

December 2016

TECHNICAL DESCRIPTION TD-01/8

4.3MVAR, 21kV (2.42MVAR at 15.75kV) SHUNT CAPACITOR BANK

I. SCOPE

This technical description covers performance characteristics, construction features and testing of outdoor shunt capacitor banks.

II. KEYWORDS

Capacitor element, Capacitor Unit, Capacitor Bank, Reactive Compensation, Voltage Control.

III. USE

1. The Capacitor banks will be used for reactive power compensation and will be connected to the 20 kV side of 150/20 kV Substations or to the 15.75 kV side of 150/15.75 kV Substations which will be changed later to 150/20 kV, without however, changing the internal connections of the capacitor bank.
2. The Capacitor banks must be suitable for continuous or frequent switched operation via capacitor switches. (Load break switches).

IV. OPERATING CONDITIONS

- | | | | |
|----|---------------------|---|------------------------------------|
| 1. | Installation | : | Outdoor |
| 2. | Ambient Temperature | : | Minimum (-20°C)
Maximum (+45°C) |
| 3. | Altitude | : | Up to 1000 m above sea level |
| 4. | Other Conditions | : | Snow and Ice |
| 5. | Pollution level | : | Moderate |

V. ELECTRIC POWER SYSTEM CHARACTERISTICS

1. Nominal Voltage (phase-to-phase) : 20 kV rms
2. Maximum Operating Voltage (phase-to-phase) : 24 kV rms
3. Number of phases : 3
4. Number of wires : 3
5. Nominal Frequency : 50Hz
6. Short Circuit Level : 10 kA
7. Basic Insulation Level : 150kV
8. Grounded neutral via a 12 Ω resistor at the 20kV and 9 Ω at 15.75kV.

VI. ELECTRIC AUXILIARY SUPPLY CHARACTERISTICS

1. Auxiliary A.C. Voltage: 3-phase, 4-wire, 230/400 V, 50 Hz.
(For all other uses).
2. Auxiliary D.C. Voltage: 110 V available from the station battery.
(For control and signalling).

VII. STANDARDS

All material, equipment, fabrication and testing shall conform to IEEE std. 18-1992 unless, herein, otherwise described.

VIII. ELECTRICAL REQUIREMENTS OF THE CAPACITOR BANK

1. Rated Voltage : 21 kV (line to line)
2. Rated Capacity of the bank at 21 kV : 4.3 MVAR
3. Rated frequency : 50 Hz
4. Rated Capacity of the bank at 15.75 kV : 2.42 MVAR
5. Connection arrangement of the Capacitor bank : Double - Wye, ungrounded.
6. Clearance between the conductor which connects the two neutrals of the two Wyes of the bank and the metallic parts of the capacitor structure : $\geq 22\text{cm}$
7. Number of capacitor units per Wye and rated capacity per capacitor unit : Each Wye must have six (6)

of capacitor units with each unit having a 358.33 KVAR rated capacity .

IX. CAPACITOR UNIT - DESIGN REQUIREMENTS

1. The capacitor units shall be of the two bushings type, with the container (case) earthed.
2. The units shall be hermetically sealed and the contained dielectric fluid shall be non-toxic and biodegradable. Dielectric fluids like polychlorinated biphenyls (PCB's/PCTs) are banned due to their toxicity and damage to the environment. Only non-toxic dielectric fluids are allowed.
3. Each of the capacitor units shall be equipped with an external fuse of appropriate rating, suitable for outdoor installation, with indicating device.
4. The temperature rise shall not exceed 25°C at any point of an individual isolated capacitor unit operating continuously at rated voltage and frequency at 40°C ambient temperature.
5. Impulse voltage level of capacitor unit : 125 KV
(1.2/50µs)
6. Rated voltage of the capacitor unit :12.125KV
(terminal to terminal)
7. Terminal to case 50Hz voltage withstand : 40KV rms for 10sec
8. Terminal to terminal voltage withstand : 24.25kV A.C.- 50Hz
or 52.1375kV DC
9. Rated frequency : 50Hz
10. Maximum power loss : 0,15 W/KVar

X. CAPACITOR BANK - DESIGN REQUIREMENTS

1. The capacitor bank shall be outdoor, open type, three-phase, consisting of three (3) tiers with each tier containing 4.3 MVAR and elevated on a metal structure so that the base of the lowest tier

shall be at least 2.30 meters above ground level.

It should be noted that there shall not be any support insulators between the tiers of the support structure.

2. The capacitor bank shall be connected double-wye ungrounded with the respective floating neutrals connected together through a current transformer with a 40/5 Amp ratio for detection of unbalanced conditions caused by the failure of an individual capacitor unit fuse.
3. Rated capacity of each capacitor unit : 358.33 KVAR
4. The MVAR of each capacitor bank can be changed slightly by the bidder in a way to suit his standard capacitor units, as long as the total capacity of the bank is not lower than specified.
5. The number of capacitor units per phase of each wye, shall be two (2) (two (2) in parallel) so that the loss of one capacitor unit does not produce a voltage across the remaining units exceeding 110% of rated capacitor unit voltage.

XI. TOLERANCES IN RATINGS AND MOMENTARY RATINGS

1. Capacitors shall give not less than the rated reactive power at rated sinusoidal voltage and frequency and not more than 115% of this value, measured at 25°C uniform case and internal temperature.
2. Capacitors shall be suitable for continuous operation at 135% of rated reactive power. This maximum reactive power shall include the following factors, the combined effects of which shall not exceed 135%:
 - a. Reactive power due to voltage in excess of nameplate rating at fundamental frequency but within the permissible voltage limitations described in XI - 3b.
 - b. Reactive power due to harmonic voltages superimposed on the fundamental frequency.
 - c. Reactive power in excess of nameplate rating due to manufacturing tolerance within the limits described in XI-1.
3. Capacitors shall be capable of continuous operation provided that none of the following limitations are exceeded:

- a. 135% of nameplate KVAR
 - b. 110% of rated voltage rms, and crest voltage not exceeding $1.2 \cdot \sqrt{2}$ of rated rms voltage, including harmonics but excluding transients.
 - c. 180% of rated current rms, including fundamental and harmonic currents.
4. Capacitors shall be capable of withstanding, with full life expectancy, switching transients having peak voltages up to $2 \cdot \sqrt{2}$ times rated voltage rms and other transient disturbances inherent in the operation of power systems.

XII. ADDITIONAL REQUIREMENTS

1. Capacitor Elements

All capacitor elements which are to be used for the construction of the bank must be of the all - film dielectric type.

2. Bushings

The characteristics of the two (2) bushings of each capacitor unit shall be according to IEEE std. 18-1992, and with the following Characteristics:

- a. Minimum insulation creepage distance : 43.18cm
- b. Power frequency voltage withstand 50Hz
 - dry : 60kV, rms 1 minute
 - wet : 50kV, rms 10sec
- c. Impulse (1.2/50 μ s) full wave voltage withstand : 150kV peak
- d. Material of the insulating housing of the bushings : Porcelain

3. Discharge devices

Capacitors shall be equipped with an internal discharge device that will reduce the residual voltage to 50V or less within 5 minutes after the capacitor is disconnected from the source of supply.

The discharge devices shall be permanently connected to the terminals of the capacitors.

4. External Fuses

- a. The voltage rating of the individual fuses shall be equal to or greater than the rated voltage of the capacitor unit. The

current rating shall be at least 135% of the rated current of the capacitor unit.

- b. Failure of a capacitor unit should result in a fault current sufficient to blow the relative fuse of the unit before the container (case) ruptures.
- c. Fuses shall be able to withstand relatively high inrush currents due to capacitor back-to-back switching.

5. Neutral Current Transformers

The floating neutrals of the double wye bank will be connected together through a current transformer of ratio 40/5A, class 5P10, and of output power of 20VA. The current transformers shall be installed on the support structure of the entire bank as indicated in drawing OM-P-32.

6. Support Structure

The offer for the capacitor bank shall include one (1) support steel structure per three (3) capacitor banks installed in three tiers as indicated in the attached drawing No. OM-P-32.

All dimensions of the support steel structure as shown in drawing OM-P-32 are obligatory.

Along with the support structure and the equipment shown on drawing No. OM-P-32, the offer must also include the anchoring bolts, all bus-work (conductors) for the connection of various capacitor units and necessary racks.

The supplied anchoring bolts shall be suitable for the entire support structure taking into consideration that it must be able to withstand a wind speed of 150Km/h, which corresponds to a wind pressure of 180Kg/m² (with dynamic pressure sufficient of 1,5).

All exposed steel parts shall be hot dip galvanised in accordance with the latest ASTM or DIN Standards.

7. Capacitor Unit Line Terminals (studs)

Line terminals (studs) must be of a suitable for connection with copper tubes or copper conductors.

8. Drawings

The offer shall include a detail drawing of the entire support structure and of the capacitor banks.

XIII. TESTS

The following tests as per IEEE Std 18-1992 shall be carried out on capacitor units.

1. Design (Type) Tests

a. Impulse withstand test

Between case and terminals with the terminals connected together: three successive positive full-wave impulses (1.2 x 50µs) of 150 kV Crest .

b. Thermal stability test according to IEEE std. 18-1992.

c. Radio influence voltage test according to IEEE std. 18-1992.

- Test voltage: 13.95kV

- Radio influence voltage level : $\leq 250\mu V$

d. Voltage decay test according to IEEE std. 18-1992.

Time for decay to 50V or less: ≤ 5 minutes

e. Bushing tests

1. 50Hz voltage withstand test

- dry: 60kV rms, 1 minute

- wet: 50kV rms, 10sec

2. Impulse voltage (1.2x50µs) withstand: 150kV crest (peak)

2. Production (Routine) Tests

a. Short - Time overvoltage test.

Terminal-to-terminal : 50 Hz, 10 sec, 2 times the rated voltage rms of the capacitor unit, or DC, 10 sec, 4.3 times the rated voltage rms of the capacitor unit.

Terminal-to-case : 50 Hz, 10 sec, 40kV rms

b. Capacitance test.

The capacitance of the units supplied, measured at 25°C and at rated voltage, must be not less than the rated KVAR and not more than 115% of rated KVAR.

c. Loss Determination test.

The power losses in capacitor units, as determined by statistical sampling method, shall be not more than 0.15 Watts per KVAR at rated voltage and frequency, corrected to a capacitor temperature of 25°C.

i. In case of first time winning contract and for the first delivery, a thermal stability type test will be executed on a sample of capacitor units, according to ISO-2891, for general inspection level 1, acceptance quality limit following table 2A (normal inspection) and for zero number of pieces not following the power loss limit declared in the Bid. The correction coefficient, which will come up from the above type test, will be used for the correction of the measured power losses at the routine tests and it will be the mean value of the ratios of the measured losses, of the samples.

$$\frac{P_{loss,init} - P_{loss,stabil}}{P_{loss,init}} \quad (I)$$

where

$P_{loss,init}$: initial power losses before the thermal stability test

$P_{loss,stabil}$: power losses after the thermal stability test.

During the power loss measurement at the routing tests, the measured losses shall be corrected using the above coefficient (I) and will be compared with the guaranteed losses declared by the Bidder.

ii. For following deliveries of the same material, it is allowed the sampling for the power loss measurement at the routine tests to be done for special inspection level S4, acceptance quality limit following table 2A (normal inspection) and for zero number of pieces not following the power loss limit declared in the Bid.

As correction coefficient will be used the one coming from the thermal stability type test, which is not repeated.

d. Discharge resistor test.

Each capacitor shall be tested to ensure that the internal discharge device will reduce an initial residual voltage equal to $\sqrt{2}$ times rated voltage rms to 50V or less within 5 minutes.

e. Leak test.

A suitable leak test shall be made to demonstrate that the capacitor unit is free from leaks.

XIV. ECONOMIC COMPARISON OF OFFERS

The economic comparison of the offers shall be based on the capacitor bank total first cost and the cost per kW of guaranteed losses , that is on

the total annual cost. The total first cost will be computed by the purchaser, who will consider the Seller C & F price, as amended after the evaluation of the terms of payment. It shall include also any custom duties.

For this reason, all bidders must fill paragraph 1-c of attachment "B" only, and submit this along with all other technical information in the technical offer.

If during inspection, the losses exceed the guaranteed ones, a penalty shall be imposed on seller consisting of 1819€ per kW of losses in excess. The guaranteed capacitor losses in W/KVAR must be clearly indicated in attachment "A" as well.

XV. SPARE PARTS

The following spare parts with unit and total prices, shall be submitted. These spare parts shall consist of two capacitor units, and fifteen (15) fuse links only.

The Purchaser reserves the right to determine - when signing the contract to purchase or not, these spare parts.

XVI. NAMEPLATE MARKINGS

Each capacitor shall be provided with a permanent nameplate that includes the following information:

1. Name of manufacturer.
2. Unique serial number.
3. Manufacturer's type, model or catalog number.
4. Year of manufacture.
5. Rated reactive power.
6. Rated voltage, rms.
7. Number of phases.
8. Rated frequency.
9. BIL
10. Statement that the capacitor contains an internal discharge device.
11. Statement as to whether insulating liquid is or is not flammable.
12. Marking (decal or stick-on label, of blue color) visible from the ground to indicate non-PCB liquid or other toxic liquid.

XVII. DATA TO BE SUPPLIED BY BIDDER

1. Bidders must provide all information requested by "ATTACHMENT A" attached to this hereby technical description. Failure on the Bidder's part to comply in this respect will be taken as reasonable ground for the rejection of the offer.

2. Bidders must provide the information of paragraph 1-c only of attachment ``B``. Failure to comply shall result in rejection of the offer.
3. Bidders are required to submit, along with the offer, drawings showing the outline dimensions of the capacitor banks and its support structure for erection purposes as well as any information and data necessary for a complete description of the capacitor bank and its related equipment
4. Any available type test certificates for the capacitors and bushings. Acceptance or not of the certificates lies on the judgement of ADMIE S.A

XVIII. DATA TO BE SUPPLIED BY THE SUCCESSFULL BIDDER

1. Three (3) sets of drawings before the construction of the banks for approval.

These drawings shall include the following:

- a. Assembled capacitor banks outline drawing together with its entire support structure. (Top view and cross views)
- b. All necessary data for the entire support structure so that ADMIE can calculate the it steel reinforced concrete base.
- c. Capacitor Unit drawings.
- d. Electrical drawing of the entire capacitor connection.

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4.3 MVAR, 21kV (2.42MVAR at 15.75kV) SHUNT CAPACITOR BANK

ATTACHMENT "A"

DATA TO BE SUPPLIED BY BIDDER

Failure to comply may constitute reason for rejection of the offer.

1. Rated voltage of the bank : kV
2. Rated frequency of the bank : Hz
3. MVAR at 15.75 kV and 21 kV
at rated frequency : MVAR / MVAR
4. Phases :
5. Connection arrangement of
the bank :
6. Limits at Ambient Temperature : °C / °C
7. Initial Watts Loss at 20 kV at
25°C after operations
(guaranteed value) : W/KVAR
8. Total number of capacitor
Units per bank :
9. For the capacitor bushings :
 - a. Minimum Insulation Creepage Distance : mm
 - b. Withstand Voltage, 50 cycles,
dry, 1 minute : kV Rms
 - c. Withstand Voltage, 50 cycles,
wet, 10 sec. : kV Rms
 - d. Impulse withstand Test Voltage,
(1.2 x 50µs) Full Wave : kV Crest
 - e. Type of material of the insulating
housing :
 - f. Color of the insulating housing

material :

10. For the capacitor units:

a. Impulse Withstand voltage between case and terminals connected together, three successive positive full-wave impulses ($1.2 \times 50\mu\text{s}$). : kV

b. Short-time Overvoltage withstand

- Terminal-to-terminal, 50 cycles, 10 sec.: kV

- Terminal-to terminal, DC, 10sec. : kV

- Terminal-to-case, 50 cycles, 10 sec. : kV

c. Type of dielectric fluid :

d. Number of bushings per capacitor unit :

e. Number of capacitor units per phase of the bank :

f. Indicate arrangement of capacitor units for each phase :

g. Number of capacitor elements per unit :

h. Rated voltage of the unit :

i. Rated frequency of the unit :

j. Rated power of the unit :

11. CT Data (for the detection of unbalance) :

a. Ratio :

b. VA :

c. Accuracy class :

- d. Impulse voltage withstand (BIL) :
12. Dielectric stress across the film : Volts/ μ m
13. Type of external fuses
(Expulsion or current limiting) :
14. Rating of the external fuses : A
15. Weight of bank (double wye)
(approximate Weight) : kg
16. Weight of the entire support
structure :kg
17. Overall dimensions of the entire
support structure :
18. Type of terminals (studs) of the
capacitor bushings :
19. Are the capacitors equipped with
a discharge device which reduces
the residual voltage to 50V or less
within 5 minutes ? (Yes / No) :
20. Are the anchoring bolts for the
support steel structure part of the
supply? :
21. Can the entire support structure
of the three capacitor banks installed
in three tiers one on top of the other
withstand wind speed of 150Km/h?
(180 Kg/m²) :
.....

22. Is the steel support structure hot-dip
galvanized? :

23. Total weight of the steel support structure
with the three (3) banks of 4.3 MVAR on it
along with the three (3) CTs
and their support insulators. :

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4.3 MVAR, 21kV (2.42MVAR at 15.75kV) SHUNT CAPACITOR BANK

ATTACHMENT "B"

1. INITIAL COST AND LOSSES

a. Capacitor rating : 4,3 MVAR

b. Capacitor first cost (The capacitor total 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.

This cost will also include the corresponding custom duties and any other charge which Purchaser will consider necessary).

: K=.....€

c. Total capacitor losses : A=.....kW

2. Capacitor annual cost

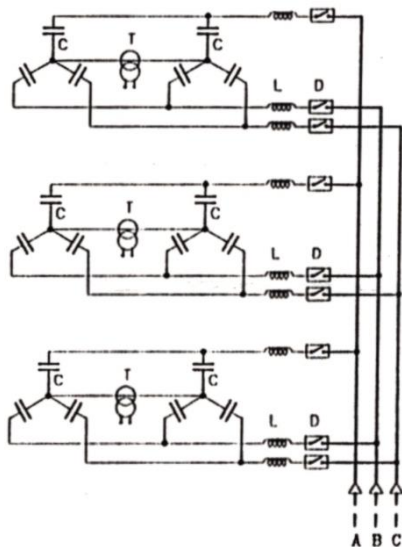
a. at (9,37% per cent) : $\frac{9,37.K}{100} = \dots\dots\dots\text{€}$

b. Power cost : 130€/Kw.A =.....€

c. Energy cost : 0,0374€/Kwh.A.1080hours =.....€

Total annual cost : sum of (a+b+c) =.....€

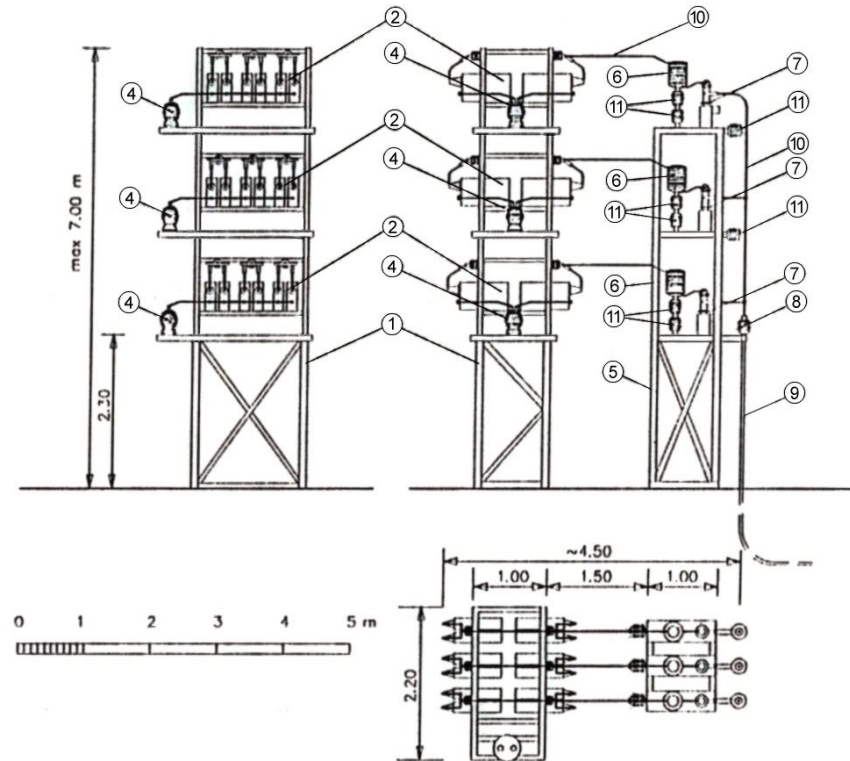
SCHEMATIC DIAGRAM



C: Capacitor unit
(Number of units depends
on manufacture's design)
L: Damping reactor
D: Load break switch

LEGEND

1. Support structure for three (3) capacitor banks.
2. Capacitor bank of 4 MVar, ungrounded double-wye.
4. Neutral current transformer.
5. Load break switch and reactor support structure
6. Damping reactor.
7. Capacitor load break switch.
8. Terminal cable-end box.
9. Underground cable, 300 mm² (length = ~ 50 m).
10. Connection conductor (bus of Cu tube Φ 20/16 mm).
11. 20 kV support porcelain insulator



NOTES

1. The height of the capacitor banks support structure base must be 2.30 m.
2. The total height of the capacitor banks support structure can not be greater than 7.0 m
3. Items 1,2,3 & 4 will be included in the offer for the capacitor banks.

ΠΕΡΙΓΡΑΦΗ				ΤΙΤΛΟΣ				PPC-NTPD		CAPACITOR BANK ARRANGEMENT		SCALE 1:100		DRWG. No	
ΑΝΑΘΕΩΡΗΣΕΙΣ				ΣΧΕΤΙΚΑ ΣΧΕΔΙΑ						3x4 MVar		Sheet 1 of 1		OM-P-32	
1	2	3	4	5	6	7	8								