 765 kV Surge Arrester shall be suitable for mounting on lattice type support structures.

3.11. For 624kV Surge arresters, number of stacks shall be three (3). The FRP tube outer diameter shall be 300mm (min) and FRP tube thickness shall be 25mm (min).

4. FITTINGS AND ACCESSORIES

4.1. Arresters shall be complete with insulating base having provision for bolting to flat surface of structure.

4.2. Self contained discharge counters, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit along with necessary connection arrangement. Suitable leakage current meters should also be provided. The reading of milliammeter and counters shall be visible through an inspection glass panel. The terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. The surge counter shall be provided with a potential free contact rated for 220 Volt (DC) which shall close whenever a surge is recorded by the surge monitor. Necessary arrangement shall be provided for extending the contact information to Substation Automation System/RTU.

4.3. Surge monitor consisting of discharge counters and milliammeters should be suitable to be mounted on support structure of the arrester and should be tested for IP66 degree of protection. The standard supporting structure for surge arrester should be provided with a mounting pad, for fixing the surge monitor. The surge monitor should be suitable for mounting on this standard insulating mounting pad. Also all nuts, bolts, washers etc. required for fixing the surge monitor shall be supplied by the Contractor. The arrangement for Surge Monitor enclosure fixing to the structure shall be at its rear/bottom. Connection between the Surge Arrester base and Surge Monitor shall be through a 2.0 m (minimum) long insulated copper rod/strip of at least 75 sq.mm cross sectional area or **PVC insulated flexible copper cable of at least 70 Sqmm.** The cable shall be terminated at rear/bottom side of the Surge Monitor. The gaskets of the surge monitors shall be of Neoprene, Butyl or equivalent material.

4.4. Grading/corona rings shall be provided on each complete arrester unit, as required. Suitable terminal connectors shall be supplied by the Contractor.

5. TESTS

5.1. In accordance with the requirements stipulated under Section-GTR, the surge arresters should have been type tested as per **latest IEC/IS** and shall be subjected to routine and acceptance tests in accordance with **latest IEC/IS**.

5.2. Test reports for all type tests **as per latest IS 15086 part4/IEC-60099-4** including following additional type tests shall also be submitted for the Employer's review:

a. Seismic withstand test as per Annexure-B of Section-GTR.

b. Corona Extinction Voltage test as per Annexure-A of Section-GTR.

c. Cantilever test on complete arrester as per requirement of Annexure-I.

5.3. (a) **Acceptance Tests:**

a. Measurement of power frequency reference voltage of the arrester units.

b. Lightning Impulse Residual voltage on arrester units as per IEC.

c. Internal Ionisation or partial Discharge test.

(b) **Special Acceptance Test:**

a. Thermal stability test on three sections as per IEC Clause 9.2.2.

b. Aging test for Zinc oxide blocks is to be carried out on 3 samples for 72 hours at maximum continuous over voltage (MCOV) and at a temperature of 115°C. Acceptance norm being Ir (resistive current)/watt loss shall remain or decrease at the end of 72 hrs from the value taken after 1 hour of start of test.

c. Watt loss test.

(c) **Routine Tests:**

a. Sealing test: Water dip test at 1.5m depth from top of Surge Arrestor for 30 minutes shall be performed during assembly of Surge Arrester stacks (followed by other routine tests, i.e. P.D. Measurement, Reference Voltage, Residual Voltage & IR measurement).

b. Measurement of reference voltage.

c. Residual voltage test of arrester unit.

d. Internal Ionisation test or partial discharge test.

e. Verticality check on completely assembled Surge arresters as a sample test on each lot.

(d) **Routine Tests on Surge Monitors:**

a. The Surge monitors shall be connected in series with the test specimens during residual voltage and current impulse withstand tests to verify efficacy of the same. Additional routine/ functional tests with one 100A and 10kA current impulse (8/20 micro sec.) shall also be performed on the Surge monitor.

b. Surge monitors shall be routinely tested for water dip test at 1.5m depth for 30 minutes. No water vapours shall be visible on the monitor glass.

(e) **Routine Tests on insulators**

All routine tests shall be conducted on the hollow column insulators as per IEC 62155. Polymer housing shall be tested in accordance to IEC-61462.

6. MANDATORY SPARES

Bidder shall include in his proposal mandatory spares as mentioned in the Bidding Documents.

7. TECHNICAL PARAMETERS

The technical parameters shall be as per enclosed Annexure-I.

8. PRE-COMMISSIONING TESTS

8.1. An indicative list of tests is given below:

a. Operation check of LA counters.

b. Insulation resistance measurement

c. Capacitance and Tan delta measurement of individual stacks.

d. Third harmonic resistive current measurement (to be conducted after energisation.)

8.2. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment manufacturer or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates at his own cost.

8.3. For pre-commissioning procedures and formats for Surge Arresters, Doc.No.: CF/SA/08/R-4 dtd-01/04/2013 under POWERGRID Document no. D-2-01-03-01-04 will be reference document. This document will be available at respective sites and shall be referred by the contractor.

ANNEXURE-I

Technical Parameters for 765kV, 400kV, 220kV and 132kV Surge Arresters (with Polymer/Porcelain Housing)

Sl. No.	Description	Unit	800kV SA	420kV SA	245kV SA	145kV SA
1	Nominal System Operating voltage	kV, rms	765	400	220	132
2	Rated frequency	Hz	50	50	50	50
3	No. of Poles	No.	1	1	1	1
4	Design ambient temperature	℃	50	50	50	50
5	Rated arrester voltage	kV	624	336	216	120
6	Continuous operating voltage at 50 deg.C	kV	490	267	168	102
7	Nominal discharge current		20 kA of 8/20 microsecond wave	20 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave
8	Discharge current at which insulation co-ordination will be done		20 kA of 8/20 microsecond wave	20 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave
9	**Rated thermal energy rating Wth**	kJ/kV **of rated arrester voltage**	13kJ/kV	12kJ/kV	**7kJ/kV**	**7kJ/kV**
10	**Repetitive charge transfer rating Qrs in coulombs**	**C**	**3.6C**	**2.4C**	**1.6C**	**1.6C**
11	Max. switching surge residual voltage	kVp	1180 (at 1kA) 1220 (at 2kA)	670(at 2kA) 650 (at 500A)	500 (at 1kA)	280 (at 1kA)
12	Max. residual voltage at					
i)	5kA	kVp	-	-	560	310
ii)	10 kA nominal discharge current	kVp	-	800	600	330
iii)	20 kA nominal discharge current	kVp	1480	850	-	-
iv)	Steep fronted wave residual voltage at 20 kA	kVp	**1650**	925	-	-
13	**Arrester classification**		**Station High duty(SH)**	**Station High duty(SH)**	**Station Medium duty (SM)**	**Station Medium duty(SM)**
14	High current short duration test value(4/10 micro second wave)	kAp	100	100	100	100
15	Current for pressure relief test	kA rms	63	40 / 50 / 63 (as applicable)	40 / 50 (as applicable)	40

Sl. No.	Description	Unit	800kV SA	420kV SA	245kV SA	145kV SA
16	Low current long duration test value	As per IEC				
17	Insulation Level					
a)	Full wave impulse withstand voltage (1.2/50 microsec.)					
i)	Arrester Housing	kVpeak	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**
b)	Switching impulse withstand voltage (250/2500 micro-second) dry/wet					
i)	Arrester Housing	kV peak	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**	-NA-	-NA-
c)	One minute power frequency dry/wet withstand voltage					
i)	Arrester Housing	kV rms	**-N/A-**	**-NA-**	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**
18	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz. in all positions	micro volts	2500 at 508 kVrms	500 at 266 kVrms	500 at 156 kVrms	500 at 92 kVrms
19	Minimum Creepage distance	mm	As per Section-GTR	As per Section-GTR	As per Section-GTR	As per Section-GTR
20	Cantilever Strength (for 1 minute withstand test)	kg	500	350	150	150
21	Maximum deflection at above cantilever load	mm	200	200	**125**	**50**
22	Seismic acceleration		As per IS:1893	As per IS:1893	---	---
23	Partial Discharge at 1.05 COV		≤ 10pC	≤ 10pC	≤ 10pC	≤ 10pC
24	System neutral earthing		Effectively Earthed	Effectively Earthed	Effectively Earthed	Effectively Earthed

Note: The above insulation levels are applicable for altitude up to 1000 meters above M.S.L. For higher altitudes, suitable correction factor as per relevant IEC shall be applied.

Technical parameters for 72.5kV, 36 kV and 11 kV Surge Arresters (with Porcelain /Polymer Housing)

Sl. No.	Description	Unit	72.5kV SA	36kV SA	12kV SA
1	Nominal System Operating voltage	kV, rms	66kV	33kV	11kV
2	Rated frequency	Hz	50	50	50
3	No. of Poles	No.	1	1	1
4	Design ambient temperature	℃	50	50	50
5	Rated arrester voltage	kV	60	30	9
6	Continuous operating voltage at 50 deg.C	kVrms	51	25	7.2
7	Nominal discharge current	kA	10 kA of 8/20 microsecond wave		
8	Discharge current at which insulation co- ordination will be done	kA	10 kA of 8/20 microsecond wave		
9	**Rated thermal energy rating Wth**	kJ/kV **of rated arrester voltage**	**7**	4	4
10	**Repetitive charge transfer rating Qrs in coulombs**	**C**	**1.6**	**1**	**1**
11	Max. switching surge residual voltage	kVp	136 (at 1kA)	72 (at 1kA)	22.4 (at 1kA)
12	Max. residual voltage at				
i)	5kA	kVp	160	85	26
ii)	10 kA nominal discharge current	kVp	170	90	28
iii)	20 kA nominal discharge current	kVp	190	- -	--
iv)	Steep fronted wave residual voltage at 10 kA	kVp	190	- -	--
13	**Arrester designation**		**Station Medium duty (SM)**	**Station Low duty (SL)**	**Station Low duty (SL)**
14	High current short duration test value(4/10 micro second wave)	kArms	100	100	100
15	Current for pressure relief test	kAp	40	25	25
16	Low current long duration test value		As per IEC		
17	Insulation Level				
a)	Full wave impulse withstand voltage (1.2/50 microsec.)				
i)	Arrester Housing	kVpeak	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**

Sl. No.	Description	Unit	72.5kV SA	36kV SA	12kV SA
b)	One minute power frequency dry/wet withstand voltage				
i)	Arrester Housing	kV rms	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**	**As per latest IEC:60099-4/IS 15086 part 4**
18	Minimum Creepage distance	mm	As per Section-GTR	As per Section-GTR	As per Section-GTR
19	Cantilever Strength (for 1 minute withstand test)	kg	150	150	150
20	Maximum deflection at above cantilever load	mm	**20**	**20**	**20**

Note: The above insulation levels are applicable for altitude up to 1000 meters above M.S.L. For higher altitudes, suitable correction factor as per relevant IEC shall be applied.

SECTION: POWER AND CONTROL CABLE

Table of contents

SECTION: POWER & CONTROL CABLES

1. POWER & CONTROL CABLES[FOR WORKING VOLTAGES UP TO AND INCLUDING 1100 V]

CRITERIA FOR SELECTION OF POWER & CONTROL CABLES

1.1.1. Aluminium conductor XLPE insulated armoured cables shall be used for main power supply purpose from LT Aux. Transformers to control room, between distribution boards, ***supply to oil filtration units, DG supply to AC distribution board*** and for supply for colony lighting from control room.

1.1.2 Aluminium conductor PVC insulated armoured power cables shall be used for various other applications in switchyard area/control room except for control/protection purposes.

1.1.3 For all control/protection purposes, PVC insulated armoured control cables of minimum 2.5 sq. mm. size with stranded Copper conductors shall be used.

1.1.4 POWERGRID has standardised the sizes of power cables for various feeders. Bidders are to estimate the quantity of cables and quote accordingly. The sizes of power cables to be used per feeder in different application shall be as follows:

S.No.	From	To	Cable size	Cable type
1.	Main Switch Board	LT Transformer	2-1C X 630 mm^2 per phase 1-1C X 630 mm^2 for neutral	XLPE
2.	Main Switch Board	AC Distribution Board	2-3½C X 300 mm^2	XLPE
3.	Main Switch Board	Oil Filtration Unit ***& looping to other oil filtration units.***	1-3½C X 300 mm^2	XLPE
4.	Main Switch Board	Colony Lighting	1-3½C X 300 mm^2	XLPE

5.	Main Switch Board	HVW pump LCP	1-3½C X 300 mm^2	XLPE
6.	Main Switch Board	Main Lighting distribution board	1-3½C X 300 mm^2	XLPE
7.	AC Distribution Board	D.G. Set AMF Panel	2-3½C X 300 mm^2	XLPE
8.	AC Distribution Board	Emergency Lighting distribution board	1-3½C X 70 mm^2	PVC
9.	AC Distribution Board	ICT MB	1-3½C X 70 mm^2	PVC
10.	AC Distribution Board	Bay MB	1-3½C X 70 mm^2	PVC
11.	Bay MB	AC Kiosk	1- 3 ½ x 35 mm^2	PVC
12.	AC Distribution Board	Battery Charger	1-3½C X 70 mm^2	PVC
13.	DCDB	Battery	2-1C X 150 mm^2	PVC
14.	DCDB	Battery Charger	2-1C X 150 mm^2	PVC
15.	DCDB	Protection/PLCC panel	1-4C X 16 mm^2	PVC
16.	Main Lighting DB	Lighting panels(Indoor)	1-3½C X 35 mm^2	PVC
17.	Main Lighting DB	Lighting panels (outdoor)	1-3½C X 70 mm^2	PVC
18.	Main Lighting DB	Receptacles (Indoor)	1-3½C X 35 mm^2	PVC
19.	Main Lighting DB	Receptacles (Outdoor)	1-3½C X 70 mm^2	PVC
20.	Lighting Panel	Sub lighting panels	1-4C X 16 mm^2	PVC
21.	Lighting Panel	Street Lighting Poles	1-4C X 16 mm^2	PVC
22.	Lighting Panel/ Sub lighting panels	Lighting Fixtures (Outdoor)	1-2C X 6 mm^2	PVC
23.	Bay MB	Equipments	1-4C X 16 mm^2 /1-4C X 6 mm^2 /1-2C X 6 mm^2	PVC

1.1.5 Bidder may offer sizes other than the sizes specified in clause 1.1.4. In such case and for other application where sizes of cables have not been indicated in the specification, sizing of power cables shall be done keeping in view continuous current ***(including future bays/load requirement)***, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by bidder during detailed engineering for purchaser's approval. ***The entire power and control cables & special cables (if any) required shall be executed by contractor for completion of present scope of work.***

1.1.6 Cables shall be laid conforming to IS : 1255.

1.1.7 While preparing cable schedules for control/protection purpose, following shall be ensured:

1.1.7.1 Separate cables shall be used for AC & DC.

1.1.7.2 Separate cables shall be used for DC1 & DC2.

1.1.8 For different cores of CT & CVT separate cable shall be used

1.1.9 At least one (1) cores shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

1.1.10 For control cabling, including CT/VT circuits, 2.5 sq.mm. size copper cables shall be used per connection. However, if required from voltage drop/VA burden consideration, additional cores shall be used. Further for potential circuits of energy meters, separate connections by 2 cores of 2.5 sq.mm. size shall be provided.

1.1.11 Standard technical data sheets for cable sizes up to and including 1100V are enclosed at Annexure. Cable sizes shall be offered/manufactured in accordance with parameters specified in standard technical data sheets. Technical data sheet for any other cores/sizes required during detailed engineering shall be separately offered for owner's approval by the contractor/supplier. ***Submission of standard technical data sheets for these cable sizes are not required for approval. Contractor/supplier shall intimate name of proposed approved cable manufacturer along with cable sizes, its quantity required during detailed engineering for purchaser's information and acceptance.***

1.2. TECHNICAL REQUIREMENTS

1.2.1. General

1.2.1.1. The cables shall be suitable for laying in racks, ducts, trenches, conduits and underground buried installation with uncontrolled back fill and chances of flooding by water.

1.2.1.2. They shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions. The XLPE /PVC insulated L.T. power cables of sizes 240 sq. mm. and above shall withstand without damage a 3 phase fault current of at least 45 kA for at least 0.12 second, with an initial peak of 105 kA in one of the phases at rated conductor temperature (70 degC for PVC insulated cables and 90 degC for XLPE insulated cables). The armour for these power cables shall be capable of carrying 45 kA for at least 0.12 seconds without exceeding the maximum allowable temperature of PVC outer sheath.

1.2.1.3. The XLPE insulated cables shall be capable of withstanding a conductor temperature of 250°C during a short circuit without any damage. The PVC insulated cables shall be capable of withstanding a conductor temperature of 160°C during a short circuit.

1.2.1.4. The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All Aluminium used in the cables for conductors shall be of H2 grade. In case of single core cables armours shall be of H4 grade Aluminium.

1.2.1.5. The fillers and inner sheath shall be of non-hygroscopic, fire retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

1.2.1.6. Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

1.2.1.7. Strip wire armouring method (a) mentioned in Table 5, Page-6 of IS : 1554 (Part 1) – 1988 shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

1.2.1.8. The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

1.2.1.9. All the cables shall pass fire resistance test as per IS:1554 (Part-I)

1.2.1.10. The normal current rating of all PVC insulated cables shall be as per IS:3961.

1.2.1.11. Repaired cables shall not be accepted.

1.2.1.12. Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

1.2.2. **XLPE Power Cables**

1.2.2.1. The XLPE (90°C) insulated cables shall be of FR type, C1 category conforming to IS:7098 (Part-I) and its amendments read alongwith this specification. The conductor shall be stranded aluminium circular/sector shaped and compacted. In multicore cables, the core shall be identified by red, yellow, blue and black coloured strips or colouring of insulation. A distinct inner sheath shall be provided in all multicore cables. For XLPE cables, the inner sheath shall be of extruded PVC of type ST-2 of IS:5831. ***All cables shall be of armoured type***. For single core cables, the ***armouring*** shall consist of aluminium wires/strips. The outer sheath shall be extruded PVC of Type ST-2 of IS:5831 for all XLPE cables.

1.2.3. **PVC Power Cables**

1.2.3.1. The PVC (70°C) insulated power cables shall be of FR type, C1 category, conforming to IS: 1554 (Part-I) and its amendments read alongwith this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IS: 5831. A distinct inner sheath shall be provided in all multicore cables. ***All cables shall be of armoured type.*** For multicore armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IS: 5831 for all cables.

1.2.4. **PVC Control Cables**

1.2.4.1. The PVC (70°C) insulated control cables shall be of FR type C1 category conforming to IS: 1554 (Part-1) and its amendments, read alongwith this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IS: 5831. A distinct inner sheath shall be provided in all cables. ***All cables shall be of armoured type.*** The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour.

1.2.4.2. Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS 1554 (Part-1).

2. HV POWER CABLES[FOR WORKING VOLTAGES FROM 3.3 kV AND INCLUDING 33 kV]

2.1. *HV* POWER CABLE FOR AUXILIARY POWER SUPPLY

(a) The HV cable of 1Cx185 mm^2 (Aluminium Conductor) or 1Cx120mm^2 (Copper Conductor) of voltage class as specified for 630 kVA ***and 800 kVA*** LT transformer for interconnecting 630kVA ***and 800 kVA*** LT transformer to the SEB feeder shall be, XLPE insulated, armoured cable conforming to IS 7098 (Part-II) or IEC 60502-2 1998. Terminating accessories shall conform to IS 17573-1992 or IEC 61442-1997/IEC60502-4 1998.

(b) The HV cable of 3Cx95 mm^2 (Aluminium Conductor) or 3Cx70mm^2 (Copper Conductor) of voltage class as specified for 250kVA LT transformer for interconnecting 250kVA LT transformer to the SEB feeder shall be, XLPE insulated, armoured cable conforming to IS 7098 (Part-II) or IEC 60502-2 1998. Terminating accessories shall conform to IS 17573-1992 or IEC 61442-1997/IEC60502-4 1998.

2.2. Only overhead connection has been foreseen for interconnecting ***630 kVA and*** 800 kVA, LT transformer to the tertiary of the ICT. However, HV cable connections in place of overhead connection, if necessary shall also be in the scope of contractor. In this case contractor shall provide 1C x 185 mm^2 (Aluminium Conductor) or 1Cx120mm^2 (Copper Conductor), 38/66kV HV cable along with necessary terminating accessories. The construction of XLPE insulated, armoured HV cable shall be generally conforming to IS 7098 (Part-III). Terminating accessories shall conform to IEC60840 1999.

2.3. Bidder may offer sizes other than the sizes specified in clause 2.1 and 2.2. In such case sizing of power cables shall be done keeping in view continuous current, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by bidder during detailed engineering for purchaser's approval.

2.4. Constructional Requirements

Cable shall have compacted circular Aluminium conductor, Conductor screened with extruded semi conducting compound , XLPE insulated, insulation screened with extruded semi conducting compound, ***distinct extruded PVC inner sheath (Type ST-2) with FR properties***, armoured with non-magnetic material ***for single core cables and galvanized steel wire/strip for multicore cables*** , followed by extruded PVC outer sheath(Type ST-2), with FR properties . ***The armour shall be capable of withstanding rated short time current of conductor***.

2.5 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of the cable.

2.6 The cables shall have outer sheath of a material with an Oxygen Index of not less than 29 and a Temperature index of not less than 250°C.

2.7 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

3. EHV XLPE POWER CABLE [FOR WORKING VOLTAGES FROM 66 kV UP TO AND INCLUDING 500 kV]

3.1 TECHNICAL REQUIREMENTS

The XLPE insulated, EHV cable shall conform to the requirements of IEC 60502-2 (applicable clauses only) for construction and IEC 60840/ IEC62067 (as applicable) for testing. The terminating accessories shall conform to IEC 60840 / IEC62067 (as applicable).

3.2 The cable shall be of specified EHV grade, single core, unarmoured, stranded compacted Copper conductor, core screening by a layer of semiconducting tape followed by a layer of semiconducting compound, cross linked polyethylene (XLPE) dry cured insulation, insulation screening with semiconducting compound extruded directly over the insulation, longitudinal sealing by a layer of non woven tape with water swellable absorbent over insulation screen, followed by radial sealing (Metal sheath of Lead alloy ‘E’), metallic screening by concentric layer of plain copper wire followed by an open helix of copper & overall ***HDPE*** sheathed & graphite coated and conforming to the technical particulars of specification.

3.3 The construction of cable shall generally conform to the description mentioned in above mentioned clause of the specification. Bidder may offer necessary layers such as separation tape, binder tapes etc additionally as per their manufacturing practices for meeting required performance of the offered cable. The bidder shall enclose with the bid, drawing showing cross section of the cable. The conductors screen (non-metallic semi-conductive) shall be extruded in a single one-time process to ensure homogeneity and absence of voids.

3.4 The conductors screen (non-metallic semi-conductive) shall be extruded in a single one-time process to ensure homogeneity and absence of voids.

3.5 They shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions.

3.6 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of the cable.

3.7 The cables shall have outer sheath of ~~a~~ ***HDPE*** material.

3.8 Repaired cables shall not be accepted.

3.9 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

4 CABLE DRUMS

4.1 Cables shall be supplied in returnable wooden or steel drums of heavy construction. Wooden drum shall be properly seasoned sound and free from defects. Wood preservative shall be applied to the entire drum. ***Drums offered shall conform to relevant standards. Drum drawings are not required to be submitted for approval.***

4.2 Standard lengths for each size of power and control cables shall be 500/1000 meters. The cable length per drum shall be subject to a tolerance of plus or minus 5% of the standard drum length. The owner shall have the option of rejecting cable drums with shorter lengths. Maximum, One (1) number non standard length of cable size(s) may be supplied in drums for completion of project.

4.3 A layer of water proof paper shall be applied to the surface of the drums and over the outer most cable layer.

4.4 A clear space of at least 40 mm shall be left between the cables and the lagging.

4.5 Each drum shall carry the manufacturer's name, the purchaser's name, address and contract number and type, size and length of the cable, net and gross weight stencilled on both sides of drum. A tag containing the same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

4.6 Packing shall be sturdy and adequate to protect the cables, from any injury due to mishandling or other conditions encountered during transportation, handling and storage. Both cable ends shall be sealed with PVC/Rubber caps so as to eliminate ingress of water during transportation and erection.

5 TYPE TESTS

5.1 All cables shall conform to all type, routine and acceptance tests listed in the relevant IS.

5.2 ***XLPE INSULATED POWER CABLES (For working voltages up to and including 1100V):-***

5.2.1 Following type tests (on one size in a contract) as per IS: 7098 (Part 1) – 1988 including its amendments shall be carried out as a part of acceptance tests on XLPE insulated power cables for working voltages up to and including 1100 V:

a) Physical tests for insulation
   - i) Hot set test
   - ii) Shrinkage test

b) Physical tests for outer sheath
   - i) Shrinkage test
   - ii) Hot deformation
   - iii) Heat shock test
   - iv) Thermal stability

5.2.2 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Section: GTR for the following tests-

a) Water absorption (gravimetric) test.
b) Ageing in air oven
c) Loss of mass in air oven
d) Short time current test on power cables of sizes 240 sqmm and above on
   i) Conductors.
   ii) Armours.
e) Test for armouring wires/strips.
f) Oxygen and Temperature Index test.
g) Flammability test.

5.3 ***PVC INSULATED POWER & CONTROL CABLES (For working voltages up to and including 1100V)-***

5.3.1 Following type tests (on one size in a contract) as per IS: 1554 (Part 1) - 1988 including its amendments shall be carried out as a part of acceptance tests on PVC insulated power & control cables for working voltages up to and including 1100 V:

a) Physical tests for insulation and outer sheath
   i) Shrinkage test
   ii) Hot deformation
   iii) Heat shock test
   iv) Thermal stability
b) High voltage test (water immersion test only a.c. test as per clause no. 16.3.1).

5.3.2 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Section: GTR for the following-

a) High voltage test (water immersion d.c. test as per clause no. 16.3.2 of IS: 1554 (Part 1) - 1988).
b) Ageing in air oven.
c) Loss of mass in air oven.
d) Short time current test on power cables of sizes 240 sqmm and above on
   i) Conductors.
   ii) Armours.
e) Test for armouring wires/strips.
f) Oxygen and Temperature Index test.
g) Flammability test.

5.4 ***XLPE INSULATED HV POWER CABLES(For working voltages from 3.3 kV and including 33 kV)-***

5.4.1 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Section: GTR for XLPE insulated HV power cables (as per IS 7098 Part-II including its amendment or as per IEC).

5.5 ***XLPE INSULATED EHV POWER CABLES (For working voltages from 66kV up to and including 500 kV)-***

5.5.1 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Section: GTR for XLPE insulated EHV cables (as per IEC60840 for cables up to 150 kV & IEC 62067 for cables above 150 kV).

5.6 TERMINATING & JOINTING ACCESSORIES-

5.6.1 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Section: GTR for Terminating/jointing accessories as per IS 17573:1992/ IEC 60840:1999/ IEC62067.

STANDARD TECHNICAL DATA SHEET
(1.1 kV GRADE XLPE POWER CABLES)

SN				
	CUSTOMER :		**POWERGRID CORPORATION OF INDIA LIMITED**	
	Name of manufacturer :		**As per approved list**	
	Cable Sizes		**1 C x 630**	**3½ C x 300**
1	Manufacturer's type designation	:	A2XWaY	A2XWY
2	Applicable standard	:	---------------------IS: 7098/PT-I/1988 & its referred specifications---------------------	
3	Rated Voltage(volts)	:	----------------------1100 V grade--	
4	Type & Category	:	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	:	----------------------for both--	
6	Continuous current rating when laid in air in a ambient temp. of 50°C and for maximum conductor temp. of 70 °C of PVC Cables[For information only]	:	732	410
7	Rating factors applicable to the current ratings for various conditions of installation:	:	-------------------------------As per IS-3961-Pt-II-67-------------------------------------	
8	Short circuit Capacity			
	a) Guranteed Short Circuit Amp. (rms)KA for 0.12 sec duration at rated conductor temperature of 90 degree C, with an initial peak of 105 KA.	:	45 KA	45 KA
	b) Maximum Conductor temp. allowed for the short circuit duty (deg C.) as stated above.	:	-------------------------------------250 °C---	
9	Conductor			
	a) Material		Stranded Aluminium as per Class 2 of IS : 8130	
	b) Grade	:	------------------------------------ H 2 (Electrolytic grade) ------------------------	
	c) Cross Section area (Sq.mm.)	:	630	300/150
	d) Number of wires(No.)minimum	:	53	30/15
	e) Form of Conductor		Stranded and compacted circular	Stranded compacted circular/sector shaped
	f) Direction of lay of stranded layers	:	-------- Outermost layer shall be R.H lay & opposite in successive layers --------	
10	Conductor resistance (DC) at 20 °C per km-maximum		0.0469	0.1 / 0.206
11	Insulation			
	a) Composition of insulation	:	-------------------------------------Extruded XLPE as per IS-7098 Part(1)----------------	
	b) Nominal thickness of insulation(mm)	:	2.8	1.8/1.4
	c) Minimum thickness of insulation	:	2.42	1.52/1.16
12	Inner Sheath			
	a) Material	:	--------------------------------Extruded PVC type ST-2 as per IS-5831-84----------------	
	b) Calculated diameter over the laid up cores,(mm)	:	NA	52
	c) Thickness of Sheath (minimum)mm	:	N.A	0.6
	d) Method of extrusion		NA	Pressure/Vacuum extrusion
13	Armour			
	a) Type and material of armour	:	Al. Wire[H4 grade]	Gal. Steel wire
	b) Direction of armouring	:	----------------------------------left hand---	
	c) Calculated diameter of cable over inner sheath (under armour), mm	:	33.9	53.2
	d)Nominal diameter of round armour wire (minimum)	:	2	2.5
	e)Guranteed Short circuit capacity of the armour for 0.12 sec at room temperature.		45 KA	45 KA
	f) DC resistance at 20°C (Ω/Km)		$	0.577
14	Outer Sheath			
	a) Material (PVC Type)	:	ST-2& FR	ST-2& FR
	b) Calculated diameter under the sheath	:	38.3	59.50
	c) Min.thickness of sheath(mm)	:	1.72	2.36
	d) Guaranteed value of minimum oxygen index of outer sheath at 27 °C		Min 29.0	Min 29.0
	e) Guranteed value of minimum temperature index at 21 oxygen index		Min 250	Min 250
	f) colour of sheath	:	Black	Black
15	a) Nominal Overall diameter of cable		$	$
	b) Tolerance on overall diameter (mm)	:	---------------------------------+2/-2 mm--	
16	Cable Drums	:	---------------- shall conform to IS 10418 and technical specification	
	a) Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)		1000/500	1000/500
	b) Non standard drum lengths		**: Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project).**	
17	Whether progressive sequential marking on outer sheath provided at 1 meter interval	:	-- YES --	
18	Identification of cores			
	a) colour of cores		As per IS 7098 Part(1)	
	b) Numbering	:	-- N.A ---	
19	Whether Cables offered are ISI marked	:	-- YES --	
20	Whether Cables offered are suitable for laying as per IS 1255	:	-- YES --	

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET
(1.1 kV GRADE PVC POWER CABLES)

SN							
	CUSTOMER :	POWERGRID CORPORATION OF INDIA LIMITED					
	Name of manufacturer :	As per approved list					
	Cable Sizes	1 c x 150	3.5 cx 70	3.5 cx 35	4 c x 16	4c x 6	2 c x 6
1	Manufacturer's type designation	: AYWaY	AYFY	AYFY	AYFY	AYWY	AYWY
2	Applicable standard	: ------------ -------------------------IS: 1554/PT-I/1988 & its referred standards---------------------------					
3	Rated Voltage(volts)	: -----------------------1100 V grade--					
4	Type & Category	: FR & C1	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	: -----------------------for both--					
6	Continuous current rating when laid in air in a ambient temp. of 50^{o}C and for maximum conductor temp. of 70 ^{o}C of PVC Cables[For information only]	: 202	105	70	41	24	28
7	Rating factors applicable to the current ratings for various conditions of installation:	: x-------------------------------As per IS-3961-Pt-II-67--					
8	Short circuit Capacity						
	a) Short Circuit Amp. (rms)KA for 1 sec duration	: 11.2	5.22	2.61	1.19	0.448	0.448
	b) Conductor temp. allowed for the short circuit duty (deg C.)	: --------------------------------------160 ^{o}C--					
9	Conductor						
	a) Material	: --------------------------------------STRANDED ALUMINIUM ---					
	b) Grade	: ------------------------------------- H 2 (Electrolytic grade) ---					
	c) Cross Section area (Sq.mm.)	: 150	M-70 N-35	M-35 N-16	16	6	6
	d) Number of wires(No.)	: -- as per Table 2 of IS 8130 --					
	e) Form of Conductor	Non-compacted Standed circular	shaped conductor	shaped conductor	shaped conductor	Non-compacted Standed circular	Non-compacted Standed circular
	f) Direction of lay of stranded layers	: -------- Outermost layer shall be R.H lay & opposite in successive layers --------					
10	Conductor resistance (DC) at 20^{o}C per km-maximum	0.206	0.443/ 0.868	0.868/ 1.91	1.91	4.61	4.61
11	Insulation						
	a) Composition of insulation	: --------------------------------------Extruded PVC type A as per IS-5831-84--------------------------					
	b) Nominal thickness of insulation(mm)	: 2.1	1.4/1.2	1.2/1.0	1.0	1.0	1.0
	c) Minimum thickness of insulation	: 1.79	1.16/0.98	0.98/0.8	0.8	0.8	0.8
12	Inner Sheath						
	a) Material	: --------------------------------Extruded PVC type ST-I as per IS-5831-84----------------------------------					
	b) Calculated diameter over the laid up cores,(mm)	: N.A	27.6	20.4	15.7	11.6	9.6
	c) Thickness of Sheath (minimum)mm	: N.A	0.4	0.3	0.3	0.3	0.3
13	Armour	: -------------------------- as per IS 3975/88 ---					
	a) Type and material of armour	: Al. Wire[H4 grade]	Gal.steel strip	Gal.steel strip	Gal.steel strip	Gal. Steel wire	Gal. Steel wire
	b) Direction of armouring	: -----------------------------------left hand--					
	c) Calculated diameter of cable over inner sheath (under armour), mm	: 18	28.4	21	16.3	12.2	10.2
	d) Nominal diameter of round armour wire/strip	: 1.6	4 x 0.8	4 x 0.8	4 x 0.8	1.4	1.4
	e) Number of armour wires/strips	: -------------------Armouring shall be as close as practicable--					
	f) Short circuit capacity of the armour along for 1 sec-for info only	: --K x A√t (K Amp)(where A = total area of armour in mm^2& t = time in seconds), K=0.091 for Al & 0.05 for steel					
	g) DC resistance at 20^{o}C (Ω/Km)	: 0.44	2.57	3.38	3.99	3.76	4.4
14	Outer Sheath						
	a) Material (PVC Type)	: ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR
	b) Calculated diameter under the sheath	: 21.2	30.1	22.6	17.9	15	13
	c) Min.thickness of sheath(mm)	: 1.4	1.56	1.4	1.4	1.4	1.24
	d) Guaranteed value of minimum oxygen index of outer sheath at 27^{o}C	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
	e) Guranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
	f) colour of sheath	: Black	Black	Black	Black	Black	Black
15	a) Overall diameter of cable	;--$---------------------------------------					
	b) Tolerance on overall diameter (mm)	: ---------------------------------+2/-2 mm--					
16	Cable Drums	: ---------------- shall conform to IS 10418 and technical specification					
	a) Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500	1000/500	1000/500	1000/500	1000/500	1000/500
	b) Non standard drum lengths	: Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project).					
17	Whether progressive sequential marking on outer sheath provided	: --- YES --					
18	Identification of cores						
	a) colour of cores	Red	R,Y,Bl &Bk	R,Y,Bl &Bk	R,Y,Bl &Bk	R,Y,Bl &Bk	Red & Bk
	b) Numbering	: --- N.A --					
19	Whether Cables offered are ISI marked	: --- YES --					
20	Whether Cables offered are suitable for laying as per IS 1255	: --- YES --					

$'- As per manufacturer design data

TECHNICAL DATA SHEET
(1.1 kV GRADE PVC CONTROL CABLES)

SN	Item		2c x 2.5	3c x 2.5	5c x 2.5	7c x 2.5	10c x 2.5	14c x 2.5	19c x 2.5	27c x 2.5
	CUSTOMER :		POWERGRID CORPORATION OF INDIA LIMITED							
SN	Name of manufacturer :		As per approved list							
	Cable Sizes		2c x 2.5	3c x 2.5	5c x 2.5	7c x 2.5	10c x 2.5	14c x 2.5	19c x 2.5	27c x 2.5
1	Manufacturer's type designation	:	YWY	YWY	YWY	YWY	YWY	YWY	YWY	YWY
2	Applicable standard	:	------------------------IS: 1554/PT-I/1988 & its referred standards-------------------------------							
3	Rated Voltage(volts)	:	--1100--							
4	Type & Category	:	--FR & C1--							
5	Suitable for earthed or unearthed system	:	------------------------------for both--							
6	Continuous current rating when laid in air in a ambient temp. of 50°C and for maximum conductor temp. of 70°C of PVC Cables[For information only]	:	22	19	19	14	12	10.5	9.7	8
7	Rating factors applicable to the current ratings for various conditions of installation:	:	------------------------------As per IS-3961-Pt-II-67---------------------------------------							
8	Short circuit Capacity									
	a) Short Circuit Amp. (rms)KA for 1 sec-for information only	:	0.285	0.285	0.285	0.285	0.285	0.285	0.285	0.285
	b) Conductor temp. allowed for the short circuit duty (deg C.)	:	-------------------------------------160 °C-------------------------------							
9	Conductor									
	a) Material	:	---------- Plain annealed High Conductivity stranded Copper (as per IS 8130/84) -----							
	b) Grade	:	------------------------------------ Electrolytic--							
	c) Cross Section area (Sq.mm.)	:	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	d) Number of wires(No.)	:	------------------- as per Table 2 of IS 8130 ----------------------------------							
	e) Form of Conductor	:	-------------------------------------Non-Compacted stranded circular conductor---------							
	f) Direction of lay of stranded layers	:	----------------- Outermost layer shall be R.H lay -------------------------							
10	Conductor resistance (DC) at 20 °C per km(maxm)		7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41
11	Insulation									
	a) Composition of insulation	:	-------------------------------------Extruded PVC type A as per IS-5831-84-----------------							
	b) Nominal thickness of insulation(mm)	:	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
	c) Minimum thickness of insulation		0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
12	Inner Sheath									
	a) Material	:	-------------------------------Extruded PVC type ST-I as per IS-5831-84-----------------							
	b) Calculated diameter over the laid up cores,(mm)	:	7.2	7.8	9.7	10.8	14.4	15.9	18	22.1
	c) Thickness of Sheath (minimum)mm	:	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
13	Armour	:	------------------------- as per IS 3975/99 ---							
	a) Type and material of armour	:	Gal. Steel wire	Gal. Steel wire	Gal. Steel wire	Gal. Steel wire	Gal. Steel wire	Gal. Steel wire	Gal. Steel wire	Gal. Steel wire
	b) Direction of armouring	:	---------------------------------left land--							
	c) Calculated diameter of cable over inner sheath (under armour), mm	:	7.8	8.4	10.3	11.4	15	16.5	18.6	22.7
	d) Nominal diameter of round armour wire / dimensions of armour strip	:	1.4	1.4	1.4	1.4	1.6	1.6	1.6	1.6
	e) Number of armour wires	:	------------------Armouring shall be as close as practicable------------------							
	f) Short circuit capacity of the armour and duration-for info only	:	--0.05 x A√t (K Amp)(where A = total area of armour in mm²& t = time in seconds)----							
	g) DC resistance at 20 °C (Ω/Km) & Resistivity of armour	:	-------------As per IS 1554 Part(1), whereever applicable & IS 3975-1999-----------------							
14	Outer Sheath									
	a) Material (PVC Type)	:	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR
	b) Calculated diameter under the sheath	:	10.6	11.2	13.1	14.2	18.2	19.7	21.8	25.9
	c) Min.thickness of sheath(mm)	:	1.24	1.24	1.24	1.24	1.4	1.4	1.4	1.56
	d) Guaranteed value of minimum oxygen index of outer sheath	:	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
	e) Guranteed value of minimum temperature index at 21 oxygen index		Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
	f) colour of sheath	:	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey
15	a) Overall diameter of cable	:	$							
	b) Tolerance on overall diameter (mm)	:	--------------------------------+2/-2 mm--------------------------------------							
16	Cable Drums	:	---------------- shall conform to IS 10418 and technical specification							
	a) Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	:	1000/500	1000/500	1000/500	1000/500	1000/500	1000/500	1000/500	1000/500
	b) Non standard drum lengths	:	Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project).							
17	Whether progressive sequential marking on outer sheath provided	:	-- YES ---							
18	Identification of cores	:								
	a) colour of cores		R & Bk	R,Y &Bl	:,Y,Bl,Bk&(	Grey	Grey	Grey	Grey	Grey
	b) Numbering		N.A.	N.A.	N.A.	Numerals in black ink	Numerals in black ink	Numerals in black ink	Numerals in black ink	Numerals in black ink
19	Whether Cables offered are ISI marked	:	-- YES --							
20	Whether Cables offered are suitable for laying as per IS 1255	:	-- YES --							

$'- As per manufacturer design data

Technical Specification

SECTION- SHUNT REACTOR UPTO 400kV, NEUTRAL GROUNDING REACTOR AND SURGE ARRESTER

REV 11

JUNE'2021

Major changes in the latest Technical Specification Section – Shunt Reactor 400kV, Neutral Grounding Reactor and Surge Arrester REV 11

Sr. No.	Clause	Brief Description of Major Changes
1.	1.2,1.3, 1.4	*New clause added*
2.	3.3, 3.5, 3.6	*Clause modified*
3.	4.7	*New clause added*
4.	6.1, 6.2, 6.4, 7.1.6, 7.1.7, 7.1.8, 7.1.9,	*Clause modified*
5.	7.1.10	*New clause added*
6.	7.2.3, 7.3, 7.4, 7.5.1, 7.6.3, 7.8, 7.9, 7.10, 7.11, 7.12, 7.14.4, 7.17, 7.18.2, 7.19.1, 7.19.2, 7.19.3, 7.19.9, 7.19.13,	*Clause modified*
7.	7.19.14	*New clause added*
8.	9, 9.1, 11.2, 11.4,11.14, 11.15, 13.3, 13.4, 14.6, 14.7.1, 14.9, 15, 16.3, 17, 18.1, 22, 23.1	*Clause revised.*
9.	Annexure-A	*Reactor Technical parameters revised*
10.	Annexure-I	*Cable specification revised.*
11.	Annexure-L	*On-line insulating oil drying system included with each Reactor*
12.	-	*Optical Temperature Sensors & Measuring Unit deleted*

Disclaimer:
Major changes are listed above. However, for details of all major and minor modifications, please refer the complete technical specification Section - Shunt Reactor 400kV, Neutral Grounding Reactor and Surge Arrester REV 11.

SECTION- SHUNT REACTOR (UPTO 400kV), NEUTRAL GROUNDING REACTOR AND SURGE ARRESTER

TECHNICAL SPECIFICATION FOR SHUNT REACTOR (UPTO 400kV), NEUTRAL GROUNDING REACTOR AND SURGE ARRESTER

1. General

1.1. This specification covers design, engineering, manufacture, testing, delivery at site including all materials, accessories, spares, unloading, handling, proper storage at site, erection, testing and commissioning of the equipment specified.

1.2. The Reactor offered by the contractor shall at least conform to the requirements specified under relevant IS standard. In case of discrepancy between IS and other international standard, provisions of IS shall prevail. If the IS standard is not available, then other applicable International standard (IEC/Equivalent), as per the specification, shall be accepted.

1.3. Any material and equipment not specifically stated in this specification but which are necessary for satisfactory operation of the equipment shall be deemed to be included unless specifically excluded and shall be supplied without any extra cost.

1.4. Components having identical rating shall be interchangeable.

2. Type of Reactor

The shunt reactor shall be of either gapped core type or magnetically shielded air core type (shell type) construction. The impedance ratio (X0/X1) specified shall be achieved by any one of the following methods:

i) Adopting single phase construction in separate tanks.
ii) Adopting 5 limb core construction, for 3-Phase

In case of coreless construction following requirements are stipulated.

i) A magnetic shield shall be provided around the coreless coils.
ii) Non-magnetic material sheet shall form the central core to minimize the vibrations.

The neutral grounding reactors are required for grounding of the neutral point of shunt reactors to limit the secondary arc current and the recovery voltage to a minimum value.

3. Transportation

3.1. The Contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the contractor to coordinate the arrangement for transportation of the Reactor for all the stages from the manufacturer’s work to site.

3.2. The contractor shall carry out the route survey along with the transporter and finalise the detail methodology for transportation of reactor and based on route survey, any modification/ extension/ improvement to existing road, bridges, culverts etc. if required, shall be in the scope of the bidder.

3.3. The inland transportation of the reactor unit shall be on trailer equipped with GPS system for tracking the location of Reactor at all times during transportation from manufacturer works to designated site. The contractor shall intimate to Employer about the details of transporter engaged for transportation of the Reactor. The requisite details for tracking the Reactor during transit shall be provided to Employer. Requirement of Hydraulic trailer is envisaged for a load of more than 40 T.

3.4. All metal blanking plates and covers, which are specifically required to transport the reactor, shall be considered part of the reactor and handed over to the Employer after completion of the erection. Bill of quantity of these items shall be included in the relevant drawing/document.

3.5. The Contractor shall despatch the Reactor filled with dry air at positive pressure. The necessary arrangement shall be ensured by the contractor to take care of pressure drop of dry air during transit and storage till completion of oil filling during erection. A dry air pressure testing valve with necessary pressure gauge and adaptor valve shall be provided. The dry air cylinder(s) provided to maintain positive pressure can be taken back by the contractor after oil filling.

In case, turrets are having insulation assembly and is transported separately then the same shall also be filled with dry air.

3.6. The Reactor shall also be fitted with atleast 2 numbers of Electronic impact recorders (on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The acceptance criteria and limits of impact, which can be withstood by the equipment during transportation and handling in all three directions, shall not exceed“3g” for 50mSec (20Hz) or as per contractor standard, whichever is lower.

4. Performance

4.1. Shunt Reactors will be connected to the transmission system for reactive compensation and shall be capable of controlling the dynamic over voltage occurring in the system due to load rejection.

4.2. The reactors shall be designed for switching surge overvoltage of 2.5 p.u. and temporary overvoltage of the order of 2.3 p.u. for few cycles followed by power frequency overvoltage upto 1.5 p.u. The reactor must withstand the stress due to above transient dynamic conditions which may cause additional current flow as a result of changed saturation characteristics/slope beyond 1.5 p.u. voltage.

4.3. Shunt Reactors of 420kV Class shall be capable of operating continuously at a voltage 5% higher than their rated voltage without exceeding winding hot spot temperature 140 Deg Celsius. Maximum ambient temperature shall be considered as 50 Deg C.

4.4. Shunt Reactors of 245kV Class and below shall be capable of operating continuously at a voltage 10% higher than their rated voltage without exceeding winding hot spot temperature 140 Deg Celsius. Maximum ambient temperature shall be considered as 50 Deg C.

4.5. The reactor shall be designed to withstand the following over-voltages repeatedly without risk of failure (w.r.t. Hotspot temperature & core saturation):

1.05 Ur for continuous (for 420kV Class Reactor)
1.10 Ur for continuous (for below 420kV Class Reactor)
1.25 Ur for 1 minute
1.50 Ur for 5 seconds

4.6. The winding hot spots shall be calculated using the maximum localized losses, insulation thickness at the maximum loss positions, and the oil flow patterns in the winding. The oil temperature rise in the windings shall be used to determine hot spots rather than the bulk top oil temperature. The hot spot for all leads shall be calculated and it shall not exceed the calculated hot spot of the windings.

4.7. Also, the most onerous temperature of any part of the core and its supporting structure in contact with insulation or non-metal material shall not exceed the safe operating temperature of that material. Adequate temperature margins shall be provided to maintain long life expectancy of these materials.

4.8. Tank hotspot temperature under over voltage condition specified above shall not exceed 110 Deg C considering maximum ambient temperature as 50 Deg C.

4.9. The magnetic circuit will be designed such that the reactor is linear upto voltage specified at **Annexure – A**.

4.10. **Radio Interference and Noise Level**

4.10.1. The reactor shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth so as to minimise interference with communication circuit.

4.10.2. The noise level of reactor, when energised at rated voltage and frequency shall not exceed the values specified at **Annexure-A** measured under standard conditions.

5. Measurable Defects

The following shall constitute as Measureable Defects for the purpose of Defect Liabilities as per relevant clauses of GCC / SCC of the bidding document:

a) Repair, inside the Reactor either at site or at factory is carried out after commissioning.

b) The concentration of any fault gas is more than values of condition-1 indicated in clause no 6.5 of IEEE-C57.104-2008, which are given below:

H2	CH4	C2H2	C2H4	C2H6	CO	CO2	TDCG
100	120	1	50	65	350	2500	720

c) The winding Tan delta goes beyond 0.005 or increase more than 0.001 within a year w.r.t. pre-commissioning values. No temperature correction factor shall be applicable for tan delta

a) The moisture content goes above 12 ppm at any temperature during operation.

6. Design review

6.1. The reactor shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin w.r.t. thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc. The scope of such design review shall include but not limited to the requirement as mentioned at Annexure – D.

6.2. Design reviews shall be conducted by Employer or by an appointed consultant during the procurement process for Reactors; however the entire responsibility of design shall be with the manufacturer. Employer may also visit the manufacturers works to inspect design, manufacturing and test facilities.

The design review will commence after placement of award with the successful bidder and shall be finalised before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the reactor under the scope of this specification. It shall be conducted generally following the ""CIGRE TB 529: Guidelines for conducting design reviews for power transformers".

6.3. The manufacturer shall provide all necessary information and calculations to demonstrate that the reactor meets the requirements for mechanical strength and durability due to inrush current. The latest recommendations of IEC and Cigre SC 12 shall be applied for short circuit withstand evaluation.

6.4. **Type test requirement & it's validity**

The offered Reactor or the Reactor, the design of which is similar to the offered Reactor, should have been successfully type tested. Manufacturer may use same or different approved make of Bushings and other accessories used in type tested or short circuit tested unit in their Reactor. Further, type test report of Reactor shall only be acceptable provided the offered Reactor has been manufactured from the same plant. The Reactor Type test validity period shall be as per Technical Specification Section-General Technical Requirement (GTR).

Central Electricity Authority's "Guidelines for the validity period of type tests conducted on major electrical equipment in power transmission system" shall be followed regarding the validity of type tests of Bushings and other accessories.

7. Construction Details

The construction details and features of each Shunt Reactor shall be in accordance with the requirement stated hereunder.

7.1. Tank

7.1.1. Tank shall be fabricated from tested quality low carbon steel of adequate thickness. Unless otherwise approved, metal plate, bar and sections for fabrication shall comply with IS 2062.

7.1.2. All seams and those joints not required to be opened at site, shall be factory welded, and wherever possible they shall be double welded. Welding shall conform to IS 9595. After fabrication of tank and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment of tank/stress relieving shall be based on recommendation of IS 10801.

7.1.3. Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.

7.1.4. The tank shall be of proven design either bell type with bolted /welded joint or conventional type with welded / bolted top cover. Bell type tank shall be provided with joint at about 500 mm above the bottom of the tank. The welded joint shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld spatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise at the joint.

7.1.5. The tank shall be designed in such a way that it can be mounted on the plinth directly.

7.1.6. The base of each tank shall be so designed that it shall be possible to move the complete Reactor unit by skidding in any direction without damage when using plates or rails and the base plate shall have following minimum thickness:

Length of tank (m)	**Minimum plate thickness (mm)**
Flat bases	
over 2.5m but less than 5m	20
over 5m but less than 7.5m	26
exceed 7.5m	32

7.1.7. The hotspot temperature in any location of the tank shall not exceed 110 degree Celsius at max. continuous operating voltage. This shall be measured during temperature rise test at manufacturer’s works.

7.1.8. Tank shall be capable of withstanding, without damage, severe strains that may be induced under normal operating conditions or forces encountered during lifting, jacking and pulling during shipping and handling at site or factory. Tank, tank cover and associated structure should be adequately designed to withstand, without damage or permanent deflection / deformation, the forces arising out of normal oil pressure, test pressures, vacuum, seismic conditions and short circuit forces specified.

7.1.9. Tank MS plates of thickness >12 mm should undergo Ultrasonic Test (UT) to check lamination defect, internal impurities in line with ASTM 435 & ASTM 577.

7.1.10. All pipes connected to Reactor shall follow IS 1239.

7.1.11. Tank shall be provided with:

a. Lifting lugs: Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete Reactor when filled with oil without structural damage to any part of the Reactor. The factor of safety at any one point shall not be less than 2.

b. A minimum of four jacking pads in accessible position to enable the Reactor complete with oil to be raised or lowered using hydraulic jacks. Each jacking pad shall be designed to support with an adequate factor of safety at least half of the total mass of the Reactor filled with oil allowing in addition for maximum possible misalignment of the jacking force to the centre of the working surface.

c. Suitable haulage holes shall be provided.

d. Suitable provision (valves, etc.) as required for installation of Nitrogen Injection Fire Protection System in Reactor shall be provided.

e. 04 nos. of Gate valves for UHF sensors for PD Measurements (applicable for 420kV Reactor only) at various locations. Location of valves shall be finalized during design review.

7.1.12. The base of each tank shall be so designed that it shall be possible to move the complete Reactor unit by skidding in any direction without damage when using plates or rails.

7.2. **Tank Cover**

7.2.1. The tank cover shall be designed to prevent retention of water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the buchholz relay.

7.2.2. At least two adequately sized inspection openings one at each end of the tank, shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.

7.2.3. The tank cover shall be provided with pockets for OTI, WTI and RTDs including 2 spare pockets. The location of pockets shall be in the position where oil reaches maximum temperature. Further, it shall be possible to remove bulbs of OTI/WTI/RTD without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

7.2.4. Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

7.2.5. All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression

7.2.6. **Currents flowing in tank cover and bushing turrets** - To allow for the effect of possible induced and capacitive surge current, the tank cover and bushing turret shall be fixed to the Reactor in such a way that good electrical contact is maintained around the perimeter of the tank and turrets.

7.2.7. The Reactor shall be provided with a 100 mm nominal diameter butterfly valve and bolted blanking plate, gasket and shall be fitted at the highest point of the Reactor for maintaining vacuum in the tank.

7.2.8. **Gas venting** - The reactor cover, and generally the internal spaces of the reactor and all pipe connections shall be designed so as to provide efficient venting of any gas in any part of the reactor to the Buchholz relay. The space created under inspection /manhole covers shall be filled with suitable material to avoid inadvertent gas pockets. The Covers shall be vented at least at both longitudinal ends. The design for gas venting shall take into accounts the slopes of the plinth (if any) on which the Reactor is being mounted.

7.3. **Gasket for tank & cover**

All gasketed joints in contact with oil shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. All gasketed joints unless otherwise approved shall be of the O-ring and groove type. All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression.

All tank gaskets used shall be of NBR (Acrylonitrile butadiene Rubber generally known as NBR) and properties of all the above gaskets / O-Rings shall comply with the requirements of IS-11149 (Grade IV) Material selected shall suit temperature conditions expected to be encountered. Neoprene / cork sheets gaskets are not acceptable. The Gaskets and O-rings shall be replaced every time whenever the joints are opened.

7.4. **Foundation, Roller Assembly & Anti Earthquake Clamping Device**

The Reactor shall be placed directly on concrete plinth foundation. To facilitate the movement of reactor to its foundation over rail track, bi-directional flanged rollers shall be provided. It shall be suitable for fixing to the under carriage of Reactor. The rail track gauge shall be 1676 mm. Two rails shall be provided as per the drawing mentioned at **Annexure-C.**

Scope shall include supply of complete two sets of rollers assembly for movement of Reactors over rail track for each substation in case scope covers more than one Reactor per sub-station under the package. Otherwise, atleast one set shall be supplied.

Foundation bolts and other locking devices shall be in the scope of contractor.

Regarding cooler pipe supports, Buchholz pipe (if required) and fire-fighting pipe supports shall be fixed on concrete block through Anchor Fastener with chemical grouting and no pockets for bolting shall be provided.

All control cubicles shall be mounted at least one meter above FGL (Finished Ground Level) to take care of water logging (if any) during flooding. Suitable arrangement (ladder and platform) shall be provided for safe access to control cubicles.

All fittings (Foundation bolts, supports, embedded plates if any) including anchor fastener with chemical grouting are in the scope of contractor.

7.5. **Conservator**

7.5.1. Conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture.

Conservator Protection Relay (CPR)/Air cell puncture detection relay shall be installed to give alarm in the event of lowering of oil in the conservator due to puncture of air cell in service.

Conservator shall be fitted with magnetic oil level gauge with potential free high and low oil level alarm contacts and prismatic oil level gauge and Conservator Protection Relay

7.5.2. Conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the reactor and cooling equipment from minimum ambient temperature to top oil temperature of 110 deg C. The capacity of the conservator tank shall be such that the reactor shall be able to carry the specified overload without overflowing of oil.

7.5.3. The conservator shall be fitted with lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator as applicable.

7.5.4. Conservator shall be positioned so as not to obstruct any electrical connection to Reactor.

7.5.5. The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator. The main conservator tank shall be stencilled on its underside with the words **"Caution: Air cell fitted".** Lettering of at least 150 mm size shall be used in such a way to ensure clear legibility from ground level when the Reactor is fully installed. To prevent oil filling into the air cell, the oil filling aperture shall be clearly marked. The Reactor rating and diagram plate shall bear a warning statement that the **"Conservator is fitted with an air cell".**

7.5.6. Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth. The temperature of oil in the conservator is likely to raise up to 110^{O}C during operation. As such air cell used shall be suitable for operating continuously at this temperature.

7.5.7. The reactor manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate shelf life, life expectancy in operation, and the recommended replacement intervals.

7.5.8. The conservator tank and piping shall be designed for complete vacuum / filling of the main tank and conservator tank. Provision must be made for equalising the pressure in the conservator tank and the air cell during vacuum / filling operations to prevent rupturing of the air cell.

7.5.9. The contractor shall furnish the leakage rates of the rubber bag/ air cell for oxygen and moisture. It is preferred that the leakage rate for oxygen from the air cell into the oil will be low enough that the oil will not become saturated with oxygen before 10 years. Air cells with well proven long life characteristics shall be preferred.

7.6. Piping works for conservator

7.6.1. Pipe work connections shall be of adequate size for their duty and possibly short and direct. Only radiused elbows shall be used.

7.6.2. The feed pipe to the Reactor tank shall enter the reactor cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the reactor side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay. This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degrees. The feed pipe diameter for the main conservator shall be not less than 80 mm for reactor. Gas-venting pipes shall be connected to the final rising pipe between the reactor and Buchholz relay as near as possible in axial direction and preferably not less than five times pipe diameters from the Buchholz relay.

7.6.3. This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degrees. The feed pipe diameter for the main conservator shall be not less than 80mm.

7.6.4. A double flange valve of preferably 50 mm size shall be provided to fully drain the oil from the main tank conservator.

7.6.5. Pipe work shall neither obstruct the removal of the opening of inspection or manhole covers.

7.7. Dehydrating Silicagel Filter Breather

Conservator shall be fitted with a dehydrating silicagel filter breather. Connection shall be made to a point in the oil conservator not less than 50 mm above the maximum working oil level by means of a pipe with a minimum diameter of 25 mm. Breathers having a mass less than 10 kg may be supported by the connecting pipe, whereas units of 10 kg and above shall be supported independent of the connecting pipe. Connecting pipes shall be securely cleated to the reactor, or other structure supplied by the contractor, in such a manner so as to eliminate undesirable vibration and noise. In the case where a breather of less than 10 kg is supported by the pipe, there shall be a cleat directly above the breather flange. It shall be so designed that:

a) Passage of air is through silicagel.
b) Silicagel is isolated from atmosphere by an oil seal.
c) Moisture absorption indicated by a change in colour of the crystals.
d) Breather is mounted approximately 1200 mm above rail top level.
e) To minimise the ingress of moisture three breathers (of identical size) shall be connected in series for main tank conservator. Contractor shall provide flexible connection pipes to be used during replacement of any silicagel breather.
f) Two breathers (each of 2.5 litres minimum volume) shall be connected in series for NGR tank conservator

7.8. Pressure Relief Device

One PRD of 150 mm Diameter is required for every 30000 Litres of oil. However, at least two numbers PRDs shall be provided. Its mounting should be either in vertical or horizontal orientation, preferably close to bushing turret or cover. PRD operating pressure selected shall be verified during design review. PRD shall be provided with special shroud to direct the hot oil in case of fault condition. It shall be provided with an outlet pipe which shall be taken right up to the soak pit of the reactor. The size (Diameter) of shroud shall be such that it should not restrict rapid release of any pressure that may be generated in the tank, which may result in damage to equipment. Oil shroud should be kept away from control cubicle and clear of any operating position to avoid injury to personnel in the event of PRD operation. The device shall maintain its oil tightness under static oil pressure equal to the static operating head of oil plus 20 kPa. It shall be capable of withstanding full internal vacuum at mean sea level. It shall be mounted directly on the tank. Suitable canopy shall be provided to prevent ingress of rain water. One set of potential free contacts (with plug & socket type arrangement) per device shall be provided for tripping. Following routine tests shall be conducted on PRD:

a) Air pressure test
b) Liquid pressure test
c) Leakage test
d) Contact operation test
e) Dielectric test on contact terminals

7.9. **Sudden Pressure Relay**

One number of Sudden Pressure relay with alarm/trip contacts (**Terminal connection plug & socket type arrangement**) shall be provided on tank of Reactor. Operating features and size shall be reviewed during design review. Suitable canopy shall be provided to prevent ingress of rain water. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Sudden Pressure Relay.

Plug & socket type arrangement with factory fitted cable of adequate length shall be supplied by OEM. Connection of plug and socket with cable at site is not acceptable.

7.10. **Buchholz Relay**

One number Double float, reed type Buchholz relay complying to IS 3637 shall be provided in the connecting pipe between the oil conservator and the Reactor tank with minimum distance of five times pipe diameters between them. Any gas evolved in the Reactor shall be collected in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling while the Reactor in service. Suitable canopy shall be provided to prevent ingress of rain water. Each device shall be provided with two potential free contacts **(Plug & socket type arrangement),** one for alarm / trip on gas accumulation and the other for tripping on sudden rise of pressure.

Plug & socket type arrangement with factory fitted cable of adequate length shall be supplied by OEM. Connection of plug and socket with cable is not acceptable at site.

It should be possible to inspect Buchholz relay or Oil surge relay, standing on tank cover and suitable arrangement shall be made to access Buchholz relay safely.

The Buchholz relay shall not operate during starting/stopping of the Reactor oil circulation under any oil temperature conditions. The pipe or relay aperture baffles shall not be used to decrease the sensitivity of the relay. The relay shall not mal-operate for through fault conditions or be influenced by the magnetic fields around the Reactor during the external fault conditions. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Buchholz relay.

7.11. **Oil Temperature Indicator (OTI)**

All Reactors shall be provided with a dial type thermometer of around 150 mm diameter for top oil temperature indication with angular sweep of 270°. It shall have adjustable, potential free alarm and trip contacts besides that required for control of cooling equipment if any. A temperature sensing element suitably located in a pocket on top oil shall be provided. This shall be connected to the OTI instrument by means of flexible capillary tubing with stainless-steel armoured. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Range of temperature should be 0- 150°C with accuracy of ±1.5% (or better) of full scale deflection. The setting of alarm and tripping contacts shall be adjustable at site. Adjustable range shall be 20-90% of full-scale range. Heavy duty micro switch of 5A at 240V AC shall be used. The instruments case should be weather proof and having epoxy coating at all sides. Instruments should meet ingress protection class of IP55 as per IS 13947/IEC60529. The instruments should be capable of withstanding line to body high voltage of 2.5kV AC rms, 50Hz for 1 minute.

In addition to the above, the following accessories shall be provided for remote indication of oil temperature:

Temperature transducer with Pt100 sensor

RTD shall be provided with PT100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The PT100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751 or equivalent. The PT100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil for OTI system and shall provide dual output 4-20mA for SCADA system. The transducer shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between PT100 temperature sensor and transducer, shall be in the scope of Contractor. 4-20mA signal shall be wired to Digital RTCC panel / BCU for further transfer data to SCADA through IS/IEC 61850 compliant communications.

7.12. Winding Temperature Indicator (WTI)

All Reactor shall be provided with a device for measuring the hot spot temperature of winding with dial type thermometer of 150 mm diameter for winding temperature indication with angular sweep of 270°and shall have adjustable potential free alarm and trip contacts besides that required for control of cooling equipment if any. The setting of alarm and tripping contacts shall be adjustable at site. A temperature sensing bulb located in a thermometer pocket on tank cover should be provided to sense top oil. This shall be connected to the WTI instrument by means of flexible capillary tubing with stainless-steel armoured. WTI shall have image coil and auxiliary CTs, if required to match the image coil, shall be mounted in the Marshalling Box / cooler control cabinet. Temperature indicator dials shall have linear gradations to clearly read at least every 2^{0}C. Range of temperature should be 0- 150°C with accuracy of ±1.5% (or better) of full scale deflection. Adjustable range shall be 20-90% of full-scale range. Heavy duty micro switch of 5A at 240V AC shall be used. The instruments case should be weather proof and having epoxy coating at all sides. Instruments should meet ingress protection class of IP55 as per IS 13947 /IEC60529. The instruments should be capable of withstanding line to body high voltage of 2.5kV AC rms, 50Hz for 1 minute.

In addition to the above, the following accessories shall be provided for remote indication of winding temperature:

Temperature transducer with Pt100 sensor for each winding

RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil, Auxiliary CTs, if required to match the image coil, for WTI system and shall provide dual output 4-20mA for remote WTI and SCADA system individually. The transducer, Auxiliary CT shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Contractor. 4-20mA signal shall be wired to Digital RTCC / BCU panel for further transfer data to SCADA through IS / IEC 61850 compliant communications.

7.13. The temperature indicators (OTI & WTI) shall be so mounted that the dials are about 1200 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

7.14. **Earthing Terminals**

7.14.1. Two (2) earthing pads (each complete with two (2) nos. holes, M16 bolts, plain and spring washers) suitable for connection to 75 x 12 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

7.14.2. Two earthing terminals suitable for connection to 75 x 12 mm galvanised steel flat shall also be provided on each individual/common marshalling box and any other equipment mounted separately. For the tank-mounted equipment like online drying/ Online DGA/etc double earthing shall be provided through the tank for which provision shall be made on the tank and connected through two flexible insulated copper link.

7.14.3. To allow for the effect of possible induced and capacitive surge current, good electrical connection is maintained between the tank and turrets. Equi-potential flexible copper link of suitable size at least 4 Nos. for Tank mounted turret with tank and tank with cover and or Bell shall be provided. For other components like - pipes, conservator support etc connected to tank shall also be provided with equipotential flexible copper link.

7.14.4. Each Reactor unit should have provision for earthing and connected to grounding mat when not in service. For this purpose, line Terminals shall also be earthed through neutral by flexible copper connection. Contractor shall provide suitable arrangement for the above. 1.1kV Grade PVC FR type cable of 16 sq.mm (minimum) shall be used for above connection. Neutral shall have provision for connection to ground by a brass/tinned copper grounding bar supported from the tank by using porcelain insulator. The end of the tinned/brass copper bar shall be brought to the bottom of the tank at a convenient point for making bolted connection to 75 X 12 mm GS flat connected to station grounding mat. The other end of the tinned/brass copper bar shall be connected to the neutral bushing through flexible conductor/jumper.

7.15. **Core**

7.15.1. The core shall be constructed from non-ageing, cold rolled grain oriented silicon steel laminations of conventional grade (as per BIS) / regular grade (as per IEC) or better. Indian reactor manufacturers shall use core material as per above specification with BIS certification.

7.15.2. The leg magnetic packets (cheeses) shall be made from state of the art low loss electrical steel CRGO (conventional/regular grade or better). The "Cheeses" shall be designed to minimize losses and equalize the distribution of flux in the legs.

7.15.3. The "cheeses" shall be bonded using high temperature epoxy resins to assure that they will remain bonded in service at the maximum temperatures that will occur in the magnetic circuit and for the full expected life. Vacuum impregnation is preferred. The contractor shall present data on the characteristics of the packets at the time of design review.

7.15.4. Material with high temperature withstand capability such as ceramic/ slate spacers shall be used to separate the packets. High temperature, mechanically stable material shall be used between the end packets and the top and bottom yokes. Special care shall be taken not to impede the cooling in these areas.

7.15.5. Means shall be provided to distribute the flux from the "cheeses" and the windings to the top and bottom yokes to prevent concentrations of flux with resulting high temperatures in the yokes.

7.15.6. The yokes shall be designed such that high temperatures resulting from unequal distribution of the flux in the yokes will not occur.

7.15.7. The spaces between "cheeses" will be designed so that high temperatures will not result due to fringing of flux at the oil gaps between them. The designer shall calculate the temperatures resulting from fringing.

7.15.8. The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating.

7.16. Internal Structure Design

7.16.1. The structural design shall be made so that pressure will be maintained to prevent loosening resulting from thermal expansion and contraction during all loading cycles.

7.16.2. The design shall be made in such a way that excessive vibration does not occur in the windings, structural supports of the windings and magnetic circuit and this will be subjected to design review.

7.16.3. The structure shall be designed to withstand the clamping and magnetic forces. The calculated magnetic forces will be furnished at the time of design review.

7.16.4. Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

7.17. Calculation of hot spots

7.17.1. The winding hot spots shall be calculated using the maximum localized losses, insulation thickness at the maximum loss positions, and the oil flow patterns in the winding. The oil temperature rise in the windings shall be used to determine hot spots rather than the bulk top oil temperature.

7.18. The hot spot temperature and surface temperatures in the core shall be calculated for over voltage conditions specified in the document and it shall not exceed 125 deg C and 120 deg C respectively.

7.18.1. The hot spot for all leads shall be calculated and it shall not exceed the calculated hot spot of the windings.

7.18.2. The hot spot in the windings and magnetic circuit shall be calculated for the over voltage conditions specified.

7.18.3. The most onerous temperature of any part of the core and its supporting structure in contact with insulation or non-metal material shall not exceed the safe operating temperature of that material. Adequate temperature margins shall be provided to maintain long life expectancy of these materials.

7.19. Earthing of core and clamping structure

7.19.1. If grounding of the core cheeses are required a separate strap shall be brought to a terminal located in a waterproof enclosure on the tank. Separate ground leads will be routed from the top and bottom yokes to separate terminals in the enclosure.

7.19.2. Single point core earthing should be ensured to avoid circulating current. Core earth should be brought separately on the top of the tank to facilitate testing after installation on all Reactors. The removable links shall have adequate section to carry ground fault current. Separate identification name plate/labels shall be provided for the ‘Core’ and ‘Core clamp’.

Cross section of Core earthing connection shall be of minimum size 80 sq.mm copper with exception of the connections inserted between laminations which may be reduced to a cross-sectional area of 20 sq. mm tinned copper where they are clamped between the laminations.

7.19.3. Where the core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the laminations, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

7.19.4. A drawing showing the details of the earthing design and connection shall be furnished during detailed engineering.

7.20. Windings

7.20.1. The manufacturer shall ensure that windings of all reactors are made in clean, dust proof (Cleanroom class ISO 9 or better as per ISO 14644-1), humidity controlled environment with positive atmospheric pressure.

7.20.2. The conductors shall be of electrolytic grade copper free from scales and burrs. Oxygen content shall be as per IS 12444.

7.20.3. Epoxy bonded Continuously Transposed Conductor (CTC) shall be used in main winding for rated current of 400 A or more.

7.20.4. The insulation of Reactor windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and shall be non-catalytic and chemically inactive in Reactor oil during service.

7.20.5. Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

7.20.6. The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes.

7.20.7. The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalise the distribution of currents and temperature along the winding.

7.20.8. The windings shall be designed to withstand the dielectric tests specified. The type of winding used shall be of time tested. An analysis shall be made of the transient voltage distribution in the windings, and the clearances used to withstand the various voltages. Margins shall be used in recognition of manufacturing tolerances and the fact that the system will not always be in the new factory condition.

7.20.9. The barrier insulation including spacers shall be made from high density pre-compressed pressboard (1.15 gm/cc minimum for load bearing and 0.95 gm/cc minimum for non-load bearing) to minimize dimensional changes. Kraft insulating paper used on conductor should have density of >0.75 g/cc.

7.20.10. All spacers shall have rounded edges. Radially stepped spacers between winding disks will not be accepted.

7.20.11. The conductor insulation shall be made from high-density (at least 0.75 gm/cc) paper having high mechanical strength. The characteristics for the paper will be reviewed at the time of design review.

7.20.12. An electrostatic shield, made from material that will withstand the mechanical forces, will be used to shield the high voltage windings from the magnetic circuit unless otherwise approved.

7.20.13. Either brazing/crimping type of connections are permitted for joints. It shall be time proven and safely withstand the cumulative effect of stress which may occur during handling, transportation, installation and service including line to line and line to ground faults /Short circuits. Manufacturer shall have system which allows only qualified personnel to make brazing or crimping joints.

7.20.14. Winding paper moisture shall be less than 0.5%.

7.20.15. All winding insulation shall be processed to ensure that there will be no detrimental shrinkage after assembly. All windings shall be pre-sized before being clamped. Windings shall be provided with clamping arrangements which will distribute the clamping forces evenly over the ends of the winding.

Full details of the winding clamping arrangements, and their adjustment in or out of the tank together with relevant drawings and values, shall be submitted during design review.

7.21. **Current carrying connections**

The mating faces of bolted connections shall be appropriately finished and prepared for achieving good long lasting, electrically stable and effective contacts. All lugs for crimping shall be of the correct size for the conductors. Connections shall be carefully designed to limit hot spots due to circulating eddy currents.

7.22. **Winding terminations into bushings**

7.22.1. Winding termination interfaces with bushings shall be designed to allow for repeatable and safe connection under site conditions to ensure the integrity of the Reactor in service.

7.22.2. The winding–end termination, insulation system and transport fixings shall be so designed that the integrity of the insulation system generally remains intact during repeated work in this area.

7.22.3. Allowances shall be made on the winding ends for accommodating tolerances on the axial dimensions of the set of bushings and also for the fact that bushings may have to be rotated.

7.22.4. In particular, rotation or straining of insulated connections shall be avoided during the fastening of conductor pads (or other methods) on the winding ends onto the termination surfaces of the bushing.

7.22.5. Suitable inspection and access facilities into the tank in the bushing oil-end area shall be provided to minimize the possibility of creating faults during the installation of bushings.

8. Painting system and procedures

The typical painting details for reactor main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given in **Annexure – E**. The proposed paint system shall generally be similar or better than this. The quality of paint should be such that its colour does not fade during drying process and shall be able to withstand temperature up to 120 deg C.

9. Unused inhibited Insulating Oil

The insulating oil shall be virgin high grade inhibited, conforming to IS 335 / IEC-60296 & all parameters specified at **Annexure – F**, while tested at oil supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned at **Annexure – F**, prior to despatch of oil from refinery to site. The Unused Inhibited Insulating Oil parameters including parameters of oil used at manufacturer’s works, processed oil, oil after filtration and settling are attached at **Annexure – F**. The oil test results shall form part of equipment test report.

Sufficient quantity of oil necessary for maintaining required oil level in case of leakage in tank, radiators, conservator etc. till the completion of warranty period shall be supplied.

Oil used for first filling, testing and impregnation of active parts at manufacturer's works shall be of same type of oil which shall be supplied at site and shall meet parameters as per specification.

9.1. **Particles in the oil**

The particle analysis shall be carried out in an oil sample taken before carrying out FAT at manufacturer's works and after completion of the oil filtration at site. The procedure and interpretation shall be in accordance with the recommendation of CIGRE report WG-12.17- "Effect of particles on transformer dielectric strength". Particle limit as shown below shall be ensured by manufacturer, implying low contamination, as per CIGRE Brochure 157, Table 8. After filtration the oil is to be flushed and particle count to be measured.

Limiting value for the particle count are 1000 particle/100 ml with size ≥ 5 µm; 130 particle/100 ml with size ≥ 15 µm.

9.2. **Oil filling**

9.2.1. Procedures for site drying, oil purification, oil filling etc shall be done as per Field Quality Plan (FQP).

9.2.2. The duration of the vacuum treatment shall be demonstrated as adequate by means of water / dew point measurement with a cold trap or other suitable method. The vacuum shall be measured on the top of the Reactor tank and should be less than 1mbar.

9.2.3. Oil filling under vacuum at site shall be done with reactor oil at a temperature not exceeding 65°C. Vacuum shall not be broken until the Reactor is oil filled up to the Buchholz relay.

9.2.4. The minimum safe level of oil filling (if different from the Buchholz level) to which the Reactor shall be oil filled under vacuum, shall be indicated in the manual.

9.2.5. **Oil treatment plant**

The Ultra High Vacuum type oil treatment plant (on returnable basis) of suitable capacity (**minimum 6000** litres per hour) shall be arranged by the contractor at his own cost for treatment of oil in EHV class Reactor in order to achieve properties of treated oil. The plant shall be capable of treatment of oil at rated capacity on single pass basis as follows:

i) Removal of moisture from 100 ppm to 3 ppm (max.)
ii) Removal of dissolved gas content from 10% by Vol. to 0.1% by vol.
iii) Improvement of dielectric strength break down voltage from 20 to 70 KV
iv) Vacuum level of degassing chamber not more than 0.15 torr/0.2 mbar at rated flow and at final stage. Machine shall have minimum of two degassing chambers and these should have sufficient surface areas to achieve the final parameters.
v) Filter shall be capable of removing particle size more than 0.5 micron in the filtered oil.

vi) Processing temperature shall be automatically controlled and have an adjustable range from 40°C to 80°C.

9.2.6. **Transportation of Oil**

The insulating oil for the Reactor shall be delivered at site generally not before 90 days from the date of commissioning, with prior information to the Employer, in view of risk involved in balk storage, pilferage and fire hazard. In case this oil is not filled in reactor due to delay in commissioning, same oil shall be used only after testing and ensuring that oil parameters are well within the specified limits.

Insulating oil shall be delivered to the site in returnable oil drums / flexi bag / stainless steel tanker. The oil drums / flexi bag / tanker shall be taken back without any extra cost to Employer within generally 45 days after utilisation of oil but in any case before contract closing. However, the spare oil shall be delivered in non-returnable drums.

10. Spare Reactor Units Storage & Connection Arrangement

Detail procedure for storage of spare reactor unit with and without **isolator switching arrangement** is enclosed at **Annexure-Q.**

11. Bushings

11.1. Bushings shall be robust and designed for adequate cantilever strength to meet the requirement of seismic condition, substation layout and movement along with the spare Reactor with bushing erected and provided with proper support from one foundation to another foundation within the substation area. The electrical and mechanical characteristics of bushings shall be in accordance with IEC: 60137/DIN 42530. All details of the bushing shall be submitted for approval and design review.

11.2. Bushing for voltage of 145 kV and above shall be RIP (Resin Impregnated paper) condenser type with composite polymer insulator (housing) or RIS (Resin Impregnated Synthetic) condenser type with composite polymer insulator (housing). 52kV Bushing shall of porcelain or composite polymer housing and hermetically sealed Oil filled condenser type or RIP (Resin Impregnated paper) condenser type with composite polymer insulator (housing) or RIS (Resin Impregnated Synthetic) condenser type with composite polymer insulator (housing). 36 kV and below rating bushing shall be solid porcelain or oil communicating type.

11.3. RIP/RIS type bushing shall be provided with tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.

11.4. Oil filled condenser type bushing shall be provided with at least following fittings:

a) Oil level gauge
b) Tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable
c) Oil filling plug & drain valve (if not hermetically sealed)

11.5. Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.

11.6. Bushings of identical rating of different makes shall be interchangeable to optimise the requirement of spares. Mounting dimensions of bushing shall be as per drawing mentioned at **Annexure – C**.

11.7. Porcelain used in bushing manufacture shall be homogenous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.

11.8. Polymer / composite insulator shall be seamless sheath of a silicone rubber compound. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique being followed with detailed procedure and sampling shall be finalized during finalization of MQP.

The weather sheds of the insulators shall be of alternate shed profile as per IEC 60815-3. The weather sheds shall be vulcanized to the sheath (extrusion process) or moulded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams / burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC60587**.** The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

The hollow silicone composite insulators shall comply with the requirements of the IEC publications IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462 (Type & Routine test)

11.9. Clamps and fittings shall be of hot dip galvanised/stainless steel.

11.10. Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.

11.11. No arcing horns shall be provided on the bushings.

11.12. Bushing shall be specially packed to avoid any damage during transit and suitable for long storage, with non-returnable packing wooden boxes with hinged type cover. Without any gap between wooden planks. Packing Box opening cover with nails/screws type packing arrangement shall not be acceptable. In case of RIP bushing with polymer housing, Bushing oil end portion shall be fitted with metal housing with positive dry air pressure and a suitable pressure monitoring device shall be fitted on the metal housing during storage to avoid direct contact with moisture with epoxy. Alternatively, oil filled metal housing with suitable arrangement for taking care oil expansion due to temperature variations shall also be acceptable. Manufacturer shall submit drawing/ documents of packing for approval during detail engineering. Detail method for storage of bushing including accessories shall be brought out in the instruction manual.

11.13. The terminal marking and their physical position shall be as per IEC: 60076.

11.14. Tan delta at variable frequency (in the range of 20 Hz to 350 Hz) shall be carried out on each condenser type bushing (OIP & RIP) at reactor manufacturing works / bushing manufacturing works as routine test before despatch and the result shall be compared at site during commissioning to verify the healthiness of the bushing.

11.15. Tan δ value of RIP / RIS condenser bushing shall be 0.005 (max.) in the temperature range of 20°C to 90°C. The measured Tan δ value at site of in-service bushing should not exceed by 0.001 w.r.t. factory results (measured at approx. similar temperature conditions) during warrantee period.

Tan delta value of OIP Bushing shall be 0.004 (Max) measured at ambient temperature. The measured Tan δ value at site of in-service bushing should not exceed by 0.001 w.r.t. factory results during warrantee period.

12. Neutral Formation and Earthing Arrangement.

12.1. **For 1-Phase Unit (if specified in BPS)**

The contractor shall connect the neutrals of three (3) 1-phase reactor by overhead connection using IPS Al tube / Cable of suitable size. The neutral formation shall be such that neutral winding of single-phase spare reactor can be disconnected or connected to the three phase banks. The connection from the neutral bushing to neutral bus shall be through IPS Al tube / cable of suitable size and wherever flexible jumper needs to be provided, same shall be through twin conductor. All material like Bus post insulator, Aluminium tube, conductor, clamps & connectors, earthing materials, support structure, hardware etc required for neutral formation and connection with neutral CT and earthing of neutral shall be provided.

12.2. **For 3-Phase Unit:**

The neutral of the shunt reactor shall be brought out through neutral bushing. The Contractor shall provide Aluminium clamps & connectors suitable for conductor between neutral of the shunt reactor, surge arrester and the neutral grounding reactor (NGR) as applicable.

12.3. The neutral of shunt reactor shall be grounded either directly or through a neutral grounding reactor (NGR) as the case may be. The neutral terminal of Reactors and NGR shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) 75 x 12 mm galvanised steel flats connected to Employer's grounding mat.

13. Cooling Equipment

13.1. The reactor shall be designed for Oil Natural Air Natural Cooling (ONAN)

13.2. The radiator bank of the shunt reactor shall be either tank mounted. For neutral grounding reactor, the radiator, if required, may be tank mounted.

13.3. Design of cooling system shall satisfy the performance requirements. The radiator shall be of sheet steel in accordance with IS 513 and minimum thickness 1.2 mm. Each radiator bank shall be provided with the following accessories:

(a) Top and bottom shut off valve
(b) Drain Valve and sampling valve
(c) Air release plug
(d) Two grounding terminals for termination of two (2) Nos. 75x12 mm galvanised steel flats.
(e) Thermometer pockets with captive screw caps at cooler inlet and outlet.
(f) Lifting lugs

13.4. Each radiator bank (tank mounted) shall be detachable and shall be provided with flanged inlet and outlet branches. Expansion joint shall be provided on top and bottom cooler pipe connection for separately mounted radiator bank.

13.5. If radiators are directly mounted on tank, sufficient number of thermometer pockets fitted with captive screw cap on the inlet and outlet of tank side pipe of radiators shall be provided to record temperature during temperature rise test.

13.6. The cooler pipes, support structure including radiators and its accessories shall be hot dip galvanised or corrosion resistant paint should be applied to external surface of it.

14. Valves

14.1. All valves upto and including 100 mm shall be of gun metal or of cast steel/cast iron. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel.

14.2. Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.

14.3. Each valve shall be provided with the indicator to show clearly the position of the valve.

14.4. All valves flanges shall have machined faces.

14.5. All valves in oil line shall be suitable for continuous operation with Reactor oil at 115 deg C.

14.6. Gland packing/gasket material shall be of “O” ring of nitrile rubber for all the valve’s flanges. All the flanges shall be machined.

14.7. The oil sampling point for main tank shall have two identical valves to be put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.

14.7.1. Valves or other suitable means shall be provided to fix various on line monitoring systems to facilitate continuous monitoring.

Type of valves shall be used for Reactor as per following table. The location, size of valves for other application shall be finalised during design review.

Sr. No.	Description of Valve	Type
1	Drain Valve	Gate
2	Filter valve	Gate
3	Sampling Valve	Globe
4	Radiator isolation valve	Butterfly
5	Buchholz relay isolation valve	Gate
6	Sudden pressure relay	Gate
7	Valve for vacuum application on Tank	Gate
8	Conservator Drain valve	Gate
9	Aircell equalizing valve	Gate/Globe/Ball
10	Valve for Conservator vacuum (top)	Gate
11	Valve for N2 injection (NIFPS)	Gate
12	Valve for NIFPS Drain	Gate
13	Valve for UHF Sensors (for 400kV Reactor)	Gate

14.7.2. All valves shall be painted with a shade (preferably red or yellow) distinct and different from of main tank surface and as per the painting system and procedure specified.

14.8. All hardware used shall be hot dip galvanised / stainless steel.

14.9. **Flow sensitive conservator Isolation valve**

a) In order to restrict the supply of oil in case of a fire in Reactor, flow sensitive valve shall be provided to isolate the conservator oil from the main tank. The valve shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. It shall not operate when oil pumps are switched on or off. This valve shall be located in the piping between the conservator and the buchholz relay and shall not affect the flow of oil from and to the conservator in normal conditions.

b) When the flow from conservator to main tank is more than the normal operating conditions, the valve shall shut off by itself and will have to be reset manually. It shall be provided with valve open/close position indicator along with alarm contact indication in control room during closing operation of valve. This valve shall be provided with locking arrangement for normal position and oil filling / filtration position. A suitable platform or ladder (if required) shall be provided to approach the valve for manual reset. All valves shall be painted with a shade (preferably red or yellow) distinct and different from of main tank surface and as per the painting system and procedure specified.

14.10. All valves shall be painted with a shade (preferably red or yellow distinct and different from of main tank surface and as per the painting system and procedure specified.

14.11. All hardware used shall be hot dip galvanised / stainless steel.

15. Cabling

15.1. Buchholz Relay, Magnetic Oil Level Gauge, Pressure Relief Device & Sudden pressure relay to be wired through unarmoured cable of 1.5 sq.mm (minimum), inside GI conduit, with no part exposed. Cable shall be protected by flexible stainless steel pipe, at both ends as per requirement. Proper sealing arrangement to be provided at both ends to avoid ingress of water.

The cross section of "control cable" shall be 1.5 sq.mm (minimum) except for CT circuits which should be 2.5 sq.mm (minimum).

All other cables shall be armoured type and shall be routed through covered cable tray or GI conduit and shall be properly dressed.

15.2. Cable terminations shall be through stud type TB and ring type lugs. Typical Technical specification for cables is attached at Annexure-I. All cables should be provided from approved sources with valid type test report. However, charges for type testing is not envisaged. Both ends of all the wires (control & power) shall be provided with proper ferrule numbers for tracing and maintenance. Further, any special cables (if required) shall also be considered included in the scope. All cable accessories such as glands, lugs, cable tags/ numbers etc. as required shall be considered included in the scope of supply.

15.3. Cabling of spare unit with isolator switching arrangement shall be in such a way that spare unit of Reactor can be connected in place of faulty unit without physically shifting and all the control, protection, indication signals of spare unit shall be brought in common marshalling box of all the banks. From CMB all the control, protection and indication signals of R, Y, B and Spare units shall be transferred to Purchaser's Control panels / SCADA. Change-over of spare unit signals with faulty unit shall be done through Purchaser's C & R panels / SCADA level.

16. Individual Marshalling Box and Common Marshalling Box

16.1. Each single phase reactor unit shall be provided with Individual Marshalling Box and Common Marshalling (for a bank of three single phase unit) Box shall be provided.

16.2. Common marshalling box shall be floor mounted and of size, not less than 1600 mm (front) X 650 mm (depth) X 1800 mm (height). Individual Marshalling Box and Cooler Control Box shall be tank mounted.

16.3. The Individual Marshalling Box, Common Marshalling Box, Junction box and all other outdoor cubicles shall be made of stainless-steel sheet of minimum grade of SS304 (SS 316 for coastal area) and of minimum thickness of 1.6 mm.

16.4. The degree of protection shall be IP: 55 for outdoor and IP: 43 for indoor in accordance with IS 13947/IEC: 60947.

16.5. All doors, removable covers and plates shall be gasketed all around with suitably profiled. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion to make a tight seal. For Control cubicle / Marshalling Boxes etc. which are outdoor type, all the sealing gaskets shall be of EPDM rubber or any better approved quality, whereas for all indoor control cabinets, the sealing gaskets shall be of neoprene rubber or any better approved quality. The gaskets shall be tested in accordance with approved quality plan, IS: 1149 and IS: 3400.

16.6. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh of brass. All the separately mounted cabinets and panels shall be free standing floor mounted type and have domed or sloping roof. All the control cabinets shall be provided with suitable lifting arrangement. Individual Marshalling Box shall be tank mounted only.

16.7. All the contacts of various protective devices mounted on the reactor and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the Marshalling box. All the CT secondary terminals in the Marshalling box shall have provision for shorting to avoid CT open circuit while it is not in use. All the necessary terminations for remote connection to Employer's panel shall be wired upto the Common Marshalling box.

16.8. A space heater and cubicle lighting with ON-OFF switch shall be provided in each panel.

16.9. Control and power supplies are to be given after suitable selection at Common Marshalling Box. Necessary isolating switches and protective devices shall be provided at suitable points as per Employer's approved scheme.

16.10. All the control circuit connections from Individual Marshalling Box and of three single phase units of a bank including spare reactor unit to Employers Control panels shall be routed through common marshalling box. Common marshalling box shall be floor mounted and of size not less than 1600mm (front) X 650mm (depth) X 1800mm (height).

16.11. Details of station auxiliary power supply are mentioned in Section - GTR. Common marshalling box shall have following arrangement:

16.12. Two auxiliary power supplies, 415 volt, three phase four (4) wire shall be provided by the Employer at Common Marshalling Box (for Single Phase unit) or Marshalling Box (for Three Phase unit).

16.13. Suitably rated power contactors, MCBs/MCCBs as required for entire auxiliary power supply system including distribution to marshalling boxes, Online DGA monitoring system, Online drying system and Fibre optic sensor Box etc., shall be provided by contractor. For each circuit separate MCBs / MCCBs shall be provided in the Common Marshalling Box.

16.14. In case auxiliary power supply requirement is different than station auxiliary AC supply, then all necessary converters shall be provided by the Contractor. Auxiliary power supply distribution scheme shall be submitted for approval.

16.15. For 1-Ph Reactor Unit, supply and laying of Power, Control and special cables from Common Marshalling Box to Individual units (including spare unit) is in the scope of the contractor.

16.16. All loads shall be fed by one of the two feeders through an electrically interlocked automatic transfer scheme housed in the common marshalling box. Design features of the transfer scheme shall include the following:

a) Provision for the selection of one of the feeder as normal source and other as standby.
b) Upon failure of the normal source, the loads shall be automatically transferred after an adjustable time delay to standby sources.
c) Indication to be provided at marshalling box for failure of normal source and for transfer to standby source and also for failure to transfer.
d) Automatic re-transfer to normal source without any intentional time delay following re-energization of the normal source.
e) Both the transfer and the re-transfers shall be dead transfers and AC feeders shall not be paralleled at any time.

17. SCADA Integration

17.1.1. All required power & control cables including optical cable, patch chord (if any) upto Common MB shall be in the scope of contractor. Further, any special cable between CMB to switchyard panel room/control room shall be under the present scope.

17.1.2. Fiber optic cable, power cable, control cables, as applicable, between CMB to switchyard panel room/control room and power supply (AC & DC) to MB and integration of above said IEC-61850 compliant equipment with Substation Automation System shall be under the scope of EPC contractor.

17.1.3. SCADA Integration of online monitoring equipment (**if applicable**):

All the online monitoring equipment i.e. Online Dissolved Gas (Multi-gas) and Moisture Analyser, On-line insulating oil drying system (Cartridge type) etc. provided for individual Reactor unit including Spare (if any), are IEC 61850 compliant (either directly or through a Gateway). The monitoring equipment are required to be integrated with SAS through managed Ethernet switch conforming to IEC 61850. This Ethernet switch shall be provided in IMB or CMB. The switch shall be powered by redundant DC supply (110V or as per available Station DC supply). Ethernet switch shall be suitable for operation at ambient temperature of 50 Deg C.

18. Current Transformer (Bushing & Outdoor Neutral Current Transformer)

18.1. Current transformers shall comply with IS 16227 (Part 1 & 2)/IEC 61869 (part 1 & 2).

18.2. It shall be possible to remove the turret mounted current transformers from the Reactor tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

18.3. Current transformer secondary leads shall be brought out to a weatherproof terminal box near each bushing. These terminals shall be wired out to common marshalling box using separate cables for each core.

18.4. For 1-Phase Reactor, one number single phase current transformer (outdoor) for earth fault protection shall be provided for each bank of reactor and shall be located in the neutral conductor connecting common neutral point with earth.

18.5. Technical Parameters of Bushing CTs and Neutral CTs are enclosed at **Annexure – G.** The CT's used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection. Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Employer's approval before proceeding with the design of bushing current transformers.

18.6. Secondary resistance and magnetising current characteristics of PX / PS class (protection) (as per IS or IEC) CT of same rating shall match. This is applicable for Neutral CT (outdoor) also and shall be reviewed during detail engineering.

19. Surge Arrester

19.1. General

The surge arresters (if specified in BPS) shall conform in general to IEC-60099-4 except to the extent explicitly modified in the specification. The bidder shall offer surge arresters of gapless type without any series or shunt gap. Arresters shall be hermetically sealed units, of self supporting construction, suitable for mounting on structures.

19.2. Duty Requirements

The surge arresters shall be of heavy duty station class type. It shall be physically located between the neutral of shunt reactor (brought out at bushing) and neutral grounding reactor and shall be electrically in parallel with the latter.

The surge arresters shall be capable of discharging over voltage occurring during switching of unloaded reactors. It shall be capable of spark over on severe switching surges and multiple strokes. It shall be able to withstand wind load calculated at 195 kg/sq.m.

19.3. Constructional Features

19.3.1. The non linear blocks shall be of sintered metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent electrical and mechanical properties even after repeated operations.

19.3.2. The reference current of the arrester shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

19.3.3. The surge arresters shall be fitted with pressure relief devices and arc diverting parts suitable for preventing rupture of polymer housing and providing path for flow of rated fault currents in the event of arrester failure.

19.3.4. The arresters shall incorporate anti-contamination feature to prevent arrester failure consequent to uneven voltage gradient across the stack in the event of contamination of the arrester housing.

19.3.5. Seals shall be provided in such a way that these are always effectively maintained even when discharging rated lightning current.

19.3.6. Outer insulator shall be polymer / composite insulator housing. Details specification of polymer/composite insulators are given in clause 11.7

19.3.7. The end fittings shall be made of non-magnetic and corrosion proof material.

19.3.8. The name plate shall conform to the requirement of IEC incorporating the year of manufacture.

19.3.9. The arrester shall be supplied with suitable support structure either of tubular GI pipe or lattice steel galvanised.

19.3.10. The heat treatment cycle details along with necessary quality checks used for individual blocks along with insulation layer formed across each block to be furnished. Metallised coating thickness for reduced resistance between adjacent discs to be furnished along-with procedure for checking the same.

19.3.11. Technical parameters of Surge Arrester is enclosed at **Annexure-H**

19.4. **Fittings and Accessories**

19.4.1. Each arrester shall be complete with insulating base, support structure and terminal connector. The height of the support structure shall not be less than 2500 mm. The structure would be made of galvanized steel generally conforming to IS: 802. The surge arrester can also be mounted on the neutral grounding reactor in lieu of separate support structure.

19.4.2. Self contained discharge counter, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation along with necessary connection, shall be provided for each unit. The counter shall be visible through an inspection window from ground level. The counter terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. One no. potential free change over type contacts (rated for 220V DC) shall be provided for monitoring of surge counter operation in substation automation system.

19.4.3. Suitable milli-Ammeter on each arrester with appropriate connections shall be supplied to measure the resistor grading leakage current. The push buttons shall be mounted such that it can be operated from ground level.

19.4.4. Discharge counter and milli-ammeter shall be suitable for mounting on support structure of the arrester with minimum protection class IP 55.

19.4.5. Grading/Corona rings shall be provided on each complete arrester unit as required for proper stress distribution.

19.5. **Tests**

19.5.1. The surge arresters shall conform to type tests and shall be subjected to routine tests as per IEC-60099-4.

19.5.2. Surge arrester shall be subjected to additional acceptance tests.

(i) Polymer insulator test as per IEC 61462
(ii) Construction check (visual check)
(iii) Measurement of insulation resistance by 1kV megger.

20. Hand Tools (if specified in BPS)

One set of hand tools of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tubular with Tommy bar each of sizes 9mm to 24mm, one set each), adjustable wrenches (8 &12 inch one set), gasket punches (of different sizes used - one set), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one), files with handle (two), knife with handle (one), adjustable hacksaw (one), and cold chisel (one), bushing handling and lifting tools with nylon rope/belt, chain block (2 Nos.) and D-Shackle shall be supplied.

21. Test Kit (if specified in BPS)

BDV Kit as per Annexure-J of specification
Portable DGA Kit as per Annexure-J of specification

22. Fittings

The following fittings & accessories (as applicable) shall be provided with each Reactor & NGR covered in this specification. The fittings listed below are not exhaustive and other fittings, which are required for satisfactory operation of the Reactor, are deemed to be included.

22.1. Shunt Reactor

i) Conservator for main tank of reactor with aircell, isolating valves, drain valve, magnetic oil level gauge (with canopy) with potential free high and low oil level alarm contacts and prismatic oil level gauge and Dehydrating Silicagel Filter Breather with flexible connection pipes to be used during replacement of any silicagel breather

ii) Pressure relief devices with trip contact

iii) Sudden pressure relief relay with alarm contact (for 400kV Reactor only)

iv) Buchholz relay with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm / trip contacts.

v) Air release plug

vi) Conservator air cell rupture detection relay

vii) Inspection openings and covers

viii) Bushing of each type with metal parts and gaskets to suit the termination arrangement

ix) Winding & Oil temperature indicators

x) Cover lifting eyes, reactor lifting lugs, jacking pads, towing holes and core and winding lifting lugs

xi) Rating and diagram plates on reactors and auxiliary apparatus

xii) Roller Assembly (as per clause 7.4)

xiii) Marshalling Box, Common Marshalling Box (applicable for 1-Ph unit), Fibre optic sensor box as applicable

xiv) Cooling equipment

xv) Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently

xvi) Bushing Current Transformers, Neutral CT (if applicable)

xvii) Terminal marking plates

xviii) Valves schedule plate

xix) Bottom oil sampling valve, Drain valves, Filter valves at top and bottom with threaded male adaptors, Shut off valves on the pipe connection between radiator bank and reactor tank, Shut off valves on both sides of Buchholz relay, Sampling gas collectors for Buchholz relay at accessible height, Valves for Radiators, Valve for vacuum application, Valve for on line DGA, valves for Drying out system, Valve for UHF sensors, valves for NIFPS system (if applicable) etc.

xx) Suitable terminal connectors on bushings and surge arrester

xxi) Ladder to climb up to the Reactor tank cover with suitable locking arrangement to prevent climbing during charged condition.

xxii) Suitable Platform or ladder for safe access of Flow sensitive non-return valve and buchholz relay shall be provided, in case these are not accessible from Reactor top.

xxiii) Haulage lugs

xxiv) Fibre optic sensor based temperature measuring system (applicable for 400kV Reactor)

xxv) Two earthing terminals each on shunt reactor tank, radiators & marshalling boxes, SA structures etc.

xxvi) Neutral bus connection arrangement (3-Phase Reactor)

xxvii) Online Dissolved Gas (Multi-gas) and Moisture Analyser (if specified in BPS) as per **Annexure-K**

xxviii) On Line Dissolved Hydrogen and Moisture Monitor (if specified in BPS) as per **Annexure-L**

xxix) On-line insulating oil drying system (Cartridge type) as per **Annexure-M**

xxx) Nitrogen Injection Type Fire Protection System (NIFPS) (if specified in BPS) as per **Annexure-N**

xxxi) Oil Sampling Bottle & Oil Syringe (if specified in BPS) as per **Annexure-O**

xxxii) All Cables (Power, control and shielded / twisted pair for 4-20mA cable from Reactor MB, Cooler control cubicle, etc. (as applicable) to CMB (if applicable) shall be under the present scope. Any special cable if required to be included upto employer's C&R panel.

xxxiii) Managed Ethernet switch, LIU patch cords etc. (if applicable). shall be provided in CMB/MB (as per clause 17). All IEC 61850 compliant signals from various monitoring equipment/accessories shall be wired upto the Ethernet switch.

22.2. **NGR**

i) Conservator for NGR main tank with drain valve, isolating valve, vent pipe and prismatic oil level gauge.

ii) Pressure relief devices with trip contact

iii) Buchholz relay with isolating valves on both sides, bleeding pipe with pet cock at the end to collect gases and alarm / trip contacts.

iv) Air release plug

v) Inspection openings and covers

vi) Bushings with metal parts and gaskets to suit the termination arrangement

vii) Oil temperature indicators

viii) Cover lifting eyes, reactor lifting lugs, jacking pads, towing holes and core and winding lifting lugs

ix) Rating and diagram plates

x) Roller Assembly (if applicable as per clause 7.4)

xi) Marshalling Box (Tank mounted)

xii) Cooling equipment as applicable

xiii) Bushing Current Transformers, Neutral CT (if applicable)

xiv) Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently

xv) Terminal marking plates

xvi) Valves schedule plate

xvii) Bottom oil sampling valve with threaded male adaptors, Drain valves, Filter valves at top and bottom, shut off valves on both sides of Buchholz relay at accessible height, sampling gas collectors for Buchholz relay at accessible height, Valve for vacuum application etc.

xviii) Suitable terminal connectors on bushings

xix) Ladder to climb up to the tank cover with suitable locking arrangement to prevent climbing during charged condition.

xx) Haulage lugs

xxi) Two earthing terminals each on tank, marshalling boxes etc.

22.3. All hardware used shall be hot dip galvanised / stainless steel.

23. Inspection and Testing

The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. The inspection envisaged by the Purchaser is given below. This is however not intended to form a comprehensive programme as it is Contractor's responsibility to draw up and carry out such a programme in the form of detailed quality plan duly approved by Employer for necessary implementation. All accessories and components of reactor shall be purchased from approved soured of Employer. All process tests, critical raw material tests and witness / inspection of these testing shall be carried out as per approved manufacturing quality plan (MQP) by Employer.

23.1. **Factory Tests**

The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated in.

The contractor shall bear all additional costs related to tests, which are not possible to carry out at his own works.

The contractor shall carry out type & routine tests as per "**Annexure-B & Standard Test Procedure".** Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the test engineer of the contractor.

23.2. **Type Tests on fittings:**

Type test reports of following Bushing & accessories shall be furnished by the contractor along with drawings.

a) Bushing Type Test as per IS/ IEC:60137 for all voltage class (Seismic test on 400kV Bushings)
b) Marshalling & Common Marshalling Box and other outdoor cubicle (IP-55)

23.3. **Pre-Shipment Checks at Manufacturer's Works**

23.3.1. Check for inter-changeability of components of similar reactor for mounting dimensions.

23.3.2. Check for proper packing and preservation of accessories like radiators, bushings, dehydrating breather, rollers, buchholz relay, control cubicle, connecting pipes, conservator etc.

23.3.1. Before dispatch of Reactor from factory, following impact recorder settings are to be implemented for graphical analysis:

>1g: Start recording

>2g: Warning

>3g: Alarm

Further, drop-out setting shall be 1g and threshold setting shall be in the range of 3g to 10g.

23.3.2. Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

23.3.3. Gas tightness test to confirm tightness and record of dew point of gas inside the tank. Derivation of leakage rate and ensure the adequate reserve gas capacity.

23.4. **Inspection and Testing at Site**

The Contractor shall prepare a detailed inspection and testing programme for field activities covering areas right from the receipt of material stage up to commissioning stage. An indicative inspection programme as envisaged by the Employer is given below. Testing of oil sample at site shall be carried out as per specification. Contractor shall follow Employer Field Quality Plan (FQP).

23.5. **Receipt and Storage Checks**

23.5.1. Check and record condition of each package, visible parts of the reactor etc. for any damage.

23.5.2. Check and record the gas pressure in the reactor tank as well as in the gas cylinder.

23.5.3. Check and record reading of impact recorder at receipt and verify the allowable limits as per manufacturer's recommendations.

23.6. **Installation Checks**

23.6.1. Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general.

23.6.2. Check whole assembly for tightness, general appearance etc.

23.6.3. Oil leakage test

23.6.4. Capacitance and tan delta measurement of bushing before fixing/connecting to the winding, contractor shall furnish these values for site reference.

23.6.5. Leakage check on bushing before erection.

23.6.6. Measure and record the dew point of gas in the main tank before assembly.

23.7. **Commissioning Checks**

23.7.1. Check the colour of silicagel breather.

23.7.2. Check the oil level in the breather housing, conservator tanks, cooling system, condenser bushing etc.

23.7.3. Check the bushing for conformity of connection to the lines etc,

23.7.4. Check for correct operation of all protection devices and alarms/trip :

i. Buchholz relay
ii. Excessive winding temperature
iii. Excessive oil temperature
iv. Low oil level indication

23.7.5. Check for the adequate protection on the electric circuit supplying the accessories.

23.7.6. Check resistance of all windings. Insulation resistance measurement for the following:

i) Control wiring
ii) Main windings
iii) Bushing Current Transformer

23.7.7. 2 kV for 1 minute test between bushing CT terminal and earth.

23.7.8. Check for cleanliness of the reactor and the surroundings

23.7.9. Measure vibration and noise level

23.7.10. Capacitance and Tan delta measurement of winding and bushing

23.7.11. Frequency response analysis (FRA). FRA equipment shall be arranged by Employer.

23.7.12. DGA of oil just before commissioning and after 24 hours energisation at site.

23.7.13. Contractor shall prepare a comprehensive commissioning report including all commissioning test results as per Pre-Commissioning Procedures and handover to Employer for future record.

Annexure – A

1.0 Technical Particulars / Parameters of 420kV Shunt Reactor

Clause No.	Description	Unit	Parameters			
1.1	Rated Voltage, U_r (1p.u)	kV	420			
1.2	Rated Capacity at 420 kV	MVAR	50	63	80	125
1.3	Standard		IEC 60076-6			
1.4	Connection (3 Phase)		Star			
1.5	Cooling System		ONAN			
1.6	Frequency	Hz	50			
1.7	No of Phases		3 (THREE)			
1.8	Service		Outdoor			
1.9	System Fault Level	kA	63			
1.10	Permissible current unbalance among different phases	%	±2			
1.11	Crest value of Third Harmonic content in phase current at rated voltage with sinusoidal wave form	%	≤ 3% of the crest value of fundamental			
1.12	Range of constant Impedance (However, complete saturation characteristics of the Reactors up to 2.5 p.u. Voltage shall be furnished)		Up to 1.5 p.u. voltage			
1.13	Tolerance on current	%	0 to +5%			
1.14	Ratio of zero sequence reactance to positive reactance (X0/X1)	Range	0.9 - 1.0			
1.15	Temperature rise over 50 deg C Ambient Temp at rated voltage					
a)	Top oil measured by thermometer	^{O}C	40			
b)	Average winding measured by resistance method	^{O}C	45			
c)	Winding hot spot temperature rise over yearly weighted average temperature of 32 °C	^{O}C	61			
d)	Max. tank surface temperature	^{O}C	110			
1.16	Max. design Ambient temp	^{O}C	50			
1.17	Windings					
a)	Lightning Impulse withstand Voltage					
	HV	kV_p	1300			
	Neutral	kV_p	550			
	Chopped Wave Lightning Impulse Withstand Voltage					
	HV	kV_p	1430			
b)	Switching Impulse withstand Voltage					
	HV	kV_p	1050			
c)	Power Frequency withstand Voltage					
	Line	kV_{rms}	570			
	Neutral	kV_{rms}	230			

d)	Tan delta of windings		< 0.005	
1.18	Bushing			
a)	Rated voltage			
	HV	kV	420	
	Neutral	kV	145	
b)	Rated current (Min.)			
	HV	A	800	
	Neutral	A	800	
c)	Lightning Impulse withstand Voltage			
	HV	kVp	1425	
	Neutral	kVp	650	
d)	Switching Impulse withstand Voltage			
	HV	kVp	1050	
e)	Power Frequency withstand Voltage			
	HV	kVrms	695	
	Neutral	kVrms	305	
f)	Minimum total creepage distances		(Specific Creepage Distance: of 31mm/kV corresponding to highest line to line voltage)	
	HV	mm	13020	
	Neutral	mm	4495	
h)	Partial discharge level at U_r			
	HV	pC	< 10	
	Neutral	pC	< 10	
1.19	Maximum Partial discharge level at 1.58 $U_r / \sqrt{3}$	pC	100	
1.20	Vibration and Tank stress level at rated voltage and frequency		Max : ≤ 200 microns peak to peak Average: ≤60 microns peak to peak. Stress: ≤ 2.0kg/sq.mm at any point on tank.	
1.21	Maximum Noise level at rated voltage and frequency	dB	80	
1.22	Maximum Permissible Losses of Reactor		Maximum Total Load Loss at rated Voltage, Frequency and at 75^{O} C (kW)	Max. I2R Loss at rated current and frequency and at 75°C
i)	50MVAR, 420kV 3-Ph Reactor	kW	85	45
ii)	63MVAR, 420kV 3-Ph Reactor	kW	100	57
iii)	80MVAR, 420kV 3-Ph Reactor	kW	115	65
iv)	125MVAR, 420kV 3-Ph Reactor	kW	160	90

2.0 Technical Particulars / Parameters of 245kV Shunt Reactor

Clause No.	Description	Unit	Parameters	
2.1	Rated Voltage, U_r (1p.u)	kV	245	
2.2	Rated Capacity at 245 kV	MVAR	25	50
2.3	Standard		IEC 60076-6	
2.4	Connection (3 Phase)		Star	
2.5	Cooling System		ONAN	
2.6	Frequency	Hz	50	
2.7	No of Phases		3 (THREE)	
2.8	Service		Outdoor	
2.9	System Fault Level	kA	40	
2.10	Permissible current unbalance among different phases	%	±2	
2.11	Crest value of Third Harmonic content in phase current at rated voltage with sinusoidal wave form	%	≤ 3% of the crest value of fundamental	
2.12	Range of constant Impedance (However, complete saturation characteristics of the Reactors up to 2.5 p.u. Voltage shall be furnished)		Up to 1.5 p.u. voltage (However, complete saturation characteristics of the Reactors up to 2.5 p.u. Voltage shall be furnished)	
2.13	Tolerance on current	%	0 to +5%	
2.14	Ratio of zero sequence reactance to positive reactance (X0/X1)	Range	0.9 - 1.0	
2.15	Temperature rise over 50 deg C Ambient Temp at rated voltage			
a)	Top oil measured by thermometer	^{O}C	40	
b)	Average winding measured by resistance method	^{O}C	45	
c)	Winding hot spot temperature rise over yearly weighted average temperature of 32 °C	^{O}C	61	
d)	Max. tank surface temperature	^{O}C	110	
2.16	Max. design Ambient temp	^{O}C	50	
2.17	Windings			
a)	Lightning Impulse withstand Voltage			
	HV	kV_p	950	
	Neutral	kV_p	170	
	Chopped Wave Lightning Impulse Withstand Voltage			
	HV	kV_p	1430	
b)	Switching Impulse withstand Voltage			
	HV	kV_p	750	
c)	Power Frequency withstand Voltage			
	Line	kV_{rms}	395	

	Neutral	kV_{rms}	70	
d)	Tan delta of windings		< 0.005	
2.18	Bushing			
a)	Rated voltage			
	HV	kV	245	
	Neutral	kV	36	
b)	Rated current (Min.)			
	HV	A	1250	
	Neutral	A	800	
c)	Lightning Impulse withstand Voltage			
	HV	kVp	1050	
	Neutral	kVp	170	
d)	Switching Impulse withstand Voltage			
	HV	kVp	850	
e)	Power Frequency withstand Voltage			
	HV	kVrms	505	
	Neutral	kVrms	77	
f)	Minimum total creepage distances			
	HV	mm	7595	
	Neutral	mm	1116	
h)	Partial discharge level at U_r			
	HV	pC	< 10	
2.19	Max. Partial discharge level at 1.58 $U_r / \sqrt{3}$	pC	100	
2.20	Vibration and Tank stress level at rated voltage and frequency		Max : ≤ 200 microns peak to peak Average: ≤60 microns peak to peak. Stress: ≤ 2.0kg/sq.mm at any point on tank.	
2.21	Maximum Noise level at rated voltage and frequency	dB	75	
2.22	Maximum Permissible Losses of Reactor		Maximum Total Load Loss at rated Voltage, Frequency and at 75^{O} C (kW)	Max. I2R Loss at rated current and frequency and at 75°C
i)	25MVAR, 245kV 3-Ph Reactor	kW	50	28
ii)	50MVAR, 245kV 3-Ph Reactor	kW	80	45

4.0 Technical Particulars / Parameters of Neutral Grounding Reactor (NGR)

The neutral grounding reactors are generally used in Line Reactor between the neutral end of the Reactor and ground to limit the secondary arc current and the recovery voltage to a minimum value.

Following are the Technical particulars/ parameters envisaged for NGR:

Clause No.	Description	Unit	Parameters
4.	Technical Parameters		
	Rated voltage from insulation	kV	**145**
4.1	Connection		Between neutral of reactor and ground
4.2	Cooling System		Natural oil cooling (ONAN)
4.3	Cooling medium		Insulating oil
4.4	Frequency	Hz	50
4.5	No of Phases		1 (SINGLE)
4.6	Service		Outdoor
4.7	Type		Oil filled outdoor application
4.8	Insulation		Graded
4.9	Max. continuous current (rms)		10 A
4.10	Rated short time current (rms) (10secs.)		60A
4.11	Rated impedance at rated short time and continuous current		As specified in section project
4.12	Max. temperature rise over ambient temperature of 50^{0}C at rated voltage		
i)	of winding measured by resistance	Deg C	45
ii)	of top oil measured by thermometer	Deg C	50
4.13	Insulation level for winding		
	Lightning Impulse withstand Voltage		
i)	Line side	kV_p	550
ii)	Ground side	kV_p	95
iii)	Chopped Wave Lightning Impulse Withstand Voltage		
iv)	Line End	kVp	605
	One Minute Power Frequency withstand Voltage		
v)	Line side	kV_{rms}	230
vi)	Ground side	kV_{rms}	38
4.14	**Bushing**		
	Rated Voltage		
i)	Line side	kV	145
ii)	Ground side	kV	24

	Lightning Impulse withstand Voltage	kV_p	
iii)	Line side		650
iv)	Ground side		125
	One Minute Power Frequency withstand Voltage		
v)	Line side	kV_{rms}	305
vi)	Ground side	kV_{rms}	55
	Creepage (total minimum)		31mm/kV
vii)	Line side	mm	4495
viii)	Ground side	mm	744
4.15	Method of grounding		Solidly connected between neutral of shunt reactor and earth.
4.16	Whether neutral is to be brought out		Yes (through 24kV Porcelain bushing

Annexure -B

Test Plan

No.	Item	Test Category
1.	Measurement of winding resistance	Routine
2.	Reactance and loss measurement (Measured in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units)	Routine
3.	Measurement of insulation resistance & Polarization Index	Routine
4.	Measurement of insulation power factor and capacitance between winding and earth	Routine
5.	Measurement of insulation power factor and capacitance of bushings	Routine
6.	Core assembly dielectric and earthing continuity test	Routine
7.	High voltage withstand test on auxiliary equipment and wiring after assembly	Routine
8.	Chopped wave lightning impulse test for the line terminals (LIC)	Routine
9.	Lightning impulse test on Neutral	Routine
10.	Switching impulse test	Routine
11.	Applied voltage test (AV)	Routine
12.	Induced Over Voltage Test with Partial Discharge Measurement	Routine
13.	Gas-in-oil analysis	Routine
14.	2-Hour excitation test except type tested unit	Routine
15.	Vibration & stress measurement in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units (Measurement shall also be carried out at 1.05Um for reference only on one unit of each type)	Routine
16.	Measurement of mutual reactance on 3-phase reactor	Routine
17.	Temperature rise test	Type
18.	Measurement of harmonic content of current (Measured in Cold state)	Type
19.	Measurement of acoustic noise level (Measured in Cold and Hot state of temperature rise test)	Type
20	Knee point voltage measurement of reactor (Measured in Cold state)	Type
21.	Measurement of zero-sequence reactance (Applicable for three phase shunt reactor only)	Type
22.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	Routine
23.	Appearance, construction and dimension check	Routine
24.	Oil leakage test on Reactor tank	Routine
25.	Tank vacuum test	Routine
26.	Tank pressure test	Routine

Test on NGR	
Item	**Test**
Measurement of winding resistance	Routine
Measurement of Impedance by V/I	Routine
Measurement of insulation resistance	Routine
Measurement of Capacitance & Tan delta of winding insulation to earth and	Routine
Lightning impulse test	Routine
Separate source voltage withstand test	Routine
Isolation Test	Routine
Oil leakage test	Routine
Appearance, construction and dimension check	Routine
High voltage with stand test on auxiliary equipment and wiring after assembly	Routine
Tank Vacuum test	Routine
Tank Pressure test	Routine

Annexure –D

Reference Drawings

The list of drawings indicated below form a part of this specification.

Sr. No	Drawing Description	Drawing No.
i)	Typical Foundation Drawing	0000-000-T-E-G-001, R01
ii)	Arrangement of Current Transformer on Shunt Reactor & NGR	0000-000-T-E-J-001, REV 01
iii)	Standard details for RIP Condenser bushings (Lower portion)	Annexure-R
iv)	Conceptual Drawing for Optical Fibre Sensor	C/ENGG/STD/OPTICAL FIBRE SENSOR/AT-SR/REV 00
v)	Conceptual drawing for showing power and control cable connection for operation of 1-ph unit with spare unit	C/ENGG/RT/SPARE/CABLE/STD; REV 01
vi)	Conceptual drawing for showing power and control cable connection for operation of 3-ph unit	C/ENGG/STD/CABLE/RT
vii)	Standard Test Procedure of Transformer & Reactor	POWERGRID/STD/TEST PROCEDURE/TR-RT/REV02

Annexure – D

Design Review Document for Shunt Reactor

Sr. No.	**Description**
1.	Core and Magnetic Design
2.	Over-fluxing and Linear characteristics
3.	Inrush-current characteristics while charging
4.	Winding and winding clamping arrangements
5.	Short-circuit withstand capability considering inrush current.
6.	Thermal design including review of localised potentially hot area
7.	Cooling design
8.	Overload capability
9.	Eddy current losses
10.	Seismic design, as applicable
11.	Insulation co-ordination
12.	Tank and accessories
13.	Bushings
14.	Protective devices
15.	Radiators
16.	Sensors and protective devices– its location, fitment, securing and level of redundancy
17.	Oil and oil preservation system
18.	Corrosion protection
19.	Electrical and physical Interfaces with substation
20.	Earthing (Internal & External)
21.	Processing and assembly
22.	Testing capabilities
23.	Inspection and test plan
24.	Transport and storage
25.	Sensitivity of design to specified parameters
26.	Acoustic Noise
27.	Spares, inter-changeability and standardization
28.	Maintainability
29.	PRD and SPR (number & locations) and selection
30.	Conservator capacity calculation
31.	Winding Clamping arrangement details with provisions for taking it “in or out of tank”
32.	Conductor insulation paper details
33.	Location of Optical temperature sensors
34.	The design of all current connections
35.	Location & size of the Valves

Note: Design review document for NGR shall be decided during detailed engineering.

Painting Procedure:

PAINTING	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank & DM Box etc. (external surfaces)	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40μm)	Epoxy high build Micaceous iron oxide (HB MIO) (75μm)	Aliphatic polyurethane (PU) (Minimum 50μm)	Minimum 155μm	RAL 7035
Main tank, pipes (above 80 NB), conservator tank, oil storage tank & DM Box etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	Minimum 30μm	Glossy white for paint
Radiator (external surfaces)	Chemical / Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40μm)	Epoxy base Zinc primer (30-40μm)	PU paint (Minimum 50μm)	Minimum 100μm	Matching shade of tank/ different shade aesthetically matching to tank
	contractor may also offer Radiators with hot dip galvanised in place of painting with minimum thickness of 40μm (min)					
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish or Hot oil resistant, non-corrosive Paint	--	--	--	--
Control cabinet / Marshalling Box/Common Marshalling Box - No painting is required.						

Note: (*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

Annexure – G

UNUSED INHIBITED HIGH GRADE INSULATING OIL PARAMETERS

Sl. No.	Property	Test Method	Limits
A	**Function**		
1a.	Viscosity at 40degC	IS 1448 Part 25 or ISO 3104 or ASTM D7042	(Max.)12 mm^2/s
1b.	Viscosity at -30degC		(Max.)1800 mm^2/s
2.	Appearance	A representative sample of the oil shall be examined in a 100 mm thick layer, at ambient temperature	The oil shall be clear and bright, transparent and free from suspended matter or sediment
3.	Pour point	IS 1448 Part 10/Sec 2 or ISO 3016	(Max.) - 40degC
4.	Water content a) for bulk supply b) for delivery in drums	IEC 60814	(Max.) 30 mg/kg 40 mg/kg
5.	Electric strength (breakdown voltage)	IS 6792 or IEC 60156	(Min.) 50kV (new unfiltered oil) / 70 kV (after treatment)
6.	Density at 20 deg C	IS 1448 Part 16 or ISO 12185 or ISO 3675 or ASTM D7042	Max 0.895 g/ml
7.	Dielectric dissipation factor (tan delta) at 90 deg C	IS 16086 or IEC 60247 or IEC 61620	(Max) 0.0025
8.	Negative impulse testing KVp @ 25 deg C	ASTM D-3300	145 (Min.)
9.	Carbon type composition (% of Aromatic, Paraffins and Naphthenic compounds)	IEC 60590 and IS 13155 or ASTM D 2140	Max. Aromatic: 4 to12 % Paraffins: <50% & balance Naphthenic compounds.
B	**Refining/Stability**		
1.	Colour	ISO 2049	L0.5 (less than 0.5)
2.	Acidity	IEC 62021-2 or 62021-1	(Max) 0.01 mg KOH/g
3.	Interfacial tension at 27degC	IEC 62961 or ASTM D971	0.043 N/m (min)
4.	Total sulphur content	ISO 14596 or ISO 8754	0.05 % (Max.) (before oxidation test)
5.	Corrosive sulphur	DIN 51353	Not-Corrosive
6.	Potentially corrosive sulphur	IEC 62535	Not-Corrosive
7.	DBDS	IEC 62697-1	Not detectable (< 5 mg/kg)
8.	Presence of oxidation inhibitor	IS 13631 or IEC 60666	0.08% (Min.) to 0.4% (Max.) Oil should contain no other additives. Supplier should declare presence of additives, if any.
9.	Metal passivator additives	IEC 60666	Not detectable (<5 mg/kg)
10.	2-Furfural content and	IS 15668 or IEC 61198	Not detectable (<0.05 mg/kg) for

	related compound content		each individual compound
11.	Stray gassing under thermooxidative stress	Procedure in Clause A.4 of IEC 60296-2020 (oil saturated with air) in the presence of copper	Non stray gassing: < 50 µl/l of hydrogen (H_2) and < 50 µl/l methane (CH_4) and < 50 µl/l ethane (C_2H_6)
C	**Performance**		
1.	Oxidation stability	IEC 61125 (method c) Test duration 500 hour	
2.	Total acidity*	4.8.4 of IEC 61125:2018	0.3 mg KOH/g (Max.)
3.	Sludge*	4.8.1 of IEC 61125:2018	0.05 % (Max.)
4.	Dielectric dissipation factor (tan delta) at 90degC	4.8.5 of IEC 61125:2018	0.05 (Max.)
	*values at the end of oxidation stability test		
D	**Health, safety and environment (HSE)**		
1.	Flash point	IS 1448 Part 21 or ISO 2719	(Min.)135deg C
2.	PCA content	IP 346	< 3%
3.	PCB content	IS 16082 or IEC 61619	Not detectable (< 2 mg/kg)
E	**Oil used (inhibited) for first filling, testing and impregnation of active parts at manufacturer's works shall meet parameters as mentioned below:**		
1	Break Down voltage (BDV)		70kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (max)
4	Interfacial tension		0.04 N/m (min)
F	**Each lot of the oil shall be tested prior to filling in main tank at site for the following:**		
1	Break Down voltage (BDV)		70 kV (min.)
2	Moisture content		5 ppm (max.)
3	Tan-delta at 90°C		0.0025 (Max)
4	Interfacial tension		0.04 N/m (min)
G	**After filtration & settling and prior to energisation at site oil shall be tested for following:**		
1	Break Down voltage (BDV)		70 kV (min.)
2	Moisture content at hot condition		5 ppm (max.)
3	Tan-delta at 90°C		0.005 (Max)
4	Interfacial tension		More than 0.04 N/m
5	*Oxidation Stability		
	a) Acidity		0.3 (mg KOH /g) (max.)
	b) Sludge		0.05 % (max.)
	c) Tan delta at 90 °C		0.05 (max.)
6	*Total PCB content		Not detectable (less than 2 mg/kg total)
* Separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of EMPLOYER.			

Note: Supplier shall declare the chemical family and function of all additives and the concentrations in the cases of inhibitors, antioxidants and passivators.

Annexure – H

Technical Parameters of Current Transformers - 420 kV Shunt Reactor On each phase connection & Neutral Grounding Reactor (NGR)

(a) Ratio	**Shunt Reactor**			**NGR**
	Line Side	Neutral Side	Common Neutral Side	Earth Side
CORE 1	200/1A	200/1A	200/1A	200/1A
CORE 2	200/1A	To be decided by contractor for WTI	-	-
CORE 3	200/1A	3000-2000-500/1A	-	-
CORE 4	200/1A	3000-2000-500/1A	-	-
(b) Minimum knee point voltage or burden and accuracy class				
CORE 1	200V, PX / PS Class	300V, PX / PS Class	200V, PX / PS Class	200V, PX / PS Class
CORE 2	200V, PX / PS Class	To be decided by contractor for WTI	-	-
CORE 3	200V, PX / PS Class	3000-2000-500V, PX / PS Class	-	-
CORE 4	10VA, Class 1.0	3000-2000-500V, PX / PS Class	-	-
(c) Maximum CT Secondary Resistance				
CORE 1	1 Ohm	1 Ohm	1 Ohm	1 Ohm
CORE 2	1 Ohm	-	-	-
CORE 3	1 Ohm	15-10-2.5 Ohm	-	-
CORE 4	-	15-10-2.5 Ohm	-	-
(d) Exciting current (max.)				
CORE 1	250mA @ vk/4	250mA @ vk/4	-	-
CORE 2	250mA @ vk/4	-	-	-
CORE 3	250mA @ vk/4	20mA @3000/1 30mA @ 2000/1 120mA @ 500/1	-	-
CORE 4	-	20mA @3000/1 30mA @ 2000/1 120mA @ 500/1	-	-
(e) Application				
CORE 1	Reactor Differential	Reactor Differential	Restricted earth fault	Restricted earth fault
CORE 2	Restricted earth fault	Temperature Indicator (on one phase only)	-	-
CORE 3	Reactor Backup	Line Protection (Main-I)/T zone differential Protection/spare	-	-
CORE 4	Metering	Line Protection (Main-II)/T zone differential Protection/spare	-	-

NOTE:

i) For PX / PS class CT's, Dimensioning parameter "K", Secondary VA shall be considered 1.5 and 20 respectively.

ii) Rated continuous thermal current rating shall be 200% of rated primary current.

iii) Parameters of WTI CT for each winding shall be provided by the contractor.

iv) For estimation of spares, one set of CTs shall mean one CT of each type used in Reactor & NGR.

v) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

vi) In case of single phase reactor, Common Neutral Side shall be out door type.

Technical Parameters of Current Transformers – 245 kV Shunt Reactor
On each phase connection

(a) Ratio			
	Line Side	Neutral Side	Common Neutral Side
CORE 1	200/1A	200/1A	200/1A
CORE 2	200/1A	200/1A	-
CORE 3	200/1A	200/1A	-
CORE 4	-	To be decided by contractor for WTI	-
(b) Minimum knee point voltage or burden and accuracy class			
CORE 1	200V, PX / PS Class	10 VA, 1.0	200V, PX / PS Class
CORE 2	200V, PX / PS Class	200V, PX / PS Class	-
CORE 3	200V, PX / PS Class	200V, PX / PS Class	-
CORE 4	-	To be decided by contractor for WTI	-
(c) Instrument security factor (max.)			
CORE 1	-	20	-
CORE 2	-	-	-
CORE 3	-	-	-
CORE 4	-	-	-
(d) Maximum CT Secondary Resistance			
CORE 1	1 Ohm	-	1 Ohm
CORE 2	1 Ohm	1 Ohm	-
CORE 3	1 Ohm	1 Ohm	-
CORE 4	-	-	-
(e) Exciting current(max.) at 50V			
CORE 1	60mA	-	60mA
CORE 2	60mA	60mA	-
CORE 3	60mA	60mA	-
CORE 4	-	-	-
(f) Application			
CORE 1	Differential protection(High impedance)	Metering	Restricted earth fault protection
CORE 2	Restricted earth fault protection	Restricted earth fault	-
CORE 3	Backup impedance protection	Differential protection(High impedance)	-
CORE 4	-	Winding temp. Indication (on one phase only)	-

Note:

i) For PX / PS class CT's, Dimensioning parameter "K", Secondary VA shall be considered 1.5 and 20 respectively.

ii) Rated continuous thermal current rating shall be 200% of rated primary current.

iii) Parameters of WTI CT for each winding shall be provided by the contractor.

iv) For estimation of spares, one set of CTs shall mean one CT of each type used in Reactor & NGR.

v) The CT used for REF protection must have the identical parameters in order to limit the circulating current under normal condition for stability of protection.

vi) In case of single phase reactor, Common Neutral Side shall be out door type.

Gapless Surge Arrester – Technical parameters

Clause No.	Description	Parameters
a.	Rated arrester voltage	120 kV
b.	Rated system voltage	145 kV
c.	Rated system frequency	50Hz
d.	System neutral earthing	Earthed through NGR
e.	Installation	Outdoor
f.	Nominal discharge current	10kA of 8/20 microsec wave.
g.	Class of arrester	10kA heavy duty type
h.	Minimum discharge capacity	3.5 kJ/kV (referred to rated voltage)
i.	Continuous operating voltage at 50°C	102 kV
j.	Maximum switching surge residual voltage (1kA)	280kVp
k.	Maximum residual voltage at	
	i) 10kA	320kVp
	ii)20kA nominal discharge current	340kVp
l.	Long duration discharge class	2
m.	High current short duration test value (4/10micro-sec.wave)	100kAp
n.	Current for pressure relief test	40kArms
o.	Low current long duration test value (2000microsec.)	1000Apeak
p.	Min. total creepage distance	3625 mm.
q.	One minute dry power frequency withstand voltage of arrester housing	275kVrms
r.	Impulse withstand voltage of arrester housing with 1.2/50 micro-sec. wave	+ 650KVp
s.	Pressure relief class	A
t.	RIV at 92 kVrms.	Less than 500microvolts
u.	Partial discharge at 1.05 continuous over voltage	Not more than 50pC
v.	Seismic acceleration	As specified in section project
w.	Reference ambient temperature	50 deg C

1.1 KV GRADE POWER & CONTROL CABLES

1.1 All Power & Control cables shall be supplied from Employer's approved vendors.

1.2 Separate cables shall be used for AC & DC.

1.2 Separate cables shall be used for DC1 & DC2.

1.3 At least one (1) core shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

1.4 The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All aluminium used in the cables shall be of H2 grade and shall conform to IS 8130.

1.5 The fillers and inner sheath shall be of non-hygroscopic, fire retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

1.6 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

1.7 Strip wire armouring method (a) mentioned in Table 5, Page-6 of IS: 1554 (Part 1) – 1988 shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

1.8 The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

1.9 All the cables shall conform to fire resistance test as per IS: 1554 (Part - I).

1.10 The normal current rating of all PVC insulated cables shall be as per IS: 3961.

1.11 Repaired cables shall not be accepted.

1.12 Allowable tolerance on the overall diameter of the cables shall be ±2 mm.

1.13 **PVC Power Cables**

1.13.1 The PVC insulated 1100V grade power cables shall be of Fire Retardant Low Smoke Halogen (FRLSH) type, C2 category, conforming to IS: 1554 (Part-I) and its amendments read along with this specification and shall be suitable for a steady conductor temperature of 85°C. The conductor shall be stranded aluminium H2 grade conforming to IS 8130. The Insulation shall be extruded PVC to type-C of IS: 5831. A distinct inner sheath shall be provided in all multi core cables. For multi core armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC of Type ST-2 of IS: 5831 for all cables. The copper cable of required size can also be used.

1.14 **PVC Control Cables**

1.14.1 The 1100V grade control cables shall be of FRLSH type, C2 category conforming to IS: 1554 (Part-1) and its amendments, read along with this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC of type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The outer sheath shall be extruded PVC of type ST-1 of IS: 5831 and shall be grey in colour except where specifically advised by the purchaser to be black.

1.14.2 Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS: 1554 (Part - 1).

STANDARD TECHNICAL DATA SHEET (1.1kV GRADE XLPE POWER CABLES)

Sr. No	Description	Parameters	
1a	Cable Sizes	1 C x 630	3½ C x 300
b	Manufacturer's type designation	A2XWaY	A2XWY
2	Applicable standard	IS: 7098/PT-I/1988 & its referred specifications	
3	Rated Voltage(volts)	1100 V Grade	
4	Type & Category	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	for both	
6	Continuous current rating when laid in air in a ambient temp. of 50^{o}C and for maximum conductor temp. of 70 ^{o}C of PVC Cables[For information only]	732	410
7	Rating factors applicable to the current ratings for various conditions of installation	As per IS-3961-Pt-II-67	
8	Short circuit Capacity		
a	Guaranteed Short Circuit Amp. (rms) KA for 0.12 sec duration at rated conductor temperature of 90 degree C, with an initial peak of 105 KA	45kA	45kA
b	Maximum Conductor temp. allowed for the short circuit duty (deg C.) as stated above	250^{o}C	
9	Conductor		
a	Material	Stranded Aluminium as per Class 2 of IS : 8130	
b	Grade	H 2 (Electrolytic grade)	
c	Cross Section area (Sq.mm.)	630	300/150
d	Number of wires(No.) minimum	53	30/15
e	Form of Conductor	Stranded and compacted circular	Stranded compacted circular/sector shaped
f	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive layers	
10	Conductor resistance (DC) at 20 ^{o}C per km-maximum	0.0469	0.1/0.206
11	Insulation		
a	Composition of insulation	Extruded XLPE as per IS-7098 Part(1)	
b	Nominal thickness of insulation(mm)	2.8	1.8/1.4
c	Minimum thickness of insulation	2.42	1.52/1.16
12	Inner Sheath		
a	Material	Extruded PVC type ST-2 as per IS-5831-84	
b	Calculated diameter over the laid up cores,(mm)	NA	52
c	Thickness of Sheath (minimum)mm	NA	0.6
d	Method of extrusion	NA	Pressure/Vacuum extrusion
13	Armour		
a	Type and material of armour	Al wire [H4 grade]	Gal. Steel wire
b	Direction of armouring	Left hand	
c	Calculated diameter of cable over inner sheath (under armour), mm	33.9	53.2
d	Nominal diameter of round armour wire (minimum)	2	2.5
e	Guaranteed Short circuit capacity of the armour for 0.12 sec at room temperature.	45kA	45kA
f	DC resistance at 20 ^{o}C (Ω/Km)	$	0.577
14	Outer Sheath	ST-2 & FR	ST-2 & FR
A	Material (PVC Type)	38.3	59.50

B	Calculated diameter under the sheath	1.72	2.36
C	Min. thickness of sheath(mm)	Min 29.0	Min 29.0
D	Guaranteed value of minimum oxygen index of outer sheath at 27 ^{o}C	Min 250	Min 250
E	Guaranteed value of minimum temperature index at 21 oxygen index	Black	Black
f	colour of sheath	$	$
15a	Nominal Overall diameter of cable	+2/-2 mm	
b	Tolerance on overall diameter (mm)	shall conform to IS 10418 and technical specification	
16	Cable Drums	1000/500	1000/500
a	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)		
b	Non-standard drum lengths	Maximum one(1) non-standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)	
17	Whether progressive sequential marking on outer sheath provided at1 meter interval 18	Yes	
18	Identification of cores		
a	colour of cores	As per IS 7098 Part(1)	
b	Numbering	NA	
19	Whether Cables offered are ISI marked	Yes	
20	Whether Cables offered are suitable for laying as per IS 1255	Yes	

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC POWER CABLES

SN	Description	Parameters					
1a	Cable Sizes	1 c x 150	3.5 cx 70	3.5 cx 35	4 c x 16	4c x 6	2 c x 6
1b	Manufacturer's type designation	AYWaY	AYFY	AYFY	AYFY	AYWY	AYWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards					
3	Rated Voltage(volts)	1100 V grade					
4	Type & Category	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	for both					
6	Continuous current rating when laid in air in a ambient temp. of 50oC and for maximum conductor temp. of 70 oC of PVC Cables[For information only]	202	105	70	41	24	28
7	Rating factors applicable to the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67					
8	Short circuit Capacity						
a)	Short Circuit Amp. (rms)KA for 1 sec duration	11.2	5.22	2.61	1.19	0.448	0.448
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^0C					
9	Conductor						
a)	Material	STRANDED ALUMINIUM					
b)	Grade	H 2 (Electrolytic grade)					
c)	Cross Section area (Sq.mm.)	150	M-70 N-35	M-35 N-16	16	6	6
d)	Number of wires(No.)	as per Table 2 of IS 8130					
e)	Form of Conductor	Non-compacted Stranded circular	shaped conductor	shaped conductor	shaped conductor	Non-compacted Stranded circular	Non-compacted Stranded circular
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive layer					
10	Conductor resistance (DC) at 20 oC per km-maximum	0.206	0.443/0.868	0.868/1.91	1.91	4.61	4.61
11	Insulation						
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84					
b)	Nominal thickness of insulation(mm)	2.1	1.4/1.2	1.2/1.0	1.0	1.0	1.0
c)	Minimum thickness of insulation	1.79	1.16/0.98	0.98/0.8	0.8	0.8	0.8
12	Inner Sheath						
a)	Material	Extruded PVC type ST-I as per IS-5831-84					
b)	Calculated diameter over the laid up cores,(mm)	N.A	27.6	20.4	15.7	11.6	9.6
c)	Thickness of Sheath (minimum) mm	N.A	0.4	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/88					
a)	a) Type and material of armour	Al. Wire[H4 grade]	Gal.steel strip	Gal.steel strip	Gal.steel strip	Gal.steel wire	Gal.steel wire
b)	b) Direction of armouring	left hand					
c)	c) Calculated diameter of cable	18	28.4	21	16.3	12.2	10.2

	over inner sheath (under armour), mm						
d)	d) Nominal diameter of round armour wire/strip	1.6 4	0.8 4	0.8 4	0.8	1.4	1.4
e)	e) Number of armour wires/strips	Armouring shall be as close as practicable					
f)	f) Short circuit capacity of the armour along for 1 sec-for info only	K x A√t (K Amp)(where A = total area of armour in mm^2& t = time in seconds), K=0.091 for Al & 0.05 for steel					
g)	g) DC resistance at 20 oC (Ω/Km)	0.44	2.57	3.38 4	3.99	3.76	4.4
14	Outer Sheath						
a)	a) Material (PVC Type)	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR	ST-1& FR
b)	b) Calculated diameter under the sheath	21.2	30.1	22.6	17.9	15	13
c)	c) Min. thickness of sheath(mm)	1.4	1.56	1.4	1.4	1.4	1.24
d)	d) Guaranteed value of minimum oxygen index of outer sheath at 27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	e) Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	f) colour of sheath	Black	Black	Black	Black	Black	Black
15a)	a) Overall diameter of cable	$					
b)	b) Tolerance on overall diameter (mm)	+2/-2 mm					
16	Cable Drums	shall conform to IS 10418 and technical specification					
a)	a) Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500	1000/500	1000/500	1000/500	1000/500	1000/500
b)	b) Non standard drum lengths	Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)					
17	Whether progressive sequential marking on outer sheath provided	Yes					
18	Identification of cores						
a)	a) colour of cores	Red	R,Y,Bl & Bk	R,Y,Bl& Bk	R,Y,Bl & Bk	R,Y,Bl & Bk	Red & Bk
b)	b) Numbering	N.A	N.A	N.A	N.A	N.A	N.A
19	Whether Cables offered are ISI marked	YES					
20	Whether Cables offered are suitable for laying as per IS 1255	YES					

$'- As per manufacturer design data

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC CONTROL CABLES

SN	Description	Parameters							
1a	Cable Sizes	2 c x 2.5	3c cx 2.5	5c x 2.5	7 c x 2.5	10 c x 2.5	14 c x 2.5	19 c x 2.5	27 c x 2.5
1b	Manufacturer's type designation	YWY	YWY	YWY	YWY	YWY	YWY	YWY	YWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards							
3	Rated Voltage(volts)	1100 V grade							
4	Type & Category	FR & C1							
5	Suitable for earthed or unearthed system	for both							
6	Continuous current rating when laid in air in a ambient temp. of 50oC and for maximum conductor temp. of 70 oC of PVC Cables[For information only]	22	19	19	14	12	10.5	9.7	8
7	Rating factors applicable to the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67							
8	Short circuit Capacity								
a)	Short Circuit Amp. (rms)KA for 1 sec duration	0.285	0.285	0.285	0.285	0.285	0.285	0.285	0.285
b)	Conductor temp. allowed for the short circuit duty (deg C.)	160^0C							
9	Conductor								
a)	Material	Plain annealed High Conductivity stranded Copper (as per IS 8130/84)							
b)	Grade	Electrolytic							
c)	Cross Section area (Sq.mm.)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
d)	Number of wires(No.)	as per Table 2 of IS 8130							
e)	Form of Conductor	Non-compacted Stranded circular shaped conductor							
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay							
10	Conductor resistance (DC) at 20 oC per km-maximum	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41
11	Insulation								
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84							
b)	Nominal thickness of	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

	insulation(mm)								
c)	Minimum thickness of insulation	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
12	Inner Sheath								
a)	Material	Extruded PVC type ST-I as per IS-5831-84							
b)	Calculated diameter over the laid up cores,(mm)	7.2	7.8	9.7	10.8	14.4	15.9	18	22.1
c)	Thickness of Sheath (minimum)mm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/99							
a)	Type and material of armour	Gal. Steel Wire							
b)	Direction of armouring	left hand							
c)	Calculated diameter of cable over inner sheath (under armour), mm	7.8	8.4	10.3	11.4	15	6.5	18.6	22.7
d)	Nominal diameter of round armour wire/strip	1.4	1.4	1.4	1.4	1.6	1.6	1.6	1.6
e)	Number of armour wires/strips	Armouring shall be as close as practicable							
f)	Short circuit capacity of the armour along for 1 sec-for info only	0.05 x A√t (K Amp)(where A = total area of armour in mm2 & t = time in seconds)							
g)	DC resistance at 20 oC (Ω/Km) & Resistivity	As per IS 1554 Part (1), wherever applicable and IS 3975-1999							
14	Outer Sheath								
a)	Material (PVC Type)	ST-1& FR							
b)	Calculated diameter under the sheath	10.6	11.2	13.1	14.2	18.2	19.7	21.8	25.9
c)	Min.thickness of sheath(mm)	1.24	1.24	1.24	1.24	1.4	1.4	1.4	1.56
d)	Guaranteed value of minimum oxygen index of outer sheath at 27oC	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	colour of sheath	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey
15a)	Overall diameter of cable	$							
b)	Tolerance on overall diameter (mm)	+2/-2 mm							
16	Cable Drums	shall conform to IS 10418 and technical specification							
a)	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500							

<table>
<tr><td>b)</td><td>Non standard drum lengths</td><td colspan="8">Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)</td></tr>
<tr><td>17</td><td>Whether progressive sequential marking on outer sheath provided</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>18</td><td>Identification of cores</td><td colspan="8">Yes</td></tr>
<tr><td>a)</td><td>colour of cores</td><td>R & Bk</td><td>R, Y & Bl</td><td>Red R,Y,Bl</td><td>Grey</td><td>Grey</td><td>Grey</td><td>Grey</td><td>Grey</td></tr>
<tr><td>b)</td><td>Numbering</td><td>N.A</td><td>N.A</td><td>N.A</td><td colspan="5">Numerals in black ink</td></tr>
<tr><td>19</td><td>Whether Cables offered are ISI marked</td><td colspan="8">YES</td></tr>
<tr><td>20</td><td>Whether Cables offered are suitable for laying as per IS 1255</td><td colspan="8">YES</td></tr>
</table>

$'- As per manufacturer design data

Technical Specification of Oil BDV Test Set (Applicable as per BPS)

Item	Specification
Functional Requirement	1. The instrument should be suitable for Automatic Measurement of Electrical Breakdown Strength of Reactor oil as per relevant standards. 2. The test results should have repeatability, consistency in laboratory condition.
Test Output	0-100 kV (Rate of rise: 0.5 to 5KV/Sec)
Accuracy	± 1 kV
Resolution	0.1 KV
Switch off Time	≤ 1ms
Display/Control	LCD/Keypads.
Printer	Inbuilt/External
Measurement Programmes	Fully Automatic Pre-programmed/User programmed Test Sequences including as per latest IEC & other national/international standards.
Test Lead/ Accessories	One complete set of electrodes, gauge etc. compatible with the instruments should be provided for successfully carrying out the test in EMPLYER S/S. Additionally all the required accessories, tools, drawing, documents should be provided for the smooth functioning of kit. Further hard carrying case (which should be robust/ rugged enough) for ensuring proper safety of the kit during transportation shall have to be provided.
Design/Engg.	The complete equipment along with complete accessories must be designed / engineered by Original Equipment Manufacturer.
Power Supply	It shall work on input supply variations, V: 230 ±10 %, f: 50 Hz ±5 % on standard sockets.
Operating Temperature	0 to +50 deg C
Relative humidity	Max. 90% non-condensing.
Protection/ Control	Against short circuit, over load, transient surges etc. Also the instrument should have facility of stopping automatically on power failure. Also the kit should have facility of HV chamber interlocking as well as zero start interlocking.
Environment	The test kit shall be compatible for EMI/EMC/Safety environment requirement as per IEC.
Guarantee	Warranty/Guarantee Period: Min 05 year from the date of successful & complete commissioning at Emplyer sub-station. All the materials, including accessories, cables, laptops etc. are to be covered under warranty/guaranty period. If the kit needs to be shifted to supplier's works for repairs within warranty/guaranty period, suppliers will have to bear the cost of spares, software, transportation of kit for repair at test lab / works.
Calibration Certificate	Unit shall be duly calibrated before supply and the date of calibration shall not be older than two month from the date of supply of Kit.
Training	Supplier shall have to ensure that the instrument is made user friendly. Apart from the detailed demonstration at site, the supplier shall also have to arrange necessary training to EMPLYER engineers.
Commissioning, handing over the Instrument	Successful bidder will have to commission the instrument to the satisfaction of EMPLOYER. The instrument failed during the demonstration shall be rejected and no repairs are allowed.
After sales service	Bidder will have to submit the documentary evidence of having established mechanism in India for prompt services.

Technical Specification of Portable Dissolved Gas Analysis of Oil (Applicable as per BPS)

S.No.	Particulars	Specification
01	Functional Requirement	The Portable DGA equipment to extract, detect, analyze and display the dissolved gases in insulating oil as specified in IEEE C 57-104-2008 and IEC 60599-2007.
02	Detection of Gases	All the fault gases i.e. H2, CH4, C2H2, C2H4, C2H6, CO & CO2 concentrations shall be individually measured and displayed. The minimum detection limits of the instrument for the above gases shall strictly be met the requirement of IEC-60567-2011-Page No. 47-clause 9.2, table-5.
03	Power Supply	It shall be operated with AC single phase,50 Hz +/-5%, 230 V +/- 10% supply. All power cable and necessary adaptors shall be provided by supplier.
05	Instrument control and Data handling, Internal Memory	a) Instrument shall be having in-built control for all the functions (data acquisitions and data storage), it shall have a facility for communication with computer for downloading the data from instrument via USB port. b) Laptop shall be provided for communication with the instrument. it shall be of latest specification along with licensed preloaded OS and software as well as software for interpreting DGA results accordance with IEEE C 57-104-1991 and IEC 60559-1999. Laptop carrying case shall also be provided. c) Internal Memory can capable of store atleast 15000 records
06	General Conditions	a) Performance Parameters like - Minimum Detection Limits, Working Range, Accuracy, repeatability etc. shall be finalized during detailed engineering. b) The portable DGA equipment supplier shall demonstrate during commissioning of the kit that the results shown by the kit are within the specified accuracy and repeatability range and EMPLOYER will provide only the insulating oil/ GAS-IN-OIL standard for testing. c) All required items/instruments /spares /consumable /connecting cables/communication cables/instruments/manuals/Certificates/training materials/original software/original licensed data/station operating software/education CD/DVDs that are essential to understand and operate the instrument shall be supplied at no extra cost.
07	Operating Temperature, Relative humidity	01. Temperature 0-50 Deg. C 02. 85% non-condensing

	& Dimensions	03. Portable
08	Warranty	The entire test set up shall be covered on warranty for a period of 5 year from the last date of complete commissioning and taking over the test set up. If the kit needs to be shifted to suppliers works for repairs, supplier will have to bear the cost of, spares, software, transportation etc of kit for repair at test lab/works.
09	Service Support	The supplier shall furnish the requisite documents ensuring that the equipment manufacturer is having adequate service team and facility in India to take care of any issues during operation of the instrument.
10	Training	The supplier shall provide adequate training for a period of two working days pertaining to the operation and troubleshooting to site personnel.

Online Dissolved Gas (Multi-gas) and Moisture Analyser (Applicable as per BPS)

1.1. Online Dissolved Gas (Multi-gas) and Moisture Analyser along with all required accessories including inbuilt display shall be provided with each reactor for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999.

1.2. The equipment shall detect, measure and analyse the following gases:

Gases & Moisture Parameters	Typical Detection Range
H_2	5 – 5,000 ppm
CH_4	5 – 5,000 ppm
C_2H_6	5 – 5,000 ppm
C_2H_4	3 – 5,000 ppm
C_2H_2	1 – 3,000 ppm
CO	10 – 10,000 ppm
CO_2	20 – 30,000 ppm
H_2O	2 – 100 % RS should have facility for measurement of moisture in oil in ppm

1.3. The analyser should measure (not calculate) all above gases and should have 100% sensitivity. The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering.

1.4. Equipment shall havefacility to give SMS alert to at least three users whenever any fault gas violates the predefined limit.

1.5. Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier.

1.6. Online DGA shall be installed out door on reactor in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately on ground. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement. The connecting oil lines must be of Stainless Steel rigid pipes or flexible hoses.The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steelenclosure, suitable for 55 ^{0}C ambient temperature and EMI and EMC compatibility.The Equipment must carry a minimum of five (5) years manufacturer’s Warranty.

1.7. The equipment shall display all the individual gas and moisture concentration on its display unit and shall have facility to download all the stored the data from the unit for further analysis. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval. The carrier and calibration gas (if applicable) shall have minimum capacity to work for at least three years without replacement. All the consumable (if any) upto warrantee period shall be included in the scope of supply

1.8. The Equipment must have an automatic Calibration facility at fixed intervals. For calibration if anything required including cylinder must be mounted with the Equipment.

1.9. The technical feature of the equipment shall be as under:

Accuracy	$\pm$ 10%
Repeatability	$\pm$3% to 10% depending upon gases
Oil temperature range	- 20^0 C to + 120^0 C
External Temp. Range	- 20^0 C to + 55^0 C (External temp range of 55^0 C is important and should not be compromise due to Indian ambient & operating conditions.)
Humidity range	10 to 95 %
Operating Voltage	230 Vac; 50 Hz (±20% variation)
Communications	USB&IEC 61850 compliant

1.10. Software for fault indication and fault diagnostics shall include following:
Fault indication:

i) IEEE, IEC or user configurable levels of dissolved gases
ii) Rate of change trending

Fault Diagnosis:

i) Key gases
ii) Ratios (Rogers, IEC. etc.)
iii) Duval's Triangle

1.11. The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply.

i) Software
ii) Operation Manual (2 set for every unit),
iii) Software Manual and
iv) Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

1.12. The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

On Line Dissolved Hydrogen and Moisture Monitor (Applicable as per BPS)

1.0 Online Dissolved Hydrogen and Moisture Analyser along with all required accessories including inbuilt display shall be provided with each Reactor for measurement & analysis of dissolved gases and moisture in the oil. Interpretations shall be as per IEC 60599-1999

2.0 The equipment shall be capable of transferring data to sub-station automation system confirming to IEC 61850. Necessary interface arrangement shall be provided by the contractor for integration with automation system. The necessary type test report for such confirmation shall be submitted during detailed engineering

3.0 Equipment should work on station auxiliary supply. In case other supply is required for the equipment then suitable converter shall be included. All the necessary power and control cables, communication cables, cable accessories as required shall be provided by the supplier

4.0 Equipment shall be installed out door on reactor in harsh ambient and noisy condition (Electromagnetic induction, Corona, and capacitive coupling). Equipment shall be mounted separately on ground. Suitable arrangement shall be provided to support and protect the inlet and outlet piping arrangement. The connecting oil lines must be of Stainless Steel rigid pipes or flexible hoses.The equipment shall be suitable for proper operation in EHV substation (800kV) environment where switching takes place in the EHV/HV System. The suitable indications for power On, Alarm, Caution, normal operation etc. shall be provided on the front panel of the equipment. The equipment shall have IP55 Stainless Steelenclosure, suitable for 55 ^{0}C ambient temperature and EMI and EMC compatibility.The Equipment must carry a minimum of five (5) years manufacturer's Warranty

5.0 The equipment shall display H_2 and moisture concentration on its display unit and shall have facility to download all the stored the data from the unit for further analysis. The sampling rate shall be selectable as 2 or 4 or 6 or 12 hours etc. The equipment shall have inbuilt memory to store these results for complete one year even if sampling is done at the lowest interval. All the consumable (if any) upto warrantee period shall be included in the scope of supply

6.0 The monitor shall also be suitable to detect Water Content measured in ppm or % RS (Relative Saturation). The sensors shall be able to withstand pressure from vacuum to 10 psi.

7.0 Technical Parameters:

Sr. No.	Parameters	Requirements
a)	The measurement range / Output:	
	Hydrogen Dissolved in oil	0 to 2000 ppm, with 4 – 20 mA output
	Water Dissolved in oil	0 to 95% RS, with 4 – 20 mA output
b)	Alarms/Indication (High & Very High)	
	Hydrogen	Programmable NO/NC contacts,
	Water	Programmable NO/NC contacts,
c)	Environment	
	Operating Ambient Temperature	– 20 to + 55 deg C

	Operating Oil Temperature	– 20 to + 105 deg C
d)	Pressure Withstand, (Oil side)	Full Vacuum to 10 psi.
e)	Communications	USB&IEC 61850 compliant

Equipment shall be mounted separately to avoid effect of vibration. Suitable arrangement shall be provided support and protect the inlet and outlet piping arrangement.

8.0 Software for fault indication and fault diagnostics shall include following:

Fault indication:

iii) IEEE, IEC or user configurable levels of dissolved gases
iv) Rate of change trending

9.0 The equipment shall be supplied with all necessary accessories required for carrying out DGA of oil sample complete in all respect as per the technical specification. The following shall be also form a part of supply.

v) Software
vi) Operation Manual (2 set for every unit),
vii) Software Manual and
viii) Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

10.0 The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

On-line insulating oil drying system (Cartridge type)

In addition to provision of air cell in conservators for sealing of the oil system against the atmosphere, each reactor shall be provided with an on line insulating oil drying system of adequate rating with proven field performance. This system shall be separately ground mounted and shall be housed in metallic (stainless steel) enclosure. The bidder shall submit the mounting arrangement. This on line insulating oil drying system shall be

i. Designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition. Oil flow to the equipment shall be controlled through pump of suitable capacity (at least 5 LPM).

ii. The equipment shall display the moisture content in oil (PPM) of the inlet and outlet oil from the drying system.

iii. In case, drying system is transported without oil, the same shall be suitable for withstanding vacuum to ensure that no air / contamination is trapped during commissioning.

    In case, drying system is transported with oil, the oil shall conform to EMPLOYER specification for unused oil. Before installation at site, oil sample shall be tested to avoid contamination of main tank oil.

iv. Minimum capacity of moisture extraction shall be 10 Litres before replacement of cartridge. Calculation to prove the adequacy of sizing of the on line insulating oil-drying system along with make and model shall be submitted for approval of purchaser during detail engineering.

v. The installation and commissioning at site shall be done under the supervision of OEM representative or OEM certified representative.

vi. The equipment shall be capable of transferring data to substation automation system confirming to IEC 61850 through FO port. Necessary interface arrangement shall be provided by the contractor for integration with automation system.

The equipment shall be supplied with Operation Manual (2 set for every unit), Software (if any), and Compact disc giving operation procedures of Maintenance Manual & Trouble shooting instructions.

Nitrogen Injection Type Fire Prevention & Extinguishing System (If specified in BPS)

1. Nitrogen Injection Type Fire Protection System (NIFPS) shall be designed to prevent explosion of transformer/reactor tank and the fire during internal faults/arc.

   The system shall work on the principle of Drain & stir. On activation, it shall drain a pre-determined quantity of oil from the tank top through drain valve to reduce the tank pressure, isolate conservator tank oil and inject nitrogen gas at high pressure from the bottom side of the tank through inlet valves to create stirring action and reduce the temperature of oil below flash point to extinguish the fire. On operation, the quantity of oil removed from the tank shall be such that adequate amount of oil shall remain to cover active part (i.e. core coil assembly).

   Electrical isolation of transformer shall be an essential pre-condition for activating the system.

2. Operational Controls
   The system operation shall be fully automatic and activate from the required fire and other trip signals. In addition to automatic operation, remote operation from control room/ remote centre and local manual control in the fire extinguishing cubicle shall also be provided. System shall operate on following situations:

2.1 Prevention of transformer from explosion and fire
To prevent transformer from explosion and fire in case of an internal fault, signals given by operation of Electrical protection relays (Differential / Restricted earth fault) and tripping of circuit breaker of transformer and operation of either Buchholz relay or pressure relief valve (PRV) shall be used to activate the system. The exact logic for system activation shall be finalized during detailed engineering.

2.2 Prevention of transformer from fire in case of fire, sensed by fire detectors, the system shall be activated only after electrical isolation of the transformer, confirmed by breaker trip. If the fire detection is not associated with any other fault, the system activation shall be only manual. Manual operation switch shall be provided in the control room with a cover to avoid accidental operation of it.

3. Operation of System
   On receiving activation signal, the following shall take place:
   i) Open the quick opening drain valve to drain the top layer oil
   ii) Shut off the conservator isolation valve to prevent flow of oil from the Conservator tank to the main tank
   iii) Open the valve to inject Nitrogen into the transformer tank to create stirring of oil.

   There shall be interlock to prevent activation of the system if the transformer is not electrically isolated.
   There shall also be provision for isolating the system during maintenance and/or testing of the transformer.

4. Technical Particulars

   The contractor shall be responsible for the design of the complete system and shall submit the drawings and design calculations for the number of fire detectors, pipe sizing of drain pipe and Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc. and get approval from POWERGRID.

Facility shall be provided to test the system when the transformer is in service, without actually draining the oil and injecting Nitrogen.

The Nitrogen regulator valve shall be designed in such a way that the Nitrogen shall not enter the transformer tank even in case of passing/ leakage of valve.

Owner shall provide two distinct station auxiliary DC feeders for control purposes. The system shall work on station DC supply with voltage variation defined in GTR. The control box of fire protection system shall have facility to receive these feeders for auto changeover of supply. It shall be the contractor's responsibility to further distribute power to the required locations. In case auxiliary DC power supply requirement is different than station auxiliary DC supply, then all necessary DC-DC converters shall be provided by the Contractor.

Following minimum indications and alarms shall be provided in the local cubicle as well as in the control box: -

- Nitrogen cylinder pressure indication - manometer with sufficient number of adjustable NO contacts
- Nitrogen cylinder pressure low
- Fire in Transformer/ Reactor
- Oil drain started
- Conservator oil isolation valve closed
- Nitrogen injection started
- DC supply fail
- Oil drain valve closed
- Gas inlet valve closed

5. Details of Supply of System Equipment and Other Related Activities:

The scope of supply shall include the following items and any other items required for safe and trouble-free operation of the system.

i) Fire extinguishing cubicle with base frame and containing at least the following:
    - Nitrogen gas cylinder of sufficient capacity with pressure regulator and manometer with sufficient number of adjustable NO contacts.
    - Oil Drain Assembly including oil drainpipe extension of suitable size for connecting pipes to oil pit
    - Mechanical release device for oil drain and nitrogen release
    - Limit switches for monitoring of the systems
    - Panel lighting
    - Flanges on top of the panel for connecting oil drain and nitrogen injection pipes for transformer
    - Back up pressure switch to operate nitrogen gas valve
    - Pressure indicators for Nitrogen pressure of the cylinder and actual injection through Nitrogen regulator
    - Fire Extinguishing Cubicle shall have oil leakage detection arrangement for detecting oil leakage from drain valve. In case of any oil leakages, alarm to be provided.
    - shall have minimum IP55 degree of protection

ii) Control box to be installed in the control room of the station for monitoring system operation, automatic control and remote operation, with alarms, indications, switches, push buttons, audio signal, suitable for tripping and signalling.

iii) Required number of fire detectors to be located in strategic locations to be finalized during detailed engineering. Fire detectors shall have minimum IP-67 class degree of protection.

iv) All controls, alarms, panels, cables, cable trays (if required), junction boxes etc.

v) Flow sensitive conservator Isolation valve to isolate the conservator oil from the main tank is being provided by the transformer/reactor supplier. This valve shall be located in the piping between the conservator and the buchholz relay.

6. Under Ground Oil Storage Tank
Each transformer unit shall be provided with an underground oil storage tank. The oil storage tank shall have Non-Corrosive, waterproof, epoxy coated (from Inside) mild steel (minimum thickness 5 mm) to store drained out oil on operation of NIFPS. The tank shall be painted from outside as per **table below:**

Painting	**Surface preparation**	**Primer coat**	**Intermediate undercoat**	**Finish coat**	**Total dry film thick-ness (DFT)**	**Colour shade**
Oil Storage Tank	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40μm)	Epoxy high build Micaceous iron oxide (HB MIO) (75μm)	Aliphatic polyurethane (PU) (Minimum 50μm)	Minimum 155μm	RAL 7035

Note: (*) indicates Sa 2 ½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

The total capacity of storage tank shall be at least 10% of transformer tank oil to avoid overflowing of oil considering that drained oil volume shall be around 10% of transformer tank oil. Necessary arrangement shall be made on underground storage tank so as to take out the drained oil from the tank for further processing and use. All the pipe and physical connection from transformer to oil pit shall be in the scope of contractor.

This storage tank shall be placed in the pit made of brick walls with PCC (1:2:4) flooring with suitable cover plates to avoid ingress of rainwater. The design of tank and pit shall be finalised during detailed engineering.

7. The entire test set up shall be covered on warranty for a period of 5 years from the last date of complete commissioning and taking over the system.

8. Installation and pre-commissioning test After installation the system pre-commissioning tests shall be carried out jointly with the Owner's representative before the system is put in service.

Oil sampling bottles (Applicable as per BPS)

Oil sampling bottles (if specified in BPS) shall be suitable for collecting oil samples from Reactors and shunt Reactors, for Dissolved Gas Analysis. Bottles shall be robust enough, so that no damage occurs during frequent transportation of samples from site to laboratory.

Oil sampling bottles shall be made of stainless steel having a capacity of 1litre. Oil Sampling bottles shall be capable of being sealed gas-tight and shall be fitted with cocks on both ends.

The design of bottle & seal shall be such that loss of hydrogen shall not exceed 5% per week.
An impermeable oil-proof, transparent plastic or rubber tube of about 5 mm diameter, and of sufficient length shall also be provided with each bottle along with suitable connectors to fit the tube on to the oil sampling valve of the equipment and the oil collecting bottles respectively.

The scope of oil sampling bottles shall be included in the bid price as per the quantity indicated in the bid price schedule.

Oil Syringe (Applicable as per BPS)

If specified in BPS, the glass syringe of capacity 50ml (approx) and three way stop cock valve shall be supplied. The syringe shall be made from Heat resistant borosilicate Glass. The material and construction should be resistant to breakage from shock and sudden temperature changes, reinforced at luer lock tip Centre and barrel base.

The cylinder-Plunger fitting shall be leak proof and shall meet the requirement of IEC-60567. Plunger shall be grounded and fitted to barrel for smooth movement with no back flow. Barrel rim should be flat on both sides to prevent rolling and should be wide enough for convenient finger tip grip. The syringe shall be custom fit and uniquely numbered for matching. The syringe shall be clearly marked with graduations of 2.0 ml and 10.0 ml and shall be permanently fused for life time legibility.

Oil Storage Tank (Applicable as per BPS)

1. Oil storage tank shall be of minimum capacity (as per BPS) along with complete accessories. The oil storage tank shall be designed and fabricated as per relevant Indian Standards e.g. IS 10987 (1992). Transformer oil storage tanks shall be towable on pneumatic tyres and rested on manual screw jacks of adequate quantity & size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of thickness as per standard. Diameter of the tank shall be 2.0 meter approximately. The tank shall be designed for storage of oil at a temperature of 100°C.

2. The maximum height of any part of the complete assembly of the storage tank shall not exceed 4.0 metres above road top.

3. The tank shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.

4. The tank shall also be fitted with manhole, outside & inside access ladder, silica gel breather assembly, inlet & outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent etc. Pulling hook on both ends of the tank shall be provided so that the tank can be pulled from either end while completely filled with oil. The engine capacity in horse power to pull one tank completely fitted with oil shall be indicated. Oil level indicator shall be provided with calibration in terms of litre so that at any time operator can have an idea of oil in the tank. Solenoid valve (Electro-mechanically operated) with Centrifugal pump shall be provided at bottom inlet so that pump shall be utilised both ways during oil fill up and draining. Suitable arrangement shall also be provided to prevent overflow and drain form the tank.

5. The following accessories shall also form part of supply along with each Oil storage tank.

5.1 Four numbers of 50NB suitable rubber hoses for Reactor oil application up to temperature of 100°C, full vacuum and pressure up to 2.5 Kg/ cm2 with couplers and unions each not less than 10 metre long shall be provided.

5.2 Two numbers of 100NB suitable for full vacuum without collapsing and kinking vacuum hoses with couplers and unions each not less than 10 metre long shall also be provided.

5.3 One number of digital vacuum gauge with sensor capable of reading up to 0.001 torr, operating on 240V 50Hz AC supply shall be supplied. Couplers and unions for sensor should block oil flow in the sensor. Sensor shall be provided with at-least 8 meter cable so as to suitably place the Vacuum gauge at ground level.

5.4 The painting of oil storage tank and its control panel shall be as per technical specification.

5.5 The tank shall contain a self mounted centrifugal oil pump with inlet and outlet valves, with couplers -suitable for flexible rubber hoses and necessary switchgear for its control. There shall be no rigid connection to the pump. The pump shall be electric motor driven, and shall have a discharge of not less than 6.0 kl/hr. with a discharge head of 8.0m. The pump motor and the control cabinet shall be enclosed in a cubicle with IP-55 enclosure.

Spare Reactor Unit Storage & Connection Arrangement

1.1. **Reactor with Isolator switching arrangement:** Employer intends to replace any of the Reactor unit by the spare Reactor unit using isolator switching arrangement so as to avoid physical shifting the Reactor.

Connection of spare unit of Reactor with other units shall be made by isolator switching arrangement. Neutral formation for spare unit of Reactor shall be done by manual connection. The spare Reactor unit shall be completely erected and commissioned similar to the other Reactor units. The contractor shall carry out all pre-commissioning tests on the spare Reactor similar to the unit kept in service.

For this purpose if specified in BPS, HV and Neutral Connections of spare unit shall be extended upto the other unit(s) by forming auxiliary buses connection through flexible/rigid conductor. All associated materials like Bus post insulators, Aluminium tube, conductors, clamps & connectors, insulator strings, hardware, cables, support structures, required for the above-mentioned arrangement shall be provided by the contractor. However, the detail configuration and hardware shall be finalised during detailed engineering and shall be subject to Employer's approval.

Any special maintenance procedure required shall be clearly brought out in the instruction manual.

1.2. **Reactor without isolator switching arrangement:** Employer intends to keep the spare Reactor unit without isolator switching arrangement due to space limitation. In case of failure of any of the running unit, this spare reactor shall be physically shifted to replace faulty reactor.

The spare Reactor shall be placed on the elevated foundation block to facilitate quick movement. The Reactor unit may be required to be stored for long duration. The spare Reactor unit shall be completely erected and commissioned similar to the other Reactor units. However, erection of separate cooler bank is not envisaged. In case conservator is cooler bank mounted, suitable arrangement for mounting of conservator on tank top cover shall be provided. The contractor shall carry out all pre-commissioning tests on the spare Reactor similar to the unit kept in service.

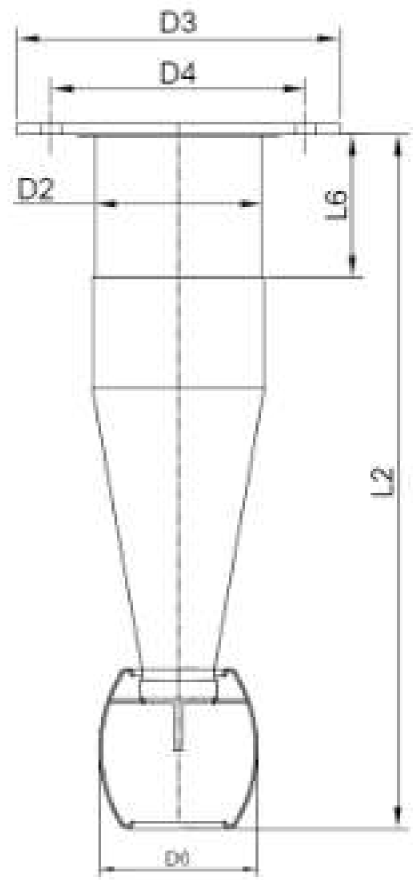
All other items shall be suitably packed in reusable boxes. Arrangement shall be made to minimize moisture ingress inside the boxes. All pipes and radiators shall be provided with blanking plates during long duration storage to prevent entry of foreign material/ water.

In case spare Reactors needs to be commissioned in switchyard bay (as advised by Engineer in-charge), the contractor shall erect, test and commission the spare reactor unit similar to other units in service. However packaging material as above for long-term storage shall be included in the scope of bidder.

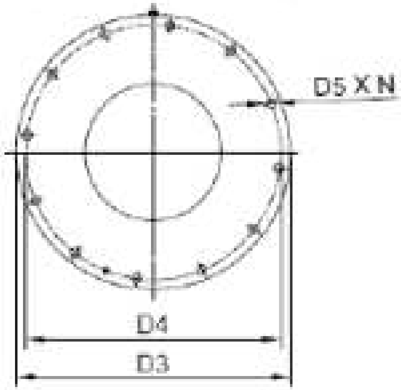
------------ X ------------

Annexure-R

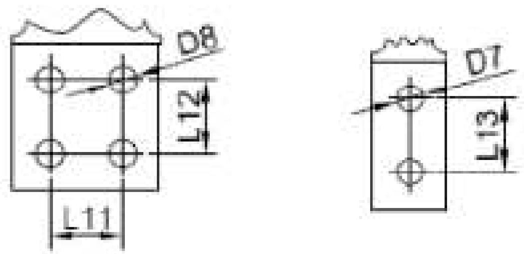
STANDARD DIMENSION FOR LOWER PORTION OF CONDENSER BUSHINGS
(For 420 kV and below voltage class Bushings)



Bushing Mounting Flange Details



Bottom Connection Details



Symbol	Description
L2	Length between bottom seat of flange and bottom of the oil end shield/ stress relieving electrode/ oil end terminal whichever is the longest
L6	Length for accommodating Bushing Current Transformer (BCT)
D2	Maximum diameter of oil immersed end
D3	Outside diameter of fixing flange
D4	Pitch Circle Diameter of fixing holes of flange
D5	Diameter of fixing hole
N	Number of fixing holes
D6	Maximum diameter of oil end shield/stress relieving electrode
L11	Horizontal Distance between holes for bushing bottom connection for 4 hole connection
L12	Vertical Distance between holes for bushing bottom connection for 4 hole connection
L13	Vertical Distance between holes for bushing bottom connection for 2 hole connection
D7	Diameter of hole for bushing bottom connection for 2 hole connection
D8	Diameter of hole for bushing bottom connection for 4 hole connection

Voltage Rating (kV)	420	245		145		72.5		52
BIL kVp	1425 1550(for GT)	1050		650		325		250
Creepage Distance (mm)	13020	7595		4495		2248		1612
Current Rating (A)	1250	1250	2000	1250	2000	800	2000	1250
Type of lead	Solid Stem (SS)	SS	SS	SS	SS	SS		SS
L2 ±5	1640	1130	1230	800/ 1250*	1030	695		450
L6 (min.)	400	300		300/500*	300	300		100
D2 (max.)	350	270		165	180	115	165	115
D3±2	720	450		335	335	225	335	225
D4±1 (PCD)	660	400		290	290	185	290	185
D5xN	24x12	20x12		15x12	15 x12	15x6	15x12	15x6
D6 (max.)	350	270		180		115		115
L11	-	-	45	-	45	-	55	-
L12	-	-	40	-	40	-	40	-
L13	40	40	-	40	-	40	-	40
D7	Φ14	Φ14		Φ14	Φ14	Φ14	Φ14	Φ14
D8	-	-	Φ 14	-	-	-	-	-
Length & Diameter of Air End Terminal	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60	125 & Φ60

* for 765 kV class shunt reactor

Notes:

1. All dimensions are in mm.
2. No positive tolerance where maximum dimension specified and no negative tolerance where minimum dimension is specified.
3. For other details of oil end terminal for 2000 A (145 kV/245 kV) solid stem type bushing, refer Fig 4 of IS 12676.
4. For other details of oil end terminal for 2000 A, 72.5 kV solid stem type bushing, refer Fig 3B of IS 12676.
5. For other details of oil end terminal for 800 A and 1250 A (52kV/72.5 kV/145 kV/245 kV/420 kV) solid stem type bushing, refer Fig 3A of IS 12676.

ANNEXURE-S

Standard Test Procedure of Transformer & Reactor

STANDARD TEST PROCEDURE
FOR
TRANSFORMER & REACTOR

DOC. No.: POWERGRID/STD/TEST PROCEDURE/TR-RT

Revision-02

June 2021

INDEX

Test procedure for transformer & Reactor are similar. Hence, same method as mentioned for transformer shall be applicable for reactor also. However, few tests which only to be performed in Reactor are given below:

1. General

Tests shall be carried out as per following procedure. However, IEC 60076 shall be followed in general for other tests. Manufacturer shall offer the transformer/reactor unit for type testing with all major fittings including radiator bank, Marshalling Box, Common Marshalling Box RTCC (as applicable) (excluding ODS, DGA, Fire protection system) assembled.

RTCC and Common Marshalling Box testing may be carried during routine testing of any one unit (Transformer/Reactor). In case of only one unit is being manufactured, RTCC and Common Marshalling Box testing may be carried out along with that unit.

All measuring systems used for the tests shall have certified traceable accuracy and be subjected to periodic calibration, according to the rules given in ISO 9001. Specific requirements on the accuracy and verification of the measuring systems are described in IEC 60060 series and IEC 60076-8.

Latest IEC standards (as applicable) shall be followed for all the tests.

1.1. Before start of FAT following tests shall be carried out on insulating oil:

Break Down voltage (BDV), Moisture content, Tan-delta, Interfacial tension and Particle count

Acceptance Criteria: POWERGRID Specification of Insulating Oil

2. Low Voltage Tests

2.1. Voltage ratio measurement & Polarity check (Vector Group)

Refer IEC 60076-1for procedure and acceptance criteria. Manufacturer's standard practice may be followed.

2.2. Measurement of insulation power factor and capacitance between winding and earth and Bushings

Standards: IEC 60076-1 & POWERGRID Technical Specification for Transformers & Reactors.

Capacitance & tan delta of HV bushings, IV bushings, LV bushings and neutral shall be measured at 5kV & 10kV. It is applicable only for condenser type bushing (having test tap)

Tan delta measurement at variable frequency (in the range of 20 Hz to 350 Hz, at multiple of 17 Hz and applied voltage shall be 2 – 5kV) shall be carried out on each condenser type bushing (OIP & RIP) at Transformer manufacturing works as routine test before dispatch for reference and the result shall be compared at site during commissioning to verify the healthiness of the bushing. No temperature correction factor shall be applicable for tan delta.

Further winding capacitances & tan delta shall also be measured in the following modes as per the table given below:-

Transformer

Connection	Configuration Auto/Two Winding Transformer	Mode	Voltage (in kV)	Capacitance in pF	Tan delta
1	(HV-IV)/LV (C_{HL})	(UST)	5		
			10		
2	(HV-IV)-E (LV GUARD) (C_H)	(GSTg)	5		
			10		
3	(HV-IV)/(LV+E) (GST) (C_{HL} + C_H)	(GST)	5		
			10		
4	LV/(HV-IV) (C_{HL})	(UST)	5		
			10		
5	LV-E (HV+IV GUARD) (C_L)	(GSTg)	5		
			10		
6	LV/(HV + IV+GROUND) (C_{HL} + C_L)	(GST)	5		
			10		

Test Criteria

The test is successful if tan delta measured is less than 0.5% or as mentioned in specification. The capacitances measured for above combinations (C_H, C_L, C_{HL} + C_H, C_{HL} +C_L, C_{HL}) may be compared.

Reactor

Connection	Configuration Auto/Two Winding Transformer	Mode	Voltage (in kV)	Capacitance in pF	Tan delta
1	(HV+N) - E (C_H)	(GST)	5		
			10		

For bushings and neutral the following table shall be filled:-

Configuration		Voltage (in kV)	Capacitance in pF	% tan delta
HV Bushing	U-Phase Sl. No.--	5		
		10		
	V-Phase Sl. No.--	5		
		10		
	W-Phase Sl. No.--	5		
		10		
IV Bushing	U-Phase Sl. No.--	5		
		10		
	V-Phase Sl. No.--	5		
		10		
	W-Phase Sl. No.--	5		
		10		
LV Bushing	U-Phase Sl. No.--	5		
		10		
	V-Phase Sl. No.--	5		
		10		
	W-Phase Sl. No.--	5		
		10		
Neutral		5		
		10		

2.3. Measurement of insulation resistance & Polarization Index

Measurement of insulation resistance between winding & earth by 5 kV megger.

Insulation resistance tests are made to determine the insulation resistance from individual winding to ground or between individual windings. The insulation resistance in such tests is commonly measured in mega-ohms, or may be calculated from measurements of applied voltage and leakage current. The dc voltage applied for measuring insulation resistance to ground shall not exceed a value equal to the half of the rated voltage of the winding or 5 kV whichever is lower.

Note

1. The insulation resistance of electrical apparatus is subjected to wide variation in design, temperature, dryness, and cleanliness of the parts. When the insulation resistance falls below prescribed values, it can, in most cases of good design and where no defect exists, be brought up to that required standard by cleaning and drying the apparatus. The insulation resistance, therefore, may offer a useful indication as to whether the apparatus is in suitable condition for application of dielectric tests.

2. Under no conditions, test should be made while the transformer is under vacuum.

Polarisation Index (PI)

The purpose of polarisation index test is to determine if equipment is suitable for operation or even for an overvoltage test. The polarisation index is a ratio of insulation resistance value at the end of 10 min test to that at the end of 1 min test at a constant voltage. The total current that is developed when applying a steady state dc voltage is composed of three components:

(1) Charging current due to the capacitance of the insulation being measured. This current falls off from maximum to zero very rapidly.

(2) Absorption current due to molecular charge shifting in the insulation. The transient current decays to zero more slowly.

(3) Leakage current which is the true conduction current of the insulation. It has a component due to the surface leakage because of the surface contamination.

The advantage of PI is that all of the variables that can affect a single IR reading, such as temperature and humidity, are essentially the same for both the 1 min and 10 min readings. Since leakage current increases at a faster rate with moisture present than does absorption current, the IR readings will not increase as fast with insulation in poor condition as with insulation in good condition. After 10 min the leakage current becomes constant and effects of charging current and absorption current die down.

Acceptable PI value for power transformer shall be better than 1.3.

2.4. Core assembly dielectric and earthing continuity test

After assembly each core shall be tested for 1 minute at 2000 AC Volts between all yoke clamps, side plates and structural steel work (core to frame, frame to tank & core to tank).

The insulation of core to tank, core to yoke clamp (frame) and yoke clamp (frame) to tank shall be able to withstand a voltage of 2.5 kV (DC) for 1 minute. Insulation resistance shall be minimum 0.5 GΩ for all cases mentioned above.

2.5. Measurement of winding resistance

After the transformer has been under liquid without excitation for at least 3 h, the average liquid temperature shall be determined and the temperature of the winding shall be deemed to be the same as the average liquid temperature. The average liquid temperature is taken as the mean of the top and bottom liquid temperatures. Measurement of all the windings including compensating (in case terminal is available at outside) at normal and extreme taps shall be done.

In measuring the cold resistance for the purpose of temperature-rise determination, special efforts shall be made to determine the average winding temperature accurately. Thus, the difference in temperature between the top and bottom liquid shall not exceed 5 K. To obtain this result more rapidly, the liquid may be circulated by a pump.

If fibre optic sensors are installed, temperature of winding and oil by FO sensors are also to be recorded in the test report. Further ensure that the FO reading should approx. match with RTD temperature reading.

Type tested unit:

Test engineer (manufacturers) add terminal cables/tube for taking immediate reading of hot resistance of winding. In that case the reference value of cold resistance of the same circuit to be measured and witnessed. Average oil temperature is also to be measured. The above is required for calculation of temperature at shut down condition.

2.6. Measurement of no load current & short circuit Impedance with 415 V, 50 Hz AC.

Measurement of no load current
415V, 50HZ 3-Ph supply (controlled) shall be supplied LV side (Tertiary side for Auto) and magnetising current shall be measured.

Voltage			Current		
U-Φ	V-Φ	W-Φ	U-Φ	V-Φ	W-Φ

Short circuit Impedance with 415 V, 50 Hz AC
Impedances shall be measured for all combinations and at Maximum, Minimum & Normal Voltage Tap – HV/IV, HV/LV & IV/LV
HV/IV – Connection
Applied Voltage at HV, IV Short circuited, Tertiary Open

Tap No.	Voltage			Current			%Z @ Base MVA
	U-Φ	V-Φ	W-Φ	U-Φ	V-Φ	W-Φ	
Max. Tap							
Normal Tap							
Min Tap							

HV/LV – Connection
Applied Voltage at HV, LV Short circuited, IV Open

Tap No.	Voltage			Current			%Z @ Base MVA
	U-Φ	V-Φ	W-Φ	U-Φ	V-Φ	W-Φ	
Max. Tap							
Normal Tap							
Min Tap							

IV/LV – Connection
Applied Voltage at IV, LV Short circuited, HV Open

Tap No.	Voltage			Current			%Z @ Base MVA
	U-Φ	V-Φ	W-Φ	U-Φ	V-Φ	W-Φ	
Normal							

Measured impedance shall be approximately matched with the impedances measured at rated current. The current at all the phases shall be approximately same.

3. No-load loss and current & harmonic measurement

As per IEC 60076-1:2011 clause 11.5. The transformer shall be approximately at factory ambient temperature. Measurement should be carried out at rated specified voltage of the transformer. Harmonics in no load current shall be measured during No Load Loss measurement.

Check points:

- The value of CT measurement range should be kept sufficiently high (3 to 5 times of measuring value) for better measurement and take care of distortions.
- Inputs like - constants, scaling factors, ratio errors, phase angle errors etc. to the loss measuring instrument shall be as per the latest calibration certificate.
- All wirings used for secondary measurements should be original as supplied by equipment manufacturer without any modification.

Note: After No load loss measurement Load loss measurement shall be commenced immediately and shall be carried out as per procedure mentioned at Sr. No. 6 below.

4. Magnetic Balance Test on 3-phase Transformers

This test is conducted only in three phase transformers to check the imbalance in the magnetic circuit. In this test, no winding terminal should be grounded; otherwise results would be erratic and confusing. Applied Test voltage shall be 415V.

Evaluation criteria

The voltage induced in the centre phase shall be 40% to 90% (approx.) of the applied voltage on the outer phases. However, when the centre phase is excited then the voltage induced in the outer phases shall be 30 to 70% (approx.) of the applied voltage. Zero voltage or very negligible voltage induced in the other two windings should be investigated. The purpose of this test basically is to ensure that there is no inter turn fault in the winding which is generally reflected in high excitation current in faulty winding.

5. Tests on On-load Tap-Changers

Operation Test

With the tap-changer fully assembled on the transformer the following sequence of operations shall be performed without failure:

a) With the transformer un-energised, eight complete cycles of operations (a cycle of operation goes from one end of the tapping range to the other, and back again).

b) With the transformer un-energised, and with the auxiliary voltage reduced to 85% of its rated value, one complete cycle of operation.

c) With the transformer energized at rated voltage and frequency at no load, one complete cycle of operation

d) With one winding short circuited and, as far as practicable, two rated current according to IEC 60076-1 in the winding, 10 tap-change operations across the range of two steps on each side from where a coarse or reversing changeover selector operates, or otherwise from the middle tapping(the tap changer will pass 20 times through the changeover position). Total tap change operations shall be 80.

6. Measurement of short-circuit impedance and load loss

The short-circuit impedance and load loss for a pair of windings shall be measured at rated current & frequency with voltage applied to the terminals of one winding, with the terminals of the other winding short-circuited, and with possible other windings open-circuited. The difference in temperature between the top and bottom liquid shall not exceed 5 K. To obtain this result more rapidly, the liquid may be circulated by a pump. Loss measurement for all combinations (HV-IV, HV-LV, IV-LV and at Normal and extreme taps).

If fibre optic sensors are installed, hotspot temperature of winding and oil may be recorded for reference.

Following parameters shall be recorded:
Current, voltage (RMS & Average), power factor, apparent power, active power, reactive power etc.

Current measured at all the phases shall be approximately same. If more variation is observed between current values of all phases measured, test circuit shall be reviewed and test shall be repeated.

Check points:

- Inputs like - constants, scaling factors, ratio errors, phase angle errors etc. to the loss measuring instrument shall be as per the latest calibration certificate.
- All wirings used for secondary measurements should be original as supplied by equipment manufacturer without any modification.
- Current can also be verified from one of the measuring type bushing CTs.

7. Dielectric Tests

Dielectric tests shall be carried in the following sequence as per IEC 60076-3:2013 clause 7.2.3:

a) Lightning impulse tests (LIC, LIN)
b) Switching impulse (SI)
c) Applied voltage test (AV)
d) Line terminal AC withstand test (LTAC)
e) Measurement of transferred surge on LV or Tertiary as applicable due to HV lightning impulse and IV lighting impulse (as applicable). This test may be carried out followed by LI & SI test.
f) Short time over voltage Test (830kVrms) for 765kV Reactor
g) Induced voltage test with partial discharge measurement (IVPD)

Oil Sample shall be taken before starting and after completion of dielectric tests for DGA. In case any abnormality during testing, oil samples may also be taken for DGA.

7.1 **Full wave lightning impulse test (LI) & chopped wave lightning impulse test (LIC)**

Reference Standard:

IEC 60076-3:2013, IEC 60060-1(General definitions of terms related to impulse tests and requirements for test circuits), IEC 60060-2 (measuring devices) & IEC 60076-4 & IEEE Std C57.98-1993

General
For liquid-immersed transformers, the test voltage is normally of negative polarity, because this reduces the risk of erratic external flashovers in the test circuit.

Tap positions
If the tapping range is ± 5 % or less and the rated power of the transformer is ≤ 2 500 kVA then, the lightning impulse tests shall be made with the transformer connected on the **principal tapping**.

If the tapping range is larger than ± 5 % or the rated power of the transformer is > 2 500 kVA then, the two extreme tappings and the principal tapping shall be used, one tapping for each of the three individual phases of a three-phase transformer or the three single-phase transformers designed to form a three-phase bank.

Records of tests

1. Applied Voltage; the records obtained shall clearly show the applied voltage impulse shape (front time, time-to-half value and amplitude).

   The recorded curve and the extreme value of the recorded curve (as defined in IEC 60060-1) shall be presented in the test record.

   The value of the test voltage (after the application of any filtering or correction for overshoot, U_t see IEC 60060-1) shall be reported in the test record.

2. At least one more measurement channel shall be used. In most cases an oscillogram of the current flowing to earth from the tested winding (neutral current). Further recommendations about failure detection, suitable time-base durations, etc. are given in IEC 60076-4.

Test connections

Test connections for lightning impulse on the Line Terminals

The impulse test sequence is applied to each of the line terminals of the tested winding in succession. The other line terminals of the transformer shall be earthed directly or, if needed to achieve the required wave shape, through an impedance. The impedance shall not exceed the surge impedance of the connected line (if a value is supplied by the purchaser) or 400 Ω whichever is lower. In all circumstances, the voltage appearing during the impulse test at the other line terminals shall not be more than 75 % of their rated lightning impulse withstand voltage for star-connected windings, or 50 % for delta-connected windings. The lowest value of impedance at each terminal needed to achieve the required wave shape shall be used.

If the winding has a neutral terminal, the neutral shall be earthed directly or through low impedance such as a current measuring shunt. The tank shall be earthed. If the required wave shape cannot be obtained without the use of a resistor between neutral and earth, then an additional complete impulse test sequence shall be applied. In this case the first impulse test sequence tests the winding at the full voltage without the resistor but the required wave shape may not be achieved and the second sequence with the resistor achieves the wave shape. Chopped waves, if required, would not be repeated in the second sequence.

When a transformer is fitted with internal non-linear elements such as surge arresters which will limit the voltage on internal parts during the impulse test then the provisions of Clause 13.2.3 of IEC 60076-3 apply. Any such internal non-linear elements which are present in the service condition shall be present during the tests. External non-linear elements and other external voltage control elements such as capacitors shall be disconnected for test.

The impulse circuit and measuring connections shall remain unchanged during reference and full voltage tests

Test connections for lightning impulse on Line terminals

Lightning impulses are applied directly to the neutral with all other terminals earthed.

Full wave lightning impulse test (LI)

Wave shape, determination of test voltage value and tolerances

The test impulse shall be a full standard lightning impulse: 1.2 ± 30 % / 50 μs ± 20 %.

The test voltage value shall be the test voltage value as defined specification If the maximum relative overshoot magnitude is 5 % or less, the test voltage value may be taken as the extreme value as defined in specification.

The tolerance on the test voltage value is ± 3 %.

If the standard impulse shape cannot reasonably be obtained because of low winding inductance or high capacitance to earth and the resulting impulse shape is oscillatory so that the relative overshoot magnitude exceeds 5 % then for windings that will receive a chopped wave lightning impulse test, the front time may be increased to reduce the overshoot. In all cases with Um ≤ 800 kV the front time shall not exceed 2.5 μs. If the relative overshoot magnitude exceeds 5 % at the full wave voltage level, then a test voltage function shall be applied in accordance with IEC 60060-1 to determine the test voltage value. It is permissible to apply the requirements of IEC 60060-1 Annex B to the evaluation of the parameters of the lightning impulse irrespective of the overshoot value.

NOTE
Case of overshoot of more than 5 % the peak voltage of the impulse (maximum value of the recorded curve) shall be increased and the frequency of oscillation is higher than about 100 kHz by the application of the test voltage function in accordance with IEC 60060-1.

Tests on transformers without non-linear elements

Test sequence

The test sequence shall consist of:

a) one reference impulse of a voltage between 50 % and 70 % of the full test voltage
b) Three subsequent impulses at full voltage.

If, during any of these applications, an external flashover in the circuit or across a bushing spark gap occurs, or if the recording fails on any of the specified measuring channels, that application shall be disregarded and a further application made.

NOTE

Additional impulses at amplitudes not higher than the reference impulse voltage level can be used, these do not need to be shown in the test report.

Test acceptance criteria

The test is successful if there are no significant differences between voltage and current transients recorded from the reference impulse and those recorded at the full test voltage.

NOTE

The detailed interpretation of the test records and the discrimination between marginal differences and differences indicating failure shall be clearly stated in the report. Further information is given in IEC 60076-4.

Additional observations during the test (abnormal sounds, etc.) may be used to confirm the interpretation of the records, but they do not constitute evidence in themselves.

Tests on transformers with non-linear elements

Test sequence

If non-linear elements or surge arresters are built into the transformer for the limitation of transferred overvoltage transients, they may operate during the test procedure and this may cause differences between impulse records made at different voltages. There will be a threshold voltage at which the differences caused by the non-linear elements start to appear and the test sequence shall include at least one record below this threshold. The test sequence shall consist of:

a) one reference impulse at between 50 % and 60 % of the full test voltage;
b) one reference impulse at between 60 % and 75 % of the full test voltage;
c) one reference impulse at between 75 % and 90 % of the full test voltage;
d) three consecutive 100 % full wave impulses;
e) a comparison impulse at as nearly as possible the same voltage as c) above;

f) a comparison impulse at as nearly as possible the same voltage as b) above;
g) A comparison impulse at as nearly as possible the same voltage as a) above.

The reference impulse voltages shall be at least 10 % (of the 100 % level) different from each other. If none of the 100 % full wave records differ from the lowest voltage record of the reference impulse records, then impulses e), f) and g) above may be omitted.

The time interval between the application of the last chopped wave and the first full wave after the chop waves shall be as short as practicable.

NOTE

Additional impulses at amplitudes not higher than the reference impulse voltage level can be used, these do not need to be shown in the test report. If, during any of these applications, an external flashover in the circuit or across a bushing spark gap should occur, or if the recording should fail on any of the specified measuring channels, that application shall be disregarded and a further application made.

The same types of measuring channels and oscillographic records are specified as for the full wave impulse test.

As far as possible the same time to chop shall be used for all chopped impulses in the sequence.

Test criteria

The test is successful if there are no significant differences between voltage and current transients recorded from the lowest voltage reference impulse and those recorded at the full test voltage. If this is not the case then the records of current and voltage from the following impulses shall be compared:
– a) and g)
– b) and f)
– c) and e)
– all the 100 % level impulse records.

The test is successful if there is no significant difference between the compared records (beyond that which can reasonably be explained by small differences in the test voltage) and any changes between successive records are progressive and smooth, consistent with the proper operation of the non-linear element.

NOTE
Additional observations during the test (abnormal sounds, etc.) may be used to confirm the interpretation of the records, but they do not constitute evidence in themselves.

Chopped wave lightning impulse test (LIC)

Wave shape

The chopped wave lightning impulse shall have a time to chopping between 3 µs and 6 µs. The time to first voltage zero after the instant of chopping shall be as short as possible. The test shall be made without the deliberate addition of impedance in the chopping circuit, but if the overswing observed during a reduced voltage application is more than 30 % then the minimum impedance required to bring the over swing below 30 % may be added to the chopping circuit.

NOTE

Transformers are normally designed to withstand an over swing to the opposite polarity of 30 % of the amplitude of the chopped wave lightning impulse. Usually, the same settings of the impulse generator and measuring equipment are used, and only the chopping gap equipment is added.

Different time bases may be used to record the chopped wave lightning impulses. It is recommended to use a triggered-type chopping gap with adjustable timing, although a plain rod-rod gap is allowed. The peak value of the chopped wave lightning impulse shall be 110 & of rated impulse voltage.

Tests on transformers without non-linear elements

Test sequence

The test is combined with the full impulse test in a single sequence. The order of the different impulse applications shall be:
a) one full wave reference impulse at between 50 % and 70 % of the full wave lightning
b) impulse test voltage;
c) one full wave impulse at the full wave lightning impulse test voltage;
d) two chopped impulses at the chopped wave lightning impulse test voltage;
e) Two full wave impulses at the full wave lightning impulse test voltage.

The same types of measuring channels and oscillographic records are specified as for the full wave impulse test.

NOTE

Additional impulses (full or chopped) at amplitudes not higher than the reference impulse voltage level can be used, these do not need to be shown in the test report If, during any of these applications, an external flashover in the circuit or across a bushing spark gap should occur, or if the recording should fail on any of the specified measuring channels, that application shall be disregarded and a further application made. As far as possible the same time to chop shall be used for all chopped wave lightning impulses in the sequence.

Test criteria

The test is successful if there are no significant differences between voltage and current transients recorded from the reference reduced level full impulse and those recorded at the full test voltage including the chopped impulses up to the time of chop. In the case of the chopped impulses differences after the chopping time may be due to minor variations in the performance and timing of the chopping gap.

NOTE
The detailed interpretation of the test records and the discrimination between marginal differences and differences indicating failure requires a great deal of skill and experience. Further information is given in IEC 60076-4.

Additional observations during the test (abnormal sounds, etc.) may be used to confirm the interpretation of the records, but they do not constitute evidence in themselves.

Tests on transformers with non-linear elements

Test sequence

The test is combined with the full impulse test in a single sequence.
If non-linear elements or surge diverters are built into the transformer for the limitation of transferred overvoltage transients, they may operate during the test procedure and this may cause differences between impulse records made at different voltages. There will be a threshold voltage at which the differences caused by the non-linear elements start to appear and the test sequence shall include at least one record below this threshold.

The test sequence shall consist of:
a) one full wave reference impulse at between 50 % and 60 % of the full wave lightning impulse test voltage;
b) one full wave reference impulse at between 60 % and 75 % of the full wave lightning impulse test voltage;
c) one full wave reference impulse at between 75 % and 90 % of the full wave lightning impulse test voltage;
d) one full wave impulse at the full wave lightning impulse test voltage;
e) two chopped impulses at the chopped wave lightning impulse test voltage;
f) two full wave impulses at the full wave lightning impulse test voltage;
g) a comparison impulse at as nearly as possible the same voltage as c) above;
h) a comparison impulse at as nearly as possible the same voltage as b) above;
i) a comparison impulse at as nearly as possible the same voltage as a) above.

The reference impulse voltages shall be at least 10 % (of the 100 % level) different from each other. If none of the 100 % full wave records differ from the lowest voltage of the reference impulse record then impulses g), h) and i) above may be omitted.

The time interval between the application of the last chopped wave and the first full wave after the chop waves shall be as short as practicable.

NOTE

Additional impulses (full or chopped) at amplitudes not higher than 75 % of the full level can be used, these do not need to be shown in the test report. If, during any of these applications, an external flashover in the circuit or across a bushing spark gap should occur, or if the recording should fail on any of the specified measuring channels, that application shall be disregarded and a further application made. The same types of measuring channels and oscillographic records are specified as for the full wave impulse test. As far as possible the same time to chop shall be used for all chopped impulses in the sequence.

Test criteria

The test is successful if there are no significant differences between voltage and current transients recorded from the lowest voltage reference impulse and those recorded at the full test voltage including the chopped wave impulses up to the time of chop. In the case of the chopped impulses differences after the chopping time may be due to minor variations in the performance and timing of the chopping gap. If this is not the case then the records of current and voltage from the following impulses shall be compared:
– a) and i);
– b) and h);
– c) and g);
– all the 100 % level impulse records;
– both the chopped wave records up to the time of chop.

The test is successful if there is no significant difference between the compared records (beyond that which can reasonably be explained by small differences in the test voltage) and any changes between successive records should be progressive and smooth, consistent with the proper operation of the non-linear element.

NOTE

Further information is given in IEC 60076-4.

Additional observations during the test (abnormal sounds, etc.) may be used to confirm the interpretation of the records, but they do not constitute evidence in themselves.

NOTE

The information given in IEC 60076-4 with reference to waveshape evaluation is based on the visual observation of oscillographic records. Under certain circumstances it might be appropriate to evaluate the waveshape parameters of non-standard waveshapes and perform the interpretation of deviations manually rather than relying completely on software tools.

Lightning impulse test on a neutral terminal (LIN)

General
Full wave lightning impulses at the impulse voltage level specified for the neutral are applied directly to the neutral with all other terminals earthed.

Waveshape
The wave shape of the full wave impulses shall be as given in 13.2.1 of IEC-60076-3 except that the duration of the front may be up to a maximum of 13 μs.

Test sequence
The test sequence shall be as given in clause 13.2.2.1 of IEC-60076-3 for transformers without a non-linear element and clause 13.2.3.1 of IEC-60076-3for transformers with a non-linear element.

Test criteria

The test criteria shall be as given in clause 13.2.2.2 of IEC-60076-3 for transformers without a non-linear element and clause 13.2.3.2 of IEC-60076-3 for transformers with a non-linear element.

7.2 **Switching impulse test**

Standards:

IEC 60076-3, 60076-4, IEC 60060-1 (for Reactor IEC 60076-6) & IEEE Std C57.98-1993

General

During switching impulse tests, the voltages developed across different windings are approximately proportional to the ratio of numbers of turns. The switching impulse test voltage shall be as specified for the winding with the highest *U*m value. If the ratio between the windings is variable by tappings, the tappings shall be used to bring the test voltage for the winding with lower *U*m as close as possible to the corresponding test value given in Table 2 of IEC-60076-3.

The windings with lower *U*m values may not receive their full test voltage; this shall be accepted. In a three-phase transformer, the voltage developed between line terminals during the test shall be approximately 1.5 times the voltage between line and neutral terminals.

Test Connection

The impulses are applied either directly from the impulse voltage source to a line terminal of the highest voltage winding, or to a lower voltage winding so that the test voltage is inductively transferred to the highest voltage winding. The specified test voltage shall appear between the line terminal of the highest voltage winding and earth. The voltage shall be measured at the line terminal of the highest voltage winding. A three-phase transformer shall be tested phase by phase.

Star connected windings with the neutral brought out shall be earthed at the neutral terminal either directly or through a low impedance such as a current measuring shunt. A voltage of opposite polarity and about half amplitude appears on the two remaining line terminals which may be connected together but not connected to earth. To limit the voltage of opposite polarity to approximately 50 % of the applied level, it is permissible to connect high resistance damping resistors (5 kΩ to 20 kΩ) to earth at the non-tested phase terminals.

For delta connected windings the terminal corresponding to the end of the phase under test shall be earthed either directly or through a small measuring impedance, the other terminals shall be open circuit. Tests on a three-phase transformer shall be arranged so that a different terminal of the delta is earthed for each phase test. Delta connected windings with more than three terminals brought out shall have the delta closed for the test.

For a single phase transformer with one or more windings which will have both ends connected to a line in service and with a switching impulse test specified, then the switching impulse test shall be applied to both ends of the winding.

Bushing spark gaps may be removed or their spacing increased to prevent spark over during the test.

Reactor shall also be tested by the method mentioned above. However, additionally for reactor, clause 8.3 of IEC 60076-4 may also be referred. Since there is only one winding per phase, the application point for the test voltage is the line terminal of the phase winding which is to be tested. The other terminal of this phase winding should be earthed.

For three-phase reactors, the normal impulse test procedures as used for lightning impulse tests are required.

Wave shape

The test voltage is normally of negative polarity to reduce the risk of erratic external flashover in the test circuit.
The voltage impulse shall have a time to peak (*T*p as defined in IEC 60060-1) of at least 100 µs, a time above 90 % (*T*d as defined in IEC 60060-1) of the specified amplitude of at least 200 µs, and a time to zero (*T*z as defined in IEC 60060-1) of a minimum of 1000 µs.

Normally the transformer characteristic of Td ≥ 200 µs is not a problem for small reactors (<100 Mvar for three-phase reactors with relatively high impedances). For large reactors, Td and Tz as specified for transformers would require excessive impulse generator extension. For such cases, a minimum value for Td and Tz should be 120 µs and 500 µs respectively to assure adequate volt-time stress.

Test Sequence

The test sequence shall consist of one reference impulse of a voltage between 50 % and 70 % of the full test voltage and three impulses at full voltage. Sufficient reverse polarity applications shall be made before each full impulse to ensure the magnetization of the core is similar before each full wave impulse in order to make the time to first zero as uniform as possible.

Oscillographic records shall be made of the impulse wave-shape on the line terminal under test and the current between the tested winding and earth. If during any of these applications an external flashover in the circuit or across a bushing spark gap should occur, or if the recording should fail on any of the specified measuring channels, that application shall be disregarded and a further application made.

Acceptance Criteria

The test is successful if there is no sudden collapse of voltage or discontinuity in the voltage or current indicated on the oscillographic records.

Additional observations during the test (abnormal sounds, etc.) may be used to confirm the oscillographic records, but they do not constitute evidence in themselves.

7.3 Applied voltage test (AV)

The test shall be carried out on each separate winding of the transformer in turn.

The full test voltage shall be applied for 60 s between all accessible terminals of the winding under test connected together and all accessible terminals of the remaining windings, core, frame and tank or casing of the transformer, connected to earth.

The test shall be made with an approximately sinusoidal single-phase alternating voltage at rated frequency. The peak value of voltage shall be measured. The peak value divided by $\sqrt{2}$ shall be equal to the test value.

NOTE
Approximately sinusoidal can be taken to mean that the peak value divided by $\sqrt{2}$ does not differ from the r.m.s value of the waveform by more than about 5 % (see IEC 60060-1), but wider deviations may be accepted.

The test shall commence at a voltage not greater than one-third of the specified test value, and the voltage shall be increased to the test value as rapidly as is consistent with measurement. At the end of the test, the voltage shall be reduced rapidly to less than one-third of the test value before switching off.

The test is successful if no collapse of the test voltage occurs.

For windings with non-uniform insulation, the test is carried out with the test voltage specified for the neutral terminal. In transformers where windings having different U_m values are connected together within the transformer (usually auto-transformers), the test voltages shall be determined by the insulation of the common neutral and it's assigned U_m.

7.4 Line terminal AC withstand test (LTAC)

The test shall be arranged so that the test voltage appears between the tested terminal and earth. Each phase terminal of the tested winding shall be tested in turn. The test time, frequency and voltage application shall be same as Induced voltage withstand test (IVW).

Test time in Seconds = $120 \times \frac{\text{rated frequency}}{\text{test frequency}}$, but not less than 15 s

For transformers with taps and a non-uniformly insulated lower voltage winding, the tap position for test shall be selected so that when the required test voltage appears on the highest voltage winding terminals, the voltage appearing on the lower voltage winding terminals shall be as close as possible to the required test value. For transformers with a uniformly insulated lower voltage winding subject to an applied voltage test, the tap position may be chosen by the manufacturer.

The test is successful if no collapse of the test voltage occurs.

NOTE
This test is intended only as a withstand test for each line terminal of a non-uniformly insulated transformer to earth, it is not intended to test the phase to phase or turn to turn insulation so the test arrangement can be made in any convenient way, for example with voltage at the neutral to reduce the turn to turn voltage and the test will normally be carried out as three single phase tests. Partial discharge measurements can be made during this test.

7.5 Induced voltage withstand test (IVW)

The test time at full test voltage shall be 60 s for any test frequency up to and including twice the rated frequency, unless otherwise specified. When the test frequency exceeds twice the rated frequency, the test time in seconds of the test shall be:

$$120 \times \frac{\text{rated frequency}}{\text{test frequency}}, \text{ but not less than 15 s}$$

The test shall commence at a voltage not greater than one-third of the specified test value, and the voltage shall be increased to the test value as rapidly as is consistent with measurement. At the end of the test, the voltage shall be reduced rapidly to less than one-third of the test value before switching off.

The test is successful if no collapse of the test voltage occurs.

7.6 Measurement of transferred surge on LV or Tertiary due to HV & IV Lightning impulse

The voltage shall be applied on the phase for which transferred surge shall be measured in the same phase of tertiary (i.e. if voltage is applied on 1W, the transferred surge shall be measured at 3W terminal). The above process shall be repeated for the remaining HV & IV terminals.

Similar tests to be conducted for switching surge transformer at Max, Nor. and Min. Voltage Tap (if applicable). However, applied voltage shall be selected such a way that induced voltage at other winding should not go more than the SI limit of that winding.

Following tests shall be carried out with applying 50% to 80% of rated Impulse & Switching impulse (upto 60% for IV to limit the max. limit of HV SI level) voltage. Finally, measured value shall be extrapolated for 100% rated voltage.

For each tap position, atleast 2 nos. shots (for LI - one at approx. 50% and other at approx. 80% and for SI – one at approx. 40% & at approx. 60%*) shall be applied and measured values shall be extrapolated to 100%. Measured and extrapolated values shall be recorded.

Transformer with non-linear element in the winding

If Lightning Arrestor (or **non-linear element)** is connected with tertiary or LV to limit the surges, transfer surge shall be carried out with LA (as to be connected in service) during Test at factory for HV and IV lightning & switching impulse Test. In that case applied voltage shall be raised gradually to the level where the LA shall operate/actuate. It shall be below the impulse / SI level of LV or tertiary winding.

Table for Transfer surge (Impulse) at Max, Nor. and Min. Voltage Tap

1-Phase Transformer

Sr. No.	Impulse Type	Voltage applied	Earthed Points	Open / not earthed point	Measurement Point
1	FW	1.1	2.1, N & 3.2	-	3.1
2	FW	1.1	2.1, N & 3.1	-	3.2
3	FW	2.1	1.1, N & 3.2	-	3.1
4	FW	2.1	1.1, N & 3.1	-	3.2

Where,

1.1 : HV Terminal
2.1 : IV Terminal
3.1 & 3.2 : LV or Tertiary Terminal

(*): Should not reach beyond the SI limit of HV winding

3-Phase Transformer

Sr. No.	Impulse Type	Voltage applied	Earthed Points	Open / not earthed point	Measurement Point
5	FW	1U	1V, 1W, 2U, 2V, 2W, N, 3V & 3W	-	3U
6	FW	1V	1U, 1W, 2U, 2V, 2W, N, 3U & 3W	-	3V
7	FW	1W	1U, 1V, 2U, 2V, 2W, N, 3V & 3U	-	3W
8	FW	2U	1U, 1V, 1W, 2V, 2W, N, 3V & 3W	-	3U
8	FW	2V	1U, 1V, 1W, 2U, 2W, N, 3U & 3W	-	3V
9	FW	2W	1U, 1V, 1W, 2U, 2V, N, 3V & 3U	-	3W

Acceptance criteria

Transfer surge at Tertiary should not exceed the rated impulse level of that winding. The extrapolated values measured at 50% and 80% (for LI) or 40% and 60% (for SI) as stated above shall be approximately matched.

When non-linear element is connected in the winding, the non-linear element should limit the transferred voltage below the rated impulse level of that winding. LA / nonlinear element shall operate/actuate below the impulse level of Tertiary or LV winding.

7.7 Induced voltage test with partial discharge measurement (IVPD)

Standards

IEC 60076-3, IEC 60270 & POWERGRID Technical Specification for Transformers & Reactors.

General

This test is intended to verify that the transformer will be free of harmful partial discharges under normal operating conditions. The test voltage is applied in the same way as the voltage that the transformer will experience in service. During the test, symmetrical voltages appear at all the line terminals and between turns, **with no voltage at the neutral**. The test is performed with a three phase voltage on three phase transformers

Each PD measurement channel including the associated bushing or coupling capacitor shall be calibrated in terms of apparent charge (pC) according to the method given in IEC 60270.

Voltage calibration to be done to check the test voltages to be applied as per test sequence given below before start of PD Test as there is no option of keeping the voltage divider connected to the transformer for voltage measurement continuously during PD test.

The PD measurement shall be given in pC and shall refer to the highest steady-state repetitive impulses indicated by the measuring instrument**. Occasional bursts of high partial discharge level may be disregarded.**

If high partial discharge is coming repeatedly, and may be due to external reason, manufacturer should improve the system and bring the value to ambient level before starting the PD cycle.

For each required PD measurement step in the test sequence, PD measurements shall be made and recorded on all the line terminals equipped with bushings with a $U_m \geq 72.5$ kV, during the test, however if there are more than six such terminals then only six measurements need to be made (one on each of the highest voltage terminals) unless otherwise specified.

Test sequence

The test sequence shall be as follows:

a) The voltage shall be switched on at a voltage not higher than $(0.4 \times Ur)/\sqrt{3}$.
b) The voltage shall be raised to $(0.4 \times Ur)/\sqrt{3}$ and a background PD measurement shall be made and recorded.
c) The voltage shall be raised to $(1.2 \times Ur)/\sqrt{3}$ and held there for a minimum duration of 1 min and only long enough to make a stable PD measurement.
d) The PD level shall be measured and recorded.
e) The voltage shall be raised to the one hour PD measurement voltage and held there for a minimum duration of 5 min and only long enough to make a stable PD measurement.
f) The PD level shall be measured and recorded.
g) The voltage shall be raised to the enhancement voltage and held there for the test time mentioned below.

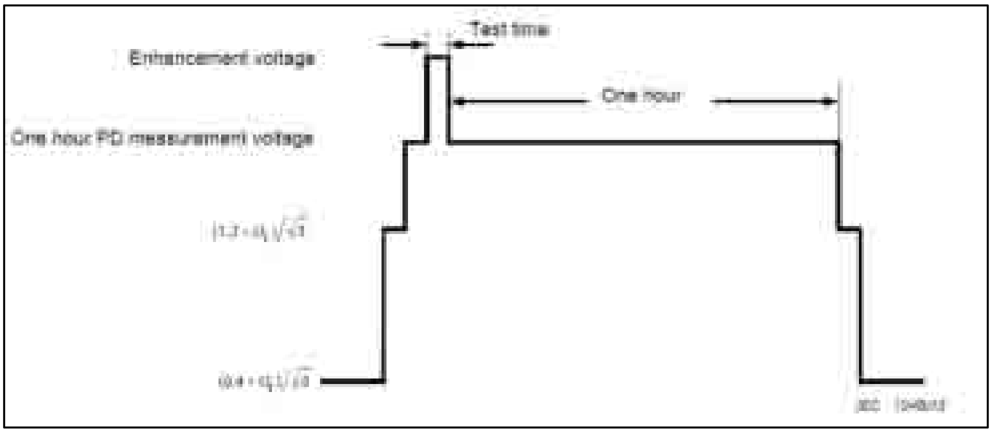
h) Immediately after the test time, the voltage shall be reduced without interruption to the one hour PD measurement voltage.
i) The PD level shall be measured and recorded.
j) The voltage shall be held at the one-hour PD measurement voltage for a duration of at least one hour following the PD measurement.
k) The PD level shall be measured and recorded every 5 min during the one hour period.
l) After the last PD measurement in the one hour period the voltage shall be reduced to (1.2 × Ur) /√3 and held there for a minimum duration of 1 min and only long enough to make a stable PD measurement.
m)The PD level shall be measured and recorded.
n) The voltage shall be reduced to (0.4 × Ur) /√3 and the background PD level shall be measured and recorded.
o) The voltage shall be reduced to a value below (0.4 × Ur) /√3.
p) The voltage shall be switched off.

An enhancement (phase to earth) voltage level of (1.8 × Ur) /√3 and a one hour PD measurement voltage of (1.58 × Ur) /√3. Alternative higher voltage levels may be used if specified by the purchaser. In particular an enhancement voltage of Um and a one hour PD measurement voltage of (1.5 × Um) /√3 may be used if higher.

The partial discharge level shall be continuously observed on at least one measuring channel for the entire duration of the test.

During the test sequence the inception and extinction voltages of any significant PD activity should be noted to aid the evaluation of the test result if the test criteria are not met.

Test sequences are illustrated in below figure.



Test Duration & Frequency

The test time at the enhancement voltage shall be 60 s in case Um ≤ 800 kV and 300 s in case U_m > 800 kV for any test frequency up to and including twice the rated frequency, unless otherwise specified. When the test frequency exceeds twice the rated frequency, the test time in seconds of the test shall be:

120 × rated frequency / test frequency, but not less than 15 s for Um ≤ 800 kV

The duration of the test, except for the enhancement level, shall be independent of the test Frequency.

Test acceptance criteria

The test can only be considered valid if the measured background PD level does not exceed 50 pC at both the beginning and the end of the test. For tests on shunt reactors a background PD level higher than 50pC may be accepted.

The test is successful if all the following criteria are fulfilled:

a) No collapse of the test voltage occurs;
b) None of the PD levels recorded during the one hour period exceed 100 pC;
c) The PD levels measured during the one hour period do not exhibit any rising trend and no sudden sustained increase in the levels occur during the last 20 min of the test;
d) The measured PD levels during the one hour period do not increase by more than 50 pC;
e) The PD level measured at a voltage level of $(1.2 \times U\mathrm{r})/\sqrt{3}$ after the one hour period does not exceed 100 pC.
f) If the criteria c) or d) are not met, the one hour period may be extended and these criteria will be considered to have been met if they are fulfilled for a continuous period of one hour.

Check points:

1. For 3-Ph Transformer/Reactor, IVPD test shall be carried out by 3-Phase supply

2. Before start of the test, all parameters / data used for PD testing and mentioned in the computer software to be checked with calibrated result of the instrument.

3. In case of doubt, change of PD measuring channel, creating PD temporarily, and check the healthiness of the measuring channel.

4. Before and after the PD test, calibration of the channel and measuring circuit to be repeated.

5. Continuous PD recording (if facility available) to be carried out for reference.

8. Temperature Rise Test on Transformer

Reference Standard:

IEC 60076-1 Edition 3.0 2011-04 Clause 11.4 Measurement of short-circuit impedance and load loss & IEC 60076-2 Edition 3.0 2011

For each cooling combination with cooler bank, tests shall be done for a minimum of 12 hours for ONAN/ONAF and 24 hours for ODAF or OFAF or ONAF2 with saturated temperature for at least 4 hours while the appropriate power and current for core and load losses are supplied.

The total testing time, including ONAN heating up period, steady period and winding resistance measurements is expected to be about 48 hours.

Gas chromatographic analysis on oil shall also be conducted before, during and after this test and the values shall be recorded in the test report. The sampling shall be in accordance with IEC 60567.

Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. Keep the pumps running for 2 hours before and after the heat run test. Take oil samples during this period. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shut down. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181. The DGA results shall generally conform to IEC/IEEE/CIGRE guidelines.

Temperature of the cooling media

Ambient temperature

For the temperature rise test, the cooling air temperature should be in the range between 10 °C and the maximum ambient temperature 50 °C for which the transformer is designed.

At least four sensors shall be provided and the average of their readings shall be used to determine the ambient temperature for the evaluation of the test results.

Around an ONAN transformer, the ambient sensors shall be placed at a level about half-way up the cooling surfaces. The sensors shall be distributed around the tank, about 2 m away from the perimeter of tank and cooling surfaces, and protected from direct heat radiation.

For a forced-air-cooled (ONAF, OFAF, ODAF) transformer the sensors shall be placed in the air at about 0.5 m from the intake of the coolers.

Readings should be taken at regular intervals (30 minutes). Automatic continuous recording may be used.

In the case of separate cooling equipment placed at a distance of at least 3 m from the transformer tank, the ambient temperature shall be measured around the cooling equipment applying the same rules given above. For separate cooler bank arrangement (distance of at least 3 m from the transformer tank) 4 numbers sensors shall be used to measure the ambient temperature.

Attention shall be paid to possible recirculation of hot air. The transformer should be placed so as to minimize obstructions to the air flow and to provide stable ambient conditions.

Total loss injection

The Contractor before carrying out this test shall submit detailed calculations showing losses on various taps and for the three types of ratings of the transformer and shall recommend the combination that result in highest temperature rise for the test. The Temperature rise type test results shall serve as a "finger print" for the units to be tested only with short term heat run test.

2-Winding Transformer

Load Loss measurement for HV-LV connection and at Normal & extreme taps) shall be carried out. For 2-winding transformer, total losses to be fed during temperature rise test shall be **2-Winding Loss at tap corresponding to maximum measured loss and No load loss.**

2-Winding Loss = [HV-LV] (Max MVA)

The total losses to be injected during the first part of the test shall be equal to the highest value of total loss appearing at any tapping (corresponding to the particular tapping). This tapping is also often, but not always, the maximum current tapping. This part of the test determines the maximum top-liquid temperature rise. For the determination of winding temperature rise at the maximum current tapping, the value of liquid temperature rise to be used in the evaluation shall correspond to the total losses of that tapping.

3-Winding Transformer

Load Loss measurement for all combinations (HV-IV, HV-LV, IV-LV and at Normal and extreme taps) shall be carried out. The temperature rise test shall be conducted at a tap for the worst combination of loading (3-Winding Loss) for the Top oil of the transformer. Total losses to be fed during temperature rise test shall be **3-Winding Loss and No load loss.**

3-Winding Loss = HV (Max MVA) + IV (Max MVA) + LV (Max MVA)

The injection of total loss for the determination of liquid temperature rise may be made in an approximate manner by not short-circuiting or closing certain windings. The total losses shall be fed to HV or IV while LV winding is left open and raise the current until the correct total loss is obtained.

The top-liquid temperature and cooling medium temperature are monitored, and the test is continued until steady-state liquid temperature rises are established. The first part of the test may be terminated when the rate of change of top-liquid temperature rise has fallen below 1 K/h and has remained there for a period of 4 h. If discrete readings have been taken at regular intervals, the mean value of the readings during the last hour is taken as the result of the test. If continuous automatic recording is applied, the average value during the last hour is taken.

After the top-liquid temperature rise has been established, the test shall be continued without a break with the test current reduced to rated current for the winding combination connected. This condition is maintained for 1 h, during which time continuous temperature records of top-liquid, winding hot-spot (if measured) and external cooling medium should be taken at least every 15 min.

At the end of the hour, the resistances of the windings are measured, either after a rapid disconnection of the supply and short circuits (IEC 60076-2 clause 7.8 and Annex C) or, without switching off the supply, by means of the superposition method which consists of injecting into the windings and measuring direct current of low value superimposed on the load current. In the similar way winding hotspot, average winding rise etc. shall be measured for tertiary winding for various cooling.

Determination of liquid temperatures

Top-liquid temperature

The top-liquid temperature (θo) is conventionally determined by one or more sensors immersed in the insulating liquid at the top of the tank or, in pockets in the cover. The recommended number of pockets is the following:

− rated power ≥ 100 MVA:	3 pockets;
− rated power from 20 MVA to <100 MVA:	2 pockets;
− rated power < 20 MVA:	1 pocket.

The position of the sensors should be chosen to present the top-liquid temperature possibly in correspondence to the wound columns.

If more than one pocket is used, the readings of the sensors shall be averaged in order to obtain a representative temperature value.

Bottom and average liquid temperatures

The bottom liquid temperature (θb) shall be determined by sensors placed at the return headers from coolers or radiators. If several banks of cooling equipment are fitted, more than one sensor should be used and the reading average assumed as bottom liquid temperature.

Average liquid temperature (θom) is used for the calculation of the average winding gradient and correction of certain temperature rise test results. The average liquid temperature is:

$\theta om = (\theta o + \theta b)/ 2$

Determination of top, average and bottom liquid temperature rises

The top-liquid temperature rise ($\Delta\theta o$) shall be determined by difference between the top-liquid temperature measured at the end of the test period with total losses (θo) and the external cooling medium temperature at the end of the test period with total losses (θa), that is:

$\Delta\theta o = \theta o - \theta a$

The average liquid temperature rise ($\Delta\theta om$) shall be determined by difference between the average liquid temperature (θ om) calculated according to 4.2 and the external cooling medium temperature (θa), that is:

$\Delta\theta om = \theta om - \theta a$

The bottom liquid temperature rise ($\Delta\theta b$) shall be determined by difference between the bottom liquid temperature (θb) defined according to clause 7.4.2 of IEC 60076-2 and the external cooling medium temperature (θa), that is:

$\Delta\theta b = \theta b - \theta a$

Determination of average winding temperature

The average winding temperature is determined by measurement of winding resistance. On three-phase transformers, the measurement should be normally performed including the middle phase of the windings.

For star connected, low voltage and high current windings, the measurement should be made between line terminals in order to exclude the neutral connection from the test circuit. A reference measurement (R1,θ1) of all winding resistances is made with the transformer at ambient temperature, in a steady-state condition (see IEC 60076-1).

When the resistance (R2) is measured after disconnection of the power supply, extrapolated to the instant of shutdown, this yields the temperature value:

$$\theta_2 = \frac{R_2}{R_1}(235 + \theta_1) - 235 \qquad \text{for copper}$$

Where $\theta 2$ is the average temperature of the winding at the instant of shutdown. In the formula, the temperatures are expressed in Celsius degrees.

Determination of winding resistance at the instant of shutdown

The winding resistance (R2) before shutdown shall be determined using the rules indicated below.

Immediately after disconnection of the test power supply and removal of the short-circuiting connection, a direct current measuring circuit shall be connected across the winding terminals corresponding to the resistance to be measured.

As the resistance of the winding varies with time as the winding cools down, it shall be measured for a sufficient time to permit extrapolation back to the instant of shutdown.

As the windings have a large electrical time constant (L/R), accurate readings are therefore obtained only after a certain delay.

The delay can be reduced by minimizing as much as possible the time between the shutdown and the switching on the resistance circuit, as well as reducing the electrical time constant by an adequate choice of the parameters of the circuit.

The cooling conditions should preferably not be disturbed during the time the resistance measurements are made. If pumps are operating during the temperature rise test, they should be maintained during the measurements.

The detailed execution of the measurement are given in IEC 60076-2 Annex C. Resistance shall be measured for atleast 30 minutes.

Determination of average winding temperature rise at the instant of shutdown

The average winding temperature rise shall be determined using the value of resistance at the instant of shutdown. The corrected winding average temperature rise of the winding ($\Delta\theta w$) is:

$\Delta\theta w = \theta 2 + \Delta\theta ofm - \theta a$

where $\theta 2$ is the average winding temperature at the instant of shutdown, θa is the external cooling medium temperature at the end of the test period with total losses, $\Delta\theta ofm$ the fall of the temperature of the average liquid during the 1 h test at rated current.

The detailed execution of the measurement are given in IEC 60076-2 Annex C. The calculation details, Graph with Annexure C (duly filled) shall be submitted with temperature rise test result.

After hot resistance measurement of HV and IV winding, Tertiary winding shall be loaded at rated MVA (of LV) for 1 hour. After it, hot resistance measurement shall be carried for LV winding. The above sequence shall be followed for all cooling combinations (ONAN/ONAF/OFAF as applicable).

Determination of the average winding to liquid temperature gradient

The average winding to average liquid temperature gradient (g) shall be determined as the difference between the uncorrected average winding temperature ($\theta 2$) and the average liquid temperature θom at shutdown:

$g = \theta 2 - \theta om$.

Determination of the hot-spot winding temperature rise

Direct measurement during the temperature rise test

A number of thermal sensors (e.g., optical fibre sensors) shall be mounted inside the windings in positions where it is supposed the hot-spots are located.

When more than one sensor is used on the same winding, the maximum reading shall be taken as the hot-spot winding temperature.

The hot-spot winding temperature rise ($\Delta\theta h$) is then obtained by:

$\Delta\theta h = \theta h + \Delta\theta of - \theta a$

where θh is the temperature reading at shutdown, $\Delta\theta$ of the fall of the top-liquid temperature during the 1 h test at rated current, and θa the ambient temperature at the end of the total loss test period.

Determination by calculation

The hot-spot winding temperature rise can be determined using the following equation:

$\Delta\theta h = \Delta\theta o + Hg$

The average thermal gradient between each winding and liquid along the limb (g) is taken as the difference between the average winding temperature rise ($\Delta\theta w$) and average liquid temperature rise ($\Delta\theta om$).

$(g) = (\Delta\theta w) - (\Delta\theta om)$.

H = Hotspot factor = 1.3 (As per existing practice) and also furnish the design calculate of this factor in line with IEC. Derive winding hotspot rise based on above factors and values should not exceed the guaranteed parameters for both the cases.

Hotspot temperature rise shall be measured by direct FO sensors and shall be recorded for reference only.

Calculation of Hotspot factor as per IEC 60076-2 shall also be furnished during design review.

The format of measuring parameters is attached at Annexure-I.

ANNEXURE-I

TRANSFORMER SR. NO.			
TRANSFORMER RATING :			WNDING
COOLING :			
The top-liquid temperature (θo)	(θo)	°C	
The bottom liquid temperature (θb)	(θb)	°C	
External cooling medium temperature at the end of the test period with total losses (θa)	(θa)	°C	
The average liquid temperature θom	$= (\theta o + \theta b)/ 2$	°C	
The top-liquid temperature rise ($\Delta\theta o$)	$\Delta\theta o = \theta o - \theta a$	°C	
The average liquid temperature rise ($\Delta\theta om$)	$= \theta om - \theta a$	°C	
Winding			
Average winding temperature at the instant of shutdown, $\theta 2$	$\theta 2$	°C	
Fall of the temperature of the average liquid during the 1 h test at rated current , $\Delta\theta ofm$	$\Delta\theta$ ofm	°C	
The corrected winding average temperature rise of the winding $\Delta\theta w$	$= \theta 2 + \Delta\theta ofm - \theta a$	°C	
The average winding to average liquid temperature gradient (g) (Uncorrected)	$g = \theta 2 - \theta om$	°C	
Temperature reading at shutdown by fiber optic sensor (direct reading), θh	θh	°C	
The top-liquid temperature during the 1 h test at rated current, $\Delta\theta of$	$\Delta\theta of$	°C	
The average winding to average liquid temperature gradient (g) (corrected)	g =g (uncorrected)+$\Delta\theta ofm$	°C	
The hot-spot winding temperature rise ($\Delta\theta h$)	$= \theta h + \Delta\theta of - \theta a$	°C	
The average thermal gradient of Winding, (g)	= ($\Delta\theta w$) - ($\Delta\theta om$)	°C	
Calculated Hotspot rise ($\Delta\theta h$) [where Hotspot factor, H = 1.3]	$= \Delta\theta o + H g$	°C	
Hotspot rise ($\Delta\theta h$) [where design Hotspot factor, H = to be furnished by manufacturer]	$= \Delta\theta o + H g$	°C	
Top liquid temperature rise		**°C**	
HV Winding average temperature rise		**°C**	
The hot-spot winding temperature rise ($\Delta\theta h$) by fiber optic sensor (reference purpose)		**°C**	
The hot-spot winding temperature rise ($\Delta\theta h$) by conventional method		**°C**	
The hot-spot winding temperature rise ($\Delta\theta h$) considering design hotspot factor and measured top oil rise.		**°C**	

9. Overload testing in short-circuit method

The test shall be carried out on the tapping position that will cause the highest current under normal conditions. Hot spot temperature measurement shall be done by using temperature probes or sensors in approved locations.

The transformer shall be fully erected as for service with all cooling equipment.

I. Testing option 1:

Pre-load the unit with 100% of full load current for a period long enough to stabilise the top oil temperature with cooling as for service conditions.

- Increase the loading to 120% overload rating. Forced cooling shall be activated as per service conditions.
- Scan and record infra-red images of all four sides and the top of the transformer at the interval of every one hour.
- Hold the overload current for a period of 4 hours.
- Measure and record the hotspot temperatures (by resistance method & fiber optic sensors).

II. Testing option 2:

Pre-load the unit with 100% of full load current for a period long enough to stabilise the top oil temperature with 100% cooling as per service conditions.

- Increase the loading to 130% overload rating.
- Scan and record infra-red images of all four sides and the top of the transformer every 30 minutes.
- Hold the current at 130% for a period of 2 hours.
- Measure and record the hotspot temperature (by resistance method & fiber optic sensors).

III. Acceptance criteria:

Winding hotspot temperatures shall not exceed 130°C for option 1 and 135 °C for option 2.
The temperature rise recorded by infra-red shall be not more than 10°K above top oil temperature or 15°K above the local oil temperature.
The rate of gas development as determined from oil samples shall be determined. Samples shall be taken before and after the test and acceptance criteria shall be in accordance with IEC/IEEE guidelines.

IV. Test records:

Full details of the test arrangements, procedures and conditions shall be supplied with the test certificates and shall include the following:

- Purchaser's reference number and site designation
- Manufacturer's name and transformer serial number
- MVA rating and voltage ratio
- Vector group

- Altitude of test bay
- Designation of terminals supplied and terminals strapped
- Colour photographs of the four sides and top of the transformer.

V. Overload test:

A log of the following quantities taken at a minimum of 30-minute intervals:

- time
- voltage between phases
- current in each phase
- power in each phase and total power
- ambient temperature
- top oil temperature
- FO sensors readings

10. Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)

In addition to the type test for temperature rise conducted on one unit, each cooling combination shall routinely be subjected to a short term heat run test to confirm the performance of the cooling system and the absence of manufacturing defect such as major oil flow leaks that may bypass the windings or core.

DGA samples shall be taken at intervals to confirm the gas evolution.

For ODAF or OFAF cooling, the short term heat run test shall be done with the minimum number of pumps for full load operation in order to shorten the temperature build up. Each short term heat run test is nevertheless expected to take about 3 hours.

For ODAF or OFAF cooled transformers an appropriate cross check shall be performed to prove the effective oil flow through the windings. For this purpose the effect on the temperature decay by switching the pumps off/ on at the end of the heat run should demonstrate the effectiveness of the additional oil flow. Refer to SC 12, 1984 cigre 1984 SC12-13 paper by Dam, Felber, Preiniger et al.

Short term heat run test may be carried out with the following sequence:

- Heat run test with pumps running but oil not through coolers.
- Raise temperature to 5 deg less than the value measured during temperature rise test.
- Stop power input and pumps for 6 minutes and observe cooling down trend
- Restart pumps and observe increased cooling trend due to forced oil flow

The cooling down trend shall be observed by recording top and bottom oil temperature and winding resistance.

This test is applicable for the Transformer without Pump also (ONAN or ONAF rating). For such type of transformer test may be carried out with the following sequence:

Arrangement shall be required with pump of suitable capacity (considering the oil velocity) without cooler bank. Raise the oil temperature 20-25 deg C above ambient. Stop power input and pumps for 6 minutes and observe cooling down trend. Restart pumps and observe increased cooling trend due to forced oil flow. FO sensors data shall be recorded during the test.

11. Over excitation test

A routine over excitation test at 1.05 p.u voltage for 12 hours shall be done on the tap position giving the highest flux. This test shall be carried out immediately after the routine short-term heat run test on the transformer. The rate of gas development during the test shall be evaluated using IEEE /IEC/CIGRE guidelines. FO sensors data shall be recorded during the test.

12. Measurement of zero-sequence impedance(s) on three-phase transformers/reactors

Standards: IEC 60076-1:2011, IEC 60076-8

General

In the case of transformers having more than one star-connected winding with neutral terminal, the zero-sequence impedance is dependent upon the connection.

The zero-sequence impedance may have several values because it depends on how the terminals of the other winding or windings are connected and loaded.

The zero-sequence impedance may be dependent on the value of the current and the temperature, particularly in transformers without any delta-connected winding.

The zero-sequence impedance may also be expressed as a relative value in the same way as the (positive sequence) short-circuit impedance

Test Procedure

The zero-sequence impedance is measured at rated frequency between the line terminals of a star-connected or zigzag-connected winding connected together, and its neutral terminal. It is expressed in ohms per phase and is given by ($3U/I$), where U is the test voltage and I is the test current. The test current per phase ($I/3$) shall be stated in the test report.

It shall be ensured that the current in the neutral connection is compatible with its current carrying capability.

In the case of a transformer with an additional delta-connected winding, the value of the test current shall be such that the current in the delta-connected winding is not excessive, taking into account the duration of application.

If winding balancing ampere-turns are missing in the zero-sequence system, for example, in a star-star-connected transformer without delta winding, the applied voltage shall not exceed the phase-to-neutral voltage at normal operation. The current in the neutral and the duration of application should be limited to avoid excessive temperatures of metallic constructional parts.

For autotransformers and YY transformers, there are several combinations of tests to perform:
– HV with LV open circuit;
– HV with LV short circuit;
– LV with HV open circuit;
– LV with HV short circuit.
– For YD transformers, the zero sequence impedance is measured from the Y side only.
– Auto-transformers with a neutral terminal intended to be permanently connected to earth shall be treated as normal transformers with two star-connected windings.

Thereby, the series winding and the common winding together form one measuring circuit, and the common winding alone forms the other. The measurements are carried out with a current not exceeding the difference between the rated currents on the low-voltage side and the high voltage side.

For Reactor, this measurement shall be carried out at a voltage corresponding to a neutral current equal to the rated phase current.

NOTE 1 In conditions where winding balancing ampere-turns are missing, the relation between voltage and current is generally not linear. In that case, several measurements at different values of current may give useful information.

NOTE 2 The zero-sequence impedance is dependent upon the physical disposition of the windings and the magnetic parts, measurements on different windings may therefore not agree. In particular, for a transformer with a zigzag winding the zero sequence impedance measured between line terminals connected together and the neutral may result in a different value to that obtained when a three phase symmetrical voltage is applied and one line terminal is connected to the neutral.

NOTE 3 An additional zero-sequence impedance test may be required for transformers with delta windings with two connections to one corner brought out so that it can be either open or closed.

NOTE 4 Further guidance is given in IEC 60076-8.

315MVA, 500MVA 400/220/33kV Transformer Connections

Tap No.	Current Applied	Open Terminals	3xU/I	%ZO
1	Between HV (1U, 1V & 1W Shorted) and Neutral	2U, 2V, 2W and Tertiary		
9	-Do-	-Do-		
17	-Do-	-Do-		
1	Between IV (2U, 2V & 2W Shorted) and Neutral	1U, 1V, 1W and Tertiary		
9	-Do-	-Do-		
17	-Do-	-Do-		

The above measurements shall be repeated with Tertiary terminals shorted. Voltage and current shall be measured and recorded.

13. Measurement of acoustic noise level (Measured in Cold and Hot state of temperature rise test)

Test shall be performed as per IEC 60076-10 and clause 7.8.12 of IEC 60076-6 (for reactor). The measured value shall not be exceeded the limit as specified at Annexure-A of this specification. Sound pressure levels shall be established in line with specification. Sound power level shall be calculated from sound pressure level using the method described in IEC 60076-10. Location of microphones shall be in line with IEC 60076-10.

Important check points

The available frequency response of the measuring instrument shall range from below the rated power frequency to above the upper limit of the human ear capability of 20 kHz.

The upper limit for the actual measurement shall be chosen in accordance with the highest emitted significant frequency, usually below 10 kHz. The selected frequency range for background noise measurements and the test measurement shall be the same.

Sound pressure measurements shall be made using a type 1 sound level meter complying with IEC 61672-1 and IEC 61672-2 and calibrated in accordance with 5.2 of ISO 3746:2010.

The sound pressure method of measurements described in this standard is based on ISO 3746. Measurements made in conformity with this standard tend to result in standard deviations of reproducibility between determinations made in different laboratories which are less than or equal to 3 dB.

The measuring equipment shall be calibrated in accordance with manufacturer's instructions immediately before and after the measurement sequence. If the calibration changes by more than 0.3 dB, the measurements shall be declared invalid and the test repeated.

All measurements shall be made using the energetic average over the measurement duration of the sound quantity (pressure). Statistically derived sound quantities such as percentiles shall not be applied.

The fast response indication of the meter shall be used to identify and avoid measurement errors due to transient background noise.

The sound level measurement is usually of manual operation but the errors introduced by varying distances will tend to average out. Their impact on the final measurement is of less significance than other acoustical factors. Nevertheless, all effort shall be made to keep the measurement distance as constant as possible.

Test Report shall be in line with Annexure-B of IEC 60076-10.

14. Measurement of power taken by fans and oil pumps (100 % cooler bank)

Losses of each fan and pumps including spare shall be measured at rated voltage (415V) and frequency. Fans and Pumps shall be mounted with cooler bank as per approved drawing during measurement. Serial No, Applied voltage, measured current, frequency and make shall be furnished in the test report.

15. High voltage with stand test on auxiliary equipment and wiring after assembly

The wiring for auxiliary power, and control circuitry shall be subjected to a 1 min AC separate source test of 2 kV to earth. The test is passed if no voltage collapse or other sign of breakdown occurs.

The wiring for current transformer secondary windings shall be tested at 2.5 kV AC to earth for 1 min. The test shall be carried out at the manufacturer's works. If the current transformer knee-point voltage exceeds 2 kV AC the test shall be performed at 4 kV AC. The test is passed if no voltage collapse or other sign of breakdown occurs.

16. Frequency Response analysis (SFRA)

Frequency Response Analysis (FRA) is conducted to assess the mechanical integrity of the transformer. FRA signatures will be taken at works in oil filled condition after completion of all tests.

It is recommended to follow the standard procedure for the SFRA measurement as per the below Table. It should be done on maximum, normal and minimum tap of the transformer.

Combination of test for Autotransformer

Test Type	**Test**	**3- Phase**	**1-Phase**
Series Winding (Open circuit) All other terminals floating	Test 1	H1-X1	H1-X1
	Test 2	H2-X2	
	Test 3	H3-X3	
Common Winding (Open circuit) All other terminals floating	Test 4	X1-H0X0	X1-H0X0
	Test 5	X2-H0X0	
	Test 6	X3-H0X0	
Tertiary Winding (Open circuit) All other terminals floating	Test 7	Y1-Y3	Y1-Y2 (Y1-Y0)
	Test 8	Y2-Y1	
	Test 9	Y3-Y2	
Short circuit (SC) High (H) to Low (L) Short (X1-X2-X3)	Test 10	H1-H0X0	H1-H0X0 Short (X1- H0X0)
	Test 11	H2-H0X0	
	Test 12	H3-H0X0	
Short circuit (SC) High (H) to Tertiary (Y) Short (Y1-Y2-Y3)	Test 13	H1-H0X0	H1-H0X0 Short (Y1-Y0)
	Test 14	H2-H0X0	
	Test 15	H3-H0X0	
Short circuit (SC) Low (L) to Tertiary (Y) Short (Y1-Y2-Y3)	Test 16	X1-H0X0	X1-H0X0 Short (Y1-Y2)
	Test 17	X2-H0X0	
	Test 18	X3-H0X0	

H1: HV Terminal; X1: IV Terminal; H0X0: Neutral

In case of Shunt Reactor, FRA to be done in following combinations:

- H1-H0
- H2-H0
- H3-H0

17. Tank Tests

i. Oil Leakage Test

All tanks and oil filled compartments shall be completely filled with oil of a viscosity not greater than that of insulating oil conforming to IEC 60296 at the ambient temperature and subjected to a pressure equal to normal head of oil plus 35 kN/sq.m (5 psi) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil during which no leakage shall occur. Pressure may slightly vary with ambient temperature change during 12 hours.

ii. Vacuum Test

All transformer tanks shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 KN/Sq.m absolute (25 torr) for one hour. The permanent deflection of flat plate after the vacuum has been released shall not exceed the values specified below:

Horizontal Length of flat plate (in) mm	Permanent deflection (in mm)
Up to and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
Above 3000	19.0

iii. Pressure Test

All transformer tanks, its radiator, conservator and other fittings together or separately shall be subjected to a pressure corresponding to twice the normal head of oil or normal oil head pressure plus 35 KN/sq.m whichever is lower, measured at the base of the tank and maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

18. Appearance, construction and dimension check

At Complete assembled transformer, Dimensions, fittings/accessories, clearances shall be verified in line with approved General Arrangement drawing, Bill of material, drawings of other accessories (OLTC, Bushing, Online DGA, Drying system, Buchhoolz relay, PRD, SPR, OTI, WTI, etc. as applicable).

19. Dynamic Short circuit withstand Test

19.1 Reference Standard: IEC 60076-5 (Latest Standard)

19.2 The tests shall be carried out on a new transformer ready for service. Protection accessories, such as gas-and-oil-actuated relay and pressure-relief device, shall be mounted on the transformer during the test. However, Detachable type cooler bank may not be required to install during short circuit test.

19.3 Prior to the short-circuit tests, the transformer shall be subjected to the routine tests and type tests as per POWERGRID specification (including routine tests which are specified in IEC 60076-1). If the windings are provided with tappings, the reactance and, if required, also the resistance shall be measured for the tapping positions at which short-circuit tests will be carried out. All the reactance measurements shall be to a repeatability of better than ±0.2 %. A report containing the result of the routine tests shall be available at the beginning of short-circuits tests.

Manufacturers shall compare the reactance measured at short circuit test lab with the value measured at their manufacturing works before proceeding to short circuit test.

19.4 At the beginning of short-circuit tests, the average temperature of the oil/winding shall preferably be between 10 °C and 40 °C (see 4.2.2.3 of IEC 60076-5).

19.5 During the tests, winding temperature may increase owing to the circulation of the short-circuit current. This aspect shall be taken into consideration when arranging the test circuit for transformers of category I.

19.6 **Test current peak value $\hat{\imath}$ for two-winding transformers**

The test shall be performed with current holding maximum asymmetry as regards the phase under test. The amplitude $\hat{\imath}$ of the first peak of the asymmetrical test current is calculated as follows:
$\hat{\imath} = I \cdot k \cdot \sqrt{2}$, where *I* the is symmetrical short-circuit current (see 4.1.2 of IEC 60076-5).
The factor *k* accounts for the initial offset of the test current and $\sqrt{2}$ accounts for the peak to-r.m.s. value of a sinusoidal wave. The factor $k\sqrt{2}$, or peak factor, depends on the ratio *X/R*

Where, *X* is the sum of the reactances of the transformer and the system (Xt + Xs), in ohms (Ω); *R* is the sum of resistances of the transformer and the system (Rt + Rs), in ohms (Ω), where Rt is at reference temperature (see 10.1 of IEC 60076-1).

In the case *X/R* >14 the factor $k \cdot \sqrt{2}$ is assumed to be equal to

$1.8\sqrt{2} = 2.55$ for transformers of category II;

$1.9\sqrt{2} = 2.69$ for transformers of category III.

19.7 **Tolerance on the asymmetrical peak and symmetrical r.m.s. value of the short-circuit test current**

If the duration of the short-circuit test is sufficiently long, the asymmetrical current having first peak amplitude î will change into the symmetrical current having r.m.s. value I (see 4.1.2 of IEC 60076-5). The peak value of the current obtained in testing shall not deviate by more than 5 % and the symmetrical current by more than 10 % from the respective specified value. However any positive tolerance may be acceptable subject to meeting the other requirements as per IEC.

The short-circuiting of the winding may either follow (post-set short circuit) or precede (pre-set short circuit) the application of the voltage to the other winding of the transformer.

If the post-set short circuit is used, the voltage shall not exceed 1.15 times the rated voltage of the winding

19.8 In order to avoid injurious overheating, an appropriate time interval (minimum 15 minutes between two consecutive shots) shall occur between successive overcurrent applications.

19.9 In order to check the values î and I of the test currents, oscillographic records shall always be taken.

19.10 The frequency of the test supply shall be, in principle, the rated frequency of the transformer.

19.11 Test connection shall be followed as per Clause 4.2.5.4 of IEC 60076-5.

19.12 The number of tests on three-phase and single-phase transformers is determined as follows, not including preliminary adjustment tests carried out at less than 70 % of the specified current to check the proper functioning of the test set-up with regard to the moment of switching on, the current setting, the damping and the duration.

19.13 For categories I, II & III single-phase transformers, the number of tests shall be three. The three tests on a single-phase transformer with tappings are made in a different position of the tap-changer, i.e. one test in the position corresponding to the highest voltage ratio, one test on the principal tapping and one test in the position corresponding to the lowest voltage ratio.\

19.14 For categories I, II & III three-phase transformers, the total number of tests shall be nine, i.e. three tests on each phase. Unless otherwise specified, the nine tests on a three-phase transformer with tappings are made in different positions of the tap changer, i.e. three tests in the position corresponding to the highest voltage ratio on one of the outer phases, three tests on the principal tapping on the middle phase and three tests in the position corresponding to the lowest voltage ratio on the other outer phase (manufacturer may change sequence).

19.15 For particular winding combination (HV-IV, HV-LV or HV-LV) number of shots shall be as per the following:

– for single-phase transformers: three;

– for three-phase transformers: nine.

19.16 For Tertiary winding dynamic short circuit shall be carried out either on HV-LV or IV-LV combination, whichever draws higher short circuit current as per calculation.

19.17 The duration of each test shall be 0.5 s for transformers of category I & 0.25 s for transformers of categories II and III, with a tolerance of ±10 %.

19.18 Detection of faults and evaluation of test results including acceptance criteria shall be followed as Clause 4.2.7 of IEC 60076-5. However, variations of short-circuit reactance (Acceptable limit) values shall be as per the following :

19.18.1 Transformers of categories I and II

2% for transformers with circular concentric coils and sandwich non-circular coils. However, for transformers having metal foil as a conductor in the low-voltage winding and with rated power up to 10 000 kVA, higher values, not exceeding 4 %,are acceptable for transformers with a short-circuit impedance of 3 % or more.

7,5 % for transformers with non-circular concentric coils having a short-circuit impedance of 3 % or more.

19.18.2 Transformers of categories III

The short-circuit reactance values, in ohms, evaluated for each phase at the end of the tests do not differ from the original values by more than 1 %.

Detail information pertaining to sort circuit test shall be furnished as per the format attached in Annexure-A.

ANNEXURE-A

Sr. No.	Parameters	Data
1	MVA Rating	
2	Phase	
3	Voltage Rating	
4	Tapping Range & Variation	
5	Fault MVA	
6	Fault Current	
7	Short circuit current feed to HV/LV	*Ex. From HV side for HV-IV Combination* *From LV side for HV-LV combination*

Tap Position	Maximum Voltage Tap	Normal Voltage Tap	Minimum Voltage Tap
Combination		HV-IV	
Short circuit method (Pre/Post short circuit connection)			
Precaution for saturation of the magnetic core / inrush of magnetizing current considered or not			
Transformer Impedance at Base MVA			
System Impedance			
Symmetrical short circuit current (Feeding current)			
$k.\sqrt{2}$ Value			
Asymmetrical short circuit current			
No of Shots			
Combination		IV-LV	
Short circuit method (Pre/Post short circuit connection)			
Precaution for saturation of the magnetic core / inrush of magnetizing current considered or not			
Transformer Impedance at Base MVA			
System Impedance			
Symmetrical short circuit current (Feeding current)			
$k.\sqrt{2}$ Value			
Asymmetrical short circuit current			
No of Shots			

20. Short time over voltage Test (830kVrms)

The test duration is 5 minutes at rated frequency. When the test frequency exceeds the rated frequency, the test time in seconds of the test shall be:

300 × rated frequency / test frequency

21. Shunt reactor loss measurement & temperature rise test

Reference Standard:

IEC 60076-6:2007 Clause 7.8.6 & Annex D (Temperature correction of losses for liquid-immersed gapped-core and magnetically-shielded air-core reactors)

Losses are based on reactor operation with rated current at rated frequency and at reference temperature. Measured losses shall be corrected to rated current and reference temperature.

For three-phase reactors, the measurement of loss shall be performed under three-phase excitation and loss shall be measured phase wise.

Method

Reactor shall be assembled with all accessories, cooling system as per approved GA drawing (Unit being offered for Type test). No deviation shall be accepted. The tests shall be done for a minimum of 24 hours with saturated temperature for at least 4 hours. DGA tests shall be performed before and after heat run test and DGA results shall generally conform to IEC61181. Please also refer temperature rise test procedure of transformer.

Full details of the test arrangements, procedures and conditions shall be provided with the test certificates and the following shall at least be included.

All the parameters as per specification shall be measured and recorded.

After completion of temperature rise test (24 hours) hot resistance shall be measured. During this period of hot winding resistance measurement, preparation for loss measurement at hot state shall be made. After completion of resistance measurement (atleast for 20 minutes) connection shall be made for loss measurement at hot state. During this complete process oil temperature shall be recorded.

Calculation methodology:

Average oil temperature at cold state:	θ_c
Top oil temperature after 24 hours:	θ_1
Average winding temperature at shut-down (measured by resistance):	θ_2
Difference between Average winding & Top oil temperature:	$\theta_2 - \theta_1$

Rated voltage shall be supplied during hot loss measurement. The supply shall continue for at least 30 minutes and subsequently loss shall be measured.

Top oil temperature during loss measurement: $\theta_{3\ (U,\ V,W)}$

Average winding temperature during loss measurement: $\theta_4 = \theta_3 + (\theta_2 - \theta_1)$

Calculation of Temperature co-efficient phase wise
Following parameters shall be measured during Loss measurement;

Rated Voltage KV	Current $I_{measured}$ A		Loss (Measured or calculated)		Top Oil Temperature $\theta_{3\ (U,\ V,W)}$		Tan Delta	
	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot
90%								
100%								
110%								

Loss measured at cold state: W_c

Cold Loss t atedacurrent: $W_{cr} = W_c \times (I_{rated}/I_{measured})^2$

Loss measured at hot state: W_h

Hot Loss at rated current: $W_{hr} = W_h \times (I_{rated}/I_{measured})^2$

Establishing the temperature coefficient of loss for individual phase:
$\Delta P\text{tot} / \Delta\theta = (W_{hr} - W_{cr})\ \text{kW} / (\theta_4 - \theta_c)\ °\text{C} = \alpha\ \ \text{kW} / °\text{C}$

Recalculation to reference temperature 75 °C with temperature coefficient:
$P\text{tot}\ (75\ °\text{C}) = P\text{tot}\ (\theta_4) + \alpha\ (75 - \theta_4)\ °\text{C}$

The same process shall be followed for other 2 phases for calculation of temperature coefficient of individual phase.

Measurement of loss on a second identical unit at ambient temperature (routine test):

Measured mean oil temperature at cold state: θt
Loss easumed at old tate: s W_c
Cold Loss at rated current Ptot (θt): °C $W_c \times (I_{rated}/I_{measured})^2$

Total losses, Ptot (Measured)	I^2R loss (at rated current)	Additional losses
Ptot (θt °C) = $W_1 + W_2$	W_1 (Calculated)	W_2 (Calculated)

Re-calculation to reference temperature 75 °C with temperature coefficient derived after temperature rise test:

$\text{Ptot}\ (75\ °\text{C}) = \text{Ptot}\ (\theta t\ °\text{C}) + \alpha \times (75 - \theta t)\ °\text{C}$

The loss shall be calculated for each phase at reference temperature (75 Deg C) and shall be added for total losses of all three phases. This value is the measured loss value against the guaranteed loss value for the second identical unit.

Check Points:

Inputs like – Value of Standard Capacitor, constants, scaling factors, ratio errors, phase angle errors etc. to the loss measuring instrument shall be as per the latest calibration certificate.

22. Two hours excitation test

a) Each reactor to be excited at Um for 2 hours except type tested unit.
b) Measure Vibration at Um and 1.05Um
c) DGA rate interpretation shall be as per IEC/ CIGRE/ IEEE guidelines
d) Test shall be performed before partial discharge test
e) Reactance & Loss measurement shall be carried out after completion of the above test to check the healthiness of the reactor

23. Stress measurement

After all dielectric test reactor shall be energized and Stress will be measured at one point (please refer specification for no. of points) of each wall where vibration reordered is maximum. Measurement shall be carried out at Um and 1.05Um voltage.

24. Measurement of harmonic content of current (Measured in Cold state) - Reactor

The harmonics of the current in all three phases are measured at rated voltage, by means of a harmonic analyser. The magnitude of the relevant harmonics is expressed as a percentage of the fundamental component. For more information on the magnetic characteristic, see Annex B of IEC 60076-6. The harmonics of the applied voltage shall be adequately measured at the same time.

25. Knee point voltage measurement of reactor (Measured in Cold state)

The test shall be carried out as per IEC 60076-6 clause B.7.1 “DC current charging – discharging method (theory)” or applying AC voltage from 0.7p.u, 0.8p.u, 0.9p.u and so on upto the level as per specification and measure the current at various voltages and calculate the tolerance of reactance as per annexure-A of this specification.

26. Standards:

IEC Standards	Latest IEC
Power transformers - Part 1: General	Edition 3.0 2011 -04
Power transformers - Part 2: Temperature rise for liquid-immersed transformers	Edition 3.0 2011-02
Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air	Edition 3.1 2018-03
Power transformers - Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors	First edition 2002-06
Power transformers - Part 5: Ability to withstand short circuit	Third edition 2006-02
Power transformers - Part 6: Reactors	Edition 1.0 2007-12
Power transformers - Part 7: Loading guide for mineral-oil-immersed power transformers	Edition 2.0 2018-01
Power transformers - Part 8: Application guide	First edition 1997-10
Power transformers - Part 10: Determination of sound levels	Edition 2. 0 201 6 -03
Power transformers - Part 14: Liquid-immersed power transformers using high-temperature insulation materials	Edition 1.0 2013-09
Power transformers - Part 18: Measurement of frequency response	Edition 1.0 2012 -07
Power transformers - Part 19: Rules for the determination of uncertainties in the measurement of losses in power transformers and reactors	Edition 1.0 2013-03

Check Lists for Transformer & Reactor Tests

Sr. No.	Test	Acceptance Criteria*	Check list (✓ if conducted)
1.	Measurement of insulation power factor and capacitance between winding and earth and Bushings	Insulation power factor for windings < 0.5% Insulation power factor for Bushing as per GTP/TS	
2.	Measurement of insulation resistance & Polarization Index	PI > 1.3	
3.	Core assembly dielectric and earthing continuity test	IR >1 GΩ	
4.	Measurement of winding resistance	As per GTP	
5.	Full wave & Chopped lightning impulse test for the line terminals (LI & LIC) and Neutral (LI)	Refer procedure	
6.	Switching impulse test for the line terminal (SI)		
7.	Applied voltage test (AV)	No collapse of voltage or other sign of breakdown	
8.	Induced voltage withstand test (IVW)		
9.	Induced voltage test with PD measurement (IVPD)	Refer procedure	
10.	Temperature rise test	As per GTP/ TS	
11.	Measurement of acoustic noise level	As per GTP/ TS	
12.	High voltage with stand test on auxiliary equipment and wiring after assembly	No voltage collapse or other sign of breakdown	
13.	Frequency Response analysis (Soft copy of test report to be submitted to site along with test reports)	For record	
14.	Oil leakage test on transformer/ Reactor tank	No oil leakage	
15.	Tank vacuum test	Refer procedure	
16.	Tank pressure test	Refer procedure	
17.	Appearance, construction and dimension check	Dimensions measured shall match with approved GA drawing	

(*) Acceptance criteria to be read in conjunction with applicable Technical Specification

Check lists for additional tests applicable only for Transformer

Sr. No.	Test	Acceptance Criteria*	Check list (√ if conducted)
1.	Voltage ratio measurement & Polarity check (Vector Group)	≤0.5% as per IEC 60076-1 for Voltage ratio. Vector group as per specification.	
2.	Measurement of no load current & Short circuit Impedance with 415 V, 50 Hz AC	For record	
3.	No-load loss and current measurement	As per GTP / TS	
4.	Measurement of harmonic level in no load current	For record	
5.	Magnetic balance test (for three phase Transformer only)	Refer procedure	
6.	On-load tap changer test	Refer procedure	
7.	Measurement of short-circuit impedance and load loss	As per GTP/ TS	
8.	Line terminal AC withstand voltage test (LTAC)	No collapse of voltage or other sign of breakdown	
9.	Measurement of transferred surge on LV or Tertiary as applicable due to HV lightning impulse and IV lighting impulse (as applicable)	Refer procedure	
10.	Overload testing in short-circuit method	Refer procedure	
11.	Short duration heat run test (Not Applicable for unit on which temperature rise test is performed)	Refer procedure	
12.	Over excitation test	Refer procedure	
13.	Measurement of Zero seq. reactance (for three phase Transformer only)	As per GTP/ TS	
14.	Measurement of power taken by fans and oil pumps (Not applicable for ONAN)	As per GTP/ TS	
15.	Dynamic Short circuit withstand test (If specified in BPS)	Refer procedure	

Check lists for additional tests applicable only for Reactor

Sr. No.	Test	Acceptance Criteria*	Check list (√ if conducted)
1.	Short time over voltage Test (830kVrms) (765kV Reactor)	No voltage collapse or other sign of breakdown	
2.	Reactance and loss measurement (Measured in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units)	As per GTP/ TS	
3.	2-Hour excitation test except type tested unit	Refer procedure	
4.	Vibration & stress measurement in Cold and Hot state for the unit on which temperature rise test is performed & in Cold state for all other units (Measurement shall also be carried out at 1.05Ur for reference only on one unit of each type)	As per GTP/ TS	
5.	Measurement of harmonic content of current (Measured in Cold state)	As per TS	
6.	Knee point voltage measurement of reactor (Measured in Cold state)	As per GTP/ TS	

(*) Acceptance criteria to be read in conjunction with applicable Technical Specification

MODEL TECHNICAL SPECIFICATION

SECTION: LT TRANSFORMER

SECTION: LT TRANSFORMER

Table of contents

SECTION: LT TRANSFORMER

1.0 SCOPE

1.1 This specification covers design, engineering, manufacture, testing, delivery at site including all materials, accessories, spares, Transportation inclusive of insurance and delivery FOR site basis, unloading, handling, proper storage at site, erection, testing and commissioning of the equipment specified.

2.0 Fittings

The following fittings shall be provided with each transformer covered under this specification:

i) Conservator with drain plug and oil filling hole with blanking plate
ii) Plain oil Gauge
iii) Silica gel Breather
iv) Pressure Relief vent
v) Pocket on tank cover for Thermometer
vi) Valves
vii) Earthing Terminals
viii) Rating & Terminal Marking Plates
ix) Lifting Lugs
x) Rollers
xi) Air Release Plug

The fittings listed above are only indicative and any other fittings which generally are required for satisfactory operation of transformer are deemed to be included.

3.0 General Information

3.1 All temperature indicators, Buchholz relays and other auxiliary devices shall be suitable for 220 V/110V (as applicable) DC Control supply. All alarm and trip Contacts shall also be suitable for connection in 220V/110V DC Circuits.

3.2 Transformers offered shall conform to dynamic short circuit test and dielectric test as per IS-2026. Test report for the same shall be submitted during detail engineering for approval of EMPLOYER.

4.0 TECHNICAL REQUIREMENTS

4.1 Core

The core shall be constructed from high grade, non-aging, cold rolled grain-oriented (conventional or better) silicon steel laminations. The maximum flux density in any part of the cores and yoke at rated voltage and frequency shall be such that the flux density with +12.5% combined voltage and frequency variation from rated voltage and frequency shall not exceed 1.9 Tesla.

4.2 **Windings**

The conductor shall be of electrolytic copper, free from scales and burrs.

4.3 **Insulating Oil**

The oil supplied with transformer shall be unused and shall have the parameters conforming to IS:335 while tested at oil Contractor's premises, No inhibitors shall be used in oil.

4.4 **Terminal Arrangement**

a) Bushing terminals shall be provided with suitable terminal connectors of approved type and size for cable/overhead conductors termination of HV side and cable termination on LV side.

b) The neutral terminals of 433V winding shall be brought out on a bushing along with the 433 volt phase terminals to form a 4 wire system. Additional neutral bushing shall also be provided for earthing.

4.5 **Off Circuit Tap Changing Equipment**

The tap change switch shall be three phase, hand operated for simultaneous switching of similar taps on the three phases by operating an external hand wheel.

4.6 **Marshalling Box**

A metal enclosed (Stainless steel of minimum 1.5 mm thickness), weather, vermin & dust proof marshalling box shall be provided with each transformer to accommodate temperature indicators, terminal blocks etc. It shall have a degree of protection of IP 55 as per IS: 13947Part-1.

4.7 **Cable boxes**

Whenever cable connections are required, suitable cable boxes shall be provided and shall be air insulated. They shall be of sufficient size to accommodate Purchaser's cables and shall have suitable removable side/top cover to facilitate cable termination and inspection. Cable boxes shall be dust & vermin proof.

5.0 Inspection and Testing

The Contractor shall draw up and carry out a comprehensive inspection and testing program during manufacture and commissioning of the transformer.

5.1 Inspection

All stage inspection checks (Raw material) and In-process checks need to be carried out in line with approved MQP of POWERGRID

5.1.1 Assembled Transformer

a) Check complete transformer against approved outline drawing provision for all fittings, finish etc.

b) Jacking test on all the assembled transformers.

5.1.2 Oil

All standard tests in accordance with relevant Standards shall be carried out on oil samples taken from the transformer before and after testing of the transformer.

5.1.3 Fittings:

All sub-contracted items shall be sourced from POWERGRID approved vendors as listed in Compendium of Vendors (COV) of POWERGRID. The contractor shall also prepare a comprehensive inspection and testing programme for all bought out sub-contracted items. Such programme shall include the following components:

a) Buchholz Relay
b) Winding temperature Indicator
c) Bushings
d) Marshaling Box
e) Tap changer switch
f) Oil temperature indicator
g) Magnetic Oil gauge
h) Pressure Relief valve or explosion vent
i) Silica gel breather assembly
j) Oil conservator tank

5.2 Testing (Factory Test)

5.2.1 All standard routine tests in accordance with latest issue of IS : 2026 shall be carried out on each transformer.

5.2.2 All auxiliary equipment shall be tested as per the relevant **Indian Standard** (IS)

5.2.3 High voltage withstand test shall be performed on auxiliary equipment and wiring after complete assembly.

5.2.4 **Tank Tests**:
Following tests (as routine test) shall be performed on tank as per 'CBIP manual on Transformers':

i) Vacuum Tests
ii) Pressure Test

5.2.5 **Type Tests**:

The transformer shall conform to all the type tests including following special test (as type test) in accordance with latest issues of IS : 2026 :

a) Measurement of zero sequence impedance
b) Short circuit test
c) Measurement of acoustic noise level. This shall conform to NEMA standard publication TR-1.
d) Measurement of capacitance and tan delta of transformer winding

The manufacturer shall submit type tests & special test reports as listed above, already carried out on transformers of identical design for EMPLOYER's acceptance. In such a case validity of type test reports shall be in line with clause 9.2 of Sec-GTR of technical specifications. Following parameters in general shall be ensured for establishment of identical design as per IEC 60076, Part-V.

a) Same Voltage ratio, KVA rating, vector group & impedance.
b) Same conceptual design of core and winding.
c) Same arrangement and geometrical sequence of the main windings.
d) Same type of winding conductors with proper covering
e) Same type of internal clearances, core, winding dimension
f) Same type of main windings.
g) Absorbed power at short circuit (i.e. rated power/per unit short circuit impedance) between 30% and 130% of that relating to the reference transformer.
h) Same manufacturing process.
i) Same Clamping and winding support arrangement..

5.3 In addition to the above, the following checks should be carried out at manufacturer's works before despatch for all transformers:

a) Check for interchangeability of components of similar transformers and for mounting dimensions.

b) Check for proper packing and preservation of accessories like radiators, bushings explosion vent, dehydrating breather, Buchholz relay, conservator etc.

c) Check for proper provision of bracings to arrest the movements of core and winding assembly inside the tank.

d) Test for gas tightness and derivation of leakage rate. To ensure adequate reserve gas capacity during transit and storage.

5.4 **Site Testing:**

The indicative checks and tests at site are given below:

a) Physical checks on each transformer on receipt at site for any damage or short supply.
b) Tests on oil samples
c) Oil leakage test
d) Physical checks for colour of silica in breather
e) Check for oil level in breather housing, conservator tank, etc.
f) Check for correct operation of all protections and alarms.
g) Insulation Resistance Measurement for Main Winding, control wiring etc.
h) Continuously observe the transformer operation at no load for 24 hours.

6.0 The major technical parameters of LT Transformer is defined at **Annexure - A**

ANNEXURE-A

Technical Parameters

S. N.	Description	Unit	Parameters						
1	Rated Capacity	kVA	250	315	630	800	315	630	800
2	Rated Voltage								
a)	HV	kV	11	11	11	11	33	33	33
b)	LV	kV	0.433	0.433	0.433	0.433	0.433	0.433	0.433
3	Standard		IS 1180 & IS 2026						
4	Type of Winding		Two Winding						
5	Service		Outdoor						
6	No of Phases	No.	Three						
7	Frequency	Hz	50						
8	Type of Cooling		ONAN	ONAN	ONAN	ONAN	ONAN	ONAN	ONAN
9	Impedance at 75 Deg C (Minimum)	%	4.5	4.5	4.5	5	5	5	5
10	Tolerance on Impedance	%	±10	±10	±10	±10	±10	±10	±10
11	Duty		Continuous						
12	Overload		IS 2026						
13	Max. Temp. Rise over an ambient of 50 Deg C								
a)	Oil (Temperature rise measurement by thermometer)	$^{\circ}C$	40						
b)	Winding Temperature rise measurement by resistance method)	$^{\circ}C$	45						
14	Windings								
a)	System Apparent Short circuit level (kA)		As per IS 2026-Part 1						
b)	Winding Connection								
(i)	HV		Delta	Delta	Delta	Delta	Delta	Delta	Delta
(ii)	LV		Star	Star	Star	Star	Star	Star	Star
15	Vector Group		Dyn1						

S. N.	Description	Unit	Parameters						
16	Insulation		Uniform						
17	Insulation Level	kVrms							
a)	Power Frequency Test Level								
(i)	HV	kVrms	28	28	28	28	95	95	95
(ii)	LV	kVrms	2						
18	Basic Impulse Level								
(i)	HV	kVp	75	75	75	75	250	250	250
(ii)	LV	kVp	-	-	-	-	-	-	-
19	Highest voltage (kV) for each winding	kV	12	12	12	12	52	52	52
20	Method of earthing		Solidly earthed						
21	Tap changer								
a)	(i) Tap Change		+5% to -10% in step of 2.5% on HV side						
b)	(ii) Tap control		Off Circuit Tap Change Switch						
22	HV Bushing								
a)	Rated Voltage	kV	12	12	12	12	52	52	52
b)	Rated current	A	100	100	100	100	100	100	100
c)	Basic Impulse Level (kVp)	kVp	75	75	75	75	250	250	250
d)	Wet & Dry Power frequency Withstand Voltage	kVrms	28	28	28	28	95	95	95
e)	Min. Total Creepage Distance	mm	300	300	300	300	1300	1300	1300
f)	Mounting		Tank / Transformer Body						
23	LV & Neutral Bushing								
a)	Rated Voltage	kV	1	1	1	1	1	1	1
b)	Rated current	A	630	630	1000	2000	630	1000	2000
c)	Wet & Dry Power frequency Withstand Voltage	kVrms	5	5	5	5	5	5	5
d)	Mounting		Tank / Transformer Body						
24	Terminal Details								

S. N.	Description	Unit	Parameters						
a)	HV		Suitable for 11kV Cable or Over Head Conductor				Suitable for 33kV Cable or Over Head Conductor		
b)	LV & Neutral		Cable Box						
25	Min. Clearance in Air and cable box								
a)	Ph-Ph (HV/LV)	mm	**As per IS: 1180**						
b)	Ph-Earth (HV/LV)	mm	**As per IS: 1180**						
26	Rated Short Circuit Current	kA	**25 kA for 3 second**						
27	**Maximum Permissible Loss* (No-Load+load loss at 75° C)**	**Rating (KVA)**	**250**	**315**	**630**	**800**	**315**	**630**	**800**
i)	**50% Load***	**kW**	**0.920**	**0.955**	**1.745**	**2.147**	**1.026**	**1.875**	**2.308**
ii)	**100% Load***	**kW**	**2.7**	**2.750**	**4.850**	**5.837**	**2.956**	**5.213**	**6.274**

*** LT Transformer losses shall not exceed the value specified above (at 50 % and/or 100 % loads), failing which, the LT Transformer shall be rejected.**

SECTION: STRUCTURE

Table of contents

SECTION: STRUCTURES

1.0 GENERAL

The scope of specification covers fabrication, proto-assembly, supply and erection of galvanised steel structures for towers, beams, lightning masts and equipment support structures. If specified in section – Project, design of steel structure shall also be in the scope of contractor. The structures shall be of pipe type or lattice type as per Bid Proposa Sheet. Lattice structures shall be fabricated from structural steel conforming to IS: 2062 (latest). All pipe structures shall be fabricated from GI pipe conforming to YST 22 or of higher grade as per IS 806.

Line diagrams of Towers, beams, Lightning masts, equipment support structures are enclosed with the tender document. The fabrication drawings along with BOMs for these structures shall be provided to the successful bidder after the award. However structure, which are to be designed at detailed engineering stage by the employer, only line diagram shall be provided by POWERGRID and fabrication drawing shall be prepared by the Contractor. Support structure for circuit breaker shall be designed by the Manufacturer. Any other structure necessary to suit the layout for a particular substation to complete the work in all respect shall be designed by the employer / contractor at detailed Engineering stage.

Equipment support structure standardization has been carried out by the employer with the provision of stool to facilitate interchangeability of equipments at a later stage. Stools shall be provided by the Contractor between the equipment and its support structure to match the bus bar height. The top of stool shall be connected to the equipment and the bottom of the stool shall be connected to the Base support structure.

The scope shall include supply and erection of all types of structures including bolts, nuts, washers, step bolts, inserts in concrete, gusset plates, equipment mounting bolts, structure earthing bolts, foundation bolts, spring washers, fixing plates and any other items as required to complete the job.

The connection of all structures to their foundations shall be with base plates and embedded anchor/foundation bolts. All steel structures including anchor/foundation bolts shall be fully galvanized. The weight of the zinc coating shall be at least 610 gm/sq.m. Zinc coating for costal areas, if defined in section – Project shall not be less than 900gm/sq.m

Suitable modification shall be carried out in the drawings of equipment support structures by the Contractor in order to suit fixation of accessories such as marshalling boxes, MOM boxes, Control Cabinets, Junction box, surge counter, etc. in the standard structure fabrication drawings. Nothing extra shall be payable or recoverable from the contractor on account of modification in support structures.

2.0 DESIGN REQUIREMENTS FOR STRUCTURES (To be referred only for structures to be designed by the Contractor)

2.1 For design of steel structures loads such as dead loads, live loads, wind loads etc. shall be based on IS:875,Parts I to V.

2.2 For materials and permissible stresses IS: 802, Part-I, Section-2 shall be followed in general. However, additional requirements given in following paragraphs shall also be considered.

2.3 Minimum thickness of galvanized tower member shall be as follows:

Members	**Minimum thickness (mm)**
Leg members, Ground wire Peak members/Main members	5
Other members	4
Redundant members	4

Size and thickness of gusset plate, pack washer and pack plate shall be as per requirement.

2.4 Maximum slenderness ratios for leg members, other stressed members and redundant members for compression force shall be as per IS-802.

2.5 Minimum distance from hole center to edge shall be 1.5 x bolt diameter. Minimum distance between center to center of holes shall be 2.5 x bolt diameter.

2.6 All bolts shall be M16 or higher as per design requirement.

2.7 Step Bolts

In order to facilitate inspection and maintenance, the structures shall be provided with climbing devices. Each tower shall be provided with M16 step bolts 175mm long spaced not more than 450mm apart, staggered on faces on one leg extending from about 0.5 meters above plinth level to the top of the tower. The step bolt shall conform to IS: 10238.

2.8 **Design Criteria**

a) All structures shall be designed for the worst combination of dead loads, live loads, wind loads as per code IS:875, seismic forces as per code IS:1893, loads due to deviation of conductor, load due to unbalanced tension in conductor, torsional load due to unbalanced vertical and horizontal forces, erection loads, short circuit forces including "snatch" in the case of bundled conductors etc. Short circuit forces shall be calculated considering a fault level of 40 kA, 50kA, 63kA or as applicable. IEC-60865 may be followed for evaluation of short circuit forces.

b) Switchyard gantry structures shall be designed for the two conditions i.e. normal condition and short circuit condition. In both conditions the design of all structures shall be based on the assumption that stringing is done only on one side i.e. all the three (phase) conductors broken on the other side.
Factor of safety of 2.0 under normal conditions and 1.5 under short circuit condition shall be considered for the design of switchyard structures.

c) Vertical load of half the span of conductors/string and the earth wires on either side of the beam shall be taken into account for the purpose of design. Weight of man with tools shall be considered as 150 kgs. for the design of structures.

d) Terminal/line take off gantries shall be designed for a minimum conductor tension of 9 metric tonnes per phase for 765kV, 4 metric tonnes per phase for 400kV, 2 metric tonnes per phase for 220kV and 1 metric tonne per phase for 132 kV or as per requirements whichever is higher . The distance between terminal gantry and dead end tower shall be taken as 200 metres for 765/400/220kV and 100m for 132KV. The design of these terminal gantries shall also be checked considering +/- 30 deg deviation of conductor in both vertical and horizontal planes. For other gantries the structural layout requirements shall be adopted in design.

e) The beams shall be connected with towers/ columns by bolted joints.

f) All Pipe support structures used for supporting equipments shall be designed for the worst combination of dead loads, erection load. Wind load/seismic forces, short circuit forces and operating forces acting on the equipment and associated bus bars as per IS:806. The material specification shall be as per IS: 1161 read in conjunction with IS: 806.

g) If luminaries are proposed to be fixed on gantries, then the proper loading for the same shall be considered while designing. Also holes for fixing the brackets for luminaries should be provided wherever required.

h) Foundation bolts shall be designed for the loads for which the structures are designed.

i) Height of Lightning masts shall be as per approved structure layout and designed for diagonal wind condition. Lightning masts shall be provided with plateforms for mounting lighting fixtures and a structural steel ladder within its base up to the level of plateform. The ladder shall be provided with protection rings. The platforms shall also have protection railing. The details of lighting fixtures would be as per the approved drawings.

3.0 DESIGN DRAWINGS, BILL OF MATETRIALS AND DOCUMENTS

3.1 Structures, for which line diagram has already been provided along with tender documents, fabrication drawings (structure assembly drawing) along with Bill of Material shall be provided to the successful bidder after award based on which structures shall be supplied. Fabrication drawings issued to the contractor for any project shall be valid for other projects also if wind speed of the area is same. These drawings are also available on the POWERGRID web site and can be downloaded from the web site. Hard copies, if needed, can be obtained from employer. These drawings shall be good for fabrication and inspection of steel structures for any substation. Release for construction stamp for particular substation is not required. Replacing MS section with higher section or replacing MS section with HT section of same size due to non availability of particular section shall not require employer's approval and this can be done without any additional financial implication to the employer.

3.2 STRUCTURES DESIGNED DURING DETAILED ENGINEERING:

3.2.1 In case deisign of structure is to be done by employer, only line diagram of the structure shall be provided to the contractor and fabrication drawing shall be prepared by contractor based on line diagram and submitted for approval.

3.2.2 In case design of structure is covered in the scope of contract, the contractor shall submit design alongwith line diagram for approval and based on approved line diagram, fabrication drawing shall be prepared and submitted for employers'approval. The line diagram should indicate not only profile, but section, numbers and sizes of bolts and details of typical joints.

3.2.3 The fabrication drawings to be prepared and furnished by the Contractor shall be based on line diagram provided by employer or the design approved by the employer. These fabrication drawings shall indicate complete details of fabrication and erection including all erection splicing details and typical fabrication splicing details, lacing details, weld sizes and lengths. Bolt details and all customary details in accordance with standard structural engineering practice whether or not given by the employer. The fabrication drawings and bill of material based on fabrication drawing shall be submitted to the employer for approval. Approved bill of material prepared based on fabrication drawing shall be the basis for payment.

3.3 Such approval shall, however, not relieve the Contractor of his responsibility for the safety and durability of the structure and good connections and any loss or damage occurring due to defective fabrication, design or workmanship shall be borne by the Contractor.

4.0 FABRICATION AND ERECTION

4.1 The fabrication and erection works shall be carried out generally in accordance with IS 802. A reference however may be made to IS 800 in case of non-stipulation of some particular provisions in IS 802. All materials shall be completely shop fabricated and finished with proper connection material and erection marks for ready assembly in the field.

4.2 The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified camber, if any, is provided. In order to minimize distortion in member the component parts shall be positioned by using the clamps, clips, dogs, jigs and other suitable means and fasteners (bolts and welds) shall be placed in a balanced pattern. If the individual components are to be bolted, paralleled and tapered drifts shall be used to align the part so that the bolts can be accurately positioned.

4.3 Sample towers, beams, lightning masts and equipment support structures may be trial assembled in fabrication shop in order to ensure fitment of various members and to avoid problems during erection.

4.4 The Contractor should arrange on his own all plant and equipment, welding set, tools and tackles, scaffolding, trestles equipments and all other accessories and ancillaries required for carrying out erection without causing any stresses in the members which may cause deformation and permanent damage. Minor modification, if any, required during erection shall be done at site with the approval of Engineer – in- charge.

5.0 BOLTING

i) Every bolt shall be provided with a washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.
ii) In case of fasteners, the galvanizing shall confirm to IS-1367(Part 13). The spring washer shall be electro galvanized as per Grade IV of IS-1573.

6.0 WELDING

The work shall be done as per approved fabrication drawings which shall clearly indicate various details of joints to be welded, type of weld, length and size of weld, Symbols for welding on erection and shop drawings shall be according to IS:813. Welding shall be carried out in accordance with IS:816.

7.0 FOUNDATION BOLTS

7.1 Foundation bolts for the towers and equipment supporting structures shall be embedded in first stage concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate.

7.2 The Contractor shall be responsible for the correct alignment and leveling of all steel work on site to ensure that the towers/structures are plumb.

7.3 All foundation bolts for lattice structure, pipe structure are to be supplied by the Contractor.

7.4 All foundation bolts shall be provided with two no. standard nuts of class 5 confirming to IS:1363/1367/6639, one check nut of class 4 confirming to IS:1364, one anchore plate at the bottom of foundation bolt and one plain washer.

7.5 All foundation bolts shall conform to IS 5624, however, the material, shall be MS conforming to IS:2062/ SAE:1018.

8.0 STABILITY OF STRUCTURE

The Contractor shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations.

9.0 GROUTING

The method of grouting the column bases shall be subject to approval of employer and shall be such as to ensure a complete uniformity of contact over the whole area of the steel base plate. No additional payment for grouting shall be admissible.

10.0 GALVANISING

All structural steel works, equipment support structures and foundation bolts shall be galvanized after fabrication. The galvanization shall be done as per requirement of IS 4579. Purity of zinc to be used shall be 99.95% as per IS:209.

11.0 TOUCH-UP PAINTING

Minor defects in hot dip galvanized members shall be repaired by applying zinc rich primer and two coats of enamel paint to the satisfaction the employer before erection.

12.0 INSPECTION BEFORE DISPATCH

Each part of the fabricated steel work shall be inspected as per approved quality plans and certified by the employer or his authorized representative as satisfactory before it is dispatched to the erection site. Such certification shall not relieve the Contractor of his responsibility regarding adequacy and completeness of fabrication.

13.0 TEST CERTIFICATE

Copies of all test certificates relating to material procured by the Contractor for the works shall be submitted during inspection.

14.0 SAFETY PRECAUTIONS

The Contractor shall strictly follow at all stages of fabrication, transportation and erection of steel structures, raw materials and other tools and tackles, the stipulations contained in Indian Standard Code for Safety during erection of structural steel work-IS:7205.

15.0 All tests mentioned in standard field quality plans shall have to be carried out and conformity of materials and workmanship shall be ascertained.