



BHARAT HEAVY ELECTRICALS LIMITED TRANSMISSION BUSINESS ENGINEERING MANAGEMENT

COPYRIGHT AND CONFIDENTIALITY
The information on this document is the property of BHARAT HEAVY ELECTRICALS LTD.
It must not be used directly or indirectly in any way detrimental to the interest of the company

DOCUMENT No.	TB-343-510-147	Rev. No.	00	Prepared	Checked	Approved			
TYPE OF DOC.	TECHNICAL SPECIFICATION	NAME	FAA	VK	RS				
TITLE	AC FILTER CURRENT TRANSFORMER	SIGN	<i>[Signature]</i>	<i>[Signature]</i>	<i>[Signature]</i>				
		DATE	22-5-12	22-5-12	22/5/12				
		GROUP	TBEM	W.O. No	80014				
CUSTOMER	POWER GRID CORPORATION OF INDIA LIMITED (POWERGRID)								
PROJECT	±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR INTERCONNECTOR-I PROJECT								
CA No.	C-61901R-S056-8/CA-II/3660 dated 22.11.2011 for on-shore Supplies C-61901R-S056-8/CA-IV/3662 dated 22.11.2011 for Services								
STATION	AGRA, BISWANATH CHARIALI & ALIPURDUAR								
CONTENTS									
Section	Description					No. of Sheets			
1	SCOPE, SPECIFIC TECHNICAL REQUIREMENTS AND QUANTITIES					03			
2	Requirement Specification- AC Filter Current Transformers, Doc No IJNL100125-899 Rev03					14			
3	a) Requirement Specification- General Requirements for Main circuit Apparatus, Doc No IJNL100122-145 Rev03					31			
	b) Mechanical Requirements on Apparatus Terminals, Doc No IJNL100156-049 Rev01					04			
	c) General Technical Requirements, Doc No TB-343-316-000 Rev02					34			
4	Checklist (To be furnished during Tender stage)					03			
Rev No.	Date	Altered	Checked	Approved	REVISION DETAILS				
					Distribution	<i>TBCM/ TBMM</i>	<i>ABB</i>	<i>PGCIL</i>	<i>TBEM</i>
					Copies	2	2	3	1



±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT

AC Filter Current Transformer

Doc. No. : TB-343-510-147 Rev. 00

SECTION – 1

SCOPE, SPECIFIC TECHNICAL REQUIREMENTS AND QUANTITIES

1.1 SCOPE

This specification is intended to specify the requirements for design, engineering, manufacture, assembly, stage testing, inspection, testing before supply, packing, loading at works and transport to site of AC Filter Current Transformers along with its accessories as mentioned in this section and in various other sections of this specification for **± 800 KV, 6000 MW HVDC Multi-terminal System Package** comprising three Switchyards at Agra, Biswanath Chariali and Alipurduar.

In case of any conflict among the various sections of this specification, then the order of precedence shall be in the following order.

1. Scope, Specific Technical Requirements and Quantities
2. Requirement Specification- AC Filter Current Transformers, Doc No 1JNL100125-899 Rev03
3. - Requirement Specification- General Requirements for Main circuit Apparatus, Doc No 1JNL100122-145 Rev03
 - Mechanical Requirements on Apparatus Terminals, Doc No IJNL100156-049 Rev01
 - General Technical Requirements, Doc No TB-343-316-000 Rev02

1.2 PROJECT DETAILS

The equipment is required for the following project

Project title ±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT

Owner Power Grid Corporation of India Limited (POWERGRID)

Purchaser Bharat Heavy Electricals Limited (BHEL)

Refer Section – 3 for Project Details and General Specifications

1.3 BILL OF QUANTITY

SN	DESCRIPTION	UNIT	QUANTITY
1	BNC- 24kV Single Phase HP12 CT (GND CT)	Nos	9
2	BNC- 24kV Single Phase HP12B CT (GND CT)	Nos	9
3	BNC- 24kV Single Phase HP24/36 CT (GND CT)	Nos	12
4	BNC- 24kV Single Phase HP24/36 CT (L2 & R2 CT)	Nos	12
5	BNC- 24kV Single Phase HP3 CT (GND CT)	Nos	6
SN	DESCRIPTION	UNIT	QUANTITY



±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT

AC Filter Current Transformer

Doc. No. : TB-343-510-147 Rev. 00

6	BNC- 24kV Single Phase HP3 CT (R1 CT)	Nos	6
7	BNC- 24kV Single Phase HP3 CT (F1 CT)	Nos	6
8	BNC- 36kV Single Phase HP3 CT (C2 CT)	Nos	6
9	BNC- 24kV Single Phase Shunt Capacitor CT (GND CT)	Nos	6
10	Spares BNC- 24kV Single Phase GND CT	Nos	1
11	Spares BNC- 24kV Single Phase HP24/36 CT (L2 & R2 CT)	Nos	1
12	Spares BNC- 24kV Single Phase HP3 CT (R1 CT)	Nos	1
13	Spares BNC- 24kV Single Phase HP3 CT (F1 CT)	Nos	1
14	Spares BNC- 36kV Single Phase HP3 CT (C2 CT)	Nos	1
15	APD- 24kV Single Phase HP12 CT (GND CT)	Nos	9
16	APD- 24kV Single Phase HP12B CT (GND CT)	Nos	12
17	APD- 24kV Single Phase HP24/36 CT (GND CT)	Nos	12
18	APD- 24kV Single Phase HP24/36 CT (L2 & R2 CT)	Nos	12
19	APD- 24kV Single Phase HP3 CT (GND CT)	Nos	6
20	APD- 24kV Single Phase HP3 CT (R1 CT)	Nos	6
21	APD- 24kV Single Phase HP3 CT (F1 CT)	Nos	6
22	APD- 36kV Single Phase HP3 CT (C2 CT)	Nos	6
23	APD- 24kV Single Phase Shunt Capacitor CT (GND CT)	Nos	3
24	Spares APD- 24kV Single Phase GND CT	Nos	1
25	Spares APD- 24kV Single Phase HP24/36 CT (L2 & R2 CT)	Nos	1
26	Spares APD- 24kV Single Phase HP3 CT (R1 CT)	Nos	1
27	Spares APD- 24kV Single Phase HP3 CT (F1 CT)	Nos	1
28	Spares APD- 36kV Single Phase HP3 CT (C2 CT)	Nos	1
29	AGR- 24kV Single Phase Converter Transformer CT (F2 CT)	Nos	12
30	AGR- 24kV Single Phase HP12 CT (GND CT)	Nos	9
31	AGR- 24kV Single Phase HP12B CT (GND CT)	Nos	15
32	AGR- 24kV Single Phase HP24/36 CT (GND CT)	Nos	6
33	AGR- 24kV Single Phase HP24/36B CT (GND CT)	Nos	6
34	AGR- 24kV Single Phase HP24/36 CT (L2 & R2 CT)	Nos	6
35	AGR- 24kV Single Phase HP24/36B (L2 & R2 CT)	Nos	6
36	AGR- 24kV Single Phase HP3 CT (GND CT)	Nos	6
37	AGR- 24kV Single Phase HP3 CT (R1 CT)	Nos	6
38	AGR- 24kV Single Phase HP3 CT (F1 CT)	Nos	6
39	AGR- 36kV Single Phase HP3 CT (C2 CT)	Nos	6
40	AGR- 24kV Single Phase Shunt Capacitor CT (GND CT)	Nos	18
41	Spares AGR- 24kV Single Phase Converter Transformer CT (F2 CT)	Nos	1
42	Spares AGR- 24kV Single Phase GND CT	Nos	1
43	Spares AGR- 24kV Single Phase HP24/36 CT (L2 & R2 CT)	Nos	1



±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT

AC Filter Current Transformer

Doc. No. : TB-343-510-147 Rev. 00

SN	DESCRIPTION	UNIT	QUANTITY
44	Spares AGR- 24kV Single Phase HP3 CT (R1 CT)	Nos	1
45	Spares AGR- 24kV Single Phase HP3 CT (F1 CT)	Nos	1
46	Spares AGR- 36kV Single Phase HP3 CT (C2 CT)	Nos	1

Note: Hardware (Nut Bolts and Washers) for Mounting CT on structure – 1set for each CT.

BNC Stands for Biswanath Chariali
APD Stands for Alipurduar
AGR Stands for Agra

1.4 TYPE TEST

Bidder shall submit valid type test reports (as per relevant IEC/IS Standard) of the tests carried out within last five years from the date of bid opening (i.e. 30.06.2009). The report should have been conducted on identical or similar equipment/ components to those offered. In case type test reports are more than 5 years old (from the date of bid opening) OR the reports of type tests are found to be technically unacceptable, the type test shall be conducted without cost and delivery implication to BHEL.

1.5 DOCUMENTS REQUIRED WITH OFFER

1. Clause wise confirmation
2. General Arrangement Drawings
3. Valid Type Test Reports
4. Un-price schedule
5. Filled-in Checklist

SECTION-2

ABB

Requirement Specification

HVDC

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I		Document Number 1JNL100125-899 Rev. 03	No of Pages 14
			No of Attached Pages
Prepared Johan Mood, 2008-06-27		Title AC Filter Current Transformers	Reg./Class no. NEA-FE-072
Approved Anders Petersson, 2008-06-27	Resp Dept TSD		

This document is issued by means of a computerized system. The digitally stored original is electronically approved. The approved document has a name and date entered in the approved-field. A manual signature is not required.

Summary

Table of Contents

1	GENERAL	2
2	QUANTITIES	2
3	STANDARDS	3
4	TECHNICAL DATA	4
5	DESIGN.....	10
6	NAMEPLATES	11
7	ENVIRONMENT	11
8	QUALITY PROGRAM.....	12
9	ROUTINE TESTS	12
10	TYPE TESTS.....	13
11	VERIFICATIONS	14
12	ENCLOSURES	14
13	REFERENCES	14

3	Updated due to comments, see doc. 12TSD0197	Calle Svensson 2012-04-02	Lin Jiang 2012-04-26
Rev ind	Revision text	Prepared	Approved

We reserve all rights in this document and in the information contained herein. Reproduction, use or disclosure to third parties without expressed authority is strictly forbidden. ABB Power Technologies AB (SE)



1 GENERAL

This document constitutes the Requirement Specification for the ±800 kV, 6000 MW NER/ER – NR/WR Interconnector-1 HVDC Project (NEA800). The AC Current Transformers will be installed at Biswanath Chariali, Alipurduar and Agra converter stations.

The current transformers installed in the AC filters are used for protection purposes.

The equipment shall comply with the requirements in this specification and in General Requirements for Main Circuit Apparatus [1]. In case of conflicting information, this specification shall prevail.

The equipment shall also comply with applicable requirements given in section 6.11 and 6.15 of the customer's technical specification. The customer's Technical Specifications are found in the enclosure to this RS. In case of any conflict between this RS and Customer Technical Specification, the supplier shall inform ABB for a final decision.

Alterations from the Base Design Requirement Specification for "AC Filter Current Transformers" are printed in *italic* font.

2 QUANTITIES

2.1 Biswanath Chariali Converter Station

Pos.	Item Designation	Description	Quantity
01	=W1.Z(1,2,3).Z1.T2	HP12, GND CT	9
02	=W1.Z(1,2,3).Z2.T2	HP12B, GND CT	9
03	=W1.Z(1,2,3).Z3.T2 =W1.Z2.Z4.T2	HP24/36, GND CT	12
04	=W1.Z(1,2,3).Z3.T3 =W1.Z2.Z4.T3	HP24/36, L2&R2 CT	12
05	=W1.Z(1,3).Z4.T2	HP3, GND	6
06	=W1.Z(1,3).Z4.T3	HP3, R1 CT	6
07	=W1.Z(1,3).Z4.T4	HP3, F1 CT	6
08	=W1.Z(1,3).Z4.T5	HP3, C2 CT	6
09	=W1.Z(1,3).Z5.T2	Shunt Capacitor, GND CT	6
89	Spares	Spares for pos. 01, 02, 03, 05, 09	1
90	Spares	Spares for pos. 04	1
91	Spares	Spares for pos. 06	1
92	Spares	Spares for pos. 07	1
93	Spares	Spares for pos. 08	1

2.2 Alipurduar Converter Station

Pos.	Item Designation	Description	Quantity
01	=W1.Z(1,2,3).Z1.T2	HP12, GND CT	9
02	=W1.Z(1,2,3).Z2.T2 =W1.Z1.Z5.T2	HP12B, GND CT	12

ABB
HVDC

Requirement Specification

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I

AC Filter Current Transformers

IJNL100125-899 Rev. 03

Pos.	Item Designation	Description	Quantity
03	=W1.Z(1,2,3).Z3.T2 =W1.Z2.Z4.T2	HP24/36, GND CT	12
04	=W1.Z(1,2,3).Z3.T3 =W1.Z2.Z4.T3	HP24/36, L2&R2 CT	12
05	=W1.Z(1,3).Z4.T2	HP3 , GND	6
06	=W1.Z(1,3).Z4.T3	HP3, R1 CT	6
07	=W1.Z(1,3).Z4.T4	HP3, F1 CT	6
08	=W1.Z(1,3).Z4.T5	HP3, C2 CT	6
09	=W1.Z3.Z5.T2	Shunt Capacitor, GND CT	3
89	Spares	Spares for pos. 01, 02, 03, 05, 09	1
90	Spares	Spares for pos. 04	1
91	Spares	Spares for pos. 06	1
92	Spares	Spares for pos. 07	1
93	Spares	Spares for pos. 08	1

2.3 Agra Converter Station

Pos.	Item Designation	Description	Quantity
11	=P(1,2,3,4).WT.T8	Converter Transformers, F2 CT	12
12	=W1.Z(1,2,3).Z1.T2	HP12, GND CT	9
13	=W1.Z(1,2,3,4,5).Z2.T2	HP12B, GND CT	15
14	=W1.Z(4,5).Z3.T2	HP24/36, GND CT	6
15	=W1.Z(2,3).Z3.T2	HP24/36B, GND CT	6
16	=W1.Z(4,5).Z3.T3	HP24/36, L2&R2 CT	6
17	=W1.Z(2,3).Z3.T3	HP24/36B, L2&R2 CT	6
18	=W1.Z(4,5).Z1.T2	HP3 , GND CT	6
19	=W1.Z(4,5).Z1.T3	HP3 ,R1 CT	6
20	=W1.Z(4,5).Z1.T4	HP3 ,F1 CT	6
21	=W1.Z(4,5).Z1.T5	HP3 ,C2 CT	6
22	=W1.Z(1,2,3,4,5).Z4.T2 =W1.Z1.Z3.T2	Shunt Capacitor, GND CT	18
94	Spares	Spares for pos. 11	1
95	Spares	Spares for pos. 12, 13, 14, 15, 18, 22	1
96	Spares	Spares for pos. 16, 17	1
97	Spares	Spares for pos. 19	1
98	Spares	Spares for pos. 20	1
99	Spares	Spares for pos. 21	1

3 STANDARDS

The current transformers shall unless otherwise specified herein, be designed, rated and tested in accordance with IS 2705 [4] and/or IEC 60044-1 [3].

4 TECHNICAL DATA

4.1 Electrical data

4.1.1 Biswanath Chariali / Alipurduar station

Item Designation	See Clause 2.1 & 2.2	=W1.Z(1,2,3).Z3.T3 =W1.Z2.Z4.T3	Pos. 04	=W1.Z(4,5).Z1.T3	Pos. 06	=W1.Z(4,5).Z1.T4	Pos. 07	=W1.Z(1,3).Z4.T5	Pos. 08
Position	Pos. 01, 02, 03, 05, 09								
Location	HP12, HP12B, HP24/36, HP3 (GND CT)	HP24/36 (L2&R2 CT)		HP3 (R1 CT)		HP3 (F1 CT)		HP3 (C2 CT)	
1 Voltages									
1.1	Highest voltage for equipment (U_m), rms values	kV	24	24	24	24	24	36	
1.2	Base voltage for creepage distance and maximum continuous voltage to ground at primary winding (U_s)	kV	<1	<1	<1	<1	<1	17.1	
	Minimum creepage distance	mm	N.A.	N.A.	N.A.	N.A.	N.A.	736	
2 Rated frequency		Hz	50	50	50	50	50	50	
3 Currents									
3.1	Rated primary current	A	300	400	20	300	300	2	
3.2	Rated secondary current	A	1	1	1	1	1	1	



AC Filter Current Transformers

1JNL100125-899 Rev. 03

Item Designation	See Clause 2.1 & 2.2	=W1.Z(1,2,3).Z3.T3 =W1.Z2.Z4.T3	Pos. 04	Pos. 06	Pos. 07	Pos. 08
3.3 Rated primary continuous thermal current, including harmonics, rms values - Major harmonic currents, rms values	Pos. 01, 02, 03, 05, 09	408	20	--	--	--
	301	25/330.09 11/98.97 13/95.04 5/12.26 9/11.95 7/10.30 3/7.57 15/5.51 25/4.96 17/2.53	3/18.62 5/6.96 13/1.41 1/1.26 11/1.20 7/0.7258 25/0.3661 9/0.3010 4/0.2696 23/0.2553	--	--	--
3.4 Maximum transient current, crest values	180	16	0.25	104	83	
- time to crest	17	389	10	15	8	
3.5 Minimum current-time area before saturation	--	--	--	--	--	--
4 Insulation levels						
4.1 Lightning impulse withstand level, primary winding	125	125	125	125	145	145
5 Test Voltages						
5.1 Test voltages, power frequency withstand test 60 s.						
- Primary winding	50	50	50	50	70	70
- Secondary windings	3	3	3	3	3	3
5.2 RIV test voltage	N.A	N.A	N.A	N.A	N.A	N.A

191



AC Filter Current Transformers

IJNL100125-899 Rev. 03

Item Designation	Position	See Clause 2.1 & 2.2 Pos. 01, 02, 03, 05, 09	=W1.Z(1,2,3).Z3.T3 =W1.Z2.Z4.T3	Pos. 04	=W1.Z(4,5).Z1.T3	Pos. 06	=W1.Z(4,5).Z1.T4	Pos. 07	=W1.Z(1,3).Z4.T5	Pos. 08
6 Cores Data										
6.1 Cores type		Protection & measurement	Protection & measurement	Protection & measurement	Protection & measurement	Protection & measurement	Protection & measurement	Protection & measurement	Protection & measurement	Protection & measurement
6.2 Number of cores		2	2	2	2	2	2	2	2	2
6.3 Ratio		300:1	400:1	20:1	300:1	2:1	300:1	2:1	2:1	2:1
6.4 Rated burden	VA	10	10	10	10	10	10	10	10	10
6.5 Accuracy class		0.5 & 5P20	0.5 & 5P10	0.5 & 5P10	0.5 & 5P10	0.5 & 5P10	5PR20	5PR20	0.5 & 5P20	0.5 & 5P20



4.2 Agra station

Item Designation

Position

Location

1 Voltages

- 1.1 Highest voltage for equipment (U_m), rms values kV
- 1.2 Base voltage for creepage distance and maximum continues voltage at primary winding (U_s) kV

- 1.3 Minimum creepage distance mm

2 Rated frequency

3 Currents

- 3.1 Rated primary current A
- 3.2 Rated secondary current A
- 3.3 Extended current rating %
- 3.4 Rated primary continuous thermal current, including harmonics, rms values A

Item Designation	=P(1,2,3,4),WT.T8	See clause 2.3	=W1.Z(1,2,3)Z3.T3 =W1.Z2.Z4.T3	=W1.Z(4,5)Z1.T3	=W1.Z(1,3)Z4.T4	=W1.Z(1,3)Z4.T5
Position	Pos. 11	Pos. 12, 13, 14, 15, 18 and 22	Pos. 16& 17	Pos. 19	Pos.20	Pos.21
Location	Converter Transformers, (F2 CT)	HP12, HP12B, HP24/36, HP24/36B, HP3 (GND)	HP24/36 HP24/36B (L2&R2 CT)	HP3 (R1 CT)	HP3 (F1 CT)	HP3 (C2 CT)
1.1	24	24	24	24	24	36
1.2	< 1	< 1	< 1	< 1	< 1	16.6

- N.A.

- 50

- 100

- 1

-

-

- 410

- 589

- 30

- 1

-

- 25.6

- 300

- 1

-

-

- 714

- 50

- 2

- 1

-

-



AC Filter Current Transformers

IJNL100125-899 Rev. 03

Item Designation	=P(1,2,3,4),WT.T8	See clause 2.3	=W1.Z(1,2,3)Z3.T3 =W1.Z2.Z4.T3	=W1.Z(4,5)Z1.T3	=W1.Z(1,3)Z4.T4	=W1.Z(1,3)Z4.T5
Position	Pos. 11	Pos. 12, 13, 14, 15, 18 and 22	Pos. 16& 17	Pos. 19	Pos.20	Pos.21
- Major harmonic currents, rms values	n / A	1/343.18 49/165.18 47/124.69 25/ 48.37 59/ 41.47 13/ 36.32 37/ 18.60 11/ 17.30 35/ 16.95 27/ 14.70	25/470.27 1/270.44 23/181.40 27/ 83.26 13/ 68.48 35/ 58.29 37/ 32.31 21/ 28.21 11/ 28.02 29/ 21.55	3/ 5/ 1/0.65216 11/0.63339 7/0.53583 13/0.46288 25/0.34424 9/0.27752 4/0.22763 23/0.22425	--	--
3.5 Maximum transient current, crest values	kA	205	26	0.30	140	95
- time to crest	µs	17	428	11	17	8
3.6 Minimum current-time area before saturation	As	3.2	--	--	--	--
4 Insulation levels						
4.1 Lightning impulse withstand level, primary winding	kV	125	125	125	125	145
5 Test Voltages						
5.1 Test voltages, power frequency withstand test 60 s.						
- Primary winding	kV	50	50	50	50	70
- Secondary windings	kV	3	3	3	3	3
RIV test voltage	kV	N.A	N.A	N.A	N.A	N.A

- 12 -

TB-343-510-147



AC Filter Current Transformers

IJNL100125-899 Rev. 03

Item Designation	=P(1,2,3,4),WT.T8	See clause 2.3	=W1.Z(1,2,3)Z3.T3 =W1.Z2Z4.T3	=W1.Z(4,5)Z1.T3	=W1.Z(1,3)Z4.T4	=W1.Z(1,3)Z4.T5
Position	Pos. 11	Pos. 12, 13, 14, 15, 18 and 22	Pos. 16& 17	Pos. 19	Pos. 20	Pos. 21
6 Cores data						
6.1 Cores type	Protection	Protection & measurement	Protection & measurement	Protection & measurement	Protection	Protection & measurement
6.2 Number of cores	2	2	2	2	2	2
6.3 Ratio	100:1	400:1	600:1	30:1	300:1	2:1
6.4 Rated burden	10	10	10	10	10	10
6.5 Accuracy class	5PR20	0.5 & 5P20	0.5 & 5P10	0.5 & 5P10	5PR20	0.5 & 5P20

4.3 Other data

Static withstand load according to IEC 60044-1 clause 5.2, load class I. For current transformers with a highest voltage for equipment below 72.5 kV, the static withstand load shall be 1250 N.

ABB

Requirement Specification

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I

HVDC

AC Filter Current Transformers

IJNL100125-899 Rev. 03

5 DESIGN

5.1 GENERAL

The current transformers shall be of oil insulated or solid insulated design. Oil insulated units shall be provided with the following accessories:

- oil indicator

For oil insulated Current Transformers the insulating oil to be used for instrumental transformer shall conform to IS-335 / IEC 60296

The current transformers shall be provided with lifting eyes to facilitate rapid installation and replacement.

5.2 RIV Design

The current transformers shall be free of external corona at the maximum continuous voltage.

5.3 Cores and windings

Each core shall be provided with its own secondary winding, which shall be electrically completely isolated from other windings. The combined core is protection core fulfilling both specified measuring and protective transformer requirements.

5.4 Earthing

The current transformers shall be provided with earthing connections in accordance with *Mechanical requirements on apparatus terminals* [2].

5.5 Terminals

The high voltage terminals shall be provided with terminal pads in accordance with *Mechanical requirements on apparatus terminals* [2].

The current transformer shall be provided with a weatherproof secondary terminal box fulfilling the requirements for *IP55*. Facilities shall be provided in the terminal box for short-circuiting and earthing of secondary terminals.

The secondary terminal clamps and the earthing clamps shall be suitable for connection of up to 6 mm² conductors.

The terminal markings shall be in accordance with IEC 60044-1, clause 10.

5.6 Insulators

The color of the insulators shall be according to General Requirements for Main Circuit Apparatus [1].

The minimum creepage distance (mm/kV) is determined according to General Requirements for Main Circuit Apparatus [1] and is given in ~~section 4~~ **clause 4**.

Bushing/Insulators shall conform to requirements of TS Clause 6.15.

ABB

Requirement Specification

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I

HVDC

AC Filter Current Transformers

1JNL100125-899 Rev. 03

5.7 Transient current capability

The current transformers shall be designed for the transient current specified in clause 4.

If necessary for limiting the voltage over the primary terminals, surge diverter devices such as spark gaps shall be provided. *The maximum external secondary circuit impedance at 15 kHz is 15 Ω.*

5.8 Seismic requirements

Seismic requirements shall be in compliance with the General Requirement for Main Circuit Apparatus [1].

5.9 Failure rate guarantee

In addition to all other warranties, the supplier warrants that the availability of the goods is equal to or better than the following, provided manpower, instruments and equipment are as specified in the supplier's maintenance and repair manual.

- MTBF: $5 \cdot 10^6$ hours, corresponding to a failure rate of 0.20% per year.
- Scheduled Maintenance every year shall not exceed 1 hour by 2 men.
- Maximum time for exchange to spare 12 hours with a crew of 2 men.

5.10 Surface treatment

The surface treatment shall be in compliance with the General Requirements for Main Circuit Apparatus [1].

5.11 EMC Design

The secondary system of the current transformer shall comply both in terms of emission requirements and immunity requirements as specified in General Requirements for Main Circuit Apparatus [1].

6 NAMEPLATES

General requirements on the nameplates may be specified in General Requirements for Main Circuit Apparatus [1]. The information on nameplates shall be in accordance with IEC 60044-1 clause 10 and clause 11 and/or 12, 13 as appropriate.

Each current transformer shall be provided with a circuit diagram.

7 ENVIRONMENT

The current transformers will be installed outdoors in the switchyard.

The environment conditions are specified in General Requirements for Main Circuit Apparatus [1].

ABB

Requirement Specification

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I

HVDC

AC Filter Current Transformers

1JNL100125-899 Rev. 03

8 QUALITY PROGRAM

The quality program shall be according to General Requirements for Main Circuit Apparatus [1].

9 ROUTINE TESTS

The determination of errors shall be performed after the other routine tests.

9.1 Verification of terminal marking

As per IEC 60044-1, clause 6.2, a), (IS 2705:1 cl. 9.2).

9.2 Power frequency withstand test on primary winding and partial discharge measurement

As per IEC 60044-1, clause 6.2, b) and c), (IS 2705:1 cl. 9.3). However, the maximum discharge level at the pre-stress voltage shall not exceed 50 pC for solid insulated current transformers.

9.3 Power frequency withstand test between sections of primary and secondary windings and on secondary windings

As per IEC 60044-1, clause 6.2, d) and e), (IS 2705:1 cl. 9.4).

9.4 Inter-turn over-voltage test

As per IEC 60044-1 clause 6.2, f), , (IS 2705:1 cl. 9.5).

9.5 Determination of errors

As per IEC 60044-1 clause 11 and clause 12 or clause 13, , (IS 2705:1 cl. 9.1.2)

9.6 Sealing test

The tightness of oil insulated current transformers shall be verified by a suitable test. The test procedures shall be subject to approval by ABB HVDC and shall be included in the ITP. (*Inspection Test Plan*)

9.7 Measurement of capacitance and dielectric dissipation factor

Not applicable for transformers with a highest voltage for equipment less than or equal to 72.5 kV.

ABB

Requirement Specification

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I

HVDC

AC Filter Current Transformers

IJNL100125-899 Rev. 03

10 TYPE TESTS

Certified type tests reports from tests already performed on a similar (or identical) design may be accepted in lieu of performing new type tests, *if performed later than June 30, 2004*. To be applicable, both the design and testing requirements have to comply with this Requirement Specification. The justification for compliance shall be made by means of a Type Test Summary Report (TTSR), sufficiently detailed regarding similarities and differences in design and testing, to facilitate and support an approval of reports from previously performed type tests.

The certified type test reports and supporting TTSR shall be referred to in the ITP and submitted together with the ITP for approval.

10.1 Short-time Current tests

As per IEC 60044-1 clause 6.1, a), (*IS 2705:1 cl. 9.6*).

10.2 Temperature-rise test

As per IEC 60044-1 clause 6.1, b), (*IS 2705:1 cl. 97*).

10.3 Lightning impulse test

As per IEC 60044-1 clause 6.1, c), (*IS 2705:1 cl. 9.8*)

10.4 Switching impulse test

As per IEC 60044-1 clause 6.1, d), (*IS 2705:1 cl. 9.11*)

10.5 Wet test for outdoor type transformers

As per IEC 60044-1 clause 6.1, e), (*IS 2705:1 cl. 9.9*)

10.6 Determination of errors

As per IEC 60044-1 clause 11 and clause 12 or clause 13.

10.7 Radio interference voltage measurement

As per IEC 60044-1 clause 5.1.7 and 6.1, g).

Not applicable to current transformers with highest voltage for equipment below 123 kV.

The type of terminals for external connections shall be chosen on advice of ABB HVDC.

10.8 Thermal co-efficient test

Thermal co-efficient test i.e. measurement of tan-delta as a function of temperature (at ambient and between 80 °C and 90° C) at voltage U_s .

ABB

HVDC

Requirement Specification

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I

AC Filter Current Transformers

IJNL100125-899 Rev. 03

10.9 Thermal stability test

Not applicable for transformers with a maximum continuous voltage (U_N) less than 1 kV.

11 VERIFICATIONS

The below design verifications are to be performed by means of verifying reports in lieu of performing corresponding tests. The reports shall be sufficiently detailed in its justification to facilitate and support the approval of each clause to be verified. Additionally mounted equipment shall be duly considered when influence is applicable.

The verification reports and its supporting documents, e.g. reports on previous tests etc., shall be referred to in, and submitted with, the ITP. If verifications are still "to be done" at the submittal of the ITP, the text "To be verified" shall be written in the ITP.

11.1 Transient current capability

Fulfillment of the dynamic current capability shall be verified.

11.2 Seismic requirements

Fulfillment of the seismic requirements shall be verified.

11.3 Verification of DC current effect

It shall be verified that the accuracy class of the DC current transformer is maintained also with the maximum d.c. current as specified in clause 4

11.4 CE marking

The CE-marking requirements are specified in General Requirements for Main Circuit Apparatus [1].

12 ENCLOSURES

Customer Technical Specification Part II, Volume II, Section 6.11 Instrumental transformers and Section 6.15 HVAC Insulators, Bushings, Buses And Hardware.

13 REFERENCES

- | | | |
|-----|-----------------------------|---|
| [1] | <i>IJNL100122-145</i> | General Requirements for Main Circuit Apparatus |
| [2] | <i>IJNL 100156-049</i> | <i>Mechanical requirements on apparatuses terminals</i> |
| [3] | IEC 60044-1, 2003 | Instrument transformers-Part 1: Current transformers |
| [4] | <i>IS2705 (Part 1):1992</i> | <i>Current transformers - Specification</i> |

SECTION - 3

ABB AB

Requirement Specification

HVDC

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I		Document Number 1JNL100122-145 Rev. 03	No of Pages 31
			No of Attached Pages
Prepared Nassim Raoofi, 2008-05-29		Title General Requirements for Main Circuit Apparatus	Reg./Class no. NEA-FE-000
Approved Ulf Radbrandt, 2008-06-30	Resp Dept TSD		

This document is issued by means of a computerized system. The digitally stored original is electronically approved. The approved document has a name and date entered in the approved-field. A manual signature is not required.

Table of Contents

1	GENERAL INFORMATION	2
2	LIFETIME	2
3	ENVIRONMENT	2
4	MATERIALS AND WORKMANSHIP	6
5	AUXILIARY POWER	7
6	TERMINAL BOXES AND CONTROL CABINETS	8
7	MOTORS	9
8	TERMINAL BLOCKS	9
9	QUALITY PROGRAM.....	10
10	Name plates and markings.....	11
11	INSULATORS	11
12	COLORS	16
13	ENCLOSURE	17
14	REFERENCES	17
15	Appendix 1	19
16	Appendix 2 (Extracted applicable sections from the Customer's Technical Specification)	22

3	see revision's marks & 11NEA0059	Nassim Raoofi 2011-08-15	Ulf Radbrandt 2011-08-31
Rev ind	Revision text	Prepared	Approved

We reserve all rights in this document and in the information contained herein. Reproduction, use or disclosure to third parties without expressed authority is strictly forbidden. ABB AB (SE)



1 GENERAL INFORMATION

This Specification gives the general requirements on equipment deliveries for the converter stations for the Biswanath Chariali, Alipurduar and Agra converter stations, of the ±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I Project.

In case of conflicting requirements, the supplier shall bring those to the notice for a discussion/ decision and decision of ABB AB HVDC shall be final.

Deviations from the ABB AB HVDC Base Requirement Specifications are printed in italic font.

2 LIFETIME

The design of apparatus including readable nameplates shall enable the Project to be in operation under rated conditions for at least **40** years.

3 ENVIRONMENT

The converter stations environment is defined as sub-tropical with a preponderance of high temperature and high humidity.

3.1 Seismic requirements

All structures shall be designed for seismic forces in accordance with IS-1893.

The seismic design of electrical equipment shall be performed using estimated actual earth/ground motion, defined by a response spectrum, rather than the equivalent loads specified in typical Building Codes.

For brittle materials like glass, porcelain and glass fiber reinforced plastic the maximum calculated load should not exceed 2/3 of the guaranteed minimum rupture (breaking) strength (safety factor 1.5) as defined by the manufacturer/supplier of the material used. The minimum rupture value is defined as $(X - 2 \cdot \sigma)$, where X is the mean value and ' σ ' is the standard deviation. For load combinations in porcelain insulators and similar the following expressions shall be fulfilled:

$$\{F_t / (F_t)_b\} + \{M_b / (M_b)_b\} < 2/3$$

and

$$\{F_c / (F_c)_b\} + \{M_b / (M_b)_b\} < 2/3$$

Where:

F_t, F_c, M_b : calculated maximum tensile force; compressive force and bending respectively

$(F), (F), (M)_b$: corresponding guaranteed strength values (For normal operating loads, a higher safety factor more than 1.5 shall be used, normally 2.0-2.5 depending on type of load as per recommendations of manufacturer).

ABB AB

HVDC

Requirement Specification

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I

General Requirements for Main Circuit
Apparatus

IJNL100122-145 Rev. 03

3.1.1 Seismic Coefficient

Biswanath Chariali, Alipurduar and Agra converter stations are located in zone V, IV and III respectively according to IS-1893, Criteria for Earthquake Resistant Design of Structures (see table below).

Seismic Zone	II	III	IV	V
Seismic intensity	Low	Moderate	Severe	Very severe
Zone factor (Z)	0.1	0.16	0.24	0.36

(Extracted from IS 1893: 2002)

Importance factor for the stations is 1.5 as per table no. 6 of IS-1893.

3.1.2 Seismic design requirement verification

The fulfillment of the seismic requirement shall be verified according to the procedure given in "Seismic Qualification Procedures for Electrical Equipment", [33]

3.2 Outdoor conditions

		Biswanath Chariali	Alipurduar	Agra
Maximum temperature one hour average (dry bulb)	°C	40	40	50
Maximum temperature 24 hour average (dry bulb)	°C	40	40	40
Annual mean temperature (dry bulb)	°C	30	30	30
Minimum temperature (dry bulb)	°C	0	0	0
Temperature for low ambient condition (dry bulb)	°C	33	33	33
Maximum temperature one hour average (wet bulb)	°C	33	33	33
Temperature for low ambient condition (wet bulb)	°C	23	23	23
Relative humidity	%	100	100	100
Ice loading (thickness)	mm	--	--	--
Elevation above sea level	m	<1000	<1000	<1000
Isokeraunic level of thunderstorms	days/year	150	150	50
Rain fall intensity in 24 hours	mm	250	250	200
Solar radiation per hour	Cal/cm ²	83	83	83
Wind*)	m/s	50	47	44

**) All structures shall be designed for Wind forces in accordance with IS-875 (Part III)-1987, Code of Practice for Design Loads (other than earthquake) for Buildings and Structures. The Biswanath Chariali converter station lies in Zone V with basic wind speed of 50 m/s at 10 m height above mean ground level, Alipurduar converter station lies in Zone IV with basic wind speed of 47 m/s at 10 m height above mean ground level and Agra converter station is in Zone III with basic wind speed of 44 m/s at 10 m height above mean ground level. The risk level coefficient/factor shall be taken as 1.07. If terrain, height, structure size factor is less than 1.0, then these shall be neglected, otherwise they shall be considered.*

ABB AB

HVDC

Requirement Specification

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I

General Requirements for Main Circuit
Apparatus

1JNL100122-145 Rev. 03

3.3 Design parameters for indoor equipment**3.3.1 Indoor with controlled environment**

For normal operating conditions the relative humidity is 50% in the valve hall. During the non-operation state of the station, the temperatures may be as specified for outdoor application during shorter times and then the maximum relative humidity may increase above 60%.

		<u>Valve area</u>	<u>Indoor DC hall</u>	<u>Other areas</u>
Maximum temperature	°C	60	50	40
Minimum temperature ¹	°C	5	5	5
Maximum relative humidity ¹	%	60	60	60
Minimum relative humidity	%	10	10	--
ESDD ² per year	mg/cm ²	< 0.003	< 0.003	--

3.3.2 Control cabinets in control room

During the non-operation state of the station, the temperatures may be as specified for outdoor application during shorter times, and then the maximum relative humidity may increase above 60%.

Maximum temperature	°C	55
Minimum temperature	°C	5
Maximum relative humidity	%	60
ESDD per year	mg/cm ²	< 0.003

3.3.3 Indoor without controlled environment

Maximum temperature (dry bulb)	°C	60
Maximum 24 h average temperature (dry bulb)	°C	60
Minimum temperature (dry bulb)	°C	15

3.4 Pollution level

Pollution level *light*³ for Biswanath Chariali/ Alipurduar and *heavy* for Agra as per IEC/TR 60815 (1986) shall to be considered.

3.5 Surface treatment

The equipment shall have sufficient corrosion resistance by the use of corrosion resistant materials or by using coatings. The choice of protection shall be based on the environmental classification given in ISO 12944-2 (1998).

¹ This requirement is not valid for the Thyristor valve.

² ESDD = Equivalent Salt Deposit Density

³ Minimum creepage shall however be as per clause 11.3

ABB AB

HVDC

Requirement Specification

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I

General Requirements for Main Circuit
Apparatus

IJNL100122-145 Rev. 03

The environmental classes for the different areas in the station are:

Area	Biswanath Chariali/ Alipurduar	Agra
	Class	Class
Outdoor	C2	C3
Indoor with controlled environment	C1	
Indoor without controlled environment	C2	

Hot dip galvanized coating on fabricated iron and steel articles shall be according to ISO 1461(1999).

A special moisture and fungus resistant varnish shall be applied to parts, which may be subject or predisposed to the formation of fungi due to the presence or deposit of nutrient substances. The varnish shall not be applied to any surface or part where the treatment shall interfere with the operation or performance of the equipment. Such surfaces or parts shall be protected against the application of the varnish, see clause 3.5, Appendix 2.

3.6 EMC environment

The requirements stated below shall be met for secondary equipment.

Location	Immunity requirements	Emission requirements
1. In the switchyards <i>and the indoor DC Hall</i>	<ul style="list-style-type: none"> Section 5.18 and 6.9.2 of IEC 62271-1 (2007) Area H in Tables 1 to 5 of IEC/TS 61000-6-5 (2001). 	<ul style="list-style-type: none"> Section 6.9.1 of IEC 62271-1 (2007) IEC 61000-6-4 (2006)
2. Inside valve hall or converter enclosure as applicable	<ul style="list-style-type: none"> Section 5.18 and 6.9.2 of IEC 62271-1 (2007) Area H in Tables 1 to 5 of IEC/TS 61000-6-5 (2001) Additional immunity requirements inside valve hall or converter enclosure. See table and figure below 	<ul style="list-style-type: none"> Section 6.9.1 of IEC 62271-1 (2007) IEC 61000-6-4 (2006) (Emission requirements are not applicable for the valves.)
3. Kiosks etc. in the switchyard, non-protected areas	<ul style="list-style-type: none"> Section 5.18 and 6.9.2 of IEC 62271-1(2007) Area H in Tables 1 to 5 of IEC/TS 61000-6-5 (2001) 	<ul style="list-style-type: none"> Section 6.9.1 of IEC 62271-1 (2007) IEC 61000-6-4 (2006)
4. Partly shielded areas inside enclosures and kiosks (control building etc.)	<ul style="list-style-type: none"> Area H in Tables 1 to 5 of IEC/TS 61000-6-5 (2001) 	IEC 61000-6-4 (2006)
5. Other areas inside service buildings etc.	<ul style="list-style-type: none"> IEC 61000-6-2 (2005) 	<ul style="list-style-type: none"> IEC 61000-6-4 (2006)

The selection of the immunity specifications for the apparatus is based on Figure 4, as applicable, of IEC/TS 61000-6-5 (2001).

ABB AB

HVDC

Requirement Specification

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I

General Requirements for Main Circuit
Apparatus

1JNL100122-145 Rev. 03

The electromagnetic field strength inside valve hall or converter enclosure shall be taken to be as shown in the table and figure below. The equipment inside these areas shall withstand this field strength applied to their enclosure port(s)⁴, in addition to the requirements stated earlier. However, proper screening measures will significantly reduce the field impact on ports/equipment and the withstand requirement is valid for ports/equipment in combination with screening measures.

Table Additional immunity requirements inside valve hall or converter enclosure, as applicable.

Frequency (Hz)	dB (1μV/m)
$1.0 * 10^3$	210
$1.0 * 10^4$	190
$3.0 * 10^5$	140
$\geq 3.0 * 10^5$	As per IEC/TS 61000-6-5

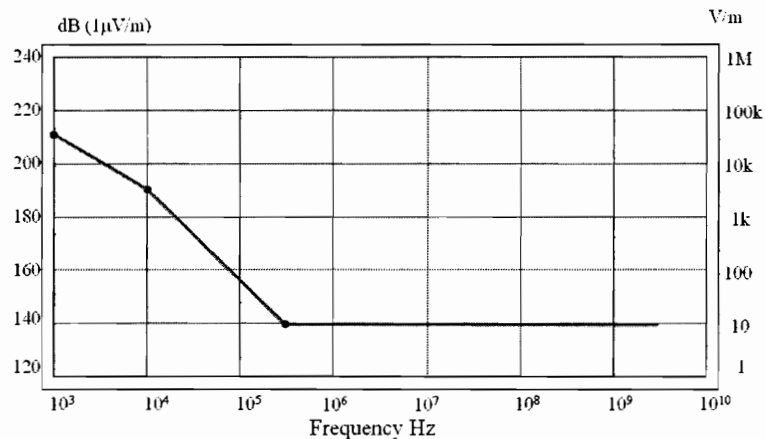


Figure Additional immunity requirements inside valve hall or converter enclosure, as applicable.

4 MATERIALS AND WORKMANSHIP

4.1 General requirements

Equipment, materials and components shall be new, of high grade and be to the best engineering practice. The material and workmanship throughout shall be in accordance with the purpose for which they are intended. Each component shall be designed to be consistent with its duty.

Screw threads shall be standard metric threads. The Supplier shall furnish locking devices for threaded fasteners.

All components exposed to rain shall be designed with sloped upper surfaces to avoid water pools and if this is not possible suitable drainage shall be arranged.

⁴ Enclosure port is defined in IEC/TS 61000-6-5 (2001) as physical boundary of the apparatus through which electromagnetic fields may radiate or impinge on.

Outdoor equipment shall be suitable for service and storage under tropical conditions of high temperature, high humidity, heavy rainfall and environment favourable to the growth of fungi and mildew. The indoor equipment located in non air-conditioned areas shall also be of the type.

4.2 Welding

Welding shall be performed as per Customer's Technical Specification clause 3.9, Appendix 2.

5 AUXILIARY POWER

5.1 Selection of supply

Control signals and supply is d.c. according to clause 5.3.1 below.

Supply to motors intended for continuous operation (e.g. fans) is three-phase a.c. according to clause 5.2 below.

Supply to motors intended for intermittent operation (e.g. motors for disconnectors, spring charging motor for breakers) is a.c. single phase according to clause 5.2 below, except for Valve hall earthing switches (RS-054) and DC disconnectors and earthing switches (RS-058).

Supply to equipment heaters is single-phase a.c. according to clause 5.2 below.

5.2 AC Supply

5.2.1 415 V 50 Hz

Nominal voltage (solidly grounded), rms value	V	415
Voltage variations, steady-state	%	±10
Minimum voltage at motor during start, rms value	V	340
Nominal frequency	Hz	50
Frequency variations	%	±5

All voltages in section 5.2.1 are phase-to-phase voltages.

5.3 DC Supply

5.3.1 220 V DC

Nominal voltage, d.c. value	V	220
Maximum/Normal operating voltage, d.c. value	V	242
Minimum voltage at motor during start, d.c. value	V	187
Maximum ripple, peak-to-peak	V	11

The midpoint of the voltage source will be impedance grounded.

ABB AB

HVDC

Requirement Specification

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I

General Requirements for Main Circuit
Apparatus

1JNL100122-145 Rev. 03

5.3.2 48 V DC

Nominal voltage, d.c. value	V	48
Maximum/Normal operating voltage, d.c. value	V	52.8
Minimum voltage at motor during start, d.c. value	V	41
Maximum ripple, peak-to-peak	V	2.5

6 TERMINAL BOXES AND CONTROL CABINETS**6.1 Design**

The control cabinets, terminal boxes, junction boxes terminal boxes and marshalling boxes shall generally comply and tested in accordance with IS-5039, IS-8623, IEC-60439 as applicable, and Customer's Technical Specification clause 3.6 and 3.7 ,Appendix 2.

All openings shall be properly provided with gaskets made of neoprene or by equivalent material approved by the ABB AB HVDC. Suitable ventilation and drainage devices or other similar arrangement shall be provided to maintain the inside of the enclosure dry.

All equipment in or on an enclosure shall be completely wired to terminal blocks or connectors ready for external connection.

All external connections shall enter the cabinet from below through weather proof and dust proof connections and be terminated on terminal blocks or connectors as adequate. There shall be a clearance of at least 120 mm between the first/bottom row of terminal blocks and the associated cable gland. The clearance between two adjacent rows of terminal blocks shall be at least 150 mm. The ABB AB HVDC may accept other terminal block arrangements after approval.

6.2 Equipment heaters

Heating elements shall be provided by the Supplier and mounted in all outdoor and "indoor without controlled environment" enclosures containing equipment with movable parts, i.e. switches and relays, or electronic equipment. At least one heater in each cabinet shall always be energized.

The heaters shall be suitable for continuous operation at 240 V ac supply voltage and shall be connected to the supply through a fuse.

Control cubicles installed in air-conditioned area need not be provided with space heaters. These cubicles shall, however, have space heaters in case of storage of cubicles for long duration.

One or more heaters shall be provided, with thermostats or hygrostat, to prevent condensation in any compartment. The heaters shall be suitable to maintain the compartment temperature at approximately 10 deg. C, above the outside air temperature to prevent condensation.

7 MOTORS

All motors shall be delivered as standard motors conforming to IEC 60034-5 (2006) /IS Standard and with the principal dimensions in accordance with IEC 60072-1 (1991), IEC 60072-2 (1990) and IEC 60072-3 (1994).

All motors shall conform as specified herein:

- 1 *Motors rated 0.5 kW and above, and reversing motors, shall be rated 415 V, three phase, grounded neutral;*
- 2 *Motors rated below 0.5 kW shall be rated 240 V one phase;*
- 3 *All motors shall be designed to operate at full load dynamic conditions with a voltage range of variation of +10%, -20% and a frequency range variation of +5%, -10%. Motors shall also be designed to operate at 125% of the rated speed without mechanical damage, and to start with 80% of their rated voltage;*
- 4 *All motors shall be designed and rated for continuous operation at maximum ambient temperature of 50°C. The class of insulation shall be at least one class higher than used for defining the temperature rise of the motor;*
- 5 *Vertical motors rated 60 kW and above shall be provided with oil-lubricated self-cooled pivoted shoe-type thrust bearing. Vertical motors below 60 kW shall be provided with re-greasable antifriction ball or roller bearings;*
- 6 *All antifriction bearings shall be guaranteed to operate successfully for a minimum of 131,000 hours;*
- 7 *All bearings shall be quiet operating and statically and dynamically balanced;*
- 8 *All belts to be used shall be "V" type and designed for the maximum power to be transmitted and for the maximum speed. The selection of the "V" belt drive for any application shall also be based on the nature of the load and the type of the driving unit. Belts installed outdoors shall be suitably protected.*

8 TERMINAL BLOCKS

The terminal blocks shall be tested with at least 2.0 kVrms, 50 Hz/60 Hz, during 1 minute. They shall be made of moulded, nonflammable thermosetting plastic. The material of the terminal block moulding shall not deteriorate because of varied conditions of heat, cold, humidity, dryness etc., that would be expected at the location the equipment is proposed to be installed.

The terminal shall be such that maximum contact area is achieved when a cable is terminated. The terminal shall have locking characteristic to prevent the cable from escaping from the terminal clamp unless it is done intentionally. The conducting part in contact with the cable shall be tinned or silver plated.

The terminal blocks shall be of extensible design.

The terminal blocks shall have a locking arrangement to prevent its escape from the mounting rails.

The terminals shall be rated to carry the maximum current continuously that is expected to be carried by the terminals.

The terminals shall be provided with marking tags for positioning identification.

ABB AB

HVDC

Requirement Specification

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I

General Requirements for Main Circuit
Apparatus

1JNL100122-145 Rev. 03

All internal wiring to be connected to external equipment shall terminate on terminal blocks. Terminal blocks shall be 650 V grade and have 10 Amperes continuous rating. All terminal blocks shall have shrouding with transparent unbreakable material.

At least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.

The terminal blocks shall be suitable for connecting the conductors of external cable on each side.

Terminal blocks shall be moulded, complete with insulated barriers, stud type terminals, complete with washers, nuts and lock nuts. Screw clamp, overall insulated, insertion type, rail mounted terminals can be used in place of stud terminals with locking type. The terminal blocks shall be of reputed make subject to Employer's acceptance.

Terminal block design shall include a white fiber marking strip with clear plastic, /clip-on terminal covers. Markings on the terminal strips shall correspond to wire numbers on the wiring diagrams.

Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. The current transformer secondary leads shall also be provided with short-circuiting and earthing facilities.

The conducting part in contact with the cable shall preferably be tinned or silver-plated however; nickel-plated copper shall also be acceptable. Insulating barriers shall be provided between the terminal blocks.

Supplier's standard practice for internal wiring of cubicles shall be acceptable. However all external cabling requirements shall be strictly as per project technical specification.

The supplier shall furnish all wire, conduits and terminals for the necessary inter-phase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets.

9 QUALITY PROGRAM

The quality program level to be applied by the Supplier is ISO 9001 or equivalent.

An Inspection and Test Plan (ITP) covering, as a minimum but not limited to, all routine tests, type tests and verifications, etc. as specified in this Requirement Specification shall be issued for approval. The ITP shall also cover Customer Witness Points, based on current market praxis, and the basic in-process inspections normally performed during production by the Supplier.

9.1 TYPE TEST

Previous type test for equipment of same design, insulation class and rating (except thyristor valves, converter transformers, shunt reactors, auto transformers, smoothing reactors, 800 kV wall bushing, transformer 800kV valve bushing and 33kV/0.4 kV transformer) shall be acceptable, in-lieu of performing new tests, if such tests are performed after June 30, 2004.

Otherwise, type tests shall be performed as per relevant IEC/ IS standard or other significant specifications as given in the Requirement Specifications (RS) document for equipment.

9.2 CE-marking

The equipment must fulfil the safety and protection requirements of the relevant EU directives and, when applicable, be CE-marked according to EU COUNCIL DIRECTIVE 93/68/EEC.

A Declaration of Conformity (DoC), including references to applicable EU Directives and, when applicable, referenced equipment standards, shall be issued. The Technical Construction File (TCF), supporting the DoC, shall be stored by the Supplier and ready to be submitted at the latest two weeks after request.

The operation and maintenance manuals, including assembly and installation instructions, must include safety precautions and adequate warnings for equipment related hazards to personal safety when handling the equipment.

In case of no applicable EU Directive for the equipment, a written statement confirming this fact shall be issued. Such a statement must explain why this is the case and before issuing, at least the following EU Directives shall be considered:

- Machinery Directive
- Low Voltage Directive
- EMC Directive

10 Name plates and markings

Name plate and marking shall be complied with an applicable IEC standard for each piece of equipment and Customer's Technical Specification clause 3.3.4, Appendix 2.

11 INSULATORS

Only composite insulators that have a surface of HTM can be used for outdoor applications. For indoor application, composite insulators of other surface materials may be used.

While specifying the requirements, the terms composite/Polymer/HTM are used interchangeably. These shall be considered to refer to HTM insulators requirements.

While specifying the requirements, the terms Porcelain/non-HTM are used interchangeably. These shall be considered to refer to non-HTM insulators requirements.

In case of conflicting information between this Requirement Specification and the standards referred to, this Requirement Specification shall prevail.

11.1 Definitions

Composite insulator:

A composite insulator is an insulator that is made, partly or completely, of polymeric materials of one or more types. More rigorous definitions are given in references [20], [21], [22] and [23].

HTM and non-HTM Material:

Polymer materials exhibit hydrophobicity and the capability to transfer hydrophobicity to the layer of pollution are referred to in this Requirement Specification as Hydrophobic property Transferable Material (HTM). Material with silicone rubber as base material is the most common HTM. Other materials, such as porcelain or other type of polymer materials, which do not exhibit hydrophobicity transfer, are referred to as non-HTM.

Installation angle:

Vertical: the center axis of the insulator is within $90 \pm 15^\circ$ to the horizontal plane

Angled: The insulator is at other positions than vertical.

Average diameter:

The average diameter of the insulator is calculated from the core diameter and sheds diameter as per the rules given in reference [7]

11.2 External surface materials of insulators

Insulators with HTM surface shall be examined and qualified by relevant tests and the test reports shall be sent to ABB AB HVDC for approval. Insulators without accepted test reports to qualify the hydrophobic characteristics shall be treated as insulators with non-HTM.

11.2.1 Qualification of HTM

Insulators with HTM surface are characterized by three criteria: exhibit hydrophobicity on the clean surface, the capability to transfer hydrophobicity to the layer of pollution, and the capability to recovery its hydrophobicity after temporarily loss of the hydrophobicity. All these three characteristics shall be examined and qualified in type tests with relevant test methods as described in [23]. For an English version of the relevant parts of [23], see Appendix 1.

11.2.2 Resistance to tracking and erosion

All the composite insulators to be used under DC shall have a good ability to prevent tracking and erosion caused by discharges and leakage current.

For insulators used outdoors, this ability shall be examined and qualified in type tests with relevant test methods as described in [20], [21], [22] and [23], see Appendix 1.

For insulators used indoors, this ability, classified as Comparative Tracking Index (CTI), should be examined and qualified in type tests with relevant test methods as described in [24] and [25] and fulfil $CTI \geq 600$.

11.2.3 Other parameters of the surface material

Other dielectric parameters that the surface material shall fulfill include those given [20], [21], [22] and [23] and also the Appendix 1:

- DC dielectric strength: $\geq 30kV/mm$

11.3 Creepage distance

11.3.1 General

The unified specific creepage distance (USCD), as per IEC/TS60815-1 (2008), shall be used.

USCD is the creepage distance of an insulator divided by the rms value of the highest operating voltage across the insulator, given in mm/kV. This voltage is evaluated by:

$$U_{rms} = \sqrt{U_{DC}^2 + \sum_n U_n^2}, \text{ where } U_n \text{ is the fundamental voltage including possible}$$

harmonics 'n' added across the insulator in rms.

U_{rms} for 400 kV, 220 kV and 132 kV AC equipment shall be considered as 420/√3 kV, 245/√3 kV and 145/√3 kV, respectively.

11.3.2 Corrections

11.3.2.1 Diameter

For ac application, the correction factor due to diameter of insulator is taken in account according to IEC/TS 60815-2 (2008) for porcelain insulators and non-HTM insulators. For HTM insulators it is taken in account according to IEC/TS 60815-3 (2008).

For dc application, the correction factor due to diameter of insulator is taken in account according to formula below for porcelain insulator and non-HTM insulators. For HTM insulators it is supposed to be 1.

$$\frac{l_2}{l_1} = \left(\frac{D_2}{300} \right)^{0.23}, \text{ where } l_1 \text{ is the required creepage distance for insulators with an}$$

average diameter equal or smaller than 300 mm; D₂ is the average diameter (in mm) of the insulator for which creepage distance l₂ is sought.

11.3.2.2 Air density

When applicable, correction will be applied for the change of air density from reference conditions due to a higher temperature or/and a higher altitude for insulators with non-HTM. For insulators with HTM, correction for air density is not required.

11.3.3 Outdoor insulators

Outdoor DC bushings shall be only of Silicone rubber type i.e. HTM-type. For outdoor insulators, unless specifically approval by ABB, the minimum nominal creepage distance shall be as below:

11.3.3.1 HTM

- *Biswanath Chariali/ Alipurduar station:*
for ac application: 43 mm/kV, based on U_{rms} defined above
for dc application: 50 mm/kV, based on U_{rms} defined above

ABB AB

HVDC

Requirement Specification

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I

General Requirements for Main Circuit
Apparatus

IJNL100122-145 Rev. 03

- *Agra station:*
for ac application: 43 mm/kV, based on U_{rms} defined above
for dc application: 50 mm/kV, based on U_{rms} defined above

11.3.3.2 Non-HTM

- *Biswanath Chariali/ Alipurduar station:*
For ac application: 43 mm/kV, based on U_{rms} defined above
for dc application: 50 mm/kV, based on U_{rms} defined above
- *Agra station:*
For ac application: 43 mm/kV, based on U_{rms} defined above
For dc application: 60 mm/kV, based on U_{rms} defined above

AC equipment connected to the 400 kV bus, the creepage distances shall not be less than 10500 mm.

11.3.4 Indoor with controlled environment

For indoor insulators with controlled environment the minimum nominal creepage distance shall be

HTM/Non HTM:**Valve hall**

- *Biswanath Chariali/ Alipurduar and Agra station:*

For dc application *maximum of:*

14 mm/kV, based on U_{rms} defined above

or

20mm/kV, based on U_{dmax} .

Indoor DC hall:

- *Agra station:*
30 mm/kV, based on U_{rms} defined above

11.4 Insulator shed profile**11.4.1 General**

The insulator shed profile (form) shall be according to the requirement by ABB AB HVDC. For profiles deviating from the requirement, drawing and justification of function shall be sent to ABB for approval.

There are no specific profile requirements for

- i. Insulators used at the indoor conditions where maximum relative humidity is always lower than 60%.
- ii. Insulators at DC neutral voltage.
- iii. Insulators with an average diameter smaller than 100 mm.
- iv. Insulators at a near horizontal position

At the following conditions, deviations from the profile requirement may be accepted after approval by ABB AB HVDC:

- v. Profiles with smaller shed spacing than required may be accepted for the insulators used at the indoor conditions where maximum relative humidity may become higher than 60%.
- vi. Profiles that deviating from the requirement may be accepted for clean outdoor conditions (verified by systematic pollution measurement or by the satisfactory operational experience for more than 5 years of an existing project of the same voltage level).

Parameters of insulator sheds are given in the figure below.

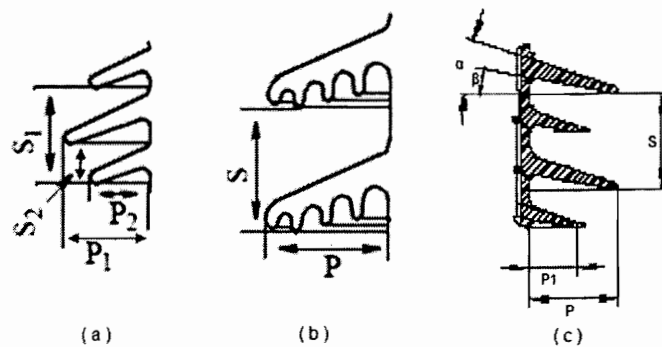


Figure Parameters of insulator sheds: (a) alternating profile of a porcelain insulator; (b) deep under-rib profile of a porcelain insulator; (c) alternating profile of a polymer insulator

11.4.2 Porcelain insulators, AC

The shed form (profile) for porcelain ac insulators shall be according to IEC/TS 60815-2 (2008).

11.4.3 Polymer insulators, AC

The shed form (profile) for polymer ac insulators shall be according to IEC/TS 60815-3 (2008).

11.4.4 Porcelain insulators, DC

Requirements for dc porcelain insulators:

- Shed spacing of alternating profile: $S_1 \geq 70$ mm.
- Shed spacing of deep under-rib profile: $S = 95$ mm.
- The ratio between shed spacing and overhang for both alternating and deep under-rib profiles: S_1/P_1 or $S/P \geq 1$.
- For alternating profile, the overhang difference between big and small shed $(P_1 - P_2) \geq 20$ mm.
- For alternating profile, the inclination of sheds should be within the range: $10^\circ \sim 25^\circ$.

11.4.5 Polymer insulators, DC

The polymer shed should have excellent electrical and mechanical characteristics. In addition, the polymer shed should be homogenous, free from laminations, cavities or other flaws affecting its mechanical strength or dielectric quality.

ABB AB

HVDC

Requirement Specification

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I

General Requirements for Main Circuit
Apparatus

IJNL100122-145 Rev. 03

For polymer insulators with non-HTM, the shed profile requirement shall be the same as that for porcelain insulators.

Requirements for dc polymer insulators with HTM:

- Spacing for nominal DC voltage up to 525 kV: $S \geq 60$ mm.
- Spacing for nominal DC voltage higher than 525 kV: $S \geq 65$ mm
- The ratio between shed spacing and overhang: $S/P \geq 0.9$.
- The overhang difference between big shed and small shed:
 $15 \text{ mm} < (P-P1) \leq 20 \text{ mm}$.
- Upper inclination angle $\alpha > 10^\circ$
- Lower inclination angle $\beta > 3^\circ$.

Note: A too large value of β will result in an area with high pollution accumulation and therefore is not recommended.

Note: If helicoidal shed profile is used in vertically mounted insulators, the combination of pitch and α shall be such that the lip inclination shall be at least 4° less than α , so that rain water will run off the shed, rather than along it.

11.5 Other requirements

Insulators shall generally conform to customer's Technical Specification clause 6.15.2, as applicable, see Appendix 2.

12 COLORS

12.1 Porcelain insulators

Color of porcelain insulators shall comply with requirements as per IEC 62155 (2003). The color shall preferably be brown glazed, according to MUNSELL no 25 Yr/2.0/4.0 or similar. Other colors may be used after approval from ABB AB HVDC.

12.2 Polymer insulators

Color of polymer insulators shall comply with requirements as per IEC 61462 (2007). The color shall preferably be grey, RAL 7035 or similar. Other colors may be used after approval from ABB AB HVDC.

12.3 Panel and cubicles

The furnishing for the indoor panel and cubicles shall be RAL 7035, and for outdoor shall be RAL 7032.

12.4 Converter Transformer

The converter transformer furnishing shall be RAL 7042.

13 ENCLOSURE

- [1] *Appendix 1; Qualification and testing of HTM (Translation)*
- [2] *Appendix 2: Extracted sections from Customer's Technical Specification for, ±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I Project*

14 REFERENCES

- | | |
|------------------------------|--|
| [1] IEC 60034-5 (2006) | Rotating electrical machines-Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) - Classification |
| [2] IEC 60072-1 (1991) | Dimensions and output series for rotating electrical machines - Part 1: frame numbers 56 to 400 and flange numbers 55 to 1080 |
| [3] IEC 60072-2 (1990) | Dimensions and output series for rotating electrical machines - Part 2: frame numbers 355 to 1000 and flange numbers 1180 to 2360 |
| [4] IEC 60072-3 (1994) | Dimensions and output series for rotating electrical machines - Part 3: Small built-in motors - flange numbers BF10 to BF50 |
| [5] IEC 60529 (2001) | Degrees of protection provided by enclosures (IP code) |
| [6] IEC/TR 60815 (1986) | Guide for the selection of insulators in respect of polluted conditions |
| [7] IEC/TS 60815-1 (2008) | Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Part 1: Definitions, information and general principles |
| [8] IEC/TS 60815-2 (2008) | Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Part 2: Ceramic and glass insulators for a.c. systems |
| [9] IEC/TS 60815-3 (2008) | Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Part 3: Polymer insulators for a.c. systems |
| [10] IEC 61000-6-2 (2005) | Electromagnetic Compatibility (EMC) – Part 6-2: Generic standards. – Immunity for industrial environment. |
| [11] IEC 61000-6-4 (2006) | Electromagnetic Compatibility - Generic Emission Standard. Part 2: Industrial environment. |
| [12] IEC/TS 61000-6-5 (2001) | Electromagnetic Compatibility (EMC) - Part 6-5: Generic standards – Immunity for power station and substation environments. |
| [13] IEC 61462 (2007) | Composite hollow insulators - Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater than 1 000 V - Definitions, test methods, acceptance criteria and design recommendations |
| [14] IEC 62155 (2003) | Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V |

[15] IEC 62271-1 (2007)	High-voltage switchgear and controlgear – Part 1: Common specifications.
[16] ISO 12944-2 (1998)	Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 2: Classification of environments
[17] ISO 9001	Quality management systems-Requirements
[18] ISO 1461 (1999)	Hot dip galvanized coatings on fabricated iron and steel articles -- Specifications and test methods
[19] COUNCIL DIRECTIVE 93/68/EEC	
[20] IEC61109 (2008)	Insulators for overhead lines – Composite suspension and tension insulators for a.c. systems with a nominal voltage greater than 1000 V - Definitions, test methods and acceptance criteria
[21] IEC61462 (2007)	Composite hollow insulators – Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater than 1000 V – definitions, test methods, acceptance criteria and design recommendations
[22] IEC62231 (2006)	Composite station post insulators for substations with a.c. voltages greater than 1000 V up to 245 kV – Definitions, test methods and acceptance criteria
[23] DL/T 810-2002	Electric Power Industry Standard of the People’s Republic of China: Technical specification for ±500 kV D.C. long rod composite insulators
[24] IEC60664-1 (2007)	Insulation coordination for equipment within low-voltage systems. Part 1: Principles, requirements and tests
[25] IEC60112 (2009)	Method for the determination of the proof and the comparative tracking indices of solid insulating materials
[26] IS-1893 (2002)	<i>Criteria earthquake resistant design of structures</i>
[27] IS-875 Part-III (1987)	<i>Code of Practice for Design Loads (other than earthquake) for Building and Structures</i>
[28] IS-2147	<i>Degrees of protection provided by enclosures for low voltage switchgear and controlgear</i>
[29] IS-5039	<i>Distribution pillars for Voltages not Exceeding 1000 Vac /1200V dc</i>
[30] IS-8623	<i>Specification for Switchgear & Control Assemblies</i>
[31] IEC-60439	<i>Rotating Electrical Machines</i>
[32] IS-325	<i>Three Phase Induction Motors</i>
[33] SECRC/TS/TR-08/199	<i>Seismic Qualification Procedures for Electrical Equipment</i>

15 Appendix 1

15.1 Qualification of HTM

The following text is an excerpt from translated English text of clause 5.6 of Ref. [23].

5.6 Hydrophobicity test

This test is to evaluate the hydrophobicity performance of the insulator, including hydrophobicity of housing/shed, transference of after polluted, loss and recovery of hydrophobicity under specified conditions.

The hydrophobicity is described with Contact Angle (θ) and Hydrophobicity Class (HC).

5.6.1 Test specimens

The formula and vulcanized formation process of the specimens should be identical to the insulator shed/housing assembled on product line. In case of difference of formula and vulcanized formation process between the insulator housing and shed, this test should be conducted on materials of housing and shed respectively.

- a. Contact Angle (CA) method: three flat-type specimens, each with area of (30~50) cm², thickness of (3~6)mm.
- b. Hydrophobicity Class (HC) method: five flat-type specimens, each with area of (50~100) cm².
- c. Surface cleaning prior to test: Use Ethanol absolute to clean the surface and then rinse the surface with deionized water (or distilled water). After dried, place the specimens in a dust-proof container and keep them under standard laboratory conditions for at least 24 hours.
- d. Specimen polluting and transference of hydrophobicity: after the specimens are pre-cleaned, spray the specimens with methods specified in B2.2 and B2.3 of Annex B, with salt density of 0.1mg/cm², ash density of 0.5mg/cm². After polluted, place the specimens in a dust-proof container under standard laboratory ambient conditions for transference of hydrophobicity over 4 days.

5.6.2 Method of hydrophobicity measurement

- a. Contact Angle (CA) method: This method has the purpose of revealing the hydrophobicity state on surface by directly measuring the static contact angle of [water] droplets on a solid surface. The contact angle (θ) may be measured with a CA meter, measuring microscope or photography. The volume of each droplet is about (4~7) μ l (i.e. each droplet weighs 4~7mg). For each specimen, the θ of five droplets will be measured (the average of the 15 measurements on the three specimens is denoted in θ_{av} , minimum denoted in θ_{min}).
- b. Hydrophobicity class (HC) method: This method has the purpose of revealing the hydrophobicity state on a solid surface so as to classify it into hydrophobicity classes. Seven classes of hydrophobicity (HC 1~ HC7) have been defined. HC 1 corresponds to a completely hydrophobic (water-repellent) surface and HC 7 to a completely hydrophilic (easily wetted) surface. See Annex E for description and typical condition of different classes of hydrophobicity.

- (1) HC measurement procedure: Spray [water] 1 time per second from a distance of 25cm. The spraying shall continue for 25 seconds. There should be runnels flowing down from the surface after the sprays. The spraying direction should be perpendicular to the surface of the specimen if possible. The judgment of the hydrophobicity class shall be performed within 30 seconds after the spraying has been finished. The specimen should be placed 20°~30° from the plane surface.
- (2) Sprayer: a spray bottle may be used. The volume of each spray should be 0.7~1 ml, dispersion angle 50°~70°. Verification of the spray dispersion angle may be measured with the following method: erect a newspaper 25cm away from the spray nozzle, with the spraying direction perpendicular to the newspaper. After 10~15 sprays, a wet area with diameter of 25~35cm will be formed.

5.6.3 Test procedure and passing criteria

Measure both the θ and HC for the specimen, which shall comply with the following criteria:

- a. Hydrophobicity: Measure the θ and HC of the clean surface of the specimen with the methods specified in 5.6.2. See 5.6.1 for the test specimens. For housing and shed of composite insulators, the following criteria apply:
 - (1) $\theta_{av} \geq 100^\circ$, $\theta_{min} \geq 90^\circ$;
 - (2) Generally HC1~HC2, no more than 1 specimen measured to HC3.
- b. Loss of hydrophobicity: Immerse 5 clean specimens into a glass vessel containing distilled water, for 96 hours, under standard lab ambient conditions. The distilled water should be enough to completely immerse the specimens, whose conductivity is less than 10 μ S/cm. See 5.6.1 for test specimens.

After taking the specimens out of the vessel, dry the surface with filter paper. Then randomly select three of the specimens and measure their Contact Angle and Hydrophobicity Class. For the other two specimens, only HC is measured. The measurement on each specimen should be finished in 10 minutes. The conformance criteria are as follows:

- (1) $\theta_{av} \geq 90^\circ$, $\theta_{min} \geq 80^\circ$;
 - (2) Generally HC3~HC4, no more than 1 specimen measured to HC5.
- a. Recovery of hydrophobicity: After completing the measurement in 5.6.3 b, place the specimens under standard lab ambient conditions for 48 hours. Then randomly select three of the specimens and measure their Contact Angle and Hydrophobicity Class. For the other two specimens, only HC is measured. The conformance criteria are as follows:
 - (1) $\theta_{av} \geq 95^\circ$, $\theta_{min} \geq 90^\circ$;
 - (2) Generally HC2~HC3, no more than 1 specimen measured to HC4.
 - b. Transference of hydrophobicity: Randomly select three of the five specimens that have been polluted and hydrophobicity transferred for 4 days with the method specified in 5.6.1 d. Then, randomly select three of the specimens and measure their Contact Angle and Hydrophobicity Class. For the other

two specimens, only HC is measured. The conformance criteria are as follows:

- (1) $\theta_{av} \geq 110^\circ$, $\theta_{min} \geq 100^\circ$;
- (2) Generally HC2~HC3, no more than 1 specimen measured to HC4.

15.2 Tracking and erosion test

The following text is an excerpt from translated text of clause 5.5.1 of Ref. [23].

5.5.1 Tracking and erosion test on housing/shed

- a. Test specimens: five specimens shall be tested in a group. The dimension of each specimen should be 120mm*50mm*6mm. The formula and vulcanized formation process of the specimens shall be identical to the insulator shed/housing assembled on product line. In case of difference of formula and vulcanized formation process between the insulator housing and shed, this test should be conducted on materials of housing and shed respectively.
- b. Test system: inclined plane method as stipulated in GB 6553 will be used in this test. The test system should provide +4.5kV D.C. voltage. During the test, in case of 60mA current flowing at the high-voltage side for 0.5s, the output voltage drop should not be greater than 5%. The polluting liquid flowing through the surface shall be (0.2 ± 0.05) ml/min.
- c. Test procedure: mount the specimens and supply polluting liquid to the specimens as per stipulations in GB 6553. Apply +4.5kV voltage to the specimens and record the time. The test will last 6 hours. Before and after the test, measure the polluting liquid volume flowing through each specimen, record the test duration of each specimen as well as the aggregate volume of the polluting liquid used. The polluting liquid should not be reused.
- d. Evaluation of the test: The test is regarded as passed if, after the 6h test, no tracking occurs and the erosion depth is no more than 2.5mm. In such case, it will be deemed that the specimens have come up to Class 4.5.

15.3 DC dielectric strength test

The following text is an excerpt from translated text of clause 5.5.2 of Ref. [23].

5.5.2 D.C. dielectric strength test on housing/shed

- a. Test specimens: The thickness of the specimen should be (2 ± 0.1) mm, other dimension indexes should comply with stipulations of GB/T 1408.
- b. Test system and procedure: This test is conducted as per GB/T 1408. D.C. voltage is used as the test voltage, with voltage ripple factor no greater than 5%. D.C. dielectric strength test is made on each of the five specimens.
- c. Compliance criterion: the D.C. dielectric strength of the specimens should not be smaller than 30kV/mm

16 Appendix 2**(Extracted applicable sections from the Customer's Technical Specification)**

The following applicable sections are extracted from the customer's technical specifications.

3.3.4 NAME PLATES AND MARKINGS

- 1) All equipment mounted on front and rear side as well as equipment mounted inside the panels shall be provided with individual nameplates with equipment designation engraved. Also on the top of each panel on front as well as rear side, large and bold nameplates shall be provided for circuit/ feeder designation.
- 2) All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring.
- 3) All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type, serial number and electrical rating data.
- 4) Name Plates shall be made of non-rusting metal or 3-ply lamicaid. Nameplates shall be black with white engraving lettering.

All the panels shall be provided with nameplate mounted inside the panel. Stainless steel nameplates shall be installed on all apparatus and on all major equipment components. For indoor cubicles, nameplates made of aluminium shall also be acceptable. Name plates shall be white with black engraved lettering and shall carry all the applicable information specified in the applicable items of the Standards, together with any other relevant information which may be required. For groups of smaller items for which this is not possible e.g. switch bays etc. a common nameplate with the title and special instructions on it shall be provided. No scratching, corrections or changes shall be allowed on nameplates. Main equipments like converter transformer, CBs, Reactor, Filter gates etc shall have nameplates in Hindi also.

All equipment mounted on front and rear sides as well as equipment mounted inside the panels shall be provided with individual name plates with equipment designation engraved. Also on the top of each panel on front as well as rear sides large nameplates with bold size lettering shall be provided for circuit / feeder / cubicle / box designation.

All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate tracing of the wiring. The nameplates shall be mounted directly by the side of the respective equipment and shall not be hidden by the equipment wiring.

The nameplate inscription and size of nameplates and letters shall be submitted to the Employer for approval.

The nameplates of the apparatus shall include, at least, the information listed below, together with any other relevant information specified in the applicable standards:

- a) A concise descriptive title of the equipment
- b) Rating and circuit diagram reference numbers
- c) Manufacturer's name, trade-mark, model type, serial number

- d) *Instruction book number*
- e) *Year of manufacture*
- f) *Total weight (for capacitor racks indicate weight, for capacitors indicate quantity of liquid)*
- g) *Special instructions, if any, about storage, transportation, handling etc.*

Each measuring instrument and meter shall be prominently marked with the quantity measured e.g. kV, A, MW etc. All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type, serial number and electrical rating data.

Danger plates and plates for phase colours shall be provided as per requirement. The Contractor shall devise a system to designate equipment and sub-systems. The nameplates/ labels displaying these designations shall be installed at appropriate locations.

Wherever motion/ flow of fluids are involved, plates/ marks showing direction of motion/ flow shall also be provided.

3.5 PAINTING AND FINISHING OF METAL SURFACES

All sheet steel work shall be phosphated in accordance with the IS: 6005 "Code of practice for phosphating iron and steel".

Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning.

Rust and scale shall be removed by pickling with dilute acid followed by washing with running water rinsing with a slightly alkaline hot water and drying.

After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of two coats of ready mixed, stoved type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.

After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after inspection of first coat of painting. The exterior colour of paint shall be of a slightly different shade to enable inspection of the painting.

A small quantity of finished paint shall be supplied for minor touching up required at site after installation of the panels.

In case the Bidder proposes to follow his own standard surface finish and protection procedures any other established painting procedures, like electrostatic painting etc., the procedure shall be submitted along with the Bids for Employer's review & approval. The Contractor shall use procedures for painting approved by the Employer during detailed Engineering.

Contractor's standard practice shall be acceptable to the Employer subject to approval during detailed engineering and meeting all functional requirements of the TS.

3.5.1 HOT DIP GALVANIZING

The minimum weight of the zinc coating shall be 615 gm/ sq.m and minimum thickness of coating shall be 85 microns for all items thicker than 6 mm. For items less than 6 mm, requirements of coating thickness shall be as per relevant ASTM. For surfaces, which shall be embedded in concrete, the zinc coating shall be 900-gm/ sq.m .

The galvanized surfaces shall consist of a continuous and uniform thick coating of zinc, firmly adhering to the steel. The finished surface shall be clean and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, which is loosely attached to the steel globules, spiky deposits, blistered surfaces, flaking or peeling off, etc. The presence of any of these defects noticed on visual inspection shall render the material liable to rejection.

After galvanizing, no drilling or welding shall be performed on the galvanized parts of the equipment except the nuts may be rethreaded after galvanizing. Sodium dichromate treatment shall be provided to avoid formation of white rust after hot dip galvanization.

The galvanized steel shall be subjected to six one-minute dips in copper sulphate solution as per IS-2633.

Sharp edges with radii less than 2.5 mm shall be able to withstand four immersions of the Standard Preece test. All other coatings shall withstand six immersions. The following galvanizing tests should be performed as per relevant Indian Standards.

- Coating thickness
- Uniformity of zinc
- Adhesion test
- Mass of zinc coating

3.6 CONTROL CABINETS, JUNCTION BOXES, TERMINAL BOXES & MARSHALLING BOXES FOR EQUIPMENT

All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with IS-5039/IS-8623, IEC-60439, as applicable, and the clauses given below:

1. *Enclosure for control cabinets, junction boxes, Marshalling boxes & terminal boxes shall be made of stainless steel or aluminium and shall be dust, water and vermin proof. The box shall be properly braced to prevent wobbling. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation.*

2. *The enclosures of the control cabinets, junction boxes, terminal boxes & marshalling boxes located outdoor shall provide a degree of protection of not less than IP 55 as per IS-2147 One control cabinet, junction box, terminal box & marshalling box of each type shall be tested for the same.*
3. *Cabinets/boxes shall be freestanding floor-mounting type, wall mounting type, or pedestal mounting type as required. Equipments such as telephone exchange, Public address systems etc shall be kept inside cubicles.*
4. *Cabinets/ boxes shall be provided with double-hinged doors with padlocking arrangements. The distance between two hinges shall be adequate to ensure uniform sealing pressure against atmosphere. The quality of the gasket shall be such that it does not get damaged / cracked during the operation of the equipment.*
5. *All doors, removable covers and plates shall be gasketed all around with suitably profiled EPDM gaskets. The gasket shall be tested in accordance with approved Quality Plan. Ventilating louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh made of brass.*
6. *All boxes/cabinets shall be designed for the entry of cables from the bottom by means of weatherproof and dust-proof connections. Boxes and cabinets shall be designed with generous clearances to avoid interference between the wiring entering from below and any terminal blocks or accessories mounted within the box or cabinet. A suitable horizontal cable gland plate positioned at least 150 mm above the base of the marshalling kiosk/box shall be provided for this purpose along with the proper blanking plates. Necessary number of cable glands shall be supplied and fitted on this gland plate. The gland shall project at least 25mm above gland plate to prevent entry of moisture in cable crutch. Gland plate shall have provision for some future glands to be provided later, if required. The glands shall be dust proof, screw on & double compression type and made of brass. The gland shall have provision for securing armour of the cable separately and shall be provided with earthing tag. The glands shall conform to BS: 6121 and shall be nickel-plated.
*Boxes / cabinets to be located inside a building in a non air-conditioned area may be designed for the entry of cables from the bottom or from the top.**
7. *Earthing*
The provision for earthing shall be generally as per requirements given in Clause 3.7.2.1.
8. *Tests*
 - a) *The Marshalling Kiosks shall be subject to routine tests as per IS: 5039*
 - b) *The following routine tests shall also be conducted:*
 - i) *Check for wiring*

ii) *Visual and dimension check*

Marshalling kiosk shall be provided with danger plate and a diagram showing the numbering/ connection/ ferruling by pasting the same on the inside of the door.

Marshalling kiosk shall also be provided with incoming MCB and one 15 Amp interlocked switched socket in addition to the MCB required

3.7 **INDOOR CONTROL CUBICLES**

The control panel, cubicles and desks shall be in accordance with the relevant IEC standards and shall be installed in air-conditioned space. Indoor electronic cubicles shall not generally require fans for cooling in order to operate successfully and correctly at the maximum ambient temperature. However, if it is absolutely necessary to install fans etc. in cubicles for cooling then these shall be driven by the same dc supply as used for control, and necessary redundancy, failure alarm etc. shall be incorporated. Louvers in the doors and side panels shall be permitted, if required.

The control and relay panels shall be suitable for numerical relays of modular type mounted in standard 19 inch racks located on the vertical front panel with rear doors for access or located on the front doors for front access type panels. Panels Cubicles shall be completely metal enclosed and shall be dust, moisture and vermin proof. The enclosure shall provide a degree of protection not less than IP 32 in accordance with IS-2147 for cubicles located in air-conditioned areas. IP 31 may also be acceptable for these areas if the layout is arranged such that there is no possibility at all of any liquid entering the area. However, for ventilation reasons the cubicles may be provided with a ventilation hood at the top with a protection class of IP21.

Panels shall be free standing, floor mounting type and shall comprise structural frames enclosed completely with specially selected smooth finished, cold rolled sheet steel of thickness not less than 2.5 mm for weight bearing members of the cubicles such as base frame, front sheet and door frames, and 1.5 mm for sides, door top and bottom portions. There shall be sufficient reinforcement to provide level surfaces, resistance to vibration and rigidity during transportation and installation. The cubicles shall be provided with lifting lugs.

All doors, removable covers and plates shall be gasketed all around with neoprene gaskets. Ventilation louvers, if provided, shall have screens and filters. The screens shall be made of either brass or GI wire mesh with a graduation of 1 mm or less.

Design, material selection and workmanship shall be such as to result in a neat appearance, inside and outside with no welds rivets or bolt heads apparent from outside, with all exterior surfaces true and smooth. All cubicles located in any room shall be matched in appearance.

The Contractor along with anchor bolts and necessary hardware for mounting the cubicles shall furnish metal sills in the form of metal channels

properly drilled. Panels shall have an additional rolled channel plinth at the bottom with a smooth bearing surface. The panels shall be fixed on channels with intervening layers of anti-vibration strips made of shock absorbing material, which shall be supplied by the Contractor.

Contractor's standard practice for control panels shall be acceptable to the Employer subject to approval during detailed engineering and meeting all functional requirements of the TS.

3.7.1 MOUNTING

All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections. The equipment on front of panel shall be mounted flush. No equipment shall be mounted on the doors.

Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent devices and are readily accessible without use of special tools. Terminal marking on the equipment shall be clearly visible.

The Contractor shall carry out cut out, mounting and wiring of the free issue items supplied by others, which are to be mounted in his panel in accordance with the corresponding equipment manufacturer's drawings. Cut outs if any, provided for future mounting of equipment shall be properly blanked off with blanking plate.

The centre lines of switches, push buttons and indicating lamps shall be not less than 750mm from the bottom of the panel. The centre lines of relays, meters and recorders shall be not less than 450mm from the bottom of the panel

The centre lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Like wise the top lines of all meters, relays and recorders etc. shall be matched.

No equipment shall be mounted on the doors.

At existing station, panels shall be matched with other panels in the control room in respect of dimensions, colour, appearance and arrangement of equipment (centre lines of switches, push buttons and other equipment) on the front of the panel.

3.7.2 EARTHING

- 1) *All panels shall be equipped with an earth bus securely fixed. Location of earth bus shall ensure no radiation interference for earth systems under various switching conditions of isolators and breakers. The material and the sizes of the bus bar shall be at least 25×6 sq. mm perforated copper with threaded holes at a gap of 50mm with a provision of bolts and nuts for connection with cable armours and mounted equipment etc for effective earthing. When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply of Contractor. Provision shall be made for extending the earth bus bars to future adjoining panels on either side.*

- 2) *Provision shall be made on each bus bar of the end panels for connecting Substation earthing grid. Necessary terminal clamps and connectors for this purpose shall be included in the scope of supply of Contractor.*
- 3) *All metallic cases of relays, instruments and other panel mounted equipment including gland plate, shall be connected to the earth bus by copper wires of size not less than 2.5 sq. mm. The colour code of earthing wires shall be green.*
- 4) *Looping of earth connections, which would result in loss of earth connection to other devices when the loop is broken, shall not be permitted. Earthing may be done in such a manner that no circulating current shall flow in the panel.*
- 5) *VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.*
- 6) *An electrostatic discharge point shall be provided in each panel connected to earth bus via 1 Mega Ohm resistor.*

3.7.3 INSTRUMENTS, METERS AND RECORDERS

For HVDC station and associated AC yards only digital displays and systems shall be provided. The requirements in this section are applicable to auxiliary systems only. All instruments, meters and recorders shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. They shall be calibrated to read directly the primary quantities. They shall be accurately adjusted and calibrated at the factory and shall have means of calibration, checking and adjustment at site.

3.7.4 MISCELLANEOUS

- 1) *The Contractor shall submit all type and routine test certificates to the Employer for approval before dispatching the equipment. Control and relay panels shall also be subjected to the following tests:*
 - i) *Mechanical operation test*
 - ii) *Verification of degree of protection as per IS-2147*
 - iii) *High voltage test*
 - iv) *Electrical control, Interlock and sequential operation test*
 - v) *Verification of wiring as per approved schematic.*
- 2) *Plug Point: 240V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.*
- 3) *Interior Lighting: Each panel shall be provided with a CFL lighting fixture rated for 240 Volts, single phase, 50 Hz supply for the interior*

illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.

- 4) *MCB's: Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with miniature circuit breakers (MCB).*
- 5) *Space Heater: Panels wherever required shall be provided with a space heater rated for 240V single phase, 50 Hz Ac supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with thermostat and switch fuse /MCB unit.*

3.9 WELDING AND WELDERS' QUALIFICATIONS

All welding shall be in accordance with the corresponding standards of the American Welding Society or the American Society of Mechanical Engineers.

Other standards to determine the quality of welding processes and qualifications of welders may be considered, provided that sufficient information is first submitted for the approval of the Employer.

Prior to the start of fabrication, the Contractor shall submit to the Employer for approval, a description of each of the welding procedures which he proposes to adopt, together with certified copies of reports of the results from tests made in accordance with these procedures.

The Contractor shall be responsible for the quality of the work performed by his welding organization. All welding operators shall be assigned to the work, including for repair of castings, shall pass the required tests for qualification of welding procedures. The Employer reserves the right to witness the qualification tests for welding procedures and operators and the mechanical tests of the samples. If the Inspector so requires, the Contractor shall furnish to the Inspector certified copies of reports of the mechanical test results of the samples.

The Contractor shall bear all his own expenses in connection with the qualification tests. If the work of any operator at any time appears questionable, such operator shall be required to pass appropriate re-qualification tests as specified by the Inspector and at the expense of the Contractor.

Strict measures for quality control shall be exercised throughout the Equipment/Works. The Engineer may call for an adequate NDT test of the work of any operator, who, in his opinion, is not maintaining the required standard of workmanship. Should this NDT test prove defective, all work done by that operator, since his last test shall be tested at the Contractor's expense. If three or more of these tests prove defective, the operator shall be removed from the project.

A procedure for the repair of defects shall be submitted to the Employer for his approval prior to any repairs being made

6.15.2 BUSHING AND SUPPORT INSULATORS

6.15.2.1 GENERAL

Bushings shall be manufactured and tested in accordance with IEC-60137 and IS-2099 & IS-3347 while hollow column insulators shall be manufactured and tested in accordance with IEC-233 and IS-5284. The support insulators shall be manufactured and tested as per IEC-60168, IEC-60273 and IS-2544. The insulators shall also conform to IEC-60815 as applicable.

All bushings shall be one piece only and no joints shall be accepted. If joint is unavoidable on a bushing, the Contractor shall seek Employer's approval on a case to case basis.

6.15.2.2 CONSTRUCTIONAL FEATURES

- a) *Porcelain used shall be homogeneous and free from imperfections that might affect the mechanical or dielectric quality.*
- b) *Glazing of the porcelain shall be of uniform brown colour, free from blisters, burns and other similar defects. The ground surface shall not be glazed.*
- c) *Condenser type bushing shall be provided with:*
 - i) *Oil level gauge.*
 - ii) *Oil filling plug and drain valve if not hermetically sealed.*
 - iii) *Tap for capacitance and tan delta test.*
- d) *When bushings have an under-oil end of re-entrant form, the pull through lead shall be fitted with a gas bubble deflector.*
- e) *Where current transformers are specified, the bushings shall be removable without disturbing the current transformers.*
- f) *Bushings of identical rating shall be interchangeable.*
- g) *No arching horns shall be provided on the bushings.*
- h) *All ferrous parts shall be hot dip galvanized or zinc plated and passivated. All joints shall be air tight. Insulator/bushing design shall be such as to ensure a uniform compressive pressure on the joints.*
- i) *Support insulators/bushings/hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they shall be used.*
- j) *When operating at rated voltage there shall be no electric discharge between conductor and insulators which would cause damage to conductors or insulators by the formation of substances produced by chemical action. No radio interference shall be caused when operating at rated voltage.*
- k) *The design of the insulator shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.*

- l) *The Bidder/Contractor shall define the type of insulator (type A or B) as per IEC-60168.*
- m) *Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps and the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.*
- n) *Special precaution shall be taken to exclude moisture from paper insulation during manufacture, assembly, transport and erection. The surface of all paper insulation shall be finished with non-hygroscopic varnish which can not be damaged easily.*

6.15.2.4 TESTS

Each type of bushing and insulator shall be subjected to type and routine tests in accordance with applicable standards and acceptance test shall include one minute dry power frequency withstand test and ultrasonic test (except for hollow insulator).

The ultra sonic test shall be done on the porcelain before assembly. All sample tests and special tests shall also be conducted.

Additional type tests to be carried out if joint is provided in bushing as follows:

- 1. Mechanical Bonding test at Jointed Section*
- 2. Tracking and Erosion Test (IEC-60587)*
- 3. Water diffusion Test (Samples to be taken from jointed area)*
- 4. Gas leakage test followed by mechanical tests at the joint area.*



Technical Report

Reporting CRC: ABB AB
 Corporate Research
 SE-721 78 Västerås Sweden
 Tel.: +46 21 323000 Fax: +46 21 121570

Responsible Person:

Project Name: **±800 kV, 6000MW HVDC Multi Terminal NER/ER-NR/WR Interconnector - I Project (India)** CRID-No.:

Document Title: **Seismic Qualification Procedures for Electrical Equipment**

Document Ref. No.: SECRC/TS/TR-08/199(rev.1) Reg.: Page 1
 Date of issue: 2008-06-24 (2011-09-28rev.1) Classification: No. of pages: 8
 Client: PS/G/DC/ODM Per H Johansson No. of encl: 5
 Order No.:

Author(s): Sören Berggren Approved: Bo Häggblad
Sören Berggren *Bo Häggblad*

Distribution:

Keywords

Summary:

This report directs the procedures to be used for seismic qualification of electric equipment in compliance with the specification for the ±800 kV, 6000 MW HVDC Multi Terminal NER/ER-NR/WR Interconnector - I project.

Load definitions and combinations are given as well as procedures and scope of documentation. References are made to the Owner specification for seismic design and relevant internationally recognized codes.

The basic procedure will be response spectrum analysis with a relevant design response spectrum. Suitable design spectra are defined corresponding to Design Basis Earthquake and Importance Factor 1.5 of IS 1893-2002 (ref. 1) with 0.27 g maximum ground acceleration in horizontal directions and 0.18 g in the vertical direction at Station Biswanath Chariali located in seismic zone V. For station Alipurduar in zone IV the acceleration level is 0.18 g (vertical 0.12g) and for station Agra in zone III the level is 0.12g (vertical 0.08g).

The proposed procedures are intended to fully comply with the Owner specification.

पावर ग्रिड कॉर्पोरेशन लिमिटेड POWER GRID CORPORATION OF INDIA LTD	
800kV 6000MW HVDC Multi Terminal NER/ER - NR/WR	
Approved in Category: <input checked="" type="checkbox"/>	IV
Checked by: <i>V</i>	Reviewed by: <i>[Signature]</i>

Revision 1 Tables 1 and 3 changed. New appendix page A-3: Various changes in text.
 2011-09-28 (Design RRS no change). Altered station Alipurduar (zone IV)
 SB *SB*

CONTENTS

1.	GENERAL OUTLINE	3
2.	SEISMIC LOAD SPECIFICATION	3
3.	DESIGN CRITERIA AND ALLOWABLES	5
4.	QUALIFICATION METHODS	5
5.	DESIGN CONSIDERATIONS	6
5.1	General	6
5.2	Thyristor Valves	6
5.3	Converter Transformers	6
5.4	Switchyard Equipment	6
5.5	Auxiliary Power and Control Equipment	6
5.6	System Design	7
5.7	Equipment Supports Supplied by Owner	7
6.	DOCUMENTATION	7
6.1	General	7
6.2	Analysis Results	7

LIST OF APPENDICES

APPENDIX A

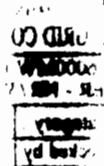
Design Response Spectrum for Electrical Equipment

APPENDIX B.

REFERENCES. Applicable Standards for Seismic Qualification

APPENDIX C

Excerpts of Project Specification Concerning Seismic Design of Electrical Equipment



1. GENERAL OUTLINE

ABB has an outstanding experience of seismic qualification of HVDC equipment satisfying severe seismic requirements for very strong earthquakes (California/USA and New Zealand) as well as areas with moderate earthquake hazard (India, Quebec/Canada, among others). ABB HVDC has for the practical seismic verification process engaged experts of ABB Corporate Research (Sweden) with over 30 years experience in the field dealing with ABB deliveries of electrical high voltage equipment all over the world.

The seismic ground motion specified for 800 kV HVDC Multi Terminal Project can be characterized as high level at station Biswanath Chariali (zone V of IS 1893-2002), moderate at Alipurduar (zone IV) and low at Agra (zone III).

The seismic design philosophy, based on previous experience, is that basically standard configuration of electrical equipment can be used, but with more or less reinforcement of critical parts, for example using stronger porcelain insulators or polymer insulators for bushings. For a key equipment like the thyristor valves the ABB standard design of a ceiling suspended valve has good inherent withstand capability to seismic load and practically no special modifications are needed except using a flexible bus connection to handle displacements. However, all significant equipment shall be carefully analyzed, checking all critical structural parts in order to demonstrate sufficient seismic - withstand capability. The verification work will be appropriately documented in technical reports and presented for information and will be available for review of the owner.

It shall be noted that ABB intends to fully comply with the Owner seismic specification and design procedures without any exceptions or limitations, as detailed below.

2. SEISMIC LOAD SPECIFICATION

The loads will be specified for seismic levels as defined in table 1 below.

For static analysis of dynamically rigid equipment (lowest natural frequency above 35 Hz, the seismic coefficient will be taken to 1.5 times the maximum ground acceleration. In this analysis the load combination of horizontal and vertical seismic forces will be done with the absolute sum method.

For dynamic analysis load definitions will be based on relevant response spectra. The shape of proposed design response spectra is as directed in *Indian Standard IS 1893:2002 scaled to given peak zone factor z/2 times the importance factor I=1.5*. This corresponds to the DBE - Design Basis Earthquake. The zone factor z of IS 1893 refers to the MCE - Maximum Considered Earthquake. The structure factor is taken to be **R=1.0** for electrical equipment with possible brittle behavior. According to IS1893: 2002 the ratio I/R need not to exceed 1.0, but for electrical equipment

the value of $I/R=1.5$ is used. This conservative assumption is due to that electrical equipment, with in particular brittle porcelain insulators, are more sensitive for its well function than typical more ductile building structures.

Table 1. Definition of Seismic Severity for Stations (DBE). Ground Level

Station	Zone	z	Peak Ground Acceleration g	Peak Response g (damping 2%)
Biswanath Chariali	V	0.36	0.27	0.95
Alipurduar	IV	0.24	0.18	0.63
Agra	III	0.16	0.12	0.42

The design spectra to be used for zone IV are depicted in Appendix A-1 and for zone V in A-2. The spectra have been modified at high frequency range to a constant value of the Peak Ground Acceleration above 35 Hz. At low frequency range the displacement response is constant below 0.25 Hz at a value depending on damping. These adjustments are for more realistic requirements for electrical equipment seismic behavior compared to practices for building design. See comparison to well-known design spectra of ref. 3 given in Appendix A-3 concerning the higher frequency range above 10 Hz.

Vertical direction spectra are 67% of horizontal one depicted in appendix A.

For equipment mounted on supports and other structures due consideration shall be taken to increased and filtered seismic input at points of attachment for the equipment. One way is to include the support structure in the analytical model. Another way is secondary (floor) response spectra for buildings derived from dynamic analysis.

Together with seismic load the one of dead weight and normal operating loads should be considered, also including terminal connection forces. But no other exceptional load like wind and short circuit need to be combined with seismic load. Even though short circuit may be likely to occur during the course of a seismic event the peak responses will be randomly correlated and not occurring at exactly the same instance as peak seismic response.

If not otherwise specified the following terminal connection forces in table 2 shall be used together with seismic load. However, special consideration of actual connection used may justify different forces, for example lower ones due to typical wire type of connections to filter components.

Table 2. Terminal Connection Forces (N) During Seismic Event.

Rated Voltage (kV)	Long. Force	Transv. Force	Vertical Force
<100	500	350	500
100-245	700	500	700
245-550	1000	700	900
>550	2000	1400	1800

Note. Longitudinal Force in direction of connection conductor
Transverse Force horizontal perpendicular to conductor

3. DESIGN CRITERIA AND ALLOWABLE VALUES

The equipment shall remain undamaged and operational during and after a seismic event within the design limit.

Allowable values for steel and aluminum structures shall be taken according to well-know applicable structural code like the ones defined in appendix B. In general normal allowable values may be increased as given for exceptional load according to the code applied, for example with a factor 1/3 (33%) according to ref. 5 and 6.3.5.1 of ref. 1 (IS 1893:2002).

For brittle components like porcelain insulator allowable load shall be less than 67 % of minimum failure load (i.e. safety factor of 1.5). Different force components (usually axial tension/compression and bending) shall be combined appropriately to a resultant design load (see appendix C). For polymer composite insulators maximum load shall be 67 % of Specified Mechanical Load (SML-allowable exceptional force with short duration). Typically SML is 2.5 times the Maximum Design Load (allowable long term force).

4. QUALIFICATION METHODS

In general, the seismic verification will be done with analysis.

Simplified static analysis can be used for dynamically rigid equipment, i.e. with no natural frequencies below 35 Hz.

The basic method for dynamic analysis will be response spectrum analysis, supplemented by time history analysis if required by the structural behavior or equipment design (for example non-linear behavior).

If structural damping above 2 % (of critical damping) is assumed it shall be verified by dynamic testing, for example free oscillation or so called snap-back test.

In dynamic analysis seismic motion shall be considered in two horizontal directions together with vertical seismic motion (tri-axial) and normal operational loads including dead weight (no live load for electrical equipment) and *terminal forces*.

In response spectrum analysis modal contribution shall be with SRSS for well separated modes but also consider also closely spaced modes correctly by using Complete Quadratic Combination (7.8.4.4 of IS1893:2002 ref. 1 or equivalent). The tri-axial response from two horizontal and vertical seismic input shall be combined with SRSS method (Square Root of Sum of the Squares) for a resultant design value (6.3.4.2 if IS1893:2002 ref. 1).

Qualification by test may be acceptable and shall demonstrate that the equipment can withstand a seismic motion defined by design spectra (appendix A) without malfunction and damage in accordance with applicable codes (see appendix B).

5. DESIGN CONSIDERATIONS

5.1 General

In general, the design of equipment and equipment supports should be made to minimize the seismic loads. It is essential to avoid resonance and other types of interaction as far as possible. Vibration isolation by frequency separation and increased energy dissipation can be used to reduce the seismic response if necessary. Special attention should be paid to the protection of brittle parts, such as porcelain insulators.

5.2 Thyristor Valves

The ceiling suspended thyristor valve design provides an excellent vibration isolation with respect to separation of fundamental frequencies and corresponding reduction of response acceleration. A consequence of the ceiling suspension is that the building becomes part of the dynamic structure and needs to be analyzed as such. The stresses in the valve structure may be influenced by interaction between the building sway modes and some vibration modes of the valve structure and suspension (hangers). Therefore, analysis shall preferably be done with a model including a complete group of valves and the building structure. The low pendulum frequencies of the valve result in large displacements, which have to be considered for estimating electrical clearances and in the design of electrical connections. Displacement can be reduced with damper device at bottom of the valve structure.

5.3 Converter Transformers

The converter transformers are heavy pieces, the critical parts being projecting items such as bushing, oil coolers and conservator tank. Special care should be exercised to avoid resonance between the vibration modes of the transformer tank (heavy part) and those projecting parts. If necessary, the high voltage bushings may be given controlled fundamental frequencies by design of the attachment flanges or introduction of spring devices. The foundation anchorage should be thoroughly designed to prevent sliding and overturning.

5.4 Switchyard Equipment

The typical piece of high voltage switchyard equipment is a cantilever type structure on a single post support. Preferably analysis shall be done with equipment and steel support. If the support is not included the seismic input shall be increased with a structure factor of 2.5 (times the ground level defined in Appendix A). A method to enhance seismic performance may be introduction of spring/damper device at base of the electrical apparatus

5.5 Auxiliary Power and Control Equipment

Control and switchgear cubicles may need improvement with respect to transmission of horizontal forces through adequate bracing or shear panels in all directions. The advantage of connecting the cubicles in rows should

be recognized. The attachment to the floor shall have positive anchorage for uplift forces and shear. Cubicles are often located at an elevated level in the service building, which is considered in the load definition by appropriate secondary (floor) response spectra derived from dynamic analysis of the building..

5.6 System Design

The clearances between different pieces of equipment as well as to other structures are chosen sufficiently large to accommodate the seismic displacements with appropriate margins with respect to electrical clearances, physical space and electrical connections.

The different electrical components are usually dynamically decoupled by the use flexible electrical connections. In the case of rigid connections, the system is analyzed as a whole with respect to seismic response.

In the station layout and location of components, precautions should be taken to prevent not seismically classified equipment from jeopardizing the seismic performance of essential equipment.

5.7 Equipment Supports

The basic approach shall be a strong and stiff support based on a static seismic load as given in table 3 applied at equipment center of gravity. Supports may alternatively be verified by dynamic analysis together with the equipment.

Table 3. Simplified Static Load for Equipment Supports and Foundations

Station	Zone	Acceleration g	
		Horizontal	Vertical
Biswanath Chariali	V	1.0	0.67
Alipurduar	IV	0.65	0.45
Agra	III	0.45	0.30

6. DOCUMENTATION

6.1 General

The verification work is accounted for in a seismic qualification report. The extent of the report is defined in the following sections. Sufficient details are given for the understanding of analysis or test procedures and models and to facilitate verification of major results.

6.2 Analysis Results

The analytical report contains the following information as applicable with regard to the method used:

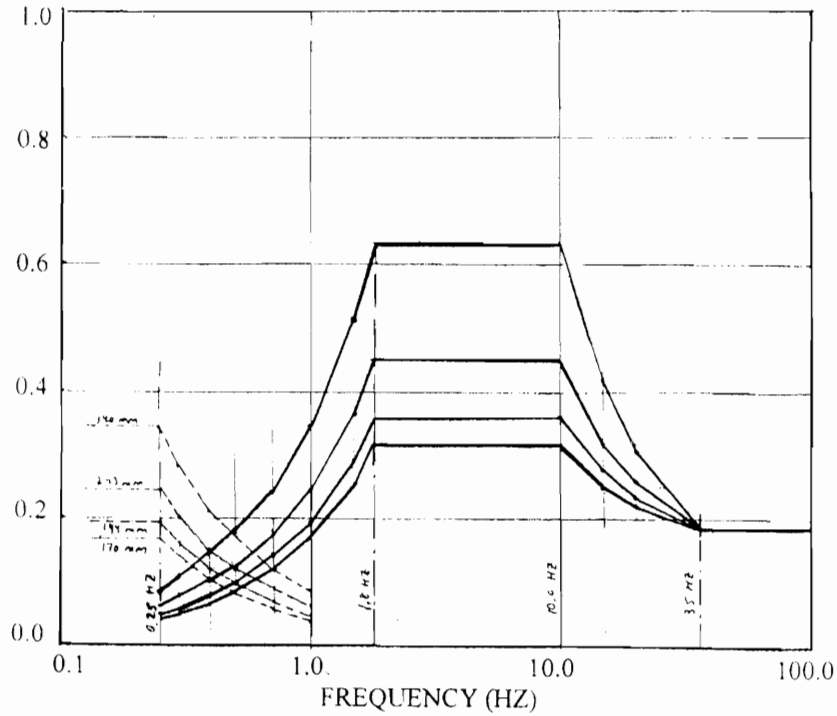
- a) Short summary including
 - Equipment identification and a brief description

- Major input conditions such as equipment mass, methods used and load definitions
 - Principal results such as fundamental frequencies, maximum response and factors of safety
 - Statement with regard to the seismic withstand capability of the equipment
- b) Description of the structure and the corresponding
- Principal dimensions
 - Mass distribution
 - Centers of gravity
 - Anchoring details
 - Material and section properties
 - Damping values
 - Boundary conditions
- c) Loads and load combinations
- d) Method description and justification
- Analytical procedure
 - Computer codes
 - Combination of modal responses
- e) Results from modal analysis
- Natural frequencies
 - Mode shapes (selection)
 - Modal participation factors
- f) System response
- Displacements
 - Section forces and moments
 - Stresses, compared to allowable
 - Strength of joints and anchoring
 - Foundation loads

APPENDIX A-1
Design Response Spectrum For Electrical Equipment For
Zone IV According IS 1893-2002

Shape From Indian Standard IS 1893-2002 Scaled to Peak Ground Acceleration 0.18 g for the case of Design Basis Earthquake and Medium Soil Site. Vertical direction spectra are 67% of the horizontal spectra defined below

Accel. (g) / Displ (m)

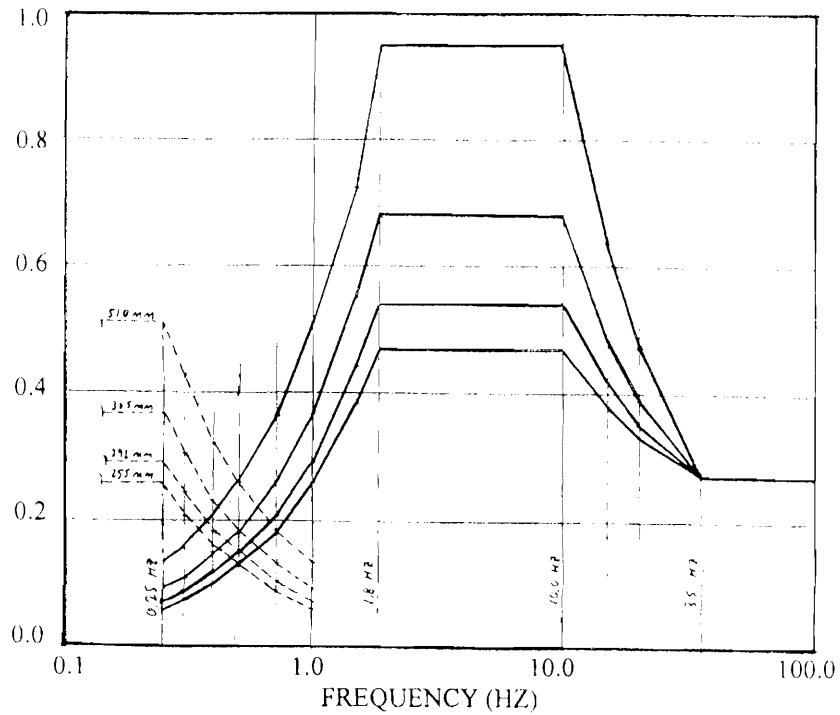


Frequency Hz	Spectrum Acceleration(g) and Displacement(mm) for Damping Ratios			
	2%	5%	10%	15%
0.25	0.086g/340mm	0.061g/243mm	0.049g/194mm	0.043g/170mm
0.3	0.103g/283mm	0.074g/202mm	0.059g/162mm	0.052g/142mm
0.4	0.137g/213mm	0.098g/152mm	0.078g/122mm	0.069g/107mm
0.5	0.17g/170mm	0.12g/121mm	0.097g/97mm	0.085g/85mm
0.7	0.24g/122mm	0.17g/87mm	0.14g/70mm	0.12g/61mm
1.0	0.34g/85mm	0.24g/61mm	0.19g/48mm	0.17g/43mm
1.5	0.51g	0.36g	0.29g	0.26g
1.8	0.63g	0.45g	0.36g	0.32g
10.0	0.63g	0.45g	0.36g	0.32g
15.0	0.42g	0.32g	0.28g	0.25g
20.0	0.31g	0.26g	0.24g	0.22g
35.0	0.18g	0.18g	0.18g	0.18g

APPENDIX A-2
Design Response Spectrum For Electrical Equipment For
Zone V According IS 1893-2002

Shape From Indian Standard IS 1893-2002 Scaled to Peak Ground Acceleration 0.27 g for the case of Design Basis Earthquake and Medium Soil Site.
Vertical direction spectra are 67% of the horizontal spectra defined below

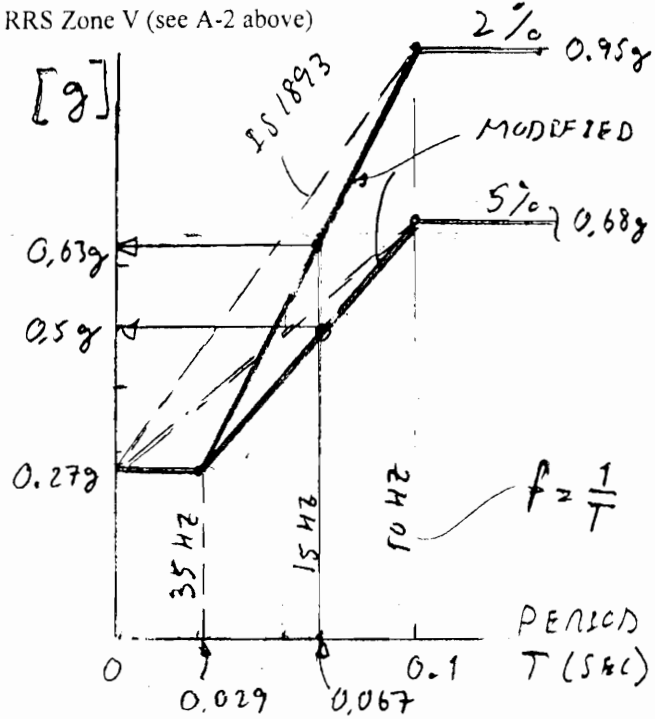
Accel. (g) / Displ (m)



Frequency Hz	Spectrum Acceleration(g) and Displacement(mm) for Damping Ratios			
	2%	5%	10%	15%
0.25	0.129g/510mm	0.092g/365mm	0.074g/291mm	0.064g/255mm
0.3	0.155g/425mm	0.110g/303mm	0.089g/243mm	0.077g/213mm
0.4	0.21g/320mm	0.15g/228mm	0.12g/183mm	0.10g/161mm
0.5	0.26g/255mm	0.18g/182mm	0.15g/146mm	0.13g/128mm
0.7	0.36g/183mm	0.26g/131mm	0.21g/105mm	0.18g/92mm
1.0	0.51g/128mm	0.37g/92mm	0.29g/72mm	0.26g/63mm
1.5	0.77g	0.55g	0.44g	0.38g
1.8	0.95g	0.68g	0.54g	0.47g
10.0	0.95g	0.68g	0.54g	0.47g
15.0	0.63g	0.48g	0.42g	0.38g
20.0	0.47g	0.39g	0.35g	0.33g
35.0	0.27g	0.27g	0.27g	0.27g

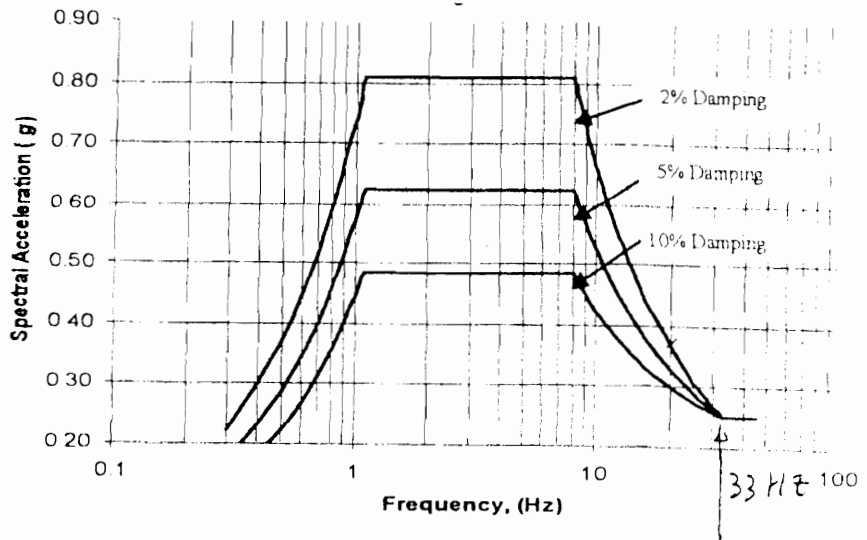
APPENDIX A-3
Design Response Spectrum For Electrical Equipment
Outline Modified Response for Frequency Range Above 10 Hz
Compared to According IS 1893-2002

RRS Zone V (see A-2 above)



Design Spectra Electrical Equipment of IEEE693 (ref. 3)

IEEE Std 693-2005
IEEE Recommended Practice for Seismic Design of Substations



APPENDIX B**References. Applicable Standards for Seismic Qualification**

- [1] *IS 1893(Part 1):2002 & 2005 (Part IV)*
Indian Standard. Criteria For Earthquake Resistant Design of Structures.
Part 1 General Provisions and Buildings (Fifth Revision)
- [2] *IEEE Std 344*
The Institute of Electrical and Electronic Engineers, Inc.:
IEEE Recommended Practices for Seismic Qualification of Class 1E
Equipment for Nuclear Power Generating Stations.
- [3] *IEEE Std 693-2005*
The Institute of Electrical and Electronic Engineers, Inc.:
IEEE Recommended Practices for Seismic Design of Substations.
- [4] *IEC 60721-2-6*
International Electronic Commission:
Classification of Environmental Conditions. Earthquake Vibration
and Shock
- [5] *AISC*
American Institute of Steel Construction, Inc.:
Specification for Structural Steel Buildings.
Manual of Steel Construction.
- [6] *AA*
The Aluminum Association (USA):
Specifications for Aluminum Structures.

APPENDIX C
Relevant Sections of Specification Concerning Seismic
Requirements for Electrical Equipment.

2.4.1.9 SEISMIC COEFFICIENT

Biswanath Chariali, Siliguri (New) and Agra converter stations are located in Zone V, Zone IV and Zone III respectively according to IS-1893, Criteria for Earthquake Resistant Design of Structures. Importance factor for the stations is 1.5 as per table no. 4 of IS-1893.

3.13 SEISMIC FORCE CONSIDERATION

All structures shall be designed for seismic forces in accordance with IS-1893. The seismic design of electrical equipment shall be performed using estimated actual earth/ground motion, defined by a response spectrum, rather than the equivalent loads specified in typical Building Codes. For brittle materials like glass, porcelain and glass fibre reinforced plastic the maximum calculated load should not exceed 2/3 of the guaranteed minimum rupture (breaking) strength (safety factor 1.5) as defined by the manufacturer/supplier of the material used. The minimum rupture value is defined as $(X - 2 \cdot \sigma)$, where X is the mean value and 'sigma' is the standard deviation. For load combinations in porcelain insulators and similar the following expressions shall be fulfilled:

$$\{ Ft / (Ft)b \} + \{ Mb / (Mb)b \} < 2/3$$

and

$$\{ Fc / (Fc)b \} + \{ Mb / (Mb)b \} < 2/3$$

Where:

Ft, Fc, Mb : calculated maximum tensile force; compressive force and bending respectively

(F), (F), (M)b : corresponding guaranteed strength values

(For normal operating loads, a higher safety factor more than 1.5 shall be used, normally 2.0-2.5 depending on type of load as per recommendations of manufacturer).

Factor regarding importance of structures (I), as defined in IS-1893, shall not be taken less than 1.5.

ABB Power Technologies

Report

±800 kV, 6000 MW HVDC Multi Terminal NER/ER - NR/WR Interconnector - I		Document Number 1JNL100156-049 Rev. 01	No of Pages 4
Prepared Amara Raja, 2011-05-04		Title Mechanical requirements on apparatuses terminals	No of Attached Pages -
Approved Per H Johansson, 2011-07-08	Resp Dept		Reg./Class no. NEA-DDB

This document is issued by means of a computerized system. The digitally stored original is electronically approved. The approved document has a name and date entered in the approved-field. A manual signature is not required.

Summary

Table of Contents

1	GENERAL	2
2	STANDARDS	2
3	HIGH CURRENT/VOLTAGE CONNECTIONS.....	2
3.1	Material	2
3.2	Terminals with rectangular shape	3
3.3	Terminals with cylindrical shape	3
4	EARTHING CONNECTIONS.....	4
5	MECHANICAL TERMINAL LOADS.....	4
6	REFERENCES	4

	पावर ग्रिड कॉर्पोरेशन ऑफ इंडिया लि. POWER GRID CORPORATION OF INDIA LTD.		
± 800kV 6000MW HVDC Multi Terminal NER/ER - NR / WR Interconnector I			
Approved in Category	I	II	III (IV) <i>cat-IV</i>
Checked by	Verified by	Reviewed by	
Signature	<i>[Signature]</i>	<i>[Signature]</i>	<i>[Signature]</i>
Date :	28.09.2011		

1	See revision marks	Sasikiran K 2011-09-08	Per H Johansson 2011-09-08
Rev ind	Revision text	Prepared	Approved

We reserve all rights in this document and in the information contained herein. Reproduction, use or disclosure to third parties without express authority is strictly forbidden. ABB Power Technologies AB (SE)



1 GENERAL

Each high voltage apparatus on a HVDC-station shall have terminals for connection to main circuit apparatus, busbars, grounding grid, or other equipment. The terminals shall comply with the requirements in this specification.

The purpose with this specification is to standardize terminals for HVDC-apparatus and to minimize the quantity of different terminal connectors used in a HVDC-station.

A terminal is a conducting part of a device to which a terminal connector is fastened. Bolts are used to make the connection separable. In a bolted type connector the contact between the two parts is made by pressure exerted by one or more clamping bolts.

A terminal with a terminal connector must:

- Function well without maintenance during a long period of time.
- be designed to secure an unbroken transmission of current.
- have low contact resistance to avoid overheating.
- withstand different mechanical loads and stresses.
- have sufficient corrosion resistance.

Terminals for current carrying connections and voltage connections are of two types:

Terminal with rectangular shape with two or more holes.

Terminal with cylindrical shape.

Terminals for earthing connections shall have a rectangular shape with two holes.

2 STANDARDS

The terminals shall be designed to meet the requirements in IEC TR62271-301 [1]

3 HIGH CURRENT/VOLTAGE CONNECTIONS

In this specification a current carrying connector is defined as a separable, stationary, non-movable connection between a terminal and a terminal connector, having the primary function of transmitting power.

3.1 Material

Terminals for high current connections shall be manufactured of aluminum alloy with the following data.

- Copper content shall be below 0,1 % to prevent internal corrosion.
- Hardness requirement for aluminium in electrical use: > 60 HV
- Recommended standard qualities are ASTM 6061-T6 (SS aluminium 4102-06), ASTM 6063-T6 (SS aluminium 4104-06) and ASTM 6351-T6 (SS aluminium 4212-06), which are alloyed and hot aged.
- Recommended cast qualities are ASTM B 26-84, 356.0-T6 (SS aluminium 4253-04) and ASTM B 108-82b, 356.0-T6 (SS aluminium 4253-07).

Terminals of aluminum shall not be treated. The alloy shall have almost the same cracking constancy as pure aluminum. The alloys sensitive for season cracking, layer corrosion or intercrystalline corrosion shall not be used.

Terminals for *surge arresters* may also be manufactured of galvanized steel.

Terminals with cylindrical shape may also be manufactured of copper. Terminals of copper or a copper alloy shall be Silver-plated to a thickness of minimum 10 μm . Nickel-plating is also acceptable, to a thickness of minimum 10 μm . A copper alloy which is sensitive for season cracking may not be used.

3.2 Terminals with rectangular shape

3.2.1 Current rating between 2500A and 3000 A

Terminals shall have 9 bolts with 14mm and distance between holes (center to center) shall be 40 mm

Thickness shall be between 15 and 30 mm.

Bolt Size shall be M12.

To reduce eddy-currents, terminal thickness on air cooled reactors may be reduced to minimum 10 mm.

3.2.2 Current rating < 2500A

Terminals with rectangular shape shall have hole diameters of 14 mm. Distance between holes (center to center) shall be 40 mm.

Bolt size shall be M12.

To avoid high temperature in the high-current connection the quantity of bolts shall be sufficient. The current must not exceed 500 A/bolt.

Terminal thickness shall be between 15 and 30 mm.

To reduce eddy-currents, terminal thickness on air cooled reactors may be reduced to minimum 10 mm.

For equipment with low current rating (< 400 A) terminal thickness may be reduced to minimum 10 mm.

3.3 Terminals with cylindrical shape

Terminals for *Converter transformer indoor bushings and wall bushings* with cylindrical shape shall have a diameter of 130 mm and a minimum length of 160 mm.

Terminals of aluminum alloy is allowed up to 2500 A.

For currents above 2500 A copper must be used.

Cylindrical terminals with current ratings between 2500A and 3000A, Tap diameter 80mm with length 150 mm shall be used.

Capacitor banks shall have aluminum tubes as terminals. The high voltage terminal shall have a diameter of 100 mm, and the low voltage terminal shall have a diameter of 60 mm.

Diameter tolerance is +/- 0,5 mm.

4 EARTHING CONNECTIONS

The terminal shall be of rectangular shape with two holes.

Hole diameter shall be 14 mm.

Distance between holes shall be 40 mm.

Bolt size shall be M12.

If clamp is provided with the apparatus it must be possible to connect a conductor with cylindrical shape and an area of maximum 120 mm².

Earthing conductors shall withstand 50 kA 1 sec on the line side of the HVDC converter transformers, minimum conductor size shall than be

- 240 mm² for copper conductors
- 720 mm² for zinc coated steel core conductors
- 1180 mm² for stainless steel 304 conductors.

5 MECHANICAL TERMINAL LOADS

Terminals for apparatus in HVDC-stations must withstand different types of mechanical loads such as:

- static load from conductor.
- dynamic loads due to equipment vibrations.
- dynamic loads in conductor due to wind, short circuit forces etc.

Minimum required mechanical strength of a terminal is to withstand a force of 2 kN in any direction.

An exception to this requirement is AC- and DC-filter equipment with a current rating less than 750 A and for an operating voltage less than 145 kV, which shall minimum withstand a terminal force of 750 N in any direction.

Additional requirements of terminal loads, if any, on 800 kV DC-apparatuses shall be informed by ABB AB, HVDC separately.

6 REFERENCES

- [1] IEC TR62271-301 High-voltage switchgear and control gear
Part 301: Dimensional Standardization of terminals



±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NRWR
INTERCONNECTOR-I PROJECT

General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02

Index

3	General	3
3.1	Definitions	3
3.2	Instructions to suppliers	4
3.3	Standards	5
3.4	Site information	5
3.5	Site temperatures for design purposes	6
3.6	Documentation	6
3.7	Quality assurance requirements	10
3.8	Materials and workmanship	14
3.9	Colour schemes	15
3.10	Clamps & connectors	16
3.11	Name plates and markings	17
3.12	Provisions for exposure to hot and humid climate	19
3.12.1	Space heaters	19
3.12.2	Fungi static varnish	19
3.12.3	Ventilation opening	19
3.12.4	Tropicalisation	19
3.13	Painting and finishing of metal surfaces	19
3.14	Hot dip galvanising	20
3.15	Control cabinets, junction boxes, terminal boxes & marshalling boxes for equipment	21
3.16	Indoor control cubicles	24
3.16.1	Mounting	25
3.16.2	Earthing	25
3.16.3	Instruments, meters and recorders	26
3.16.4	Miscellaneous	26
3.16.5	Terminal blocks and wiring	27
3.17	Degree of protection	28
3.18	Welding and welders' qualifications	28
3.19	Motors	29
3.20	Conduits, pipes and accessories	29
3.21	Packaging & protection	30
3.22	Auxiliary supply	30
3.23	Lamps and sockets	30
3.24	Availability spares	31
3.25	Commissioning spares	31
3.26	Tools & tackles	31
3.27	Seismic force consideration	31
3.28	Safety requirements	32
	<i>Annexure-A</i> "Corona and radio interference voltage (RIV) test"	33



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

GENERAL TECHNICAL REQUIREMENTS-SECTION 3

3 General

The Works covered by the Specification shall be designed, manufactured, built, tested and commissioned in accordance with the Acts, Rules, Laws and Regulations of India. The Equipment(s) shall also conform to the general requirements detailed in the following standards, which shall form an integral part of the Specification, in addition to meeting the specific requirements called for elsewhere in the Specification.

The Supplier shall note that the standards mentioned herein are not mutually exclusive or complete in themselves, but are intended to complement each other, with minimum repetition, to define the requirements of the Specification. In the event of a conflict between requirements of any two clauses of the Specification/ documents or requirements of different codes/ standards specified, the more stringent requirement as per the interpretation of the owner shall apply, unless confirmed otherwise by the owner in writing based on a written request from the Supplier.

In case of conflicting requirements between this document (General Technical Requirements - Section 3) and equipment specification (Section 1 & Section 2), equipment specification shall prevail.

When specific requirements stipulated in the Specification exceed or change those required by the applicable standards, the stipulations of the Specification shall take precedence.

Unless specifically agreed to by the Purchaser prior to Award of Contract, the Work shall be in accordance with the standards indicated and the requirements of the Specification. The Supplier shall be held responsible for any deviation.

In case of conflict between the various standards, the decision of owner shall be binding & final.

3.1 Definitions

The following words and expressions shall have the meanings hereby assigned to them throughout this document

"Biswanath Chariali " means Biswanath Chariali Converter Station

"Alipurduar " means Alipurduar Converter Station

"Agra" means Agra Converter Station

"Employer/Owner" means Power Grid Corporation of India Ltd.

"Purchaser" means Bharat Heavy Electricals Limited

"Supplier/Manufacturer" means the person or persons, firm or company assigned to execute the works as defined by the scope of supply, described here.



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

"Specification" refers to this document.

3.2 Instructions to Suppliers

The supplier should be approved by Power Grid. If not, it is the responsibility of the vendor to be assessed and approved by Power Grid, before placement of order by BHEL. Any cost involved in vendor assessment/approval must be borne by the vendor himself.

The supplier shall submit the technical requirements, data and information as per the technical data sheets provided in the appropriate clause of bid document.

Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, completion and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the Specifications unless included in the list of exclusions. Materials and components not specifically stated in the specification but which are necessary for commissioning and satisfactory operation of the switchyard/substation unless specifically excluded shall be deemed to be included in the scope of the specification and shall be supplied without any extra cost. All similar standard components/parts of similar standard equipment provided, shall be inter-changeable with one another.

The Supplier shall offer equipment whose similar equipment for similar applications have been in service for at least two years from the date of first stage bid opening (30-06-2009) and should have been type tested as per relevant standards.

The suppliers who have supplied 400 kV equipment rated for 40 kA earlier to POWERGRID, may supply 50 kA rated equipment subject to fulfilling specified requirements:

The supplier shall supply type tested (including special tests as per tech. specification) equipment and materials. The Employer shall accept the equipment type test reports under the following conditions:

(i) Type test in accordance with the relevant specified standards

(ii) Type tests performed within five (5) years from the date of first stage bid opening (30-06-2009)

(iii) The type tested equipment shall be of the same design, insulation class and rating as per the equipment offered under this contract

In the event that equipment furnished includes important modifications of, or significant departure from, the designs of equipment on which type test report has been furnished or if there is evidence that the equipment does not comply with the requirements of the Specifications, the Supplier shall conduct the type test without any cost implication to the Purchaser. In the price bid, the type test charges shall be included and no separate type test charges shall be indicated by the supplier.

Acceptance of the type test reports shall be at the discretion of the Employer. All type tests



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NRWR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

performed after the date of award of the Contract shall be witnessed by the Employer unless authority to proceed with the tests in his absence is received from the Employer in writing.

3.3 Standards

All equipment and materials, unless otherwise specifically required in the Specification, shall conform to latest revisions of the standards listed in the Specification, in force at the time of signing of the contract for this project.

Generally the standards listed in the specification are applicable in accordance with the specific requirements of the technical section covering particular alternating current equipment or materials.

3.4 Site information

Table 3.4 - 1 Table for site information

	Particular	Biswanath Chariali	Alipurduar	Agra
a)	Employer/Owner	Power Grid Corporation of India Ltd (POWERGRID)		
b)	Project Title	±800 kV, 6000 MW HVDC Multi terminal System Package		
c)	Location	70 km from Tezpur in Sonitpur district of Assam, Kolkatta port is the nearest port to the site	175 Kms. from Siliguri city in the state of West Bengal. Kolkatta port is the nearest port to the site	12.6 Km Agra-Shamsabad road PO – Shyamo, Agra
d)	Nearest Rail Head	Guwahati	Alipurduar junction	Agra
e)	Postal Address	To follow	To follow	To follow
f)	Design ambient temp.	40 °C	40 °C	50 °C
g)	SEISMIC COEFFICIENT	Zone V Importance factor for the stations is 1.5 as per table no. 6 of IS-1893.	Zone IV Importance factor for the stations is 1.5 as per table no. 6 of IS-1893.	Zone III Importance factor for the stations is 1.5 as per table no. 6 of IS-1893.
h)	Site Wind Pressure	Zone V with basic wind speed of 50 m/s at 10 m height above mean ground level. The risk level coefficient/factor shall be taken as 1.07.	Zone IV with basic wind speed of 47 m/s at 10 m height above mean ground level. The risk level coefficient/factor shall be taken as 1.07.	Zone III with basic wind speed of 44 m/s at 10 m height above mean ground level. The risk level coefficient/factor shall be taken as 1.07.
i)	Isokeraunic Level	150 days per year	150 days per year	50 days per year
j)	Relative Humidity	Max. 100%		
k)	Rain fall Intensity	In 24 hours: 250mm 80mm/hr (for drainage system Design)	In 24 hours: 250mm 80mm/hr (for drainage system Design)	In 24 hours: 200mm, 30mm/hr (for drainage system Design)



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

3.5 Site temperatures for design purposes

The Supplier shall assume the temperatures given below for the design of the works at the converter stations.

Table 3.5 - 2 Table for Site temperatures

<i>Description Site</i>	<i>Temperature in deg C</i>		
	<i>Biswanath Chariali</i>	<i>Alipurduar</i>	<i>Agra</i>
<i>Maximum dry bulb one hour average</i>	<i>40</i>	<i>40</i>	<i>50</i>
<i>Maximum dry bulb 24 hour average</i>	<i>40</i>	<i>40</i>	<i>40</i>
<i>Annual mean dry bulb temperature</i>	<i>30</i>	<i>30</i>	<i>30</i>
<i>Minimum dry bulb one hour average</i>	<i>0</i>	<i>0</i>	<i>0</i>
<i>Maximum wet bulb one hour average</i>	<i>33</i>	<i>33</i>	<i>33</i>
<i>Dry bulb temperature for low ambient condition</i>	<i>33</i>	<i>33</i>	<i>33</i>
<i>Wet bulb temperature for low ambient condition</i>	<i>23</i>	<i>23</i>	<i>23</i>

3.6 Documentation

All technical description, specifications, literature, correspondence, prints, drawings, instruction manuals, test reports(both factory and site), progress photographs, booklets, schedules and all supplementary data or documents furnished in compliance with the requirements of the Contract, shall become the property of the Purchaser/owner and the costs shall be considered as included in the Contract price.

The Supplier shall be responsible for any time delay, misinterpretation, error and conflict during design, manufacturing, testing and erection of the Works resulting from non-compliance with the requirements of this Specification.

The Purchaser/owner shall have the right to make copies of any documents, data, reports, information etc. supplied by the Supplier in connection with the Works. The Purchaser/ owner shall not impart the information of these documents to any other manufacturer or competitor but he shall be free to use these for preparation of technical papers, reports etc.

The Supplier shall submit consolidated list of all symbols used in any drawing, data and information under three separate headings namely Civil, Mechanical & Electrical. If symbols other than IS or IEC are used, the Supplier shall submit consolidated list of these symbols and their significance under a separate section.

The Supplier is not required to supply detailed drawings whose purpose is manufacture only but in case such information is specifically asked for by the Purchaser/owner during evaluation of Bid, finalization of Contract, design review by Purchaser/owner his appointed Consultant or during execution of the Contract, the Supplier shall comply with the same.

All drawings, documents manual etc. as specified in this section shall have to be provided separately for each station.

All documentation shall be in English language.

Requirements for submission of documents, information and data by the supplier



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

General

The Supplier shall submit to the Owner/Purchaser all documents in accordance with an approved schedule of submissions and shall submit any further information (in the form of drawings, documents, manuals, literature, reports etc.) when asked by the Owner/Purchaser while commenting/approving any drawings/documents etc. All applicable documents shall be provided for each converter/repeater station separately.

The documents which are subject to the approval of the Owner/Purchaser shall be identified by the Supplier with the stamp "FOR APPROVAL". All other documents shall be submitted to the Owner/Purchaser for information and shall be identified by the Supplier with the stamp "FOR INFORMATION".

The sequence of submission of the documents shall be subject to the approval of the Employer. The sequence of submissions of all documents shall be such that the necessary information is available to enable the Employer to approve or comment the document.

The Supplier shall supply 5 hard copies of all drawings and documents. The final documentation for the project shall be supplied in nine sets of hard copies (three to each site) and nine sets of CDs to the Purchaser.

The entire plant documentation shall include all construction drawings, equipment specifications, design/study reports, O&M documents, factory test reports, etc. All the final/as built drawings shall be submitted in CAD format along with the complete final documentation.

In case a "SUBSEQUENT" revision of any document is made due to any reason whatsoever, a revision of the same, highlighting the changes shall be resubmitted for the Employer's specific approval/information.

Documents for approval

Approved documents shall be considered as the working documents. However the Specification and connected documents shall prevail over these documents in case a decision is required on interpretation.

Documents for information

The Supplier shall not delay the Works pending the receipt by the supplier of the comments on documents submitted to the Owner/Purchaser for information. However, the Owner/Purchaser shall have the right to comment on all the documents submitted by the Supplier, when, in the opinion of the Owner/Purchaser the document does not comply with the Contract or otherwise. The Supplier shall satisfactorily demonstrate that the information contained in the aforesaid document does meet the requirements of the Contract or revise the document in order that the information shall comply with the requirements of the Contract.

Drawings and data

General

The Supplier shall submit to the Owner/Purchaser all assembly and detail drawings of equipment,



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NRWR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

station design, civil work, building, controls, protection, etc., as well as the corresponding computation where necessary in order to establish to the satisfaction of the Owner/Purchaser the Supplier's compliance with the requirements of the Contract.

Drawings, as set forth below shall be submitted to the Owner/Purchaser and shall be complete with all information necessary for complete interpretation of the drawings by the Owner/ Purchaser. All drawings shall show the materials, dimensions, finish, fits, clearances, tolerances, bolting and such other information as is necessary to demonstrate to the Owner/ Purchaser that all items covered by the drawings are in compliance with the requirements of the Contract.

Drawings may consist of several sheets as required in order to provide for the degree of detail required by the Employer, so that he may clearly understand such drawings.

Not later than 90 (ninety) days after completion of successful trial operation of the HVDC station, the Supplier shall supply copies of the last revision of all drawings produced for this project, stamped as "AS BUILT".

The Supplier shall provide separate sets of drawings for each control cubicle. Typical drawings for similar cubicles shall not be accepted. If there are several cubicles per system, then one common bill of material and one system schematic diagram may be provided. Such system schematic diagram shall show the control scheme for the particular system in its entirety and shall be laid out on the minimum number of drawings sheets consistent with clarity and legibility.

The Owner/Purchaser shall not accept typical drawings for control, protection and three-phase schematics, power circuits and single line diagrams. The Supplier shall supply complete set of such drawings for each system, even when drawings are duplicates.

Inspections plans and documentation

The Supplier shall submit in required number copies for the Owner's/Purchaser's approval an inspection plan (quality plan) describing the inspection system indicating the inspections to be carried out and their sequence in the manufacturing stages.

The inspection plan shall be such that it can be related to the manufacturing program. The plan shall also include a description of the inspection methods employed with reference to the Supplier's written inspection procedures.

Separate inspection plans describing the inspection systems for equipment supplied by each sub-Supplier, in the same form as that of the Supplier, shall be submitted for the approval of the Owner/Purchaser.

In addition to the inspection plans referred to above, the Supplier shall submit complete and satisfactory evidence of possessing a working scheme assuring the control of all critical activities pertinent to the assurance of quality, and objective evidence (by means of quality manuals and appropriate forms, etc.) of this capability to employ and maintain quality control to meet the required quality level of the manufacture and construction of the Works.

Supplier's Quality Control Program in the context of this Clause means the implementation of a quality assurance program by means of which full conformance of material and workmanship to best



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

quality standards can be achieved effectively and economically by the Supplier's control and surveillance of all essential inspection operations, and periodic verification of the results of the manufacture of equipment and the assembly, erection and installation of equipment at the sites.

Required number of copies of all test reports, including those supplied by Sub-Suppliers, and shall be submitted to the Owner/Purchaser for approval. The Supplier shall include in the report all additional data required by the Owner/Purchaser to permit a clear understanding of the reports.

All test reports shall be certified and shall contain the signature of the Inspector as having witnessed the test, unless such witnessing has been specifically waived by the Owner/ Purchaser. A certified test report shall be issued for each test.

Instruction manuals and operating manuals

The Supplier shall provide Instruction & Maintenance Manuals for each part of the Plant and Equipment included in the Works and Operating Manuals for each Station.

The Instruction Manuals and Operating Manuals shall be arranged in an organized library adequately cross referenced to facilitate issuing clauses of the manuals as required by the work i.e. erection instructions shall be required before operating & maintenance instructions.

All Manuals provided by the Supplier shall be fully detailed and specifically prepared for the Works and equipment provided. General manuals not specifically required for the work shall not be acceptable.

The instruction manuals shall at least contain:

- a) A general description of all components
- b) Storage instructions
- c) Erection instructions
- d) Pre-commissioning Instruction :
- e) Material and part list.
- f) Design clearances and settings
- g) Complete sets of drawings as finally issued
- h) Operating Instructions:
- i) Routine and Preventive Maintenance instructions with material requirement for each site
- j) Preventive Maintenance Schedule.
- k) Replacement instruction for all equipment

The operation manuals shall at least contain:

- a) Operator oriented functional descriptions of the equipment.
- b) Operator oriented description of the protection and control systems
- c) Description of the equipment auxiliary systems
- d) Fault finding and diagnostic tools
- e) User software interface tools for modification/augmentation etc.

Notes:

The supplier may please note that all resubmissions must incorporate all comments given in the ear-



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

lier submission by the Owner/Purchaser or adequate justification for not incorporating the same must be submitted failing which the submission of documents is likely to be returned.

If after the commissioning and initial operation of the substation, the instruction manuals require any modifications/ additions/changes, the same shall be incorporated and the updated final instruction manuals shall be submitted by the Supplier to the Owner/Purchaser.

The Supplier shall furnish to the Owner/Purchaser, catalogues of spare parts also.

3.7 Quality assurance requirements

Quality assurance programme

To ensure that the equipment and services under the scope of Contract, whether manufactured or performed at the Supplier's Works or at his Sub-supplier's premises or at the Purchaser's site or at any other place of Work, are in accordance with the specifications, the Supplier shall adopt a suitable quality assurance programme to control such activities at all points, as necessary. Such programme shall be outlined by the Supplier and shall be submitted by the supplier after the award of contract and finally accepted by the owner after discussions prior to commencement of manufacturing.

A quality assurance programme of the supplier shall generally cover the following:

- (a) Supplier's organisation structure for the management and implementation of the proposed quality assurance programme;
- (b) Design and Documentation control system;
- (c) Qualification data of Supplier's key personnel;
- (d) The procedure for purchases of materials, parts components and selection of sub-Supplier's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchased etc.
- (e) System for shop manufacturing and site erection controls including process controls and fabrication and assembly control;
- (f) Control of non-conforming items and system for corrective actions;
- (g) Inspection and test procedure both for manufacture and field activities;
- (h) Control of calibration and testing of measuring and testing equipment.
- (i) System for quality audits;
- (j) System for indication and appraisal of inspection status
- (k) System for authorising release of manufactured product to the Purchaser
- (l) System for maintenance of records;
- (m) Furnishing of quality plans (QP)/inspection and test plan (ITP) for manufacturing and field activities detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of equipment/component.

General requirements - Quality assurance

1. All services, materials, components and equipment covered under this specification shall be engineered, designed, procured, manufactured, erected, commissioned and tested at all the stages, as per a comprehensive Quality Assurance Programme. It is the Supplier's responsibility to draw up and implement agreed programme for system as a whole as well as for individual equipment.



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

The detailed Quality Plans for manufacturing and field activities shall be drawn up by the Supplier and shall be submitted to the Employer for approval.

The Supplier shall furnish with his bid a list of approved suppliers for the information of the Employer.

2. Engineering and design quality Plan shall detail out the studies, overall detail design documentation and communicating, defining interfaces and controlling changes. To achieve quality, reliability and schedule objectives that project shall be designed so that it meets performance requirements. Manufacturing Quality Plan shall detail out for all the components and equipment, various tests/inspection, to be carried out as per the requirements of this Specification and standards mentioned therein and quality practices and procedures followed by Supplier's Quality Control Organisation, the relevant reference documents and standards, acceptance norms, inspection documents etc., during all stages of materials procurement, manufacture, assembly, and final testing/performance testing.
3. Field Quality Plan shall detail out for all the equipment, the quality practices and procedures etc. to be followed by the Supplier's site Quality Control Organisation, during various stages of site activities from receipt of materials/equipment at site onwards.
4. The Supplier shall also furnish copies of the reference documents/plant standards/ acceptance norms/tests and inspection procedure etc., as referred in Quality Plans along with respective Quality Plan. These Quality Plans and reference documents/standards etc. shall be subject to Employer's approval without which manufacture shall not proceed. In these approved QPs, the Employer shall identify customer inspection points (CIP), test/checks which shall be carried out in presence of the Employer's Engineer or his authorised representative and beyond which the work shall not proceed without consent of Employer or his authorised representative in writing. All deviations to specification, approved quality plans and applicable standards must be documented and referred to the Employer for approval and disposition.
5. No material shall be dispatched from the manufacturer's works before the same is accepted subsequent to pre-dispatch final inspection including verification of records of all previous tests/inspections by Employer's Engineer and / or his authorised representative, and duly authorised for dispatch issuance of Material Inspection Clearance Certificate (MICC). Before making request for issuance of MICC, the Supplier shall ensure that approval of type tests, data sheets, drawing etc. had already been obtained from Employer. All materials used or supplied shall be accompanied by valid materials certificates and tests and inspection reports. These certificates and reports shall indicate the sheet numbers or other such acceptable identification numbers of the material. The material certified shall also have the identification details stamped on it.
6. All welding and brazing shall be carried out as per procedure drawn and qualified in accordance with requirements of ASME section - IX/BS-4870 or other International equivalent standard acceptable to the Employer.
7. All the (sub)-Vendors proposed by the Supplier for procurement of bought out item list of which shall be drawn up by the Supplier and finalised with the Employer shall be subject to the Employer's approval. Quality Plans of the successful vendors shall be discussed, finalised and approved by the Employer and shall form part of the purchase order between the Supplier and the Vendor.



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

8. The Employer reserves the right to carry out quality audit and quality surveillance of the systems and procedures of the Supplier's of their sub-Supplier's (sub-vendor's) quality management and control activities. The Supplier shall provide all necessary assistance to enable the Employer carry out such audit and surveillance.
9. As a part of quality assurance of engineering and design, the technical review meetings (TRMs) shall be conducted between the Employer and/or his consultants/representative and the Supplier and/or his subSupplier(s). The duration and cycle of such TRMs shall be as frequent and regular as required to meet the time schedules. The meetings shall be held at either at the Employer's office and/or at the office/manufacturing place of the Supplier/sub-Supplier or at any other place as agreed mutually.
10. The Supplier shall agree upon a schedule of submissions of documents concerning the Quality Assurance Program within two months of the effective date of the Contract. This schedule shall indicate the list of mutually agreed items/equipment for which quality Plans shall be submitted by the Supplier and the last dates for the submissions. It shall be ensured by the Supplier that the submissions are so programmed that all relevant approvals are obtained from the Employer for these documents in a timely manner before the material induction and commencement of the manufacture for any equipment.
11. The documents that shall be submitted by the Supplier to the Employer for review and approval as per the agreed schedule include:
 - a) QA Manuals
 - b) Quality Plans (Inspection & Test Plans) for all equipment/materials manufactured in the Supplier's works and/or in the sub-Supplier's works
 - c) Purchase Specifications for equipment procured from sub- Suppliers.
 - d) Supplier's assessment reports of his sub-Suppliers
 - e) Field Quality Plans for all activities at site
 - f) Reference documents referred to in Quality Plan.
 - g) Erection, commissioning, operation and maintenance manuals

12. QA Document Package

The Supplier shall submit the following Quality Assurance Documents to the Employer. These documents shall be as per the approved Quality Plans for the concerned equipment. The documents shall include, but not limited to, the following:

- a) Routine test reports & Acceptance test reports
- b) Type test reports
- c) Quality records etc. corresponding to items identified Quality Plan
- d) Inspection reports for Customer inspection points
- e) Reports on repair/modification carried out to make the item/equipment acceptable.
- f) Non-destructive examination result reports including radiography interpretation reports, wherever applicable.

The above documents are required to be submitted in required number of copies within three weeks after dispatch of equipment.



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

Inspection and testing

1. In order to verify that all the manufacturing of equipment by the Supplier as well as materials & equipment being procured and provided by the Supplier are in complete conformance with the requirement of the Contract, the Employer and/or his duly authorized representative shall have access to the Supplier's premises or works at all reasonable times to inspect and examine the material, equipment and workmanship during its manufacture or installation. In addition to carrying out inspection the Employer and/or his authorized representative/Consultant all carry out quality audit on the Supplier's Quality Assurance System and conduct quality surveillance to check conformance to quality procedure/practice in general. The Supplier shall provide necessary facilities to carry out all the above activities at their works and the works of the sub-Suppliers.
2. The Supplier shall provide a detailed inspection schedule for those inspection stages identified as CIP and shall furnish updated schedules once every two months.
3. The Supplier shall give the Employer/Inspector six(6) weeks written notice, by telex or by letter, of the tentative date any material/equipment shall be ready for witness points, corresponding to Customer inspection points (CIP), when the Employer/Inspector is based in India. Final confirmation shall be given at least 15 days in advance. The Employer/Inspector, unless witnessing of the tests is waived, shall attend such tests, failing which the Supplier may proceed with the test which shall be deemed to have been made in the Inspector's presence. The Supplier shall forthwith forward to the Employer copies of duly certified test reports. Test reports of all tests corresponding to CIP performed in the supply shall be reviewed and approved, subject to satisfactory conduction and successful passing of the test, by the Employer or his authorised representative (even if the witnessing of the test was waived).
4. The Employer or his authorized representative shall, within fifteen (15) days from receipt of such reports, give notice in writing to the Supplier of any objection to any aspect of the test reports or any or all equipment and workmanship which in his opinion is not in conformance with the Contract. The Employer or his authorized representative shall advise his reasons for objections on completion and review of the activity. The Supplier shall give due consideration to such objection(s) and shall either make the modifications that may be necessary to overcome the said objection(s) or shall confirm in writing giving reasons therein that no modifications are necessary to comply with the Contract. However, the Supplier may proceed with the works/dispatch even before the receipt of written objection(s), if any, at his own cost & risk.
5. Whenever the Employer's inspection engineer undertakes the inspection, at a particular stage identified as Customer inspection point (CIP) in the Quality Plan, the acceptance of test reports/test results and the MICC where applicable shall be given immediately after the test if the results, including those for previous points identified as per clause 9.6 are found to be in conformity with the Contract. In case of any deviations, the Employer/Inspector at his discretion may refer the matter to the Employer's main office, together with the manufacturer's comments, who in turn shall communicate his final decision regarding the acceptance or otherwise to the Supplier within fifteen (15) days of the receipt of such test reports/results. In case the presence of the Employer/Inspector is waived, the acceptance of test results and issuance by the Employer of Material Inspection Clearance certificate wherever applicable, shall be given within fifteen (15) days after receipt of test reports/results for the CIP as well as for previous CIP's identified in the approved Quality Plan, provided such test reports/test results are found to be in order. The Em-



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

ployer/Inspector shall at his discretion and based on the outcome of any inspection and the requirements of the contract, have the right to 'accept', 'accept as noted' or 'reject' any equipment/material. The reasons/comments in case of each ruling shall be communicated to the Supplier in writing.

6. In all cases where the contract provides for tests, whether at the premises of works of the Supplier or of any sub-Supplier, the Supplier, except where otherwise specified, shall provide free of charge such items as labour, materials, electricity, fuel, water, apparatus and instruments as required to fulfil the requirements of the approved Quality Plan.
7. The inspection by Employer/Inspector or waiver of the presence of the Employer/Inspector, issue of CIP clearance certificate and issue of Material Inspection clearance certificate (MICC) thereon shall in no way limit the liabilities and responsibilities of the Supplier in respect of the agreed quality plans forming part of the contract. The Employer shall not be found to accept the material/equipment if on further testing it is found to be not in compliance with the requirements of the contract. The Supplier shall include in all orders to his sub-Suppliers, the requirements for any equipment, being supplied by the sub-Supplier for incorporation in his equipment to be subjected to inspection and testing by the Employer or is authorised representative. Copies of such orders or purchase specifications, blanked for prices, shall be forwarded to the Employer.
8. The costs of all tests specified in the Contract together with the same for all tests facilities, test samples and such like shall be to the Supplier's account.
9. The Employer/Inspector shall have complete authority to reject, on behalf of the Employer, any material, equipment or parts thereof considered unsatisfactory and not in accordance with the Contract. Accept, accept as noted or reject materials, equipment or any components thereof shall not relieve the Supplier of any of his obligations under the Supplier, nor impose any liability whatsoever on the Employer.
10. The Employer shall have the right to have Inspectors on the Sites, on a regular basis or from time to time as required at his sole discretion to monitor the quality and the progress of the work. Generally the site inspection shall be as per the approved Field Quality Plans (FQPs) and the Installation & Operation Manual(s). All quality related documents and test results shall be a part of plant documentation.

3.8 Materials and workmanship

Where the specification does not contain references to workmanship, it is understood that the equipment shall be new, of the best quality and in accordance with the purpose for which they are intended.

In case where the equipment, materials or components are indicated in the specification as "similar" to any special standard, the owner shall decide upon the question of similarity. When required by the specification or when required by the Purchaser & owner the Supplier shall submit for approval, all the information concerning the materials or components to be used in manufacture. Machinery, equipment, materials and components supplied, installed or used without such approval shall run the risk of subsequent rejection, it being understood that the cost as well as the time delay associated with the rejection shall be borne by the Supplier.



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

The design of the Works shall be such that installation, future expansions, replacements and general maintenance may be undertaken with a minimum of time and expenses. Each component shall be designed to be consistent with its duty and suitable factors of safety shall be used throughout the design.

All joints and fastenings shall be devised, constructed and documented so that the component parts shall be accurately positioned to fulfil their required function. In general, screw threads shall be standard metric threads. The use of other thread forms will only be permitted when prior approval has been obtained from the owner.

Whenever possible, all similar parts of the works shall be made to gauge and shall also be made interchangeable with similar parts. All spare parts shall also be made interchangeable and shall be made of the same materials and workmanship as the corresponding parts of the equipment supplied under the specification. All the equipment of the same type and rating shall be physically and electrically interchangeable.

All materials and equipment shall be installed in strict accordance with the manufacturer's recommendation(s). All factory assembled rotating machinery shall be checked for alignment and adjustments made as necessary. The spare equipment(s) shall be installed at designated locations and tested for healthiness.

The Supplier shall apply oil and grease of the proper specification as is necessary for the installation of the equipment. Lubricants used for installation purposes shall be drained out and the system flushed through where necessary in readiness for applying the lubricant required for operation. The Supplier shall apply all operational lubricants to the equipment installed by him. All insulating oil, lubricating material, grease and other consumables used in the Works/ Equipment shall be purchased in India unless the Supplier has any special requirement for the specific application for a type of oil or grease not available in India. If such is the case he shall declare in the proposal where such oil or grease or other consumables is available. In any case he shall identify equivalent Indian makes and inform the Purchaser & owner of the name of at least two Indian suppliers before handing over of the Works to the Purchaser. All consumables required upto operational acceptance shall be the part of supply scope of the Supplier.

The supplier shall perform all tests and inspection necessary to ensure that the material and workmanship conform to the approved design drawings and that such tests are adequate to demonstrate that the equipment shall comply with the requirements of the Specification & relevant standards. The supplier shall test the component parts at his plant or his Sub-supplier's plant, prior to packaging and shipping, to determine that the performance requirements have been met. All testing shall be in accordance with the Standards related to the piece of work.

3.9 Colour schemes

The Supplier shall propose a colour scheme for the equipment for the approval of the Employer. The decision of the Employer shall be final. However, the finishing colour shall be RAL 7035 for indoor panels and RAL 7032 for outdoor panels. The scheme shall include:

- Finishing colour of Indoor equipment
- Finishing colour of Outdoor equipment
- Finishing colour of various auxiliary system equipment including piping
- Finishing colour of various building items.



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

- Finishing colour of all cubicles.

All steel structures, plates etc shall be painted with non-corrosive paint on a suitable primer. The galvanised structures in the switchyard shall not be painted. However galvanised structures in other areas may require painting for aesthetic reasons.

3.10 Clamps & connectors

- i) All power clamps and connectors shall conform to IS: 5561, and/or IEC standard and shall be made of materials listed below:

a)	For connecting ACSR conductors	Aluminium alloy casting, conforming to designation A6 of IS: 617 and shall be tested for all tests as per IS:617
b)	For connecting equipment terminals made of copper with ACSR conductors	Bimetallic connectors made from aluminium alloy casting, conforming to designation A6 of IS 617 with 2 mm thick Bimetallic liner and shall be tested as per IS: 617.
c)	For connecting G.I. Shield wire	Galvanised mild steel
d).1	Bolts, nuts & Plain washers.	Electro galvanised for sizes below M12, for others hot dip galvanised
d).2	Spring washers for items 'a' to 'c'	Electro-galvanised mild steel suitable for at least service condition-3 as per IS: 1573

- ii) Equipment shall be supplied with the necessary terminals and connectors, as required by the ultimate design for the particular installation. The conductor terminations of equipment shall be either expansion, sliding or rigid type. The requirements regarding external corona and RIV as specified for any equipment shall include its terminal fittings and the equipment shall be factory tested with the connectors in position. In case the connector is not available then equivalent connector may be used. If corona rings are required to meet these requirements they shall be considered as part of that equipment and included in the scope of Work.
- iii) Where copper to aluminium connections are required, bi-metallic clamps shall be used, which have been properly designed to ensure that any deterioration of the connection is kept to a minimum and restricted to parts which are not current t shall be furnished to the Employer.
- iv) Low voltage connectors, grounding connectors and accessories for grounding all equipment as specified are also included in the scope of Work.
- v) No current carrying part of any clamp shall be less than 10 mm thick. All ferrous parts shall be hot dip galvanised. Copper alloy liner of minimum 2mm thickness shall be cast integral with aluminium body for Bi-metallic clamps. When copper alloy is not cast integral with aluminium body, a bimetallic washer or strip shall be used to meet the functional requirement.
- vi) All casting shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off.



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

- vii) Flexible connectors, braids or laminated straps made for the terminal clamps for bus posts shall be suitable for both expansion or through (fixed/sliding) type connection of IPS Aluminium tube as required. In both the cases the clamp height (top of the mounting pad to centre line of the tube) should be same.
- viii) Clamp shall be designed to carry the same current as the conductor and the temperature rise shall be equal or less than that of the conductor at the specified ambient temperature. The rated current for which the clamp/connector is designed with respect to the specified reference ambient temperature, shall also be indelibly marked on each component of the clamp/connector, except on the hardware.
- ix) All current carrying parts shall be designed and manufactured to have minimum contact resistance.
- x) TESTS

The following is the list of type tests.

- a) Temperature rise test (maximum temperature rise allowed is 35deg C over 50 deg C ambient)
- b) Short time current test
- c) Dry corona and RIV test as per annexure-A
- d) Resistance test and tensile test

3.11 Name Plates and Markings

All equipment mounted on front and rear side as well as equipment mounted inside the panels shall be provided with individual nameplates with equipment designation engraved. Also on the top of each panel on front as well as rear side, large and bold nameplates shall be provided for circuit/feeder designation.

All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring.

All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type, serial number and electrical rating data.

Name Plates shall be made of non-rusting metal or 3-ply lamicaid. Name plates shall be black with white engraving lettering.

All the panels shall be provided with nameplate mounted inside the panel. Stainless steel nameplates shall be installed on all apparatus and on all major equipment components. For indoor cubicles, nameplates made of aluminium shall also be acceptable. Name plates shall be white with black engraved lettering and shall carry all the applicable information specified in the applicable items of the Standards, together with any other relevant information which may be required. For groups of smaller items for which this is not possible e.g. switch bays etc. a common nameplate with the title and special instructions on it shall be provided. No scratching, corrections or changes shall be allowed on nameplates. Main equipments like converter transformer, CBs, Reac-



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NRWR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

tor, Filter gates etc shall have nameplates in Hindi also.

All equipment mounted on front and rear sides as well as equipment mounted inside the panels shall be provided with individual name plates with equipment designation engraved. Also on the top of each panel on front as well as rear sides large name plates with bold size lettering shall be provided for circuit / feeder / cubicle / box designation.

All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate tracing of the wiring. The nameplates shall be mounted directly by the side of the respective equipment and shall not be hidden by the equipment wiring.

The nameplate inscription and size of nameplates and letters shall be submitted to the Employer for approval.

The nameplates of the apparatus shall include, at least, the information listed below, together with any other relevant information specified in the applicable standards:

- a) A concise descriptive title of the equipment
- b) Rating and circuit diagram reference numbers
- c) Manufacturer's name, trade-mark, model type, serial number
- d) Instruction book number
- e) Year of manufacture
- f) Total weight (for capacitor racks indicate weight, for capacitors indicate quantity of liquid)
- g) Special instructions, if any, about storage, transportation, handling etc.

Each measuring instrument and meter shall be prominently marked with the quantity measured e.g. kV, A, MW etc. All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type, serial number and electrical rating data.

Danger plates and plates for phase colours shall be provided as per requirement. The Supplier shall devise a system to designate equipment and sub-systems. The nameplates/ labels displaying these designations shall be installed at appropriate locations. Wherever motion/ flow of fluids are involved, plates/ marks showing direction of motion/ flow shall also be provided.

Each main and auxiliary item of substation is to have permanently attached to it in a conspicuous position a rating plate of non-corrosive material upon which is to be engraved manufacturer's name, year of manufacture, equipment name, type or serial number together with details of the loading conditions under which the item of substation in question has been designed to operate, and such diagram plates as may be required by the Purchaser. The rating plate of each equipment shall be according to IEC requirement.

All such nameplates, instruction plates, rating plates of transformers, reactors, CB, CT, CVT, SA, Isolators, C & R panels and PLCC equipments shall be bilingual with Hindi inscription first followed by English. Alternatively two separate plates one with Hindi and the other with English inscriptions may be provided.



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

3.12 Provisions for Exposure to Hot and Humid Climate

Outdoor equipment supplied under the specification shall be suitable for service and storage under tropical conditions of high temperature, high humidity, heavy rainfall and environment favourable to the growth of fungi and mildew. The indoor equipments located in non-air conditioned areas shall also be of same type.

3.12.1 Space Heaters

The heaters shall be suitable for continuous operation at 240 V ac supply voltage & shall be connected to the supply through a fuse.

One or more heaters shall be provided, with thermostats or hygostat, to prevent condensation in any compartment. The heaters shall be suitable to maintain the compartment temperature at approximately 10 deg. C, above the outside air temperature to prevent condensation.

Control cubicles installed in air-conditioned area need not be provided with space heaters. These cubicles shall, however, have space heaters in case of storage of cubicles for long duration.

3.12.2 Fungi Static Varnish

Besides the space heaters, special moisture and fungus resistant varnish shall be applied on parts which may be subjected or predisposed to the formation of fungi due to the presence or deposit of nutrient substances. The varnish shall not be applied to any surface of part where the treatment will interfere with the operation or performance of the equipment. Such surfaces or parts shall be protected against the application of the varnish.

3.12.3 Ventilation Opening

In order to ensure adequate ventilation, compartments shall have ventilation openings provided with fine wire mesh of brass or galvanized steel to prevent the entry of insects and to reduce to a minimum the entry of dirt and dust. Outdoor compartment openings shall be provided with shutter type blinds.

3.12.4 Tropicalisation

The service building and bay kiosk shall be air-conditioned whereas the valve halls and indoor DC yard at Agra shall have ventilation system with positive pressure. All equipments shall, however, be suitable for installation in a tropical monsoon area having hot, humid climate and dry & dusty seasons with ambient conditions as specified. All control wiring, equipment and accessories shall be protected against fungus growth, condensation, vermin and other harmful effects due to a tropical environment.

3.13 Painting and finishing of metal surfaces

All sheet steel work shall be phosphated in accordance with the IS:6005 "Code of practice for phos-



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

phating iron and steel".

Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning.

Rust and scale shall be removed by pickling with dilute acid followed by washing with running water rinsing with a slightly alkaline hot water and drying.

After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying.

The phosphate coating shall be sealed with application of two coats of ready mixed, stoved type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.

After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after inspection of first coat of painting. The exterior colour of paint shall be of a slightly different shade to enable inspection of the painting.

A small quantity of finished paint shall be supplied for minor touching up required at site after installation of the panels.

In case the Supplier proposes to follow his own standard surface finish and protection procedures any other established painting procedures, like electrostatic painting etc., the procedure shall be submitted along with the Bids for Purchaser's review & approval. The Supplier shall use procedures for painting approved by the Employer during detailed Engineering.

3.14 Hot Dip Galvanising

The minimum weight of the zinc coating shall be 615 gm/ sq.m and minimum thickness of coating shall be 85 microns for all items thicker than 6 mm. For items less than 6 mm, requirements of coating thickness shall be as per relevant ASTM. For surfaces, which shall be embedded in concrete, the zinc coating shall be 900-gm/sq.m .

The galvanized surfaces shall consist of a continuous and uniform thick coating of zinc, firmly adhering to the steel. The finished surface shall be clean and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, which is loosely attached to the steel globules, spiky deposits, blistered surfaces, flaking or peeling off, etc. The presence of any of these defects noticed on visual inspection shall render the material liable to rejection.

After galvanizing, no drilling or welding shall be performed on the galvanized parts of the equipment except the nuts may be rethreaded after galvanizing. Sodium dichromate treatment shall be provided to avoid formation of white rust after hot dip galvanization.

The galvanized steel shall be subjected to six one-minute dips in copper sulphate solution as per IS-2633.

Sharp edges with radii less than 2.5 mm shall be able to withstand four immersions of the Standard Preece test. All other coatings shall withstand six immersions.



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

The following galvanizing tests should be performed as per relevant Indian Standards.

- Coating thickness
- Uniformity of zinc
- Adhesion test
- Mass of zinc coating

3.15 Control cabinets, junction boxes, terminal boxes & marshalling boxes for equipment

All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with IS-5039/IS-8623, IEC-60439, as applicable, and the clauses given below:

1. Enclosure for control cabinets, junction boxes, Marshalling boxes & terminal boxes shall be made of stainless steel or aluminium and shall be dust, water and vermin proof. The box shall be properly braced to prevent wobbling. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation.
2. The enclosures of the control cabinets, junction boxes, terminal boxes & marshalling boxes located outdoor shall provide a degree of protection of not less than IP 55 as per IS-13947:Part I One control cabinet, junction box, terminal box & marshalling box of each type shall be tested for the same.
3. Cabinets/boxes shall be freestanding floor-mounting type, wall mounting type, or pedestal mounting type as required. Equipments such as telephone exchange, Public address systems etc shall be kept inside cubicles.
4. Cabinets/ boxes shall be provided with double-hinged doors with padlocking arrangements. The distance between two hinges shall be adequate to ensure uniform sealing pressure against atmosphere. The quality of the gasket shall be such that it does not get damaged/cracked during the operation of the equipment.
5. All doors, removable covers and plates shall be gasketed all around with suitably profiled EPDM gaskets. The gasket shall be tested in accordance with approved Quality Plan. Ventilating louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh made of brass.
6. All boxes/cabinets shall be designed for the entry of cables from the bottom by means of weatherproof and dust-proof connections. Boxes and cabinets shall be designed with generous clearances to avoid interference between the wiring entering from below and any terminal blocks or accessories mounted within the box or cabinet. A suitable horizontal cable gland plate positioned at least 150 mm above the base of the marshalling kiosk/box shall be provided for this purpose along with the proper blanking plates. Necessary number of cable glands shall be supplied and fitted on this gland plate. The gland shall project at least 25mm above gland plate to prevent entry of moisture in cable crutch. Gland plate shall have provision for some future glands to be provided later, if required. The glands shall be dust proof, screw on & double compression type and made of brass. The gland shall have provision for securing armour of the cable separately and shall be provided with earthing tag. The glands shall conform to BS: 6121 and shall be nickel-plated.



±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NRWR
INTERCONNECTOR-I PROJECT

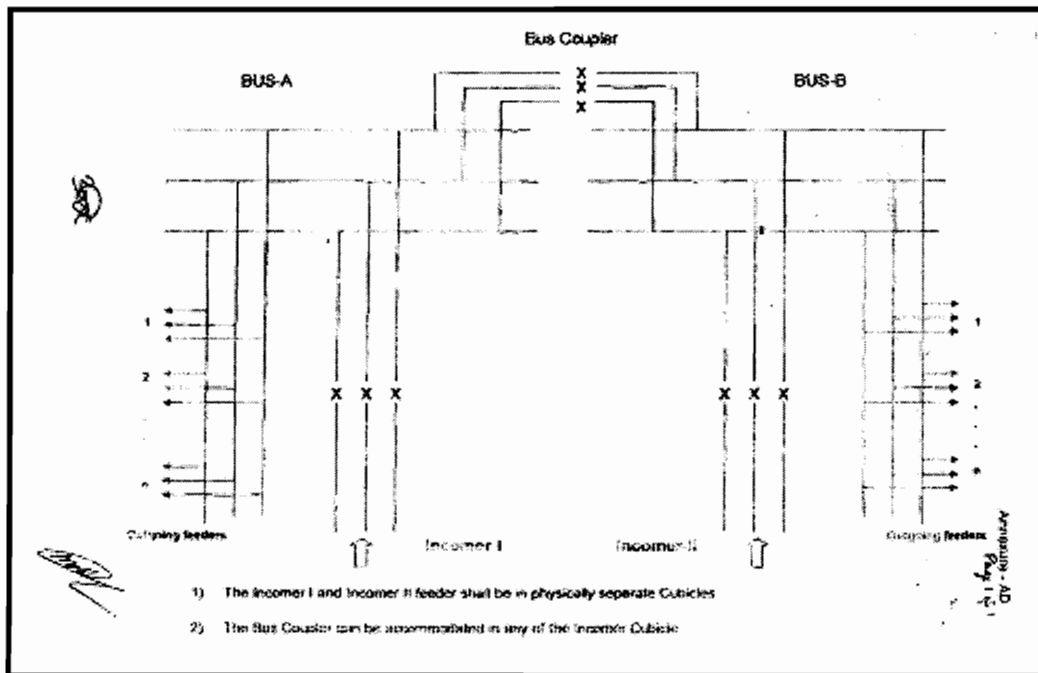
General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02

Boxes / cabinets to be located inside a building in a non air- conditioned area may be designed for the entry of cables from the bottom or from the top.

The (415 V) secondary distribution system shall be made up of 415 V power centres serving the different classes of loads either directly or through motor control centres. Two separate 415 V power centres, one for each pole shall be provided. The two sections of power control centres (PCC) feeding the duplicated loads, like pumps, fans, heat exchangers, etc. as well as the duplicated supply circuits shall be physically independent, permanently energized and fed by different sections of the 415 V power centres. A tie circuit breaker, shall be provided between the two sections of above PCC feeding the duplicated loads, in order that when one section of PCC is out for maintenance or fault, the other section can supply all the loads.

The motor control centres (MCC) shall be provided in accordance with the relevant Standards. The MCC shall be located near the supplied loads. The incomers of the MCC shall be individually interlocked to prevent paralleling of two different power centre buses. The 240 V loads shall be supplied by 240 V panels located in the MCC or outside the MCC where it is required.

415 V MCCs for valve cooling, pump house, valve hall ventilation system, air-conditioning system etc. shall be arranged as per figure given below:



25% spare feeders, but not less than one of each type and rating shall be provided on 415V switchgears, power centres and motor, control centres as well as on all dc distribution boards

The AC & DC Distribution Boards shall have a fixed type, floor-mounted, free-standing, metal enclosed, with compartmentalised construction. They shall have separate Busbar chamber and cable alleys. All equipment for each feeder (i.e. main switch, HRC fuses, neutral link and cable terminals) shall be housed in a fully enclosed compartment with a separate hinged door,



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

such that fuse replacement, cable termination/replacement etc. are possible with complete safety, even if the Busbar and adjacent feeders are live. The connections from Busbar to the main switch shall be fully insulated/shrouded, and securely bolted. The partition between the feeder compartment and cable alley shall be non-metallic and shall be of such construction as to allow cable cores with lugs to be easily inserted in the feeder compartment for termination. Cable alley shall have no exposed live parts, and shall have no communication with Busbar chamber. The main switch shall be operated from outside, and shall be interlocked with the compartment door such that the latter can be opened only when the switch is OFF. However, it shall be possible to defeat this interlock and open and close the door with the switch ON. Busbar chamber shall be completely enclosed with metallic partitions. Bolted covers shall be provided for access to horizontal and vertical Busbar and all joints, for repair and maintenance, which shall be feasible without disturbing the feeder compartment. Cable alley door shall preferably be hinged. The main switch shall have the facility of being pad-locked in both ON and OFF positions. The switch handle shall clearly indicate the position of main switch. The Supplier shall furnish suitable plugs to cover the cable openings in the partition between feeder compartment and cable alley, for at least 50% of the total number of feeders. The distribution boards shall have a degree of protection of at least IP52 as per IS-13947:Part I.

All 415V switchgear (circuit breaker boards) shall be of single front type, with fully draw out circuit breakers, which can be drawn out without having to unscrew any connections. The circuit breakers shall be mounted on rollers and guides for smooth movement between SERVICE, TEST and ISOLATED positions and for withdrawal from the Switchboard. Testing of the breaker shall be possible in the TEST position. Unless kept in OFF position it shall not be possible to withdraw the modules from service position or rack them into service position.

All outgoing feeders in distribution boards shall be through MCBs/MCCBs.

Circuit breakers shall be three pole air break horizontal draw out type and shall have inherent fault making and breaking capacities as specified. The circuit breakers which meet specified parameter only after provision of releases or any other devices shall not be acceptable.

All circuit breakers shall be provided at least with 4 NO and 4 NC potentially free auxiliary contacts. These contacts shall be in addition to those required for internal mechanism of the breaker. Separate limit switches each having required number of contacts shall be provided in both 'SERVICE' & 'TEST' position of the breaker.

Control cabinets, junction boxes, Marshalling boxes and terminal boxes shall be made of sheet steel or aluminium enclosure. Sheet steel used shall be at least 2.0-mm thick cold rolled or 2.5 mm hot rolled. In case of aluminium enclosed box the thickness of aluminium shall be such that it provides adequate rigidity and long life as comparable with sheet steel of specified thickness.

7. Earthing

The provision for earthing shall be generally as per requirements given in Clause 3.16.2

8. Tests

- a) The Marshalling Kiosks shall be subject to routine tests as per IS: 5039



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

b) The following routine tests shall also be conducted:

- i) Check for wiring
- ii) Visual and dimension check

Marshalling kiosk shall be provided with danger plate and a diagram showing the numbering/ connection/ ferruling by pasting the same on the inside of the door.

Marshalling kiosk shall also be provided with incoming MCB and one 15 Amp interlocked switched socket in addition to the MCB required.

3.16 Indoor control cubicles

The control panel, cubicles and desks shall be in accordance with the relevant IEC standards and shall be installed in air-conditioned space. Indoor electronic cubicles shall not generally require fans for cooling in order to operate successfully and correctly at the maximum ambient temperature. However, if it is absolutely necessary to install fans etc. in cubicles for cooling then these shall be driven by the same dc supply as used for control, and necessary redundancy, failure alarm etc. shall be incorporated. Louvers in the doors and side panels shall be permitted, if required.

The control and relay panels shall be suitable for numerical relays of modular type mounted in standard 19 inch racks located on the vertical front panel with rear doors for access or located on the front doors for front access type panels. Panels Cubicles shall be completely metal enclosed and shall be dust, moisture and vermin proof. The enclosure shall provide a degree of protection not less than IP 32 in accordance with IS-13947:Part I for cubicles located in air-conditioned areas. IP 31 may also be acceptable for these areas if the layout is arranged such that there is no possibility at all of any liquid entering the area. However, for ventilation reasons the cubicles may be provided with a ventilation hood at the top with a protection class of IP21.

Panels shall be free standing, floor mounting type and shall comprise structural frames enclosed completely with specially selected smooth finished, cold rolled sheet steel of thickness not less than 2.5 mm for weight bearing members of the cubicles such as base frame, front sheet and door frames, and 1.5 mm for sides, door top and bottom portions. There shall be sufficient reinforcement to provide level surfaces, resistance to vibration and rigidity during transportation and installation. The cubicles shall be provided with lifting lugs.

All doors, removable covers and plates shall be gasketed all around with neoprene gaskets. Ventilation louvers, if provided, shall have screens and filters. The screens shall be made of either brass or GI wire mesh with a graduation of 1 mm or less.

Design, material selection and workmanship shall be such as to result in a neat appearance, inside and outside with no welds rivets or bolt heads apparent from outside, with all exterior surfaces true and smooth. All cubicles located in any room shall be matched in appearance.

The Supplier along with anchor bolts and necessary hardware for mounting the cubicles shall furnish metal sills in the form of metal channels properly drilled. Panels shall have an additional rolled channel plinth at the bottom with a smooth bearing surface. The panels shall be fixed on channels with intervening layers of anti-vibration strips made of shock absorbing material, which shall be



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NRWR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

supplied by the Supplier.

Supplier's standard practice for control panels shall be acceptable to the Employer/Purchaser subject to approval during detailed engineering and meeting all functional requirements of the specification.

3.16.1 Mounting

All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections. The equipment on front of panel shall be mounted flush. No equipment shall be mounted on the doors.

Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent devices and are readily accessible without use of special tools. Terminal marking on the equipment shall be clearly visible.

The Supplier shall carry out cut out, mounting and wiring of the free issue items supplied by others, which are to be mounted in his panel in accordance with the corresponding equipment manufacturer's drawings. Cut outs if any, provided for future mounting of equipment shall be properly blanked off with blanking plate.

The centre lines of switches, push buttons and indicating lamps shall be not less than 750mm from the bottom of the panel. The centre lines of relays, meters and recorders shall be not less than 450mm from the bottom of the panel

The centre lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Like wise the top lines of all meters, relays and recorders etc. shall be matched.

No equipment shall be mounted on the doors.

At existing station, panels shall be matched with other panels in the control room in respect of dimensions, colour, appearance and arrangement of equipment (centre lines of switches, push buttons and other equipment) on the front of the panel.

3.16.2 Earthing

- 1) All panels shall be equipped with an earth bus securely fixed. Location of earth bus shall ensure no radiation interference for earth systems under various switching conditions of isolators and breakers. The material and the sizes of the bus bar shall be at least 25 X 6 sq. mm perforated copper with threaded holes at a gap of 50mm with a provision of bolts and nuts for connection with cable armours and mounted equipment etc for effective earthing. When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply of Supplier. Provision shall be made for extending the earth bus bars to future adjoining panels on either side.
- 2) Provision shall be made on each bus bar of the end panels for connecting Substation earthing grid. Necessary terminal clamps and connectors for this purpose shall be included in the scope



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

of supply of Supplier.

- 3) All metallic cases of relays, instruments and other panel mounted equipment including gland plate, shall be connected to the earth bus by copper wires of size not less than 2.5 sq. mm. The colour code of earthing wires shall be green.
- 4) Looping of earth connections, which would result in loss of earth connection to other devices when the loop is broken, shall not be permitted. Earthing may be done in such a manner that no circulating current shall flow in the panel.
- 5) VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.
- 6) An electrostatic discharge point shall be provided in each panel connected to earth bus via 1 Mega Ohm resistor.

3.16.3 Instruments, meters and recorders

Only digital displays and systems shall be provided. The requirements in this section are applicable to auxiliary systems only. All instruments, meters and recorders shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. They shall be calibrated to read directly the primary quantities. They shall be accurately adjusted and calibrated at the factory and shall have means of calibration, checking and adjustment at site.

3.16.4 Miscellaneous

- 1) The Supplier shall submit all type and routine test certificates to the Employer & Purchaser for approval before dispatching the equipment. Control and relay panels shall also be subjected to the following tests:
 - i) Mechanical operation test
 - ii) Verification of degree of protection as per IS-13947:Part I
 - iii) High voltage test
 - iv) Electrical control, Interlock and sequential operation test
 - v) Verification of wiring as per approved schematic.
- 2) Plug Point: 240V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.
- 3) Interior Lighting: Each panel shall be provided with a CFL lighting fixture rated for 240 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.
- 4) MCB's: Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with miniature circuit breakers (MCB).



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

- 5) Space Heater: Panels wherever required shall be provided with a space heater rated for 240V single phase, 50 Hz Ac supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with thermostat and switch fuse /MCB unit.

3.16.5 Terminal blocks and wiring

All internal wiring to be connected to external equipment shall terminate on terminal blocks. Terminal blocks shall be 650 V grade and have 10 Amps. Continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Markings on the terminal blocks shall correspond to wire number and terminal numbers on the wiring diagrams. All terminal blocks shall have shrouding with transparent unbreakable material.

Disconnecting type terminal blocks for current transformer and voltage transformer secondary leads shall be provided. Also current transformer secondary leads shall be provided with short circuiting and earthing facilities.

Spare terminals for Employer's use for upgrading to 6000 MW shall be provided wherever required. In addition, at least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.

The terminal blocks shall be suitable for connecting the conductors of external cable on each side.

Terminal blocks shall be of (at least) 650V grade and have 10 amps continuous rating. These shall be moulded, complete with insulated barriers, stud type terminals, complete with washers, nuts and lock nuts. Screw clamp, overall insulated, insertion type, rail mounted terminals can be used in place of stud terminals with locking type. The terminal blocks shall be of reputed make subject to Employer's acceptance.

Terminal block design shall include a white fibre marking strip with clear plastic, /clip-on terminal covers. Markings on the terminal strips shall correspond to wire numbers on the wiring diagrams.

Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. The current transformer secondary leads shall also be provided with short-circuiting and earthing facilities.

The conducting part in contact with the cable shall preferably be tinned or silver-plated however; nickel-plated copper shall also be acceptable. Insulating barriers shall be provided between the terminal blocks.

Manufacturer's standard practice for internal wiring of cubicles shall be acceptable to the Employer. However all external cabling requirements shall be strictly as per TS.

The Supplier shall furnish all wire, conduits and terminals for the necessary inter-phase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets.



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NRWR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

3.17 Degree of protection

The enclosures of the control cabinets, Junction boxes and Marshalling boxes, panels etc. to be installed as detailed here under:

The minimum requirements for panels are as follows:

Installed out door: IP- 55

Installed indoors in air-conditioned area: IP-32

Installed in covered area: IP-52

Installed indoors in non air-conditioned area where possibility of entry of water is limited: IP-41.

For LT Switchgear (AC & DC distribution Boards): IP-52.

The degree of protection shall be in accordance with IS:13947 (Part-I) / IEC-947 (Part-I) / IS 12063 / IEC 529. Type test report for degree of protection test, on each type of the box shall be submitted for approval

3.18 Welding and welders' qualifications

All welding shall be in accordance with the corresponding standards of the American Welding Society or the American Society of Mechanical Engineers. Welding shall comply with powergrid approved quality plan.

Other standards to determine the quality of welding processes and qualifications of welders may be considered, provided that sufficient information is first submitted for the approval of the Employer.

Prior to the start of fabrication, the Supplier shall submit to the Employer for approval, a description of each of the welding procedures which he proposes to adopt, together with certified copies of reports of the results from tests made in accordance with these procedures.

The Supplier shall be responsible for the quality of the work performed by his welding organization. All welding operators shall be assigned to the work, including for repair of castings, shall pass the required tests for qualification of welding procedures. The Employer reserves the right to witness the qualification tests for welding procedures and operators and the mechanical tests of the samples. If the Inspector so requires, the Supplier shall furnish to the Inspector certified copies of reports of the mechanical test results of the samples.

The Supplier shall bear all his own expenses in connection with the qualification tests. If the work of any operator at any time appears questionable, such operator shall be required to pass appropriate re-qualification tests as specified by the Inspector and at the expense of the Supplier.

Strict measures for quality control shall be exercised throughout the Equipment/Works. The Engineer may call for an adequate NDT test of the work of any operator, who, in his opinion, is not maintaining the required standard of workmanship. Should this NDT test prove defective, all work done by that operator, since his last test shall be tested at the Supplier's expense. If three or more of these tests prove defective, the operator shall be removed from the project.

A procedure for the repair of defects shall be submitted to the Employer for his approval prior to any



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

repairs being made.

3.19 Motors

All motors shall conform to IEC-60034-5 / IS Standard and with principal dimensions in accordance with IEC 60072-1 (1991), IEC 60072-2 (1990) and IEC 60072-3 (1994).

Motors rated 0.5 kW and above, and reversing motors, shall be rated 415 V, three phase, grounded neutral;

Motors rated below 0.5 kW shall be rated 240 V one phase;

All motors shall be designed to operate at full load dynamic conditions with a voltage range of variation of +10%, -20% and a frequency range variation of +5%, -10%. Motors shall also be designed to operate at 125% of the rated speed without mechanical damage, and to start with 80% of their rated voltage;

All motors shall be designed and rated for continuous operation at maximum ambient temperature of 50°C. The class of insulation shall be at least one class higher than used for defining the temperature rise of the motor;

Vertical motors rated 60 kW and above shall be provided with oil-lubricated self-cooled pivoted shoe-type thrust bearing. Vertical motors below 60 kW shall be provided with re-greasable anti-friction ball or roller bearings;

All anti-friction bearings shall be guaranteed to operate successfully for a minimum of 131,000 hours;

All bearings shall be quiet operating and statically and dynamically balanced;

All belts to be used shall be "V" type and designed for the maximum power to be transmitted and for the maximum speed. The selection of the "V" belt drive for any application shall also be based on the nature of the load and the type of the driving unit. Belts installed outdoors shall be suitably protected.

3.20 Conduits, pipes and accessories

The Supplier shall supply and install all rigid conduits, mild steel pipes, flexible conduits, hume pipes etc. including all necessary sundry materials, such as tees, elbows, check-nuts, bushings, reducers, enlargers, wooden plugs, coupling caps, nipples, gland sealing fittings, pull boxes etc. The size of the conduit/pipe shall be selected to limit the fill to a maximum of 40%. All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed in an approved manner to prevent damage to threaded portions and entrance of moisture and foreign materials.

PVC conduits shall be of high impact, heavy gauge (at least class 2) conduit conforming to BS-4607.

The outer surface of the steel conduits shall be coated with hot-dip zinc and chromate conversion coatings. The inner surface shall have silicone epoxy ester coating for easy cable pulling. Mild steel



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

pipes shall be hot-dip galvanized. All rigid conduits/pipes shall be of a reputed make.

The hume pipes and accessories shall be of reinforced concrete conforming to class NP2 of IS-458. All tests on hume pipes shall be conducted as per IS-458.

Flexible conduits shall be of heat-resistant lead coated steel, water-leak, fire and rust proof.

3.21 Packaging & protection

All the equipments shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. On request of the Purchaser, the Supplier shall also submit packing details/associated drawing for any equipment/material under his scope of supply, to facilitate the Purchaser to repack any equipment/material at a later date, in case the need arises. While packing all the materials, the limitation from the point of view of availability of Railway wagon sizes in India should be taken into account. The Supplier shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. Any demurrage, warping and other such charges claimed by the transporters, railways etc. shall be to the account of the Supplier. Purchaser takes no responsibility of the availability of the wagons.

All coated surfaces shall be protected against abrasion, impact, discolouration and any other damages. All exposed threaded portions shall be suitably protected with either a metallic or a non-metallic protecting device. All ends of all valves and piping and conduit equipment connections shall be properly sealed with suitable devices to protect them from damage.

3.22 Auxiliary supply

The sub-station auxiliary supply is normally met through a system having the following parameters. The auxiliary power for station supply, including the equipment drive, cooling system of any equipment, air-conditioning, lighting etc shall be designed for the specified Parameters as under. The DC supply for the instrumentation and PLCC system shall also conform to the parameters as indicated in the following :

Table 24 - 3 Table for Auxiliary Supply

<i>Normal Voltage</i>	<i>Variation in Voltage</i>	<i>Frequency in Hz</i>	<i>Phases</i>	<i>Neutral Connection</i>
415V	± 10%	50 ± 5%	3 or 4 Wire	Solidly Earthed
240 V	± 10%	50 ± 5%	2 Wire	Solidly Earthed
220V	190 - 242	DC	-	Isolated 2 wire system DC unearthed system
48 V	41 - 52.8	DC	-	Isolated 2 wire system positive pole directly earthed

Combined variation of voltage and frequency shall be limited to ± 10%.

3.23 Lamps and sockets

Lamps



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

All incandescent lamps shall use a socket base as per IS-1258, except in the case of signal lamps.

Sockets

All sockets (convenience outlets) shall be suitable to accept both 5 Amp & 15 Amp pin round Standard Indian plugs. They shall be switched sockets with shutters. Degree of protection for outdoor switch sockets shall be IP55.

Hand Lamp

A 240 Volts, single Phase, 50 Hz AC plug point shall be provided in the interior of each cubicle with ON-OFF Switch for connection of hand lamps.

Switches and Fuses

Each panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with switchfuse units. Selection of the main and Sub-circuit fuse ratings shall be such as to ensure selective clearance of sub-circuit faults. Potential circuits for relaying and metering shall be protected by HRC fuses. All fuses shall be of HRC cartridge type conforming to IS:9228 mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts will also be accepted. All accessible live connection to fuse bases shall be adequately shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage.

3.24 Availability spares

The Supplier shall supply the spare parts required to meet the specified guaranteed availability, and shall include such spare parts in the scope of supply. The detailed lists of spare parts to meet the guaranteed reliability & availability requirements shall be part of the contract documents. However if it is found during detailed engineering and/or Reliability & Availability prediction calculation that additional spares are required to meet target values, the same shall be made available by the Supplier without any additional cost to the Employer.

3.25 Commissioning spares

The Supplier shall supply additional spares which he expects to consume during installation, testing and commissioning of the systems. The quantity of these spares shall be decided based on his previous experience, such that site work shall not be hampered due to non-availability of these spares.

3.26 Tools & tackles

The Supplier shall also supply at each site one set of all special tools & tackles, testing equipment, handling equipment, etc. which are required by the Employer's maintenance staff to maintain the stations successfully.

3.27 Seismic force consideration



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

All structures shall be designed for seismic forces in accordance with IS-1893.

The seismic design of electrical equipment shall be performed using estimated actual earth/ ground motion, defined by a response spectrum, rather than the equivalent loads specified in typical Building Codes.

For brittle materials like glass, porcelain and glass fibre reinforced plastic the maximum calculated load should not exceed 2/3 of the guaranteed minimum rupture (breaking) strength (safety factor 1.5) as defined by the manufacturer/supplier of the material used. The minimum rupture value is defined as $(X - 2 \cdot \sigma)$, where X is the mean value and 'sigma' is the standard deviation. For load combinations in porcelain insulators and similar the following expressions shall be fulfilled:

$$\{F_t / (F_t)_b\} + \{M_b / (M_b)_b\} < 2/3 \text{ and} \\ \{F_c / (F_c)_b\} + \{M_b / (M_b)_b\} < 2/3$$

Where:

F_t, F_c, M_b : calculated maximum tensile force; compressive force and bending respectively

(F), (F), (M)_b : corresponding guaranteed strength values

(For normal operating loads, a higher safety factor more than 1.5 shall be used, normally 2.0-2.5 depending on type of load as per recommendations of manufacturer).

Factor regarding importance of structures (I), as defined in IS-1893, shall not be taken less than 1.5.

3.28 Safety requirements

The requirements regarding provision of additional staircases and approachability as defined in the Fire Protection Manual, issued by the Regional Committees of the Tariff Advisory Committee shall be completely fulfilled. All other safety requirements shall be met as per the factories Act, TAC etc.



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

**ANNEXURE-A
Corona and Radio Interference Voltage (RIV) Test**

1. General

Unless otherwise stipulated, all equipment (except Auto Transformer & Shunt Reactor) together with its associated connectors, where applicable, shall be tested for external corona both by observing the voltage level for the extinction of visible corona under falling power frequency voltage and by measurement of radio interference voltage (RIV). The test procedure shall be reviewed for different equipment during submission of MQP/ITP.

2. Test Levels:

The test voltage levels for measurement of external RIV and for corona extinction voltage are listed under the relevant clauses of the specification.

3. Test Methods for RIV:

- 3.1 RIV tests shall be made according to measuring circuit as per International Special-Committee on Radio Interference (CISPR) Publication 16-1(1993) Part -1. The measuring circuit shall preferably be tuned to frequency with 10% of 0.5 Mhz but other frequencies in the range of 0.5 MHz to 2 MHz may be used, the measuring frequency being recorded. The results shall be in microvolts.
- 3.2 Alternatively, RIV tests shall be in accordance with NEMA standard Publication No. 107-1964, except otherwise noted herein.
- 3.3 In measurement of, RIV, temporary additional external corona shielding may be provided. In measurements of RIV only standard fittings of identical type supplied with the equipment and a simulation of the connections as used in the actual installation will be permitted in the vicinity within 3.5 meters of terminals.
- 3.4 Ambient noise shall be measured before and after each series of tests to ensure that there is no variation in ambient noise level. If variation is present, the lowest ambient noise level will form basis for the measurements. RIV levels shall be measured at increasing and decreasing voltages of 85%, 100%, 115% and 130% of the specified RIV test voltage for all equipment unless otherwise specified. The specified RIV test voltage for 400 kV, 220 kV is listed in the detailed specification together with maximum permissible RIV level in microvolts.
- 3.5 The metering instruments shall be as per CISPR recommendation or equivalent device so long as it has been used by other testing authorities.
- 3.6 The RIV measurement may be made with a noise meter. A calibration procedure of the frequency to which noise meter shall be tuned shall establish the ratio of voltage at the high voltage terminal to voltage read by noise level meter.

4. Test Methods for Visible Corona

The purpose of this test is to determine the corona extinction voltage of apparatus, connectors etc. The test shall be carried out in the same manner as RIV test described above with the exception that RIV measurements are not required during test and a search technique shall be used near the onset and extinction voltage, when the test voltage is raised and lowered to determine their precise values. The test voltage shall be raised to 130% of RIV test voltage and maintained there for five minutes. In case corona inception does not take place at 130 %, test



**±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT**

**General Technical Requirements- Section 3
Doc. No. : TB-343-316-000 Rev. 02**

shall be stopped, otherwise test shall be continued and the voltage will then be decreased slowly until all visible corona disappears. The procedure shall be repeated at least 4 times with corona inception and extinction voltage recorded each time. The corona extinction voltage for purposes of determining compliance with the specification shall be the lowest of the four values at which visible corona (negative or positive polarity) disappears. Photographs with laboratory in complete darkness shall be taken under test conditions, at all voltage steps i.e. 85%, 100%, 115% and 130%. Additional photographs shall be taken at corona inception and extinction voltages. At least two views shall be photographed in each case using Panchromatic film with an ASA daylight rating of 400 with an exposure of two minutes at a lens aperture of f/5.6 or equivalent. The photographic process shall be such that prints are available for inspection and comparison with conditions as determined from direct observation. Photographs shall be taken from above and below the level of connector so as to show corona on bushing, insulators and all parts of energised connectors. The photographs shall be framed such that test object essentially, fills the frame with no cut-off.

- 4.1 The test shall be recorded on each photograph. Additional photograph shall be taken from each camera position with lights on to show the relative position of test object to facilitate precise corona location from the photographic evidence.
- 4.2 In addition to photographs of the test object preferably four photographs shall be taken of the complete test assembly showing relative positions of all the test equipment and test objects. These four photographs shall be taken from four points equally spaced around the test arrangement to show its features from all sides. Drawings of the laboratory and test set up locations shall be provided to indicate camera positions and angles. The precise location of camera shall be approved by Purchaser's inspector, after determining the best camera locations by trial energisation of test object at a voltage which results in corona.
- 4.3 The test to determine the visible corona extinction voltage need not be carried out simultaneously with test to determine RIV levels.
- 4.4 However, both test shall be carried out with the same test set up and as little time duration between tests as possible. No modification on treatment of the sample between tests will be allowed. Simultaneous RIV and visible corona extinction voltage testing may be permitted at the discretion of Purchaser's inspector if, in his opinion, it will not prejudice other test.

5. Test Records:

In addition to the information previously mentioned and the requirements specified as per CISPR or NEMA 107-1964 the following data shall be included in test report:

- a) Background noise before and after test.
- b) Detailed procedure of application of test voltage.
- c) Measurements of RIV levels expressed in micro volts at each level.
- d) Results and observations with regard to location and type of interference sources detected at each step.
- e) Test voltage shall be recorded when measured RIV passes through 100 microvolts in each direction.
- f) Onset and extinction of visual corona for each of the four tests required shall be recorded.



±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT

AC Filter Current Transformer

Doc. No. : TB-343-510-147 Rev. 00

SECTION – 4

CHECKLIST

**CHECK LIST FOR INFORMATION TO BE FURNISHED WITH OFFER RETURN THIS
CHECKLIST AS PART OF THE OFFER DULY SIGNED**

The offer may not be considered if the following information and this Checklist are not enclosed with the Offer.

BHEL ENQUIRY. NO:

BIDDER:OFFER REFERENCE:

A)

(1) S.No.	(2) Parameters	(3) Data	(4) Yes / No	(5) Remarks in case reply in Col (4) is NO
1.	Applicable Standard	IS -2705, IEC 60044-1		
2.	Type	Single Phase Outdoor type		
3.	Parameters			
3.1	Highest Voltage for equipment	a) 24kV for F2 CT, GND CT, L2&R2 CT, R1 CT, F1 CT b) 36kV for C2 CT		
3.2	Rated Frequency	50Hz		
3.3	Rated Primary Current	Conforms to Technical Data at Clause 4, Sub-Clause 3.1 of RS of AC Filter CTs		
3.4	Rated Secondary Current	1A		
3.5	Insulation Level- <i>Lightning impulse withstand level, primary winding</i>	a) 125kV for F2 CT, GND CT, L2&R2 CT, R1 CT, F1 CT b) 145kV for C2 CT		
3.6	1 min Power frequency withstand voltage test			
	- Primary Winding	a) 50kV for F2 CT, GND CT, L2&R2 CT, R1 CT, F1 CT b) 70kV for C2 CT		
	- Secondary Winding	3kV		
3.7	Core Data	Conforms to Technical Data at Clause 4, Sub-Clause 6 of RS of AC Filter CTs		
3.8	Transient current capability	Conforms to Technical Data at Clause 4, Sub-Clause 3.5 of RS of AC Filter CTs		
4.0	Construction feature			
4.1	Type of Insulation	Oil/ Solid		
4.2	Insulating Oil conforms to	IS335/ IEC60296		
4.3	Lifting eyes	Provided		
4.4	Tank and Top Metallics	Hot Dip Galvanised/ Painted		
4.5	Oil Indicator for oil insulated CTs	Provided		
4.6	Earthing connections	Provided		
4.7	Terminal pads provided as per specification	Provided		



±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT

AC Filter Current Transformer

Doc. No. : TB-343-510-147 Rev. 00

4.8	Weatherproof secondary terminal box	Provided		
4.9	Facility for short circuiting and earthing of secondary terminal	Provided		
4.10	Degree of Protection of secondary terminal Box	IP55		
4.11	Secondary terminal clamps and earthing clamps suitable for	6sqmm conductors		
4.12	Terminal Markings	According to IEC60044-1		
4.13	Bushing/ Insulator conforms to	Conforms to specification clause 6.15 of RS of AC Filter CTs		
4.14	Spark gap/ surge diverter provided to limit voltage over primary terminal during transients	Provided		
4.15	Information on nameplates	As per IEC 60044		
4.16	Circuit Diagram on name plate	Provided		
5.0	Failure Rate Guarantee	Provided and conforms to Specification		
6.0	EMC Design	Conforms to Specification		
7.0	Tests			
7.1	Routine Tests	Shall be performed as per IS2705/ IEC60044-1		
7.2	Sealing test and its procedure	Shall be verified and is subject to approval by ABB/ BHEL		
7.3	Type Test reports alongwith justification for compliance	Shall be submitted for approval		
8.0	Design Verification			
8.1	For Transient current capability	Shall be submitted for approval		
8.2	For Seismic Requirements	Shall be submitted for approval		
8.3	For DC current effect	Shall be submitted for approval		
9.0	Fixing Hardware (Nuts, Bolts and Washers) for mounting CTs	Provided		

B) TYPE TESTS

i) Whether type test reports conducted earlier on identical or similar material are available (test reports are of the test conducted not earlier than 5 (five) years prior to the date of bid opening 30.06.2009).

(YES / NO)

ii) If type test reports are not acceptable to BHEL/PGCIL then above tests shall be conducted by the bidder free of cost.

(YES)



±800KV, 6000MW, HVDC MULTI-TERMINAL NER/ER – NR/WR
INTERCONNECTOR-I PROJECT

AC Filter Current Transformer

Doc. No. : TB-343-510-147 Rev. 00

C)

S.No.	Description	Confirmation of Supplier
1.	Bidder to confirm that all drawings / data sheets/QP/ valid type tests reports/ all relevant information shall be submitted to BHEL for organising approval of ultimate customer.	
2.	Bidder to confirm that it will offer approved Make of the components and fitments at contract stage. In case the offered make is not approved by the customer, then alternate make shall be supplied without any commercial implications to BHEL.	

Date:

Signature of the authorized representative of Bidder

Company Seal