



September 2015

**SPECIFICATION SS-52/15**  
**8 MVAR – 25 MVAR, 157.5kV SHUNT REACTORS**

**I. SCOPE**

This Specification covers the design, manufacturing, testing at the manufacturer's premises and supplying of three-phase, outdoor 157,5kV shunt compensating reactors.

**II. STANDARDS**

Unless otherwise specified herein, all material, equipment, workmanship, design, inspection and testing of the subject reactors shall confirm to the latest applicable standards IEC 60076-6, 60076-3, 60076-4.

**III. SYSTEM CHARACTERISTICS**

- |    |                            |   |  |
|----|----------------------------|---|--|
| 1. | Maximum system voltage     | : | 170kV                                      |
| 2. | Rated frequency            | : | 50Hz                                       |
| 3. | System short circuit level | : | 31.5kA at 170kV                            |
| 4. | Other characteristics      | : | 3-phase, 3-wire, solidly grounded neutral. |

**IV. SERVICE CONDITIONS**

Unless otherwise stipulated in this Specification the subject shunt compensating reactors shall be suitable for outdoor installation, at an altitude less than 1000m above sea level and for an ambient temperature ranging between -25°C and +40°C and shall operate satisfactorily under snow and ice conditions.

**V. REQUIREMENTS FOR THE REACTOR**

**1. Basic Rated Quantities**

- |    |                                    |   |         |
|----|------------------------------------|---|---------|
| a. | Highest voltage for equipment (Um) | : | 170kV   |
| b. | Rated voltage (Ur)                 | : | 157.5kV |
| c. | Rated power                        | : |         |

(shall be stated in the inquiry)

- d. Rated frequency : 50Hz
- e. Maximum operating voltage (U<sub>max</sub>) : 105% of rated
- f. Rated insulation levels for windings:

	Line-end	Neutral-end
Lightning impulse withstand voltage 1.2/50µs wave, kV crest	750	125
Power frequency withstand voltage, kV r.m.s.	325	50

## 2. Type of Construction

1. The reactor tank shall be of cover bolted type.
2. The reactor coils shall be of the three-phase, oil-immersed, naturally cooled type, with copper windings and shall be suitable for outdoor installation.
3. The core shall be of the gapped iron type with five (5) limbs, including side limbs. The overall design shall be such as to provide effective magnetic shielding.  
In general, the design and construction of the reactors shall be such as to avoid detrimental effects due to vibration.
4. The magnetic core of the reactor will be earthed at only one point. The core earthing will be realized through an insulated conductor, connecting the core to an earthing box, placed externally on the reactor tank. By this way the core earthing could be tested without opening the reactor tank.
5. The reactor oil shall be mineral oil in accordance with standard IEC 60296, transformer class. Also it shall not contain any toxic substances such as PCBs or PCTs and be biodegradable.
6. The reactor shall be designed and manufactured in order to withstand a constant acceleration of at least 1g in all directions, additionally to gravity, without any damage.

## 3. Temperature Rise Limits

The following temperature rise limits for continuous operation concerning the winding shall be observed:

- Average temperature rise of winding, measured by resistance : 65 K
- Hot-spot winding temperature : 78 K
- Top oil measurement by thermometer (closed-type shunt reactors or reactors equipped with expansion tank) : 60 K
- Reference ambient temperature : 40°C

4. **Zero-Sequence Reactance**

The ratio of the zero-sequence to the positive-sequence reactance ( $X_0/X_1$ ) of the subject three-phase reactor units shall lie between 0.95 and 1.0.

5. **Connection of Windings**

The reactor shall constitute a three-phase unit, star-connected, with its neutral connected directly to ground.

6. **System Switching Over-Voltages**

The subject reactors may be connected at the end of long submarine cable lines for the purpose of compensating their reactive power requirements. In this case the reactors may be subjected to switching over-voltages of a maximum amplitude of 3 p.u. ( $1 \text{ p.u.} = 170/\sqrt{3}$ ).

7. **Harmonics**

The maximum allowable crest value of the third harmonic component of the reactor current shall be 3% of the crest value of the fundamental, when the reactor is energized at rated voltage with a sinusoidal wave form.

8. **Saturation**

The reactors must be designed in such a way so as to exhibit linear magnetization characteristics for voltages of at least equal to 1.2 times their rated voltage.

9. **Voltage Variation**

The reactors shall be designed to operate at 105% of the rated voltage continuously, without exceeding the specified temperature rise limits.

10. **Audible Sound Level**

The audible sound level of the reactors shall not surpass 72db(A). The reactors shall be designed with a natural frequency greater than 350Hz.

## VI. ACCESSORIES

### 1. Bushings

The design of bushings will be in accordance with the IEC 60137 Standard.

The line bushings will be of outdoor – immersed capacitance graded oil insulated type with one end exposed in ambient air and the other end immersed in the reactor oil. The active part of the bushing will consist of an Oil Impregnated Paper (O.I.P.) condenser type core, impregnated with oil.

The insulation housing of line bushings will be of high grade porcelain or of resin impregnated fibre tube and silicon rubber covering.

The porcelain housing will comply in all relevant respects with IEC 62155. The composite housing will comply in all relevant respects with IEC 61462. The space between the active part (core) and the insulating envelope will be oil filled (liquid-insulated bushings).

The neutral bushing will be of the solid type, either of high grade porcelain or of resin and silicon rubber covering.

The bushings are required to be of the following rating characteristics:

		<b>H.V.</b>	<b>Neutral</b>
<b>1</b>	Highest rated Voltage (phase to phase) (Um) (KV-r.m.s.)	170	24
<b>2</b>	Rated phase to earth operating voltage (KV-r.m.s.)	98	$24/\sqrt{3}$
<b>3</b>	Rated current (Ir*)(A)	800	630
<b>4</b>	Rated thermal short time current, 1 sec (Ith)	25Ir	25Ir
<b>5</b>	Rated dynamic current (Id)	2.5Ith	2.5Ith
<b>6</b>	Cantilever operating load (N)	2000	625
<b>7</b>	Creepage distance (mm)	4250	600
<b>8</b>	Angle of mounting	$\leq 30^\circ$ /vertical	$\leq 30^\circ$ /vertical
<b>9</b>	Temperature limits – class of the insulating material in contact with metal parts	105°C Class A	105°C Class A
<b>10</b>	Dielectric dissipation factor (tanδ) at $1,05U_m/\sqrt{3}$ voltage	$\leq 0.007$	-
<b>11</b>	Maximum value of partial discharge quantity at Um operating voltage	$\leq 10\text{pC}$	-
<b>12</b>	Lightning impulse withstand voltage (KV)	750	125
<b>13</b>	Power frequency withstand voltage - dry (KV)	355	55

## 1.1 **Additional characteristics of bushings**

### a. Seismic withstand capabilities.

All bushings shall be capable of withstand the following seismic stresses as per IEC-61463 and IEC-60068-3-3.

1. Horizontally (axes x and y) :0.5g ( $5\text{m/s}^2$ )
2. Vertically (axe Z) :0.25g ( $2,5\text{m/s}^2$ )
3. The frequency range should be 1Hz to 35Hz.
4. Acceptable methods of seismic qualification are:
  - Qualification by vibration test or
  - Qualification by static calculation or
  - Qualification by dynamic analysis

Bidders are obliged to submit in their offers, test reports or calculation by dynamic analysis, or static calculation.

Approval or not of all the above lies on IPTO's judgment.

- b. Bushings shall be designed for operation at ambient temperature from  $-25\text{ }^{\circ}\text{C}$  to  $+45\text{ }^{\circ}\text{C}$  and an altitude not exceeding 1000m.
- c. The maximum oil temperature under operating emergency conditions will be  $115\text{ }^{\circ}\text{C}$ .
- d. The bushings shall have a tin plated copper terminal of cylindrical shape with diameter of 30mm and length of about 100mm.
- e. If the line bushings are of a drawn lead or drawn rod type, the cross-section of the lead or rod will be selected according to the instructions of the bushing manufacturer, in order the complete bushings to have a continuous current rating of at least 125% of the rated reactor current.
- f. If after taking into consideration the above stated operating characteristics, the above indicated bushings rating current is less than what it should, then bidders must offer bushings with suitable rating.

## 1.2 **Accessories:**

Line bushings will be equipped with the accessories below:

- a. Oil level indicator.
- b. Test socket ( $\tan\delta$  tap) suitable for measurement of the dielectric dissipation factor, capacitance and partial discharge value of the bushing. The test tap will be electrically isolated from the mounting flange and will be always earthed directly when it is not used.
- c. Air release plug.
- d. Oil expansion compensator.

- e. Oil sampling and oil filling plugs.
- f. Lifting lugs if required by the manufacturer and there are no other means of lifting the bushings.
- g. Line-end bushings shall be equipped with spill gaps adjustable from 25" to 40" and having a 26" factory setting.

### 1.3 **Rating plates – markings**

The line bushings shall carry a rating plate including the following markings.

- Manufacture's name.
- Year of manufacture and serial number
- Maximum operating phase – phase voltage (Um) or rated operating phase to earth voltage and rated frequency.
- Operating rated current (Ir)
- Insulation levels BIL, P.F.
- Bushings capacitance, dielectric dissipation factor.
  
- Mass
- Angle of mounting

### 1.4 **Tests**

The reactor manufacturer is obliged to present to the IPTO inspector bushings test reports while the inspector is at the manufacturer's premises for the reactor inspection and testing.

The test reports which are to be presented shall include the following type, routine and special tests:

*The tests will be in accordance with IEC – 60137 Standard*

#### **A. Type tests**

1. Power – frequency voltage withstand test
2. Lightning impulse voltage withstand test
3. Electromagnetic compatibility test
4. Temperature rise test
5. Verification of thermal short – time current withstand
6. Cantilever load withstand test
7. Tightness test
8. Verification of dimensions.

#### **B. Routine tests**

1. Measurement of dielectric dissipation factor ( $\tan\delta$ ) and capacitance at ambient temperature
2. Power – frequency voltage withstand test
3. Measurement of partial discharge quantity

4. Test of tap insulation
5. Tightness test
6. Visual inspection and dimensional check

**C. Special tests**

1. Seismic test (IEC – 61463)
2. Artificial pollution test (IEC – 60507)

The bushings of 150kV shall be manufactured from ALSTOM Italy or TRENCH France or ABB Sweden.

The bushings of 20kV shall be manufactured from ALSTOM Italy or TRENCH France or ABB Sweden or COMEM.

**1.5 Bushing current transformers**

The bushings will be equipped with bushing current transformers as follows:

Terminal s	Number	Ratio	Accuracy & Burden
U,V,W	1	100/1	5P20 25VA For protection
U,V,W	1	500/1	5P20 25VA For protection
V	1	---	As required for thermal replica relay supply
N	1	100/1	5P20 25VA For protection

Complete test protocols for the above bushing current transformers shall be available at the time of inspection of the transformers.

Also the secondary windings of CT's of bushings will be tested with the applying a power frequency voltage of 3kV to earth.

## **2. Supervisory and Protection Equipment**

- Earthquake proof Buchholz relay of EMB manufacture, which shall be applied to the tube that connects the reactor tank with the expansion tank. The relay shall be designed and tested following EN 50216-1 and EN 50216-2 standards. The test certificates shall be presented to IPTO inspector. Isolating valves will be installed before and after the relay. This relay will be of the double float type with two sets of signaling contacts one for alarm and one for trip. The trapped gas in the Buchholz relay will be possible to be reclaimed through a gas collection device, which will be installed on the transformer at a person's height and will be connected permanently with the relay through a hose.
- Oil level indicator of magnetic type, with low level alarm contacts. The indicator shall be designed and tested following EN 50216-1 and EN 50216-5 standards. The test certificates shall be presented to IPTO inspector.
- Oil temperature indicator (dial type thermometer) of AKM or MESSKO manufacture with alarm and trip contacts.
- Winding temperature indicator (dial type thermometer) of AKM or MESSKO manufacture with alarm and trip contacts. Both temperature indicators shall be designed and tested following EN 50216-1 and EN 50216-11 standards. The test certificates shall be presented to IPTO inspector.
- Main tank pressure relief device of QUALITROL manufacture. The device will include a metallic cover with a drain, in order to convey the oil safely to the ground. The device shall be designed and tested following EN 50216-1 and EN 50216-5 standards. The test certificates shall be presented to IPTO inspector.
- Silica gel breather on oil conservator or expansion tank. The breather shall be designed and tested following EN 50216-1 and EN 50216-5 standards. The test certificates shall be presented to IPTO inspector.

## **5. Additional Accessories and Features**

Reactors shall be equipped with the following accessories and features:

- 5.1. Drain valve and other valves for connection with oil treatment equipment and oil sampling device. Also two isolating valves for the Buchholz relay. All valves shall be designed and tested to hold vacuum, following EN 12266-1, -2 standards.
- 5.2. The oil expansion tank will include a dry air cushion, which will float in oil. The dry air cushion will be connected to the breather. The expansion tank will include also an oil drain valve.

- 5.3. Filling plug on the upper radiator header.
- 5.4. Tank shall be designed for vacuum filling.
- 5.5. Detachable radiators provided with valves.
- 5.6. Gasketed joints shall be provided for bushings, manholes and radiators and shall be designed so that the gaskets will not be exposed to the weather and will provided with mechanical stops to prevent crushing of the gasket.
- 5.7. All connecting material that is bolts, nuts and lock washers must be hot-dip galvanized as per latest ISO standards.
- 5.8. Reactors shall be completely self contained. Conservator radiators and other accessories shall be supported by the reactor tank or sub-base and shall not require separate foundations or support. The radiators support will be realized by mechanical means, separate from the connecting oil pipes to the tank. The radiators shall be designed and tested following EN 50216-1 and EN 50216-6 standards. The radiator valves shall be designed and tested following EN 50216-1 and EN 50216-8 standards. The test certificates shall be presented to IPTO inspector.
- 5.9. Lifting hooks on tank, lifting eyes on cover and provision for jacking.
- 5.10. Tank grounding provision consisting of two copper faced steel pads.
- 5.11. Diagrammatic nameplate.
- 5.12. Nameplate  
The reactor shall be provided with a durable metal nameplate made by corrosion resistant material.  
It shall bear the rating and other essential operating data and it shall include reference to installation and operating instructions as recommended by the manufacturer.
- 5.13. Reactor base shall include detachable rollers for skidding and rolling in a direction to either center line. The distance between rails shall be 1435mm.
- 5.14. Provision shall be made for termination of weather resistant 600V, color-coded or marked for identification, control and signal wiring in a weatherproof terminal box. The available D.C. source for control etc. is 110V battery.
- 5.15. Reactors shall be furnished complete with oil and suitable for continuous operation.
- 5.16. Reactors shall be painted with gray color RAL 7040 and with painting thickness of  $120\mu\text{m} \pm 20\mu\text{m}$ .

## **VII. TESTS**

Any limitations regarding testing procedures (e.g test voltage, lightning impulse waveform, reactive power, etc) should be declared from the relevant bidder.

## 1. Routine Tests

The accumulative uncertainty in losses measurement will be calculated by the manufacturer, following IEC 60076-19 or EN 50462, prior to the execution of the relevant measurements (par. 1, 3). Apart of the performance of the below mentioned tests, all routine test certificates of the accessories will be presented to IPTO inspector. The following tests shall be made on all units ordered:

1. Measurement of winding resistance and dissipation factor ( $\tan\delta$ ).
2. Measurement of reactance
3. Measurement of losses at 157.5 kV at 50Hz
4. Applied voltage test 50 kV for 1 min at 50Hz for the neutral and line terminals (AV).
5. Induced voltage test with measurement of partial discharges (IVPD).  
The test will incorporate the requirements of induced voltage withstand test (IVW), in accordance with IEC 60073-3. The reactor will be tested either using three-phase test voltage or phase-by-phase in a single-phase connection circuit. The one-hour single-phase test voltage with partial discharge measurement will be 147 kV.
6. Lightning impulse test with 750KV for the line terminals (LI).
7. AC Withstand Voltage Test on Line Terminals (LTAC)  
This test is applied as a withstand test for each line terminal to earth, not to test phase-to-phase or turn-to-turn insulation. It will be performed by applying a voltage to the neutral additionally to an induced voltage to the winding, in order to produce a line terminal voltage to earth equal to the line terminal AC voltage withstand level, which is 325 kV. The test duration is the same as for the enhancement level of IVPD test.  
Alternatively to this test, the switching impulse test (SI) of par.VII.3.3.can be applied as a routine test.
8. Auxiliary wiring insulation test, 2 kV for auxiliary power and signaling circuits, 2.5 kV for secondary windings of CTs, 1 min, 50 Hz (AuxW).
9. Check of ratio and polarity of bushing current transformers
10. Functional test of auxiliary wiring

11. Tightness test  
Gas pressure of at least 30kPa over the normal oil pressure will be applied for 24h in the conservator, with the reactor in assembled state. No leaks shall be observed. The pressure at the tank bottom shall be recorded during the test with a calibrated manometer.
12. Measurement of capacitance and dissipation factor at 10 kV.  
 $\tan\delta \leq 0.5 \%$
13. Measurement of winding insulation resistance at 2.5 kV (60s and 15s DAR value). Also insulation resistance measurement between core and tank at the external earthing box (par.V.2.4).
14. Painting check  
The external painting thickness will be checked using magnetic method, according ISO 2178. The external painting adhesion will be checked using cross-cut method, according ISO 2409. The tests will be performed using equipment provided either by the manufacturer or by IPTO.

## 2. Type Tests

Temperature rise test.

Two oil temperature pockets shall be available on the reactor cover. Additionally, one oil temperature pocket shall be available at the oil input and one at the oil output of the radiators.

The test shall be carried out at 105% of rated voltage at 50Hz.

The temperature rise of the winding measurement by resistance method shall not exceed 65° C.

The temperature rise of the oil shall not exceed 60° C.

## 3. Special Tests

The following tests shall be made on one unit of the order:

1. Measurement of zero–sequence reactance.
2. Chopped wave lightning impulse test on line terminals (LIC).

During the full-wave impulse test and for each winding, application of chopped impulses shall be inserted, forming the test sequence as follows:

- a. One (1) reduced level, full wave impulse (50% to 75% of 750kV) with shape 1.2/50µsec.
- b. One (1) full wave 750KV impulse with shape 1.2/50µsec.
- c. Two (2) chopped wave 825KV impulses with shape 1.2/50µsec.
- d. Two (2) full wave 750KV impulse with shape 1.2/50µsec.

The chopping time of the chopped lightning impulse will be between 2  $\mu$ s and 6  $\mu$ s and the following overswing will be below 30%. The current to earth shall be recorded during the test.

3. Switching impulse test with 620 kV for the line terminals (SI).
4. Lightning Impulse Tests on Neutral Terminal (LIN).  
The impulses shall have a front time up to 13 $\mu$ s. The test sequence shall be as follows:
  - a. One (1) reduced level, full wave impulse (50% to 70% of 125 kV).
  - b. Three (3) full wave 125 kV impulses.
5. Measurement of acoustic sound level.  
The level of acoustic sound shall not exceed 72dB (A).
6. Measurement of vibrations at nominal voltage.  
The level of vibrations shall not exceed 200 $\mu$ m.
7. Measurement of the current harmonics.
8. Measurement of mutual reactance.
9. Measurement of linearity of reactance at 70%, 90% and 105% of rated voltage.
10. Measurement of magnetic characteristic
11. Pressure deflection test of the tank  
The permanent deflection of any point of the tank walls shall not surpass 1mm, after applying an internal pressure of at least 35kPa above the normal operating pressure.
12. Vacuum deflection test of the tank  
The permanent deflection of any point of the tank walls shall not surpass 1mm, after applying an internal vacuum.
13. Vacuum tightness test  
After applying vacuum in the tank, the mean rate of internal pressure rise shall not surpass 0.2 kPa/h over a period of 30min.

#### **4. Frequency response measurement**

A frequency response measurement will be executed on each reactor after all routine and special tests and prior to shipment, following IEC 60076-18. In case the manufacturer does not

possess SFRA testing equipment, the test will be performed with equipment provided by IPTO.

**VIII. DATA TO BE SUPPLIED BY BIDDER AND VENDOR**

1. Bidders attention is drawn to the importance of giving all the information requested by the SCHEDULE "A" of the present Specification.  
Failure on the Bidder's part to comply in this respect will be taken as reasonable ground for the rejection of the Bid.
2. Bidders are required to submit, attached to their offers, drawings showing the outline dimensions of the reactors for erection purposes as well as any information, sketches and data necessary for a complete description of the equipment offered by them.
3. Providing that a contract has been awarded, the Vendor shall furnish three (3) copies of the following drawings for approval and before the construction of the reactors :
  - a. Assembled reactor outline drawing.
  - b. Reactor outline drawing for transport, showing centre of gravity
  - c. Bushing outline drawing.
  - d. Name plate drawing.
  - e. Bushing current transformer control wiring diagrams.
  - f. Bushing current transformer characteristic curves showing open circuit secondary saturation, ratio and phase angle correction.
  - g. Wiring diagram of the reactor itself.
  - h. Detailed quality control plan (QCP), incorporating quality assurance (QA) and inspection and test plan (ITP).

Along with the subject reactors, Vendor shall furnish three (3) copies of complete instruction books for erection and maintenance and three (3) copies of final drawings.
4. The economic comparison of the offers shall be made according to the data requested by the SCHEDULE "B" of the present Specification.

**IX. SPARE PARTS**

Bidders should quote the following spare parts giving item prices:

Item Number	DESCRIPTION
1	One line-end bushing complete.
2	One neutral-end bushing complete.
	Complete set of gaskets for all bushings, covers, radiator

3	flanges, manholes and hand-holes for one reactor.
4	Set of replacement parts for each type of part likely to be damaged upon operation such as relays, instruments, safety devices, etc.

The Purchaser reserves himself the right to determine, when signing the Contract, the spare parts which Seller shall furnish on the basis of the prices set forth in his proposal.

**X. RATING PLATES**

The transformer will be provided with a rating plate of a non-corrosive material, fitted in a visible location showing the items indicated below:

1. Relevant Standard – IEC – 60076
2. The manufacturer's name
3. Serial number
4. Year of manufacture
5. Number of phases
6. Rated power (Mvar)
7. Rated frequency (Hz)
8. Rated voltage (V or KV)
9. Rated current (A or KA)
10. Type of cooling.
11. Reactor total mass
12. Oil mass (Reactor insulation material)
13. Insulation levels
14. Temperature rise of top oil and windings.
15. Type of reactor insulation oil
16. Diagram of the windings configuration
17. Reactor transportation mass.
18. Reactor untanking mass
19. Vacuum withstand capability of the tank and conservator.

The reactor will be also provided with a plate indicating the designation, position, scope of use and dimensions of all valves of the reactor tank and oil conservator. Each valve will include a small plate with its own designation.

In addition to the above mentioned plates with the above information, the reactor shall also carry nameplates with technical characteristics of auxiliary equipment, such as bushings, CTs, cooling system and OLTC according to the individual Standards.

## **XI. PACKING**

The accessories of the reactors will be packed inside robust, entirely closed, wooden boxes, of at least 20mm thickness and maximum gross weight of 5 tons.

The boxes will be of pallet type and they will be protected internally by an insulating material (e.g. nylon).

The oil will be sent inside barrels and also the instruments, control and protection equipment will be sent inside separate boxes as above.

For each shipment lot of reactors, at least one shock recorder will be provided and installed by the manufacturer on a reactor tank. For each contract, shock recorders will be installed on the 30% at least of the number of provided reactors.

The shock recorders will be of digital type and they will include GPS and time tagging of the recordings. They will be of type SMT HYBRID – MONILOG ENDAL or SHOCKWATCH – SHOCK LOG 298 or MESSKO – CARGOLOG or of an equivalent type, subject to IPTO's approval.

The alarm limit of shock recorders will be set at 1g acceleration, which is the design withstand limit, according to par.V.2.6.

**SPECIFICATION SS-52/15**  
**8 MVAR – 25 MVAR, 157.5kV SHUNT REACTORS**

**SCHEDULE “A”**

**Information by Seller**

1. Type : .....
2. Rated power at rated voltage 157.5kV : ..... Mvar
3. Maximum continuous operating voltage : ..... kV
4. Rated current of the reactor at 157.5kV : .....
5. Applicable standards : .....
6. Rated frequency : ..... Hz
7. Type of core : .....
8. Connection of windings : .....
9. Lighting impulse withstand voltage
  - a. At line-end : .....
  - b. At neutral-end : .....
10. Power frequency withstand voltages (1min, 50Hz)
  - a. At line-end : ..... kV r.m.s.
  - b. At neutral-end : ..... kV r.m.s.
11. Level of winding insulation : .....
12. Temperature rise limits
  - a. For windings : .....
  - b. For the oil : .....
13. Ratio of the zero-sequence reactance to the positive-sequence reactance ( $x_0/x_1$ ) (estimated value) : .....
14. Voltage variation without exceeding the temperature rise limits : .....

15. Harmonics of reactor current at rated voltage
  - a. Third harmonic : .....
  - b. Fifth harmonic : .....
  - c. Seventh harmonic : .....
  
16. Noise levels at rated voltage : .....
  
17. Vibration levels at rated voltage : .....µm
  
18. Normal frequency of reactor : .....
  
19. Total losses
  - a. At rated voltage 157.5kV : ..... kW
  - b. At 105% rated voltage : ..... kW
  
20. Zero-sequence losses at rated voltage (estimated value) : ..... kW
  
21. Cooling method : .....
  
22. Have the reactors been designed to employ linear magnetization characteristics with voltage equal to 1.2 of their rated voltage?: .....
  
23. Bushings
  - a. Line-end bushings
    - Type and manufacturer : .....
    - Max. phase-phase operating voltage : .....kV rms
    - Rated current : .....A
    - Lightning withstand level : ..... kV
    - 1 minute - 50Hz Power frequency withstand voltage : ..... kV rms
    - Minimum creepage distance : ..... mm
    - Cantilever withstand load : ..... N
    - Range of spill-gap settings : ..... mm
  
  - b. Neutral-end bushing
    - Type and manufacturer : .....
    - Max. phase-phase operating voltage : .....kV rms
    - Rated current : .....A
    - Lightning withstand level : .....
    - 1 minute - 50Hz Power frequency withstand voltage : ..... kV r.m.s.
    - Minimum creepage distance : ..... mm
    - Cantilever withstand load : ..... N

24. Bushing current transformers
- a. Line-End
- Ratio : .....
  - Continuous operations current : .....
  - Burden : .....VA
  - Accuracy class : .....
- b. Neutral-End
- Ratio : .....
  - Continuous operation current : .....
  - Burden : .....VA
  - Accuracy class : .....
25. Type and manufacturer BUCHHOLZ
- Installation : .....
  - Characteristics of alarm contacts : .....
  - Characteristics of tripping contacts : .....
26. Is the reactor equipped with oil level gauge with low level alarm contacts? : .....
27. Type and manufacturer of the oil temperature measurement instrument : .....
- Characteristics of alarm contacts : .....
  - Characteristics of tripping contacts : .....
28. Type and measurement of the winding temperature measurement instrument
- Characteristics of alarm contacts : .....
  - Characteristics of tripping contacts : .....
29. Type and manufacturer of the pressure relief device : .....
30. Is the reactor tank of cover bolted type? : .....
31. Accessories and features of the reactors according to paragraph VI-5 : .....
32. Reactor oil
- a. Type and manufacturer : .....
  - b. Does the oil contain PCBs or PCTs? : .....
  - c. Is it in accordance with IEC-60296, transformer class standard : .....
33. Are the terminals of line bushings made of 30mm diameter copper rodes? : .....

34. Has the reactor Silica Gel breather on the oil conservator or the expansion tank? : .....
35. Color of the reactor : .....
36. Approximate mechanical data
- a. Transfer weight : ..... kg
  - b. Total weight : ..... kg
  - c. Core and coils : ..... kg
  - d. Case and fittings : ..... kg
  - e. Oil : ..... kg
  - f. Untanking weight (heaviest piece) : ..... kg
  - g. Overall height : ..... m
  - h. Height over case : ..... m
  - i. Untanking height (with bushings) : ..... m
37. Acceptance of specified tests : .....
38. Is the packing according to the paragraph XI of the specification? : .....
39. Deviations if any from the present specification and the reasons thereof :  
 .....  
 .....  
 .....

**SPECIFICATION SS-52/15**  
**8 MVAR – 25 MVAR, 157.5kV SHUNT REACTORS**

**SCHEDULE “B”**

**EVALUATION OF LOSSES**

1. Reactor first cost and losses
  - a. The reactor first cost  
(The reactor first cost will be computed by the Purchaser who will consider the Seller C+F price, as amended after the evaluation of the proposed terms of payment) : K = ..... €.
  - b. Total losses at rated voltage  
157.5kV (guaranteed value) : C = ..... kW
2. Reactor annual cost
  - a. Reactor carrying charges  
(at 9.37 per cent) :  $\frac{9.37K}{100} = \dots\dots\dots \text{€}.$
  - b. Capacity loss(.116,7€/kW-year) : 116,7..€ x C ..... €.
  - c. Energy loss (0,0438€. per kWh) : 0,0438€x C x 7500 = ..... €.
  - d. Total annual cost : (the sum) = ..... €.
3. Penalty for excess losses  
With regard to total losses, a reactor is considered as successfully inspected if the losses ascertained during inspection do not exceed the maximum tolerance of 15% which is specified in the IEC Standards, versus the losses guaranteed by Seller.  
Otherwise the reactor shall be rejected. On each successfully inspected reactor, any difference in the losses versus the guaranteed ones (without tolerance), shall be negative or zero. If such difference is positive, i.e. the losses ascertained during inspection exceed the guaranteed ones (without tolerance) penalty shall be imposed on Seller consisting of:  
  
...4751€ per kW of total losses in excess.