ANNEXURE –I

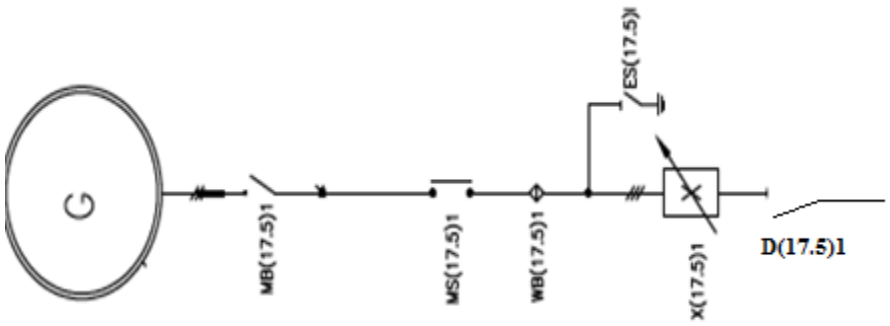
Technical specification of
Short circuit current limiting reactor banks for augmentation of short circuit test facilities at High power laboratory, CPRI Bengaluru.

Annexure - I

TABLE OF CONTENTS

Clause No.	TECHNICAL SPECIFICATION
1.0	**FOREWORD** Central Power Research Institute (herein after referred to as CPRI) intends to establish/augment the test facilities of the High Power Laboratory in Bangalore in order to meet the growing demand for high power testing by adding two nos. of 2500 MVA Short-circuit Generators (G2 and G3). The laboratory is already having one Short circuit generator of 2500MVA capacity working since 1990. (G1). The total available short-circuit power (7500MVA) shall be used to increase the testing capability of the Laboratory (by running the Generators in parallel) and to improve the efficiency of testing activities making use the Generators individually to supply power to perform tests simultaneously in different test bays i.e. mainly short-circuit tests on various power system equipment such as circuit-breakers, switches, fuses etc.. In view of this, laboratory requires new short circuit current limiting reactor banks intended for use for short-circuit tests (or other kind of tests) in the test bays. This specification covers the supply of six (06) MV single-phase current limiting reactor banks: three (03) for G2 (labelled X(17.5)2) and three (03) for G3 (labelled X(17.5)3). It also includes all the required accessories to properly install and operate the current limiting reactor banks, ready for operation in the High Power Laboratory of CPRI-Bangalore.
2.0	**GENERAL**
2.1	The purpose of this specification is to give the ratings for design, manufacture, testing, installation and commissioning of the current limiting reactor banks required for their use in the High Power Laboratory of CPRI-Bangalore.
2.2	The MV single-phase current limiting reactor banks shall be used to limit the current at a pre-set value according to the test condition.

Clause No.	TECHNICAL SPECIFICATION
3.0	**SCOPE:**
3.1	The scope covers design, engineering, manufacture, assembly, stage inspection, testing at manufacturer's works, Routine and Type tests, packing, delivery at site including all materials, accessories, spares, unloading, handling, proper storage at site, erection, testing and commissioning of six (06) identical MV single-phase current limiting reactor banks.
3.2	The supplier has also to supply all the required busbars, clamps used to connect the reactor coils, including all the required fasteners, insulating material i.e. FRP board/sheet.
3.3	These activities will be performed in a dedicated period, according to CPRI, in order to avoid interferences with other works.
4.0	**CLIMATIC CONDITIONS:** MV single-phase current limiting reactor banks shall be designed for satisfactory operation under tropical climatic conditions prevailing in India. The climatic conditions prevalent at the site of the operation are as follows; a) Altitude above Mean Sea Level : 921m b) Maximum ambient temperature : 45°C c) Minimum ambient temperature : 10°C d) Average annual temperature : 24°C e) Average Humidity : 81% f) Special corrosion conditions : Nil g) Solar Radiation (DNI) : 4.5-5.0 kWh/Sq. m/Day h) Atmospheric UV radiation : High i) Pollution level : Moderate j) Snow fall : NIL k) Seismic Zone : Zone-II l) Wind Speed : Average 5.6 km/h The site location is situated in the CPRI campus located adjacent to Indian Institute of Science. The site can be approached a) By Train: Nearest Railway station: Yeshwanthpur b) By Air: Kempegowda International airport 33 km away from site. c) Nearest Sea Port: Chennai
5.0	**REFERENCE STANDARDS:** The MV single-phase current limiting reactor banks shall generally conform to the latest versions (as on date of Purchase Order release) of the relevant IEC

Clause No.	TECHNICAL SPECIFICATION
	Publications but compulsory for the special requirements of this specification. If a relevant IEC Publication does not exist, the supplier shall adopt other internationally accepted standards and codes. The MV single-phase current limiting reactor banks shall comply with the requirements of this technical specification. Wherever specifications are not clear the latest edition of the following IEC Standard shall be applicable: [1] IEC Standard 60076- 6 Power transformers – Part 6: Reactors In the matter of conformity, the following order shall be binding: • The special requirements of this specification • The latest versions of IEC Publication • To the latest versions of other national/international standards/codes as applicable to the relevant equipment or component or the material used in the manufacture of the same. • In the event a requirement is not covered by any of the above mentioned documents the same will be decided by mutual agreement between the purchaser and the supplier.
6 **6.1** **6.2** **6.3**	**SYSTEM PARTICULARS:** The air core reactors banks intended to limit the current at a pre-set value according to the test condition. These reactors shall be installed on the first floor of approx. 9meters from ground level of the Short circuit Generator building, with sufficient phase clearance to avoid the occurrence of phase to phase fault in this part of the station. These reactors X(17.5)2 and X(17.5)3, shall be connected between the generator earthing switches and the output disconnectors of the relevant short circuit generator as shown in the figure 1, which shows the existing G1 feeder with its reactors bank X(17.5)1. 

Clause No.	TECHNICAL SPECIFICATION

Fig. 1: Single line diagram of High Power Laboratory
from source to current limiting reactors of G1

G : Short Circuit Generator (3 phase),
MB : Master Breaker
MS : Make Switch,
X : Adjustable current limiting reactors

Each phase consists of three coils i.e. Coil-1, Coil-2 and Coil-3. They forms reactor bank per phase. All three coils per phase shall have tappings in order to get fine adjustment of reactance value. The existing short-circuit current limiting reactor bank clamp setting details are tabulated in Table 1, Table 2, Table 3, Table 4 and Table 5. Coil-1 clamp settings start from 100 to 135, Coil-2 clamp settings start from 200 to 204 and Coil-3 clamp settings start from 300 to 310. The supplier shall design the reactor banks in line with the existing short circuit current limiting reactor bank requirements. The impedance value of new current limiting reactor bank for the specified clamp setting shall be same as the existing reactor bank value for the same clamp setting with a tolerance of less than ± 5% for parallel operation of two or three short circuit generators.

Clamping design and trapping arrangement shall be in line with existing reactor bank arrangement. Connection arrangement of each phase reactor bank i.e. Coil-1, Coil-2 and Coil-3 is shown in fig 2.

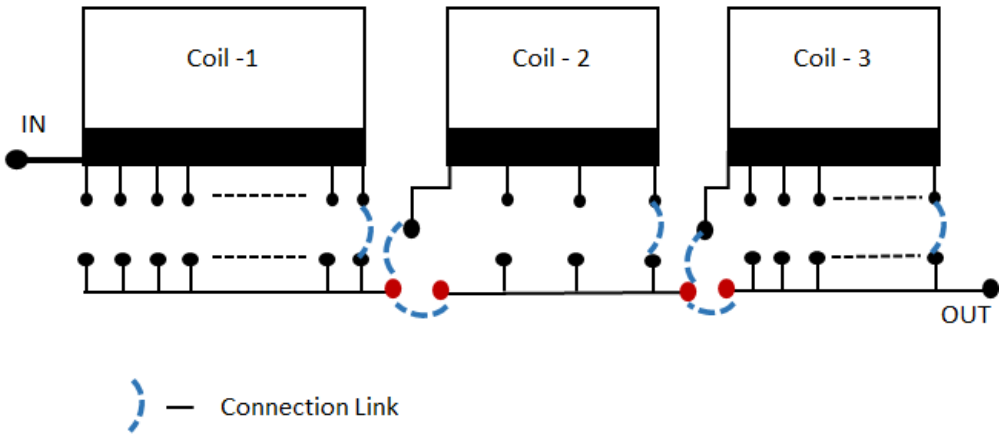


Fig. 2 : Connection arrangement of
each phase reactor bank i.e. Coil-1, Coil-2 and Coil-3.

Clause No.	TECHNICAL SPECIFICATION
7.0	**PERFORMANCE CHARACTERISTICS OF EACH REACTOR BANK**

Each phase consists of three coils i.e. Coil-1, Coil-2 and Coil-3. They forms reactor bank per phase. The technical parameters of reactor bank are shown in below;

Parameter	**Unit**	**Value**
Phases		single phase
Installation		Indoor
Rated voltage (Ur)	kV	14
Rated maximum voltage (Um)	kV	17.5
Rated frequency	Hz	50 and 60
Rated power-frequency withstand voltage for 1min	kV	38
Rated lightning impulse withstand voltage	kVpeak	95
Time constant of coils (To = L/R) at 50Hz	ms	>90
Tap reactance at 50 Hz (per phase)	mΩ	0.74 to 5981
Reactance variation between adjacent taps	%	≤5%
(1)Rated tap short-time current (I_r)	kArms	140 to 1.4(1)
(2)Rated tap peak current	kApeak	2.7 times I_r
Rated short-time current duration	s	1.0
(3)Fault tap short-time current (I_f)	kArms	189 to 1.4(3)
(4)Fault tap peak current	kApeak	2.7 times I_f
Fault short-time current duration	s	0.2

The rated normal continuous current of the reactors to be supplied is not specified. The bidder shall indicate the rated normal current of the reactors.

(1) The rated short-time current for each tap shall be calculated with the following formula:

$I_r = (Ur/\sqrt{3})/(Xe+Xr)$

where:

I_r : maximum tap short-time current
Ur : rated voltage
Xe : external circuit impedance including generator impedance, primary and secondary bus bar impedances, short circuit testing transformer impedances - 57 mΩ
Xr : tap reactance at 50Hz

(2) The rated peak intermittent current of each reactor or part of reactor shall be calculated taking into account the actual time constant of the reactor or part of the reactor and on the assumption that it will be associated with the

Clause No.	TECHNICAL SPECIFICATION
	external impedance 57 mΩ, the time constant of which is 119ms (approx.). (3) The fault short-time current for each tap shall be calculated with the following formula: $I_r = (Ur/\sqrt{3})/(Xef+Xr)$ where: I_r : maximum tap short-time current Ur : rated voltage Xe : minimum external circuit reactance (in series with the reactor bank), including generator impedance and connections only - 42 mΩ Xr : tap reactance at 50Hz (4) The maximum peak current occurs half cycle after the short-circuit making; at that instant, in case of a short-circuit at the reactor terminals, the ac component of the generator Iac, (and current limiting reactors) current may be estimated according to the following formula $Iac = (Ur/\sqrt{3})/(X"d+Xr) * 0.9$ $X"d = 30$ mΩ The corresponding peak current should be 2.7 times the value of Iac only for each tap exceeding 12 mohm. The range of impedance values available with each reactor bank shall be such that the step of current between two possible successive values of impedance will be kept lower than 5% of the previous value. The tolerances shall be covered by 5% step.
8.0 **8.1**	**DESIGN REQUIREMENTS:** The reactors design shall be single-phase, dry-type, air-core, without magnetic shield, with taps, for indoor installation. Each phase shall be mounted horizontally. The reactor banks shall be such that one unit of bank can be replaced by maximum of three sub coils. Clamping design and trapping arrangement shall be in line with the existing reactor bank arrangement. The setting of impedance value, and especially its fine adjustment could be obtained by means of tappings provided on a reduced number of main reactors.

Clause No.	TECHNICAL SPECIFICATION
	The suitable reactor or part of reactor shall be selected with a convenient manual device (clamps, fishplates) whose good operation position shall be easily checked. A self-tightening device would be advisable. Due to operations to be performed by the personnel on the reactors between tests, the temperature of accessible parts shall not exceed 65°C after a cooling time of 3 minutes corresponding to the interval after which said operations can be performed.
8.2	**Operation duty** The reactors shall be intended only for intermittent duty; they will be assigned no rated continuous current. The basic duty of reactors shall match the operating sequence of the short circuit generator. Consequently, they shall be capable to withstand a rated intermittent current, which is the rms value of the ac component at making time to be carried by the test equipment, while a 0.2 second CO short circuit test is performed at the specified short circuit power, where C – represents a closing operation of circuit breaker under test O – represents an opening operation of circuit breaker under test Each reactor tap shall be designed to withstand the thermal and dynamic effects of its rated short-time current including the associated electrical stress for the rated duration to the following test cycle: CO– t1 –CO – t2– CO Where CO represents a duty cycle under the conditions specified above. t1 = 0.3 second t2 = 3.0 minutes and 15 second This sequence shall be carried out four times per hour, taking into account a cooling time of 15 minutes between two successive cycles. Any duty cycle at currents below the rated short-time current of the tap shall be allowed provided that the let-through specific energy of the duty cycle does not exceed the rated I^2t. The expected frequency of short-circuit application is at least 1000 per year.
9.0	**CONSTRUCTION DETAILS** The features and construction details of the reactor shall be in accordance with the requirement stated hereunder.

Clause No.	TECHNICAL SPECIFICATION
9.1	**Supporting structure**
9.1.1	***Lifting Eyes*** Each reactor bank shall be provided with removable lifting eyes: four symmetrically placed lifting eyes shall be provided so that it will be possible to lift the complete reactor without structural damage to any part of the reactor. The factor of safety at any one point shall not be less than 2. The lifting eye shall be so arranged and located so as to be accessible for use when the reactor is loaded on the transport vehicle.
9.1.2	***Paint system and procedures*** Manufacturer's standard paint systems shall be furnished along with the bid. High quality, modern environment friendly paint systems shall be proposed.
9.1.3	***Earthing Terminals*** One (1) earthing pad (complete with two (2) nos. holes, M 10 bolts, plain and spring washers) suitable for connection to 75 x 12 mm galvanised steel grounding flat shall be provided at position close to earth of the supporting structure. All non-conducting parts of the reactor shall be provided with two reliable earthing terminals for connection with local earthing circuit.
9.2	**Windings** The conductors shall be of either aluminium or electrolytic grade copper free from scales and burrs. The insulation of reactor windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse during service. The coils would be made up, shaped and braced to provide for expansion and contraction due to temperature changes. The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalize the distribution of currents and temperature along the winding. The windings shall be designed to withstand the dielectric tests specified. The type of winding used shall be of type tested and in successful operation for at least 5 year in similar voltage application at the time of design review. An analysis shall be made of the transient voltage distribution in the windings, and the clearances used to withstand the various voltages. Margins shall be used in recognition of manufacturing tolerances and the fact that the system will not always be in the new

Clause No.	TECHNICAL SPECIFICATION
	factory condition.
9.2.1	***Bracing of windings*** All winding insulation shall be processed to ensure that there will be no detrimental shrinkage after assembly. All windings shall be pre-sized before being clamped. Windings shall be provided with clamping arrangements which will distribute the clamping forces evenly over the ends of the winding. The bracing of the windings and connections shall be such that these parts shall safely withstand the cumulative effects of stresses which may occur during handling, transportation, installation and service including fault current flow.
9.2.2	***Current carrying connections*** The design of all connections shall be subjected to Design Review. The mating faces of bolted connections shall be appropriately finished and prepared for achieving good long lasting, electrically stable and effective contacts.
9.2.3	***Reactor terminals*** Reactor terminals shall be designed to allow for repeatable and safe connection under site conditions to ensure the integrity of the reactor in service. Allowances shall be made on the winding ends for accommodating tolerances on the axial dimensions. In particular, rotation or straining of insulated connections shall be avoided during the fastening of removable clamps to the taps.
10.0	**FITTINGS** The following fittings shall be provided with each reactor covered under this specification. • Rating plate for reactors. • Reactor supporting structure and insulators • One earthing terminal on reactor supporting structure. • Lifting eyes. • Connecting clamps The fittings listed above are only indicative and any other fittings which generally are required for satisfactory operation of the reactors are deemed to be included.

Clause No.	TECHNICAL SPECIFICATION
10.1	**Rating plate** Each reactor shall be provided with a rating plate of weatherproof material and convenient marks to facilitate selection of impedance values, fitted in a visible position, showing in all cases the appropriate items indicated below. The entries on the plate shall be indelibly marked (for example by etching, engraving or stamping). • type of reactor; • indoor application; • reference to the IEC Standard 60076-6; • manufacturer's name; • manufacturer's serial number; • year of manufacture; • insulation levels; • rated frequency; • highest voltage for equipment; • taps impedance, measured value; • rated taps short-time current • rated taps peak short-circuit current; • rated short-circuit duration; • thermal class of insulation; • total mass.
11.0	**DESIGN REVIEW** The reactors shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin with respect to thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc. so that the reactors provided long life with least maintenance. Design reviews shall be conducted by Purchaser or an appointed consultant during the procurement process for reactors, however the entire responsibility of design shall be with the manufacturer. Purchaser may also visit the manufacturers works to inspect design, manufacturing and test facilities.
12.0	**TRANSPORTATION** It shall be the responsibility of the contractor to coordinate the arrangement for transportation of the reactor for all the stages from the manufacturer's work to site. All metal blanking plates and covers which are specifically required to transport

Clause No.	TECHNICAL SPECIFICATION
	the reactor shall be considered part of the reactor and handed over to the Purchaser after completion of the erection. Bill of quantity and relevant drawings of these items shall also be included in the manual to enable the Purchaser to have it re-manufactured, if required. The details of the proposed method of transportation shall be submitted for approval.
13.0	**INSPECTION AND TESTING** CPRI representatives shall be allowed to inspect the production process in the factory. The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the equipment. An indication of inspection envisaged by the Purchaser is given below. This is however not intended to form a comprehensive programme as it is Contractor's responsibility to draw up and carry out such a programme in the form of detailed quality plan duly approved by Purchaser for necessary implementation.
13.1	**Inspection**
13.1.1	***Winding*** • Sample check on winding conductor for mechanical properties and electrical conductivity. • Visual dimensional checks on conductor for scratches, dent marks etc. • Check for absence of short circuit between parallel strands. • Check for brazed joints wherever applicable. • Measurement of impedance by low voltage to be carried out when all connections are ready. • Conductor flexibility test. • Certification of all test results.
13.1.2	***Assembled Reactor*** • Check completed reactor against approved outline drawing provision for all fittings, finish level etc. • Lifting test on all the assembled reactors.
13.2	**Factory Tests** The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated in. The contractor shall bear all additional costs related to tests which are not possible to carry out at his own works.

Clause No.	TECHNICAL SPECIFICATION
	The contractor shall submit an Inspection and test plan (ITP) for approval. A typical test plan is indicated below. The following various routine and type tests shall be performed according to IEC Standard 60076-6; for each test, reference is made to the corresponding Standard Clause. Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the test engineer of the contractor. The contractor shall inform CPRI of the Acceptance Tests program 60 days in advance and shall allow CPRI representatives to witness them.
13.2.1	***Type tests*** For each reactor bank: • Lightning impulse test for current-limiting reactors (8.9.12); • Short-circuit current test (8.9.13): The manufacturer shall submit the calculations for withstanding the short time current for the duration stated in clause 7 for approval. One of the reactor banks out of six selected by CPRI shall be delivered to High Power Laboratory, CPRI, Bengaluru and subjected to tests at its capacity to withstand the rated short circuit current as stated in clause 7 and according to the cycle specified in clause 8 at High Power Laboratory, CPRI, Bengaluru. The current duration for the above test is based on the tap selection and limitation of the test laboratory. The tests shall be performed one time on three different values of impedance of the reactor banks. The tests shall not produce any mechanical damage on the reactors and particularly on the connecting devices (pitting marks, contact welding on traces of arc not allowed) and they shall be easily removable. No impedance variation shall be noticed after these tests. It shall withstand Separate source a.c. withstand dry voltage test at 100% of voltage. On successful short time current test, the manufacturer shall deliver the remaining five reactor banks to High Power Laboratory, CPRI, Bengaluru with the approval of Project Manager. If the equipment fails to comply the above requirement of the technical specification in first attempt, the bidder shall take back the coils to his works at his own cost; the charges for subsequent attempts to test the equipment for compliance shall be borne by bidder. If the bidder intends to do these tests at any other independent laboratory, test charges shall be borne by the bidder and shall not include in the price bid. However, CPRI

Clause No.	TECHNICAL SPECIFICATION
	shall witness these tests at its own cost. • Separate source a.c. withstand voltage test dry (8.9.8);
13.2.2	***Routine tests*** On each reactor bank: • Measurement of winding resistance (procedure as stated in relevant sub-clause of IEC 60076-6); The winding resistance of each reactor or part of reactor shall be measured at rated frequency and suitable dc current. • Measurement of impedance (as stated in relevant sub-clause of IEC 60076-6); • Winding overvoltage test dry (8.9.9).
13.2.3	***Pre-Shipment Checks at Manufacturer's Works*** Check for interchangeability of components of similar reactors for mounting dimensions.
13.3	**Inspection and Testing at Site** The Bidder shall carry out a detailed inspection and testing programme for field activities, namely covering areas right from the receipt of material stage up to commissioning stage. It is Bidder's responsibility to draw up and carry out such a programme duly approved by the Purchaser to prove current limiting reactor banks capabilities to withstand their rated intermittent currents according to cycle specified in this specification at its actual arrangement. The rated intermittent current for each tap shall be calculated with the following formula: $Ir = (Ur/\sqrt{3})/(Ze+Zr)$ where: Ir : rated intermittent current of a particular tap Ur : rated voltage Ze : external circuit impedance including generator impedance, primary and secondary bus bar impedances, short circuit testing transformer impedances - 57 mΩ Zr : tap impedance of reactor at 50Hz The corresponding peak intermittent current should be 2.7 times the value of Ir for each tap depending on its sub transient time constant.

Clause No.	TECHNICAL SPECIFICATION
	The tests shall not produce any mechanical damage on all the reactors and particularly on the connecting devices (pitting marks, contact welding on traces of arc not allowed) and they shall be easily removable. No impedance variation shall be noticed after these tests. It shall withstand Separate source a.c. withstand dry voltage test at 100% of voltage. If the equipment fails to comply the above requirement of the technical specification, the bidder shall repair at site or take back all coils to his works at his own cost and reoffer for conducting all tests at site.
13.3.1	***Receipt and Storage Checks*** • Check and record condition of each package, visible part of the reactors etc. for any damage • Visual check for condition of winding in general.
13.3.2	***Installation Checks*** • Check the whole assembly for tightness, general appearance etc.
13.3.3	***Commissioning Checks*** • Insulation resistance measurement for the main winding • Check for cleanliness of the reactor and the surrounding. Contractor shall prepare a comprehensive commissioning report including all commissioning test results and forward to Purchaser for future record.
14.0	**ERECTION/INSTALLATION AND COMMISSIONING** The supplier shall depute their expert during erection and commissioning of these short circuit current limiting reactors and provide complete technical support, in addition to materials and drawings.
15.0	**DOCUMENTS** The following drawings and document to be submitted for CPRI approval before commencement of manufacture: 1. Overall dimension drawing of reactor coils 2. Drawings showing clamp arrangement to achieve various impedances. 3. Drawings showing interconnection between reactor coils (1, 2 and 3). 4. Foundation details drawing for erection of reactor coils. 5. Chart clearly showing the impedance of each clamp and short circuit

Clause No.	TECHNICAL SPECIFICATION
	current RMS/Peak and its duration. Manual/Brochure giving details of reactor coils operation and maintenance.
16.0	**PERFORMANCE GUARANTEE** The current limiting reactor banks shall have to comply with guaranteed technical parameters as per clause 7 and meet the requirements given in clause 13.2 and clause 13.3 of this specification.
17.0	**SPARE PARTS AND MAINTENANCE** The supplier is required to list the suggested mandatory spares for the current limiting reactor banks, as well as the spares which may be required for ensuring the guaranteed availability. Any other spares which bidder feels essential for trouble free operation of current limiting reactor banks for at least 10 years may be listed as recommended spares with price and validity as an option. The recommended spares shall not be considered for Bid evaluation. The Bidder shall indicate the proposed maintenance schedule during the guarantee period and the life period of the current limiting reactor banks.

Table 1:

Existing current limiting Reactor bank (Coil-1, Coil-2, Coil-3) clamp settings for different current/impedance values

Clamp Setting			I (kA)	Z (mΩ)
Coil -1	Coil -2	Coil -3		
100	200	300	140	0.74
102	200	300	135.4	2.697
103	200	300	130.90	4.728
104	200	300	125.90	7.129
105	200	300	120.40	10.14
106	200	300	114.90	13.32
107	200	300	109.50	16.8
108	200	300	104.40	20.43
109	200	300	99.50	24.26
110	200	300	94.80	28.26
111	200	300	90.50	32.31
112	200	300	86.40	36.57
113	200	300	82.60	40.86
114	200	300	79.00	45.27
115	200	300	76.00	49.41
116	200	300	72.90	53.89
117	200	300	69.80	58.86
118	200	300	66.80	64.04
119	200	300	63.90	69.41
120	200	300	61.20	74.97
121	200	300	58.70	80.75
122	200	300	56.30	86.54
123	200	300	54.10	92.54
124	200	300	51.90	98.63
125	200	300	49.96	104.8
126	200	300	48.12	111
127	200	300	46.29	117.6
128	200	300	44.64	124.1
129	200	300	43.13	130.4
130	200	300	41.60	137.3
131	200	300	40.27	143.7
132	200	300	39.02	150.2
133	200	300	37.78	157
134	200	300	36.61	163.6

Table 2:

Existing current limiting Reactor bank (Coil-1, Coil-2, Coil-3) clamp settings for different current/impedance values

Clamp Setting				I (kA)	Z (mΩ)
Coil -1	Coil-2	Coil-2	Coil-3		
118	201	202	300	35.89	168.2
119	201	202	300	34.96	174.2
120	201	202	300	34.05	180.4
121	201	202	300	33.16	186.8
122	201	202	300	32.29	193.3
123	201	202	300	31.47	199.9
124	201	202	300	30.65	206.8
125	201	202	300	29.84	213.8
126	201	202	300	29.07	221.1
127	201	202	300	28.32	228.4
128	201	202	300	27.59	236
129	201	202	300	26.99	242.5
130	201	202	300	26.19	251.6
131	201	202	300	25.52	259.7
132	201	202	300	24.87	268
133	201	202	300	24.24	276.5
134	201	202	300	23.60	285.4
135	201	202	300	22.99	294.6
119	201	203	300	22.26	306
121	201	203	300	21.50	319
123	201	203	300	20.75	332.6
125	201	203	300	20.01	346.9
127	201	203	300	19.29	362.1
129	201	203	300	18.53	378
131	201	203	300	17.88	395
133	201	203	300	17.21	412.8

Table 3:

Existing current limiting Reactor bank (Coil-1, Coil-2, Coil-3) clamp settings for different current/impedance values

Clamp Setting					I (kA)	Z (mΩ)
Coil-1	Coil-2	Coil-2	Coil-3	Coil-3		
100	201	204	300	---	16.39	436.1
108	201	204	300	---	15.7	457.8
113	201	204	300	---	15.04	480.4
118	201	204	300	---	14.34	506.8
122	201	204	300	---	13.70	533
125	201	204	300	---	13.22	554.6
128	201	204	300	---	12.73	578.1
131	201	204	300	---	12.23	603.8
132	201	203	301	302	11.83	626.40
135	201	203	301	302	11.36	654.50
106	200	301	303	---	10.97	679.7
100	201	204	301	302	10.66	696.3
108	201	204	301	302	10.38	717.5
116	201	204	301	302	9.90	755.5
122	201	204	301	302	9.46	793.2
127	201	204	301	302	9.06	931.1
132	201	204	301	302	8.64	873.4
127	201	202	301	303	8.36	906.6
132	201	202	301	303	8.03	947.5
116	201	203	301	303	7.68	993.2
123	201	203	301	303	7.34	1039.0
130	201	203	301	303	7.01	1093.0
135	201	203	301	303	6.74	1139.0
120	201	202	301	304	6.46	1192.0
113	201	204	301	303	6.16	1249.0
123	201	204	301	303	5.891	1309.0
131	201	204	301	303	5.625	1374.0

Table 4:

Existing current limiting Reactor bank (Coil-1, Coil-2, Coil-3) clamp settings for different current/impedance values

Clamp Setting					I (kA)	Z (mΩ)
Coil-1	**Coil-2**	**Coil-3**	**Coil-3**	**Coil-3**		
116	200	301	305	---	5.389	1442.0
127	200	301	305	---	5.145	1513.0
119	201	202	301	305.00	4.92	1584.0
129	201	202	301	305.00	4.72	1654.0
116	201	203	301	305.00	4.51	1732.0
128	201	203	301	305.00	4.31	1816.0
135	201	203	301	305.00	4.17	1880.0
100	201	204	301	305.00	4.00	1957.0
121	201	204	301	305.00	3.83	2050.0
105	201	202	301	306	3.67	2142.0
124	201	202	301	306	3.51	2243.0
112	201	203	301	306	3.36	2342.0
129	201	203	301	306	3.22	2453.0
135	201	203	301	306	3.15	2508.0
110	201	204	301	306	3.01	2624.0
129	201	204	301	306	2.88	2749.0
108	201	202	301	307	2.75	2880.0
130	201	202	301	307	2.63	3020.0
125	201	203	301	307	2.52	3154.0
135	201	203	301	307	2.45	3240.0
115	201	204	301	307	2.35	3389.0
135	201	204	301	307	2.25	3545.0
120	201	202	301	304	6.46	1192.0

Table 5:

Existing current limiting Reactor bank (Coil-1, Coil-2, Coil-3) clamp settings for different current/impedance values

Clamp Setting					I (kA)	Z (mΩ)
Coil-1	**Coil-2**	**Coil-2**	**Coil-3**	**Coil-3**		
114	201	202	301	308	2.1450	3711.0
113	201	203	301	308	2.0520	3883.0
135	201	203	301	308	1.9700	4046.0
120	201	204	301	308	1.8850	4225.0
110	200	301	309	---	1.8040	4427.0
124	201	203	301	309	1.7220	4635.0
128	201	203	301	309	1.6460	4845.0
114	201	204	301	309	1.5770	5066.0
135	201	204	301	309	1.5230	5231.0
113	201	202	301	310	1.4600	5476.0
123	201	203	301	310	1.3930	5720.0
114	201	204	301	310	1.3370	5981.0

Note:

Coil-1 clamp settings start from 100 to 135,
Coil-2 clamp settings start from 200 to 204 and
Coil-3 clamp settings start from 300 to 310.