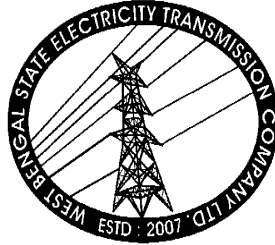


REACTOR



September 2017

Engineering Department

WEST BENGAL STATE ELECTRICITY TRANSMISSION COMPANY LIMITED

পশ্চিমবঙ্গ রাজ্য বিদ্যুৎ সংবহন কোম্পানি লিমিটেড
(পশ্চিমবঙ্গ সরকারের একটি উদ্যোগ)

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TECHNICAL SPECIFICATION FOR SHUNT REACTOR

1. **SCOPE :**

This specification covers the design, manufacturing, assembly, testing at manufacturer's works, supply and delivery at site of 3-ph., 50 MVAR & 80 MVAR, 420 KV Shunt Reactor for 400 KV bus complete with fittings and accessories for efficient and trouble free operation.

2. **DEVIATION:**

Normally the offer should be as per Technical Specification without any deviation. But any deviation felt necessary to improve performance, efficiency and utility of equipment must be stated with reasons duly supported by documentary evidence. Such deviations suggested may or may not be accepted by the WBSETCL.

3. **DUTY REQUIREMENTS:**

- a) 3-Phase Shunt Reactors will be connected to 400 KV bus for reactive power compensation and it shall be capable of controlling the dynamic over voltage occurring in the system due to load rejection.
- b) The Shunt Reactor shall be capable of withstanding maximum continuous operating voltage (5% higher than the rated voltage) under normal frequency variation of the system without exceeding the hot spot temperature of 150⁰ C at any part of the Reactor.
- c) The Shunt Reactor shall be capable of withstanding temporary over voltage and frequency fluctuation.

4. **STANDARD :**

The Reactor covered under this specification shall comply with the performance and other requirements of the latest edition of IS:5553 or relevant IEC publication 289 as amended up to date except where specified otherwise in the specification. Characteristics of oil shall be as per IS:335.

Equipment meeting the requirements of any other authoritative standards/internationally recognised standard other than those specified in the preceding clause which ensure equal or better quality than the standard mentioned above shall also be acceptable provided salient points of difference between the standard adopted and the specified standard clearly brought out in the tender and English version of the standard shall be furnished.

5. TYPE OF SHUNT REACTOR :

Reactor may be gapped core type or magnetically shielded air core type construction having fixed impedance. Either type may be acceptable depending upon the experience of the manufacturer. However, full technical particulars regarding the guaranteed performance shall be furnished.

6. DESIGN & CHARACTERISTICS :

The important characteristics of Shunt Reactors are Impedance, Thermal rating, Audio sound level and Power factor.

6.1 IMPEDANCE :

In order to avoid harmonic current generation under system over voltage conditions, the reactor shall have constant impedance up to about 1.5 times rated voltage. Furthermore, the impedance should be accurately balanced between phases of the 3-phase reactor. The insulation of core to bolts and core to clamp plates shall be able to withstand 2.0 KVrms voltage for 1 min.

6.2 THERMAL RATING :

Shunt Reactors shall be capable of operating continuously at a voltage without exceeding hot spot temperature of 150⁰C at any part of the reactor, temperature rise shall be guaranteed when shunt reactor is operating at 420 KV.

6.3 VIBRATION AND AUDIO SOUND LEVEL :

The design must ensure a minimum level of vibration and noise during continuous operation of the reactor. Care must be taken to ensure that the natural period of vibration on either the yokes or on the tank shields is such that they will not resonate when the reactor is excited at its rated frequency. The audio sound level shall not exceed the generally accepted for transformers of the same MVA and voltage rating. Shunt Reactor shall be mounted on concrete plinth foundation directly to prevent reactor movement during Earthquake. Suitable clamping arrangement is to be provided for fixing reactor to the foundation.

6.4 POWER FACTOR :

As the reactor shall be in constant operation, the total loss in the reactor shall be treated for capitalisation purpose, in the same way as the core loss of the transformer. Therefore, this loss shall be kept to a minimum.

The reactor shall be subject to switching surge over voltage upto 2.5 p.u. and temporary over voltage for few cycles of the order of 2.3 p.u. followed by power frequency over voltage upto 1.5 p.u. The reactor must withstand the stress due to above transient dynamic conditions which may cause additional current flow as a result of changed saturation characteristics/slope beyond 1.5 p.u.

7. CONSTRUCTION DETAILS :

The shunt reactor shall be designed to facilitate inspection, cleaning and repairs. All parts shall be designed to ensure satisfactory operation under such variation of load and voltage as may be met with under working condition on the system including those due to short circuits.

All material used shall be of best quality and of the class most suitable for working under the condition specified in the general technical specification and shall withstand the variation of temperature and atmospheric conditions without affecting the strength and suitability of various parts to perform work for which they have been designed.

All outdoor apparatus including the bushing insulators with their mountings shall be designed so as to avoid pockets in which water can accumulate. All connections and contacts shall be of sufficient cross sections and surfaces for carrying continuously specified current without undue heating and fixed connections shall be secured by bolts or set screws of appropriate size adequately locked.

7.1 TANK :

- a) Shunt reactor tank and cover shall be fabricated from good commercial grade low carbon steel suitable for welding and of adequate thickness.
- b) The tank and the cover shall be of welded/bolted construction and bell/shell type. All seams shall be welded and where practicable they shall be double welded. The tank shall be reinforced by stiffener of structural steel for general rigidity. The tank shall have sufficient strength to withstand without permanent distortion.
 - i) Short circuit stresses and
 - ii) Mechanical shock during transportation.
- c) Design of the tanks, the lifting lugs and bosses shall be such that the complete shunt reactor assembly filled with oil can be lifted with the use of these lugs without any damage or distortion.
- d) Manhole with a welded flange and bolted cover shall be provided on the tank cover. The manhole shall be of sufficient size to afford easy access to the lower end of the bushings, terminals etc.
- e) All bolted connection to the tank shall be fitted with suitable oil tight gasket which shall give satisfactory services under the operating condition. Where compressible gaskets are used steps shall be provided to prevent over compression. Bushings, turrets, cover of accessories, holes and other devices shall be designed to prevent any leakage of water or oil into or from the tank.
- f) Lifting eyes or lugs shall be provided on all parts of the shunt reactor requiring independent handling during assembly and dismantling. Adequate space shall be provided between the cores and the windings and the bottom of the tank for collection of any sediment. A step ladder shall be provided to Shunt Reactor.
- g) If bell type tank is offered, suitable projecting guides shall be promoted on core assembly to facilitate removal of tank. Design shall be such that Tank Cover can be lifted independently without lifting active part of core, Winding etc.

7.2 VALVES :

- i) Oil valves between cooler and main tank.
- ii) Drain valves with pad locking arrangement.
- iii) Two filter valves on diagonally opposite ends of main tank one on the top and other at the bottom with padlocking arrangement on bottom valves.
- iv) The sampling valves at the top and the bottom of the main tank.
- v) One relief valve to operate at a pressure below the test pressure of the tank.
The opening of the valve shall be suitably baffled to prevent aeration of the oil.

7.3 UNDER CARRIAGE :

Shunt reactor tank shall be supported on a structural steel base equipped with forged steel or cast steel single flanged wheels suitable for removing the reactor completely filled with oil. Jacking pads shall be provided. It shall be possible to change the direction of the wheels through 90° when the reactor is lifted on jacks to permit movement of the reactor both in longitudinal and transverse direction. A standard track broad gauge (1676mm) in both longitudinal and transverse direction shall be chosen.

Pulling eyes shall be provided to facilitate horizontal movement of the reactor and there shall be suitably braced in a vertical direction so that bending does not occur for any vertical component of pull.

Suitable jacks for lifting the reactor while changing the plane of rotation of the wheels shall be provided by the supplier.

7.4 SHIELDING:

Adequate method of shielding shall be adopted depending upon the design of the windings of the Reactor. The lone reactor shall be provided with horizontal flank shields or yokes in addition to vertical or tank shields made from magnetically permeable materials.

The equilateral coil reactor shall be provided with magnetically permeable tank shields. The top and bottom of the tank shall be screened from coil flux by plates of high conductivity.

Manufacturers adopting the different types of shielding shall furnish the full particulars of the method applied.

7.5 WINDING :

The disposition of windings may be in line or equilateral coil formation. Class A insulation as specified in IS: 1271 shall be used. The windings shall be designed to withstand without damage the electromagnetic forces due to the specified short circuit current and also the thermal effects arising therefrom. The maximum current density under the specified over current condition shall not exceed the appropriate value as specified in the relevant standard.

The insulation of the coils shall be such as to withstand the full electrical strength of the windings and shall be insoluble, non-catalytic and chemically inactive in the hot insulating oil and shall not soften or otherwise be adversely affected under the operating conditions. The coils shall be supported between adjacent sections by insulating spacers and the barriers, bracing and other insulation used in the assembly of the windings shall be arranged to ensure a

free circulation of the oil and to reduce the hot spots in the windings. The neutral point of the windings shall be solidly earthed.

The windings shall be clamped securely in place so that they will not be displaced or deformed during short circuits. The copper conductors used in the coil structures shall be best suited to the requirements and all permanent current carrying joints in the windings and the leads shall be welded or braced. All threaded connections shall be provided with locking facilities. All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration. Guide tubes shall be used where practicable.

7.6 INSULATING OIL :

The insulating oil shall have the following main characteristics or equivalent and shall apply in all respects with the provision of the latest edition of IS 335 as amended upto date. Oil for 100% filling together with 10% extra shall be supplied with the shunt reactor.

After processing of oil through filtration at site and before commissioning the breakdown voltage and moisture content shall be 60KV(r.m.s) and 15 ppm respectively.

7.7 CONSERVATOR AND DEHYDRATING FILTER BREATHER :

Diaphragm type oil sealing shall be provided to prevent oxidization and contamination of oil due to contact with air/moisture. If conservator or expansion tank is offered the conservator or expansion tank shall have two filter valves one at the bottom of one end and other at the top of opposite end. This will be in addition to the valve specified in the accessories for the main tank. The conservator or expansion tank shall also have shut-off valve and a sump with a small drain valve and the sampling cock, the latter be so arranged as not to interfere with oil line. Magnetic oil level gauge shall be mounted on the conservator or expansion tank. The conservator shall be filled in such a position so that it can be removed for maintenance purpose. Suitable provision shall be kept to replace air cell if necessary.

The flexible air cell of nitrile rubber reinforced with nylon cloth air cell shall be used in the conservator to avoid contact of oil with atmosphere. The temperature of oil is likely to rise upto 100°C during operating condition and in case of emergency situation, hence air cell used shall be suitable for operating continuously at 100°C. The connection of air cell to the top of conservator is to be made by air proof seal to prevent entrance of air into the conservator.

Conservator shall be fitted with dehydrating filter breather. Two breathers of identical size in series shall also be provided to allow breathing of the reactor due to variation of the temperature and shall be connected above diaphragm type sealing. The breather shall be accessible for inspection from bottom and as such shall be connected through connecting pipe.

Passage of air is through a dust filter and silicagel. Silicagel is isolated from atmosphere by an oil seal. Breathers to be mounted not more than 1200 mm. above ground level.

7.8 BUSHING :

The bushing shall have high factor of safety against leakage to ground and shall be so located so as to provide adequate electrical clearance between bushing and grounded parts. Bushings of identical voltage rating shall be interchangeable. All bushings shall be equipped with suitable

terminals of approved type and size and shall be suitable for bi-metallic connection. Insulation class of the neutral bushing shall be properly co-ordinated with the insulation class of the neutral of the windings.

All main windings and neutral leads shall be brought out through outdoor type bushings. Each bushing shall be so co-ordinated with the reactor insulation that all flashover will occur outside the tank.

All porcelain used in bushings shall be homogeneous and free from cavities and other flaws. The glazing shall be uniform in colour and free from blisters, burrs and other defects.

Bushings for 400 KV & 145 KV shall be of oil filled condenser type (hermetically sealed) and draw lead type and shall conform to the latest edition of IS-2099 or IEC (publication No.137). The characteristics of the oil used in the bushings shall be the same as that of the oil used in the shunt reactor. All bushings shall have puncture strength greater than the dry flash over value. The spacing between the bushings must be adequate to prevent flash over between phases under all conditions of operation.

The neutral point bushing shall be of 145 KV class and shall be oil filled condenser type and shall be solidly earthed. The neutral terminal of Bus Reactor shall be brought to the ground level by a brass/tinned copper grounding bar of adequate size, supported from the tank by using porcelain insulators. The end of this grounding bar shall be brought to the bottom of tank at a convenient point for making connection to GS flats riser, connected to grounding mat.

BUSHING CURRENT TRANSFORMER :

- i) Current Transformer shall comply with IS:2705/IEC 185.
- ii) It shall be possible to remove the turret mounted current transformer from the reactor tank without removing tank cover. Precaution shall be made to minimize eddy currents and local heat generated in the turret.
- iii) Secondary leads of C.T. shall be brought out to a weatherproof terminal box near each bushing. These terminals shall be wired out to Cooler Control Cabinet/Marshalling box using separate cable for each core.
- iv) For Bushing CT particular, refer foregoing clauses of this specification & S.T.P.
- v) The contractor shall obtain Employers' approval before proceeding with the design of bushing current transformers.

7.9 COOLING SYSTEM AND RADIATOR DETAILS:

The reactor shall be provided with heat exchanger or radiator capable of meeting the cooling required under oil natural and air natural cooling conditions. There shall be one 100% radiator bank.

Shunt reactor shall be provided with detachable radiators comprising of a series of separate circular or elliptical tubes or pressed steel plates assembly formed into elliptical oil channels, welded at the top and the bottom into headers to be connected to the tank by means of bolted oil tight flanged joints.

The radiator shall be so designed as to be accessible for cleaning and painting and to avoid pockets in which moisture may collect and ensure against formation of gas when the tank is being filled. Radiator tube shall be seamless made of mild steel CRCA having minimum wall thickness of 1.2 mm and a clean bright internal surface free from rust and scale.

7.10 CENTER OF GRAVITY :

The center of gravity of the reactor shall be low and as near the vertical center line as possible. The reactor shall be stable with or without oil.

7.11 TERMINAL AND TERMINAL MARKINGS :

The bushings shall be suitable for connection with ACSR twin moose conductor. Each terminal including neutral shall be distinctly marked in accordance with the diagram of connection supplied with the reactor.

8. EVALUATION OF LOSSES :

8.1 REACTOR LOSS :

The tenderer shall state the guaranteed total reactor losses in kilowatts at the rated voltage and rated frequency.

Capitalized value of No Load loss per kw: Rs. 4,95,943/-. No tolerance for this loss, other than specified in relevant clause of I.S.S., will be accepted.

8.2 If any or all actual losses after tests are found to exceed the guaranteed values beyond tolerance limits as prescribed in I.S.S., and it is decided by the purchaser to accept the said reactor, the penalty will be imposed for excess loss over the corresponding guaranteed loss at the rate specified in the foregoing clause. For a fraction of KW, the penalties shall be applied pro-rata. If the test figures of loss are less than guaranteed values no bonus will be allowed.

8.3 In case of Shunt Reactor, the guaranteed loss at rated voltage for each reactor shall be corrected in accordance with IEC 60289 by multiplication with square of the ratio between measured current (at rated voltage) and rated current for the purpose of comparison of guaranteed losses with measured losses for levy of liquidated damages.

However, the reactor under no circumstances shall be accepted if the measured losses are more than +15% of the guaranteed losses at the rated voltage quoted by the bidder.

9. CLEANING AND PAINTING :

9.1 Before painting or filling with oil or compound all non-galvanised parts shall be completely clean and free from rust, scale and grease and external rough surfaces on castings shall be filled by metal deposition. The interior of all reactor tanks and other oil filled chambers and internal structural steel work shall be cleaned of all scale and rust by sand blasting or other approved method. These surfaces shall be painted with an oil resisting varnish or paint. Unexposed welds need not be painted.

9.2 Except for nuts, bolts and washers, which may have to be removed for maintenance purpose, all external surfaces shall receive a minimum of three coats of paint. The primary coat shall be applied immediately after cleaning. The second coat will be of oil paint, of weather resisting

nature and of a shade or colour easily distinguishable from the primary. The final coat shall be of a glossy oil and weather resisting non-fading paint.

- 9.3** All interior surfaces of mechanism chambers and kiosks except those which have received anti-corrosion treatment shall receive three coats of paints applied to the thoroughly cleaned metal surfaces. The final coat shall be light coloured anticorrosion mixture. Any damage to paint work incurred during transport and erection should be made up by applying the full number of coats of paint that had been applied before damage was caused.
- 9.4** The minimum thickness of outside painting of tank shall be 20 micron per coat and the total thickness shall be within 70 to 100 micron.

10. ACCESSORIES :

Each reactor shall be provided with, but not necessarily be limited to the following accessories and only type tested accessories shall be supplied. All accessories mounted outdoor shall have contact housing tested with IP.55 test as per IS:13947(Part-I) in order to avoid maloperation during rain or condensation.

- i) Dial thermometer with repeater and sensing element for winding temperature with alarm contacts and trip contacts. Temperature indicator dial shall have linear graduations to closely record at least every 2°C. Accuracy Class of WTI shall be $\pm 1.5\%$ or better.
- ii) Bushing CTs shall be provided as follows :

- a) For HV side

CT ratio shall be 200/1 A. for each core.

Three (3) cores shall be of PS class for protection and one (1) core shall be of class-I, 10 VA burden for metering.

- b) For neutral side

Two (2) cores shall be of PS class having ratio 2000-1000/1 A. for protection.

One (1) core shall be of PS class having ratio 200/1 A. for protection and

One (1) core on any one phase only of metering class of burden 10 VA for winding temperature indication from local end as well as remote panel.

However, for details of core particulars of HV side CT & NCT, please follow Table attached in CT Specification. Neutral side C.T secondary terminations of all phases shall be brought out separately in the C.T. terminal box.

- iii) Dial thermometer with repeater and sensing element for oil temperature with alarm contacts and trip contacts. Temperature indicator dial shall have accuracy of $\pm 1.5\%$ or better. One oil temperature indicator as repeater shall be provided in the control panel of the reactor.
- iv) Additional pocket for inserting mercury type thermometer for oil temperature indication.
- v) One magnetic type oil level indicator readable from ground level with low oil level alarm contact.
- vi) Isolating valve for conservator in between conservator and Buchholz relay as well as between Buchholz relay and main tank.
- vii) Conservator oil filling valves.
- viii) Conservator drain valve.

- ix) Silicagel breather with oil seal and connecting pipe. Breather shall be accessible for inspection from ground.
- x) Oil sampling device/valve (Top and bottom).
- xi) Oil filter valve suitably located at the top and near the bottom of the tank.
- xii) Adequate nos. of pressure relief device with sufficient size shall be provided at suitable location for rapid release of any pressure that may be generated in the tank. Two sets of electrically insulated NO/NC contacts shall be provided for alarm/tripping.
- xiii) Cover lifting eyes.
- xiv) Lifting eyes for coil assembly.
- xv) Air release plugs on top of cover and bushing tarret.
- xvi) Lifting lugs for whole reactor.
- xvii) Jacking pads with holes at 4 corners for haulage.
- xviii) Transport lugs
- xix) Under carriage with bi-directional flanged wheels, suitable for 1676-mm rail gauge.
- xx) Tank earthing terminals – at least 2 nos. suitable for carrying full short circuit current of reactor for 2 seconds.
- xxi) One double float gas detector relay (Buchholz relay) with alarm and trip contacts to detect accumulation of gas and sudden changes of oil pressure complete with two shut up valves and flange couplings with a bleed valve for gas venting and a test valve.
- xxii) Heat exchanger or radiators complete with all fittings and accessories
- xxiii) Drain valve for main tank.
- xxiv) Rating and diagram plates as per IS-2026.
- xxv) Weather proof outdoor control cabinet for marshalling terminal connections from protective and indicating devices. That cabinet shall be provided with door operated light, power and lighting plugs, heaters etc. All control wiring from protective and indicative devices shall be wired upto terminal blocks inside the marshalling box.
- xxvi) Oil filling plate with instruction.

11. CONTRACT DRAWING, CATALOGUE AND MANUALS :

In the event of placement of Letter of Award (LOA) the contractor shall submit the following drawings in six (6) copies for approval:

- i) General outline drawing showing disposition of all fittings and accessories with dimensions, elevation and side view.
- ii) Sectional view showing general constructional features and disposition of different fittings.
- iii) General arrangement and sectional drawing of bushing with dimensions.
- iv) Catalogue and drawing of brought-out items.
- v) Name Plate particulars.
- vi) Any other drawings of documents required during detail engineering.

Four (4) sets of approved drawings, and erection, operation & maintenance manual both in soft and hard format shall be submitted for our record and distribution to site.

12. TEST AT MANUFACTURER'S WORKS AND TEST REPORTS :

The following routine tests specified in IS: 5553 & IEC: 289 shall be carried out at manufacturer's works in presence of the representative of WBSETCL.

- (i) Measurement of winding resistance.
- (ii) Measurement of insulation resistance.
- (iii) Measurement of reactance.
- (iv) Measurement of loss.
- (v) Separate source voltage withstand test.
- (vi) Induced Over-Voltage withstand test.
- (vii) Measurement of voltage ratio and shunt circuit impedance on shunt reactor with additional loading.
- (viii) Frequency Response Analysis (FRA) in factory and field (sub-station).

The contractor shall give notice of fifteen (15) days in advance of date when the tests will be carried out. Three (3) copies of routine test results shall be submitted to the CE (Tr. Project) for approval. Measurement of loss test for reactor is to be done. The entire cost of routine tests that are to be carried out as per relevant IS & IEC shall be treated as included in the quoted price of Reactor.

In addition to above, following tests shall be performed on finished and empty reactor tank at Reactor manufacturers works as well as tank manufacturer's works in presence of representative of WBSETCL at free of cost.

- (i) Vacuum withstand strength of tank shall be tested at a maximum internal pressure of 3.33 KN/M² for one hour. The permanent deflection shall not exceed the value specified in CBIP manual.
- (ii) Pressure Test : Pressure test shall be subjected to a pressure corresponding to twice the normal head of oil or to the normal pressure plus 35KN.M² whichever is lower measured at the base of the tank and will be maintained for one hour on empty tank.. The permanent deflection of flat plates after the excess pressure released shall not exceed the values specified in CBIP manual.

PRESSURE TEST ON ASSEMBLED REACTOR :

The reactor tank along with all oil filled compartments (Oil leakage test) shall be tested for 12 hrs. for oil leakage with a pressure corresponding to twice the normal head of oil in the reactor tank or normal static pressure of oil at the tank base plus 35 KN/m² (0.35 kg/cm²) whichever is lower for 12 hours.. The permanent deflection of plates, flats etc. after release of excess pressure shall not exceed the figures specified below..

Horizontal length of Plates / flats (mm) Upto and including	Permanent deflection (mm)
750	5
751 - 1250	6.5
1251 - 1750	8
1751 - 2000	9.5
2001 - 2250	11
2251 - 2500	12.5

2501 – 3000	16
Above 3000	19

The pressure relief device shall be subjected to operation test at a pressure just below the specified pressure as mentioned under pressure test above.

13. TEST REPORTS AND TYPE TESTS :

Only type tested Reactor from the maker's list of WBSETCL are to be offered conforming to our technical specification, relevant IS and IEC. Reactor offered should be identical with ones on which type testing has been carried out as per relevant IS & IEC. Three sets of complete type test reports carried out in Govt. recognized Test House or Laboratory/NABL accredited Laboratory shall have to be submitted. Successful bidder may require to produce original copies of type test report at the time of detail Engineering if asked by WBSETCL. Each type test report shall comply the following information with test result.

- i) Complete identification, date and serial no.
- ii) Relevant drawings as documented with test report.
- iii) Method of application, where applied, duration and interpretation of each test.
- iv) If mentioned in the schedule, the bidder shall quote price for carrying out type test on 400KV Reactor so that the same can be carried out as per option of WBSETCL. This price shall be considered for the purpose of evaluation of bids.

14. GUARANTEE :

Electrical characteristics shall be guaranteed by the bidder. In case of failure of materials to meet the guarantee, WBSETCL shall have right to reject the material. Guaranteed Technical particulars are to be submitted by successful bidder during detail engineering along with submitted drawings/documents. However, format for submission of GTP shall be handed over to intending bidders at the time of sale of tender documents.

15. TRANSPORTATION :

The equipment to be furnished under this specification shall be suitably packed for the shipment in such a manner as may facilitate easy handling and avoiding any damage during transit. Maximum weight and size of a single package should be such that the same can be transported in the easily available standard wagons or can be transported by road.

The Contractor shall despatch the reactor filled with oil or in an atmosphere of nitrogen or dry air at positive pressure.

In the former case, the contractor shall take care of the weight limitation on transport and handling facility at site.

In the latter case, necessary arrangement shall be ensured by the contractor to take care of pressure drop of nitrogen or dry air during transit and storage till completion of oil filling during erection. The nitrogen or dry air cylinder provided to maintain positive pressure can be taken back by the contractor after oil filling. A gas pressure testing valve with necessary pressure gauge and adaptor valve shall be provided.

Reactor shall also be fitted with at least one Electronic impact recorders (on returnable basis) during transportation to measure the movement due to impact in all three directions. The acceptance criteria and limits of impact in all three directions which can be withstood by the equipment during transportation and handling shall be submitted by the contractor during detailed engineering. The recording shall commence in the factory before despatch and must continue till the unit is installed on its foundation. The data of electronic impact recorder(s) shall be down loaded at site and a soft copy of it shall be handed over to Engineer-in-charge. Further, within three weeks the contractor shall communicate the interpretation of the data.

In case reactor is transported, nitrogen or dry air filled, the insulating oil for reactors shall be delivered at site not before 90 days from the date of commissioning, which will be informed by the owner

16. SPARES :

The bidder shall quote item wise price of spares as per price schedule.

**SPECIFIC TECHNICAL PARAMETERS
(STP)**

SL. NO.	DESCRIPTION	TECHNICAL PARAMETERS	
1.	Rated Voltage	:	420 KV
2.	Rated frequency	:	50 Hz.
3.	Number of phase	:	3 (Three)
4.	Indoor or outdoor	:	Outdoor
5.	Neutral earthing	:	Solidly earthed
6.	Rating (3 phase)	:	80 MVAR
7.	Winding connection	:	Star with neutral brought out.
8.	Insulation	:	Graded
9.	Tapping	:	Nil
10.	Short circuit current available at terminal	:	50 KA
11.	Duration of short circuit without Exceeding temperature of 250 ⁰ C	:	2 seconds
12.	Linearity of voltage	:	Upto voltage of 1.5 p.u. on 420 KV base
13.	Harmonic content in phase current	:	The crest value of the third harmonic component in phase current shall not exceed 3% of the crest value of fundamental when reactor is energized at rated voltage with sinusoidal wave form.
14.	Permissible current unbalance Among different phases (%)	:	+ 2 %
15.	% Tolerance on impedance (declared)	:	+ / - 5
16.	Ratio of zero sequence reactance to positive sequence reactance (X_0/X_1)	:	0.9 to 1.0
17.	Total loss at rated voltage and frequency as a percentage of rated MVAR (%)	:	0.5
18.	Minimum Clearance in air	:	<u>420KV</u> <u>145KV</u>
		Ph-Ph	4000 mm 1430mm
		Ph-E	3500 mm 1270 mm

19. Noise level at rated voltage & frequency		
i) 80 MVAR	:	81 db
20. Terminals :		
a) Line Terminal with test taps	:	420 KV oil filled Condenser Bushing
b) Neutral Terminal with test taps	:	145 KV oil filled condenser bushing
21. Creepage distance	:	10500 mm.
22. Type of cooling medium	:	Transformer oil as per specification
23. Temperature rise at highest system voltage		
a) Temperature rise of winding measured by resistance over an ambient temperature of 50 ⁰ C	:	55 ⁰ C
b) Temperature rise of top oil measured by Thermometer over an ambient temperature of 50 ⁰ C	:	50 ⁰ C
24. Type of cooling	:	ONAN
25. No. of cooler bank	:	1 with 100% of cooling required
26. Insulation level (for winding)		
i) 1.2/50 micro second rated lightning impulse withstand voltage	:	1300 KVp
ii) 250/2500 micro second switching impulse withstand voltage	:	1050 KVp
iii) Power frequency withstand voltage – 1 minute (for designing Shunt Reactor)	:	630 KV (rms)
27. Insulation level of neutral :		
i) Impulse withstand level	:	550 KVp
ii) One minute power frequency voltage withstand level	:	230 KV (rms)
iii) Whether neutral is to be brought out	:	Yes (through 145KV class oil filled condenser bushings)
28. Bushing	:	Line Side Neutral Side

a) Rated voltage	:	420 KV	145 KV
b) Creepage distance	:	10500 mm.	3625 mm.
c) 1.2/50 microsecond LI withstand level	:	1425 KVp	650 KVp
d) 250/2500 microsecond SI withstand level	:	1050 KVp	--
e) Mounting	:	Tank cover	Tank cover
f) One minute power frequency withstand voltage	:	630 KV (rms)	275 KV (rms)
g) Rated current	:	800 A	800 A
29. Vibration of stress level at rated voltage frequency	:	Not more than 200 micron peak to peak Average vibration shall not exceed 60 micron peak to peak.	
		Tank stresses shall not exceed 2.0 Kg./Sq.mm. at any point on the tank.	
30. Width of rail gauge (mm)	:	1676	
31. Range of constant impedance	:	Up to 1.5 P.U voltage (The bidder shall furnish complete saturation characteristics of the Reactors up to 2.5 P.U Voltage.)	
32. Maximum partial discharge (PD) level at 1.5 P.U	:	100 Pico-Columbs	
33. Tolerance Current	:	0 to + 5%.	

**GUARANTEED TECHNICAL PARTICULARS FOR
420KV SHUNT REACTOR**
(To be filled in and signed by the Bidder)

Sl.No. Particulars

1. Name of Manufacturer & Address :
2. Type & Designation :
3. Conforming Standard :
4. Class (Outdoor) :
5. Rated voltage (KV) & Capacity :
6. Rated frequency (Hz) :
7. Rated power
 - a) At 100% rated voltage :
 - b) At 105% and 110% rated voltage :
8. Rated current per phase (Amps)
 - a) At 100% rated voltage :
 - b) At 105% and 110% rated voltage :
9. Inductance per phase (Henry)
 - a) At 100% rated voltage :
 - b) At 105% and 110% rated voltage :
10. Type of core :
11. Maximum current density in copper conductor (Amps/Cm²) :
12.
 - a) Temperature rise (by resistance) of winding (° C) :
 - b) Temperature rise in oil (by the thermometer) (° C) :
 - c) Hot spot temperature over 50° C ambient temperature (° C) :
13. Limit of Hot Spot temperature for which the shunt reactor is designed :
14. Total loss at rated voltage and frequency at 75° C temperature (KW) :

15. Auxiliary losses at rated output (KW) :
16. Type of winding :
17. Insulation of winding :
18. Whether shielding between tank and winding is provided :
19. If so, nature of shielding and if not reasons :
20. Thickness of tank"splates (mm)
 - i) Sides :
 - ii) Bottom :
 - iii) Cover :
 - iv) Conservator tanks :
21. Test voltages of winding
 - A. Power frequency High Voltage Test
 - Test voltage for 1 minute withstand test (KVrms) :
 - B. Impulse test
 - i) Test voltage for 1.2/50 micro sec. full wave lightning impulse withstand test (KVp) :
 - ii) Test voltage for 250 / 2500 micro sec. full wave switching impulse withstand test (KVp) :
22. Inter turn insulation
 - i) Extent of end turns reinforcement :
 - ii) Induced over voltage test at 100 Cycles for 1 minute for inter turn Insulation test (KVrms) :
 - iii) The turn voltage during induced over voltage test (times the rated turn voltage) :
 - iv) Partial Discharge Level (pc) :

23. a) Guaranteed total loss at rated frequency and at 75° C winding temperature (KW)
i) At 100% rated voltage :
ii) At 105% and 110% rated voltage :
- b) Tolerance to above :
24. Vibration of stress level at rated voltage & Frequency (micron) :
25. Acoustic Noise level (db) :
26. Types of winding temperature indicator :
27. Bushing particulars : Line side
----- Neutral side

- i) Type of bushing :
- ii) Creepage distance (Total in mm) :
- iii) Weight of bushing (Kg) :
- iv) Quantity of oil in one bushing insulator in litres :
- v) One minute power frequency voltage withstand test
a) Dry :
b) Wet :
- vi) Impulse withstand test voltage value with 1.2 / 50 micro second full wave of bushing (KVp) :
- vii) 250 / 2500 micro-second switching Impulse withstand test voltage for 400 KV only (KVp) :
- viii) Clearance (mm) :
a) Minimum clearance between phases :
i) In oil :
ii) In air :
b) Minimum clearance between terminal to earth :
28. Weight of coil assembly (kg) :
29. Weight of tank and cover (kg) :

30. Weight of oil in shunt reactor inclusive of that in bushings conservator and cooling system (kg) :
31. Weight of complete shunt reactor with all fittings and oil (kg) :
32. Dimensions of shunt reactor :
- i) Maximum height to top of bushing from ground (mm) :
 - ii) Overall length (mm) :
 - iii) Overall width (mm) :
33. Minimum clear height for lifting coil assembly from tank (mm) :
34. Have you furnished complete GTP and floppy containing all technical information?