



November 2012

**SPECIFICATION No SS-66/12**

**30 kV, 50MVAR THREE-PHASE REACTORS**

**I. SCOPE**

This specification covers the design, manufacturing, testing at the manufacturer's premises and supplying of three-phase, outdoor 30kV, 50 MVAR compensating reactors.

**II. STANDARDS**

All materials, equipment, workmanship, design, inspection and testing of the subject reactors shall conform to IEC 60076-6, 60076-3, 60076-4

**III. SYSTEM CHARACTERISTICS**

- |                                      |   |  |
|--------------------------------------|---|--|
| 1. <u>Maximum system voltage</u>     | : | 36 kV  |
| 2. <u>Rated frequency</u>            | : | 50 HZ  |
| 3. <u>System short circuit level</u> | : | 20 KA at 30kV                                  |
| 4. <u>Other characteristics</u>      | : | 3-phase, 3-wire, ungrounded<br>neutral system. |

**IV. SERVICE CONDITIONS**

Unless otherwise stipulated in this Specification subject 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.

The reactors shall be connected to the tertiary winding of a 280/280/60 MVA, 400/150/30 kV autotransformer described in PPC Specification SS-57.

The 30kV network to which the reactor will be connected shall be considered as ungrounded.

**V. REQUIREMENTS**

**1. Basic rated quantities**

- |                                       |   |         |
|---------------------------------------|---|---------|
| a. Rated voltage (Ur)                 | : | 30 kV   |
| b. Highest voltage for equipment (Um) | : | 36 kV   |
| c. Rated power                        | : | 50 Mvar |
| d. Rated frequency                    | : | 50 HZ   |
| e. Number of phases                   | : | 3       |

- f. Maximum operating voltage (U<sub>max</sub>) : 110% of rated
- g. Type of cooling : ONAN (Natural circulation of the oil and air)
- h. Rated insulation levels for windings and bushings:

Standard impulse withstand Voltage, 1,2/50 $\mu$ s wave, for line and neutral side (kV, peak)	250
One minute power frequency withstand voltage, lines and neutral side (kV r.m.s.).	95

## 2. Type of construction

The reactors shall be of the three-phase, oil-immersed, with copper windings and shall be suitable for outdoor installation. The reactor tank shall be of cover bolted type. 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 .

The mineral oil shall be free from PCBs or PCTs non toxic and in accordance with IEC-60296 class II standard.

During the routine tests can be carried out checks of insulation oil.

In general, the design and construction of the reactors shall be such as to avoid detrimental effects due to vibration.

## 3. Temperature rise limits

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

- Average of windings by resistance 65° C
- Of top oil by thermometer (reactor sealed or equipped with a conservator) 60° C
- 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 winding

The reactor shall constitute a three-phase unit, star-connected, with fully insulated neutral brought out. This neutral shall be connected to earth through a voltage transformer (included in the supply) with 250/95 kV insulation level for detection of earth faults. The

voltage transformer shall have ratio  $\frac{30}{\sqrt{3}} \bigg/ \frac{0,1}{\sqrt{3}}$  kV, rated burden 25 VA (approximate), accuracy class 1 and thermal burden 400VA or higher.

## **6. 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.

## **7. Saturation**

The reactors must be designed in such a way so as to exhibit up to a voltage of at least equal to 1.2 times their rated voltage, a deviation from linearity not more than 1%.

## **8. Voltage variation**

The design of the reactor shall be such as to allow switching of the reactor on and off, with the rated supply voltage varying by  $\pm 10\%$ , without any special precautions and without damage to the reactor or the autotransformer on which the reactor is connected. Furthermore, the reactor shall be capable of operating continuously at this voltage range, without exceeding the allowable temperature rise limits.

## **9. Impedance Variation**

The positive tolerance on the reactor impedance corresponding to its rated MVAR shall not be greater than 5%. No negative tolerance on the impedance shall be accepted.

## **10. Audible Sound Level**

The audible sound level of the reactors shall not be higher than 80db(A) for 33kV operation according to IEC 60076-10 standard.

## **11. Vibrations**

Mechanical vibrations shall not exceed 100 $\mu$ m peak-to-peak at maximum system voltage with the cooling fans on.

## **12. Short Circuit Withstand Capability**

If proven necessary, internal separating partitions shall be provided between the phases of the reactor, so as to render impossible a phase-to-phase or a three-phase internal short circuit.

# **VI. ADDITIONAL REQUIREMENTS AND FEATURES**

## **1. Bushings**

All bushings shall be of porcelain, gray color, of the outdoor fog-type with creepage distance at least 900mm and equipped with adjustable spark-gaps.

## **2. Bushings Current Transformers**

Each line-end terminal bushing shall be equipped with one current transformer having ratio 1000/1A burden 30VA and 5P20 accuracy class for relaying.

### **3. Supervisory and Protection Equipment**

- Earthquake proof Buchholz relay of EMB manufacture with electrically separate alarm and tripping contacts or a sudden pressure relay when the reactor is sealed and not equipped with conservator or expansion tank.
- Oil level gauge with low level alarm contacts.
- Winding temperature indicator (dial type thermometer) actuated by winding temperature, of AKM or MESSKO manufacture with incorporated transducers, with alarm and trip contacts.
- Oil temperature indicator (dial type thermometer) actuated by oil temperature, of AKM or MESSKO manufacture with incorporated transducers, with alarm and trip contacts.
- Main tank pressure relief device, type XPRD of Qualitrol.
- Silica gel breather on oil conservator or expansion tank.

### **4. Additional accessories and features**

Reactors shall be equipped with the following accessories and features:

- a. Combination drain valve, bottom filter press connection and sampling device.
- b. Conservator or expansion tank drain valve.
- c. Oil level gauge of the conservator or expansion tank.
- d. Filling plug on the upper radiator header.
- e. Tank shall be designed for vacuum filling.
- f. Detachable radiators provided with valves, butterfly type.
- g. Casketed 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 be provided with mechanical stops to prevent crushing of the gasket.
- h. 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.
- i. Lifting hooks on tank, lifting eyes on cover and provision for jacking.
- j. Tank grounding provision consisting of two copper faced steel pads.
- k. Diagrammatic nameplate.
- l. 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.

13. Reactor base shall be designed for skidding and rolling in a direction to either center line and distance between its wheels of 1435 mm.
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 220V battery.

15. Reactors shall fulfill the requirements of this Specification in continuous operation when filled with oil in good condition, of qualities commonly accepted for transformer insulation oil. Reactors shall be furnished complete with oil.
16. Reactors including coolers shall be painted with RAL 7040, gray color of thickness  $120 \pm 20 \mu\text{m}$ .

## **VII. TESTS**

### **1. Routine Tests**

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 30kV and 33kV at 50Hz
4. Separate – source withstand voltage test 95KV for 1 min at 50Hz for the neutral – end and line-end terminals.
5. Short duration induced over-voltage test according to IEC 60076-3 standard.
6. Lightning impulse test with 250KV for the line – end and neutral-end terminals.

### **2. Type Tests**

Temperature rise test.

The test shall be carried out at 110% of rated voltage at 50Hz.

The temperature rise of the winding measurement by resistance method shall not exceed  $65^{\circ}\text{C}$ .

The temperature rise of the oil shall not exceed  $60^{\circ}\text{C}$ .

### **3. Special Tests**

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

1. Measurement of zero–sequence reactance.
2. Chopped wave impulse test with 275KV only of line – end terminals, according to IEC 60076-3 standard.  
The test sequence is the following:
  - a. One (1) full wave between 50% and 75% of 250kV with shape 1.2/50µsec.
  - b. One (1) full wave 250KV with shape 1.2/50µsec.
  - c. One (1) or more chopped waves between 50% and 75% of 250kV with shape 1.2/50µsec.
  - d. Two (2) chopped waves 275KV with shape 1.2/50µsec.
  - e. Two (2) full waves 250KV with shape 1.2/50µsec.
3. Measurement of acoustic sound level.  
The level of acoustic sound shall not exceed 80dB (A).
4. Measurement of vibrations at nominal voltage.  
The level of vibrations shall not exceed 200µm.
5. Measurement of the current harmonics.
6. Measurement of mutual reactance.
7. Measurement of linearity of reactance at 70%, 90% and 110% of rated voltage.
8. Measurement of magnetic characteristic.

#### **VIII. DATA TO BE SUPPLIED BY BIDDER**

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. Along with the subject reactors Seller shall furnish complete instruction books for erection and maintenance.
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:

<u>Item No</u>	<u>Description</u>
1.	One bushing complete
2.	Complete set of gaskets for all bushings, covers, radiator, flanges, manholes and handholes for one reactor.
3.	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 to him 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. 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.

## **SCHEDULE “A”**

### **30kV, 50 MVAR THREE-PHASE REACTORS**

#### **INFORMATION BY SELLER**

1. Applicable standards : .....
2. Type (short description) : .....
3. Type of core (describe) : .....
4. Winding connection : .....
5. Rated frequency : .....50HZ
6. Maximum permissible operating voltage : .....kV
7. Continuous maximum rating at operating voltage : .....Mvar
8. Rated power at nominal voltage 30kV : .....Mvar
9. Lightning impulse withstand voltages  
for both line and neutral side : ..... kV peak.
10. Power frequency withstand voltages (1 min, 50HZ)  
for both line and neutral side : ..... kV r.m.s.
11. Windings and oil temperature rise limits for 40°C (guaranteed values)
  - a) For the windings : .....
  - b) For the oil : .....
12. Voltage variation without exceeding the  
temperature rise limits : .....
13. Maximum value of third harmonic component of  
reactor current at rated voltage : .....
14. Deviation from linearity for voltage of at least  
equal to 1.2 times the rated voltage : .....
15. Audible sound level for 33kV operation  
according to IEC-60076-10 : .....
16. Tolerance on the reactor impedance  
corresponding to its rated MVAR : .....



17. Permissible mechanical vibrations ( $\mu\text{m}$ ) : .....
18. Total losses and impedance
- a) At rated voltage 30kV : ..... KW
- : ..... $\Omega$ /phase
- b) At 110% rated voltage : ..... KW
- : ..... $\Omega$ /phase
19. Ratio of the zero-sequence reactance to the positive – sequence reactance ( $X_0/X_1$ ) : .....
20. Is the reactor tank of cover bolted type? : .....
21. Bushings
- Line-end and neutral–end bushings
- Type : .....
- Standard impulse withstand voltage : ..... kV peak
- 1 minute - 50HZ withstand voltage : ..... kV r.m.s.
- Minimum creepage distance : ..... mm
- Range of spill-gap settings : ..... mm
- Color of bushings : .....
22. Bushing current transformers
- Ratio : .....
- Burden : ..... VA
- Accuracy class : .....
23. Voltage Transformer (connecting neutral)
- a. Insulation level : .....
- b. Ratio : .....
- c. Rated burden (VA) : .....
- d. Accuracy class : .....
- e. Thermal burden : .....

24. Cooling requirements
- a) Type of cooling : .....
  - b) Number of coolers : .....
  - c) Are detachable radiators provided with valves? : .....
25. Supervisory and protection equipment  
(to be listed by Bidder) : .....  
.....  
.....  
.....
26. Accessories and features  
(to be listed by Bidder) : .....  
.....  
.....  
.....
27. Approximate mechanical data
- a) Core and coils : .....kg
  - b) Case and fittings : .....kg
  - c) Oil : .....kg
  - d) Total weight : .....kg
  - e) Untanking weight (heaviest piece) : .....kg
  - f) Over-all height : .....m
  - g) Height over case : .....m
  - h) Untanking height (with bushings) : .....m
28. Approximate shipping weight data and volume
- a) Total shipping weight (reactor shipped with oil) : .....kg
  - b) Reactor in tank with oil : .....m<sup>3</sup>
  - c) Accessories shipped separately : .....m<sup>3</sup>

29. Color of the reactor : .....
30. Are conservator, radiators and other accessories mounted on the reactor tank or on the sub-base without being necessary separate foundations or supports? : .....
31. Are lifting hooks on tank, lifting eyes on cover and equipment for jacking provided? : .....
32. What is provided for tank grounding? : .....
33. Is the reactor able for skidding and rolling in a direction to either center line with a distance between its wheels of 1435 mm? : .....
34. Are reactors furnished complete with oil? : .....
35. Acceptance of specified tests : .....
36. Is the mineral oil free from PCBs or PCTs not toxic and in accordance with IEC-60296 class II standard? : .....
37. Is there any restriction concerning the test performance capability (e.g due to the laboratory's sufficient itself)? : .....
38. Deviations if any from the present Specification and the reasons thereof : .....
39. Is the packing according to the paragraph X of the specification? : .....

**SPECIFICATION SS-66/12**  
**30kV, 50MVAR 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  
30kV (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 (at 116,7€. per kW-year): 116,7€ x C ..... €.
- c. Energy loss (at 0,0438€. per kWh): 0,0438€ x C x 2400 = ..... €
- 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, 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:

2368€. per kW of total losses in excess.