

**INDEPENDENT POWER TRANSMISSION OPERATOR S.A.**

**TNPRD/ SUBSTATION SPECIFICATION & EQUIPMENT SECTION**

November 2019

**SPECIFICATION No SS-57/19**

**280MVA, 400 / 157.5 / 30kV THREE-PHASE AUTOTRANSFORMERS**



















**ATTACHMENT "A"**

**INFORMATION BY SELLER**

1. Type of auto-transformer (short description)

Nominal voltage :.……………………………..

Number of phases :.……………………………..

Connections symbolism :.……………………………..

Rated power :.……………………………..

2. Core type :…………………………………

a. Flux density at rated voltages (at no load and

principal tap position) :…………………………………

…………………………………

b. Number of core limbs :…………………………………

3. Insulation levels :…………………………………

…………………………………

…………………………………

…………………………………

…………………………………

…………………………………

…………………………………

…………………………………

…………………………………

4. Maximum permissible short circuit duration :…………………………………

…………………………………

5. Over-voltage capability

a) at no load :…………………………………

b) at 280 MVA :…………………………………

6. Long-time emergency overload capability

Maximum current at HV – MV terminals :……………………% of rated

7. Autotransformer connection. : ……………………………………

8. Insulation category of windings (uniform or

non-uniform) : ……………………………………

…………………………………

9. Temperature rise limits : …………K for windings

: …………K for oil

: …………K for winding hot-spot

10. Thermal model constants

(calculated values following IEC 60076-7):

1. Top-oil to ambient temperature rise

with losses (load + no-load) at rated loading

of all windings - Δθor : ………………………… K

1. Average winding to oil temperature gradient

at rated current - gr  : ………………………… K

1. Hot-spot to top-oil temperature rise

at rated current - Δθhr : ………………………… K

1. Hot-spot factor - H : …………………………
2. Exponential power of total losses

versus top-oil temperature rise

(oil exponent) - x : …………………………

1. Exponential power of current

versus winding temperature rise

(winding exponent) - y : …………………………

1. Average oil time constant - τo : ………………………… min
2. Winding time constant - τw : ………………………… min
3. Constant k11 : …………………………
4. Constant k21 : …………………………
5. Constant k22 : …………………………

11. Losses and PEI data

(The guaranteed losses shall be as indicated in paragraph VII-18)

11.1. No Load losses and exciting current at principal tap:

Voltage level No load loss Exciting current

(kW) (% of rated current)

a) 380 kV …………………… …………………

b) 400 kV …………………… …………………

c) 420 kV …………………… …………………

11.2. Load losses at principal tap and reference temperature 75°C:

Load on HV and Load loss (kW)

MV side (MVA) with no load

(HV = MV) on LV side

280 …………………….

210 …………………….

140 …………………….

70 …………………….

11.3. Load loss at principal tap and 75°C

with 60 MVA on HV and LV side

and no load on MV side :………………… kW

11.4. Load loss at principal tap and 75°C

with 60 MVA on MV and LV side

and no load on HV side :………………… kW

11.5. Total losses at principal tap and 75°C

with 280 MVA on HV – MV side

and 60 MVA on LV side

(no-load + load loss) :………………… kW

11.6. Total cooling system loss

(all cooling units in operation,

excluding standby cooler) :………………… kW

11.7. Cooling system losses at AT/F no-load operation

(only the first cooling control group in operation) :………………… kW

11.8. Efficiency Index (EI) at principal tap:

Load on HV and Efficiency Index

MV side in MVA with no load on

(HV = MV) LV side

280 …………………%

210 …………………%

140 …………………%

70 …………………%

11.9. Peak efficiency index (PEI)

according EN 50629 :…………………%

11.10. Load factor at HV – MV terminals

at which PEI occurs, at 280 MVA base :………………… pu

12. Impedances in (%) at principal tap, at 280 MVA power and rated voltage, corrected

to 75°C:

12.1. Positive sequence impedances

a) HV / MV :…………………………………

b) HV / LV :…………………………………

c) MV / LV :…………………………………

12.2. Zero- sequence impedances

a) HV (MV open-circuited) :…………………………………

b) HV (MV short-circuited) :…………………………………

c) MV (HV open-circuited) :…………………………………

d) MV (HV short-circuited) :…………………………………

13. Average sound pressure level

- Autotransformer without cooling (no-load) :…………………………dB(A)

- With all coolers at rated power and voltage

(excluding standby cooler) :…………………………dB(A)

14. Harmonics of no-load current for principal tap

(400/157.5/30kV):

a. Third harmonic :………% of no-load current

b. Fifth harmonic :………% of no-load current

c. Seventh harmonic :………% of no-load current

15. On - load tap changer (OLTC)

a.Manufacturer and type of the OLTC : ……………………………..

b. List all parts of the OLTC : ……………………………..

………………………………

………………………………

………………………………

………………………………

c. Is the OLTC of vacuum switching type? : ……………………………..

d. Number of tapping positions : ……………………………..

………………………………

e. Operating temperature

Minimum : ………………………………

Maximum : ……………………………...

f. Is the tap selector and the reversing

change – over selector in their own

not oil – tight compartment? : ………………………………

………………………………..

………………………………..

g. Is the diverter switch and the

transition resistors in their own

oil – tight compartment? : ………………………………

……………………………….

h. Is the OLTC equipped with its

own conservator ? : ……………………………..

i. Is the oil of OLTC free from PCBs or

PCTs, suitable for transformers and

in accordance with IEC 60296? : ………………………………

j. Is the conservator equipped with

oil level indicator and breather? : ………………………………

……………………………….

k. Is the diverter switch and

transition resistors compartment

equipped with a filling and

a drain tap ? : ………………………………

………………………………..

l. Does the OLTC consist of

a three – phase unit ? : ………………………………

m. Is the OLTC equipped with its own

oil-flow relay? : ………………………………

Describe where it is installed : ………………………………

Type and manufacturer : ………………………………

16. Tapping arrangement : ………………………………

17. Position of regulating winding : ………………………………

18. Maximum rated through current of OLTC : ………………………………

19. Maximum rated step voltage of OLTC : ………………………………

20. Rated frequency of OLTC : ………………………………

21. Rated Voltage of OLTC : ……………………………...

22. Supply voltage for the control circuits

of the motor drive unit : ……………………………...

23. Rated power frequency withstand

voltage : ………………………………

24. Rated lightning impulse withstand

voltage : ……………………………...

25. Describe the oil – flow controlled

relay and where it is installed : ………………………………

………………………………..

………………………………..

………………………………..

26. Number of make output contacts

of the oil – flow controlled relay : ……………………………….

27. Describe the pressure relief

device and where it is installed : ……………………………….

……………………………….

……………………………….

……………………………….

28. Number of make output contacts

of the pressure relief device : ………………………………

29. Time response of the pressure

relief device : ………………………………

30. Pressure or vacuum values for

the diverter switch compartment

and transition resistors : ………………………………

31. Time response of the oil – flow

controlled relay : ………………………………

32. Is the motor drive unit suitable for

Local/Remote operation? : ……………………………….

………………………………..

………………………………..

33. Is the motor drive unit equipped

with emergency stop? : ……………………………….

…………………………………

34. Indicate installation position

of the motor drive unit : ……………………………….

…………………………………

…………………………………

35. Supply voltage of the motor

drive unit motor : …………………………………

36. Frequency of the motor of the

motor drive unit : …………………………………

37. IP class protection of the motor

drive unit panel : …………………………………

38. Is the motor drive control cabinet

equipped with :

a. Local/Remote selector switch : ………………………………..

b. Three (3) Push – buttons for raising,

lowering and emergency stop : ……………………………….

c. A device indicating tap position : ……………………………….

d. Tap counter : ……………………………….

e. Anti - condensation heaters

controlled via thermostat : ……………………………….

f. Supply voltage of the

anti – condensation heaters : ………………………………..

39. Can the motor drive unit be

controlled remotely ? : ……………………………….

………………………………..

40. Can tap position, number of

operations and any alarms be

displayed at a remote distance ? : ……………………………….

41. Power frequency withstand

voltage of the auxiliary circuits

of the motor drive unit : ……………………………….

42. Warranty terms of OLTC : ……………………………….

………………………………...

…………………………………

…………………………………

43. Cooling system

a) Type of cooling system : …………………………………

b) Are the coolers separately mounted

and not on the tank walls? : …………………………………

c) Is the autotransformer equipped with

six (6) independent cooling units with

one of them on standby? : …………………………………

d) Does the cooling system meet the

requirements of paragraph IX.1.d? : …………………………………..

e) Does the cooling system meet the

requirements of the paragraph

IX.1.e? : …………………………………..

f) Does the cooling system meet the

requirements of the paragraph

IX.1.f? : …………………………………..

g) Does the cooling system meet the

requirements of the paragraph IX.1.g,

h, i, j, k, l and m? : ………………………..

h) Cooling unit data

1. Number of fans per cooling unit : …………………………

2. Rated power of the fan motor : ………………………W

3. Power of the fan motor when running : ………………………W

4. Number of pumps per cooling unit : …………………………

5. Rated power of the pump motor : ………………………W

6. Power of the pump motor when running : ………………………W

7. Oil flow of unit when running : ……………………lt/min

44. Autotransformer tank

a. Type : …………………………

b. Material of the tank : …………………………

c. Is the autotransformer tank in

accordance with the requirements of

paragraphs IX.2.b, c, d, e, f and g? : …………………………

45. Autotransformer conservator tank

a. Type : …………………………

b. Is the conservator composed of one piece? : …………………………

c. Describe the method of protection against

moisture: : …………………………

……..……………………

d. Does the conservator meet all requirements

of paragraph IX.3; : ……………………………….

46. Pressure relief device for the autotransformer tank

- Type : ……………………………….

- Location of installation : ……………………………….

- Alarm contacts : ……………………………….

……..…………………………

47. Valves

- Type : ……………………………….

……..…………………………

- Use : ……………………………….

……..…………………………

……..…………………………

48. Oil of the autotransformer :……………………………….

a. Type and manufacturer :……………………………….

b. Does the oil contain any PCBs, PCTs  
 or corrosive Sulphur? :……………………………….

c. Is the oil of the “inhibited transformer oil (I)”

class in accordance with IEC 60296? :……………………………….

49. Bushings H.V Μ.V L.V. Neutral

a. Type ......... .......... .......... ……..

b. Manufacturer ......... .......... .......... ……..

c. Max phase-phase operating voltage (rms) ......... .......... .......... ……..

d. Rated phase to earth operating voltage (rms) ......... .......... .......... ……..

e. Rated current (A) ......... .......... .......... ……..

f. Rated thermal current (A) ......... .......... .......... ……..

g. Rated dynamic current (A) ......... .......... .......... ……..

h. Cantilever withstand load (N) ......... .......... .......... ……..

i. Creepage distance ......... .......... .......... ……..

j. Angle of mounting ......... .......... .......... ……..

k. Thermal limits – class ......... .......... .......... ……..

l. Dielectric dissipation factor ......... .......... .......... ……..

m. Partial discharges at max operating

phase-phase voltage ........ .......... ........... ……..

n. Insulation levels ........ .......... ........... ……..

o. Cross-section of drawn lead or rod ........ .......... ……..

o. Seismic withstand capability ........ .......... ......... ……...

p. Do the bushings meet the requirements

of paragraph IX-8.5 and 8.6? ........ .......... ........ ……..

q. Are the bushings interchangeable

with any other having the same type,

according EN 50458? ........ .......... ........ ……..

50. Bushings current transformers

(Ratio, accuracy class, burden)

- HV : …………………………

…………………………

- MV : …………………………

…………………………

- LV : …………………………

…………………………

51. Are all cables which run on the autotransformer

inside cable trays? : …………………………

52. Type of material of the winding conductors : …………………………

53. Type and manufacturer of Buchholz : …………………………

- Location : …………………………

- Characteristics of alarm contacts : …………………………

- Characteristics of trip contacts : …………………………

54. Type and manufacturer of oil temperature : …………………………

indicator.

- Characteristics of alarm contacts and trip

contacts : …………………………

- Measurements teletransmission

capability : …………………………

55. Type and manufacturer of winding temperature : …………………………

indicator.

- Characteristics of alarm contacts and

trip contacts : …………………………

- Measurements teletransmission

capability (Yes or No) : …………………………

56. Type and manufacturer of oil flow : …………………………

indicator.

- Characteristics of alarm contacts and

trip contacts : …………………………

57. Type and manufacturer of oil level : …………………………

indicator.

- Characteristics of alarm contacts and

trip contacts : …………………………

58. Autotransformers mass protection system

- Current transformer

(ratio, burden, class) : …………………………

59. Type and manufacturer of rapid pressure rise relay : …………………………

- Location of installation : …………………………

- Characteristics of alarm contacts : …………………………

60. Type and manufacturer of on-line

moisture and dissolved gas monitoring

system §12.9 : …………………………

61. Net weights and dimensions

- Transportation weight : …………………..… kg

- Core (steel) : …………………..… kg

- Coils (copper) : …………………..… kg

- Tank and fittings : …………………..… kg

- Oil : …………………..… kg

- Total weight : …………………..… kg

- Untanking weight : …………………..… kg

- Active part weight : …………………..… kg

- Overall height (including bushings) : ………………………m

- Height over tank : ………………………m

- Projected floor dimensions:

Length : ………………………m

Width : ………………………m

- Description of the movement system : …………………………

..…………………………

- Description of the unloading and

transportation way : …………………………

..…………………………

62. Tests (acceptance of the specified tests)

(Yes or No) : …………………………

63. Type and manufacturer of the explosion

and fire prevention system (description) : …………………………

..…………………………

..…………………………

..…………………………

64. Type and manufacturer of the direct hot-spot

temperature measurement system and number

of sensors per winding (description) : …………………………

..…………………………

..…………………………

65. Color of the autotransformer : …………………………

66. Corrosivity category and durability  
 category of the autotransformer’s painting,  
 according ISO 12944 : …………………………

67. Describe with what the autotransformer

tank will be filled for transport purposes : …………………………

..…………………………

68. Type of material, manufacturer and country of

origin of the autotransformer core material : …………………………

..…………………………

69. Does the autotransformer layout follow

the drawing of par.XIII? : …………………………

70. Does the autotransformer tank layout follow

the drawings SK-883B, C and D,

as well as par.XV ? : …………………………

71. Does the autotransformer accessories

packing follow par.XX? : …………………………

72. Is the Condition Monitoring System

according to Annex A? : …………………………

(If required in the Inquiry)

**280MVA, 400 / 157.5 / 30kV THREE-PHASE AUTOTRANSFORMERS**

**ATTACHMENT "B"**

**CAPITALIZATION OF LOSSES**

**INFORMATION BY SELLER**

For the capitalization of losses, the method of EN 50629, Annex E is used.

**1. Autotransformer initial cost and losses:**

a. Autotransformer initial cost

(The auto-transformer total initial cost will be

calculated by the Purchaser according to the

Special Terms of the Inquiry – evaluation of the Bids) : IC = …………………. €

b. No-load loss at rated voltage and principal tapping

(guaranteed value) : P0 = ………………. kW

c. Load loss at rated load 280 MVA on HV and MV sides

(HV = MV), no load on LV side, at principal tapping

and at reference temperature 75°C, (guaranteed value) : PHM = ……………… kW

d. Load loss at load 60 MVA on HV and LV sides

(HV = LV), no load on MV side, at principal tapping

and at reference temperature 75°C, (guaranteed value) : PHL = ……………… kW

e. Load loss at load 60 MVA on MV and LV sides

(MV = LV), no load on HV side, at principal tapping

and at reference temperature 75°C, (guaranteed value) : PML = ……………… kW

f. Cooling loss at autotransformer no-load operation, with

only the first cooling control group in operation

(guaranteed value) : PC0 = ……………… kW

g. Total cooling loss, with all cooling units in operation,

excluding standby cooler (guaranteed value) : PCS = ……………… kW

**2. Autotransformer total ownership cost**

The capitalized losses (CL) and the total cost of ownership (TCO) of the autotransformer will be calculated from the above mentioned data and the following mathematical types. As an intermediate step, the calculation of the total load loss Pk of the autotransformer is necessary, at rated load 280 MVA on HV and MV sides, rated load 60 MVA on LV side, at principal tapping and at reference temperature 75°C. The following type for this calculation is based on the method described in IEC 60076-8. In all types, all losses are expressed in kW and all costs are expressed in €.

Pk = 0.977 ∙ PHM + 0.5 ∙ (PHL + PML)

Total load loss Pk = ………………… kW

CL = 6805 ∙ (P0 + PC0) + 1467 ∙ (Pk + PCS – PC0)

Capitalized losses (CL) = ……………………… €

TCO = IC + CL

**Total ownership cost (TCO) = ……………………… €**

**3. Penalty for losses excess**

With regard to load and no-load losses, an autotransformer is considered as successfully inspected if the losses measured during inspection (relevant routine tests, par.X.1.3, X.1.4 and type test, par.X.2.4) do not exceed the losses guaranteed by Seller (par.VII.18), by more than the maximum accepted tolerance of 15% for no-load, load and cooling losses, as well as 10% for the total losses, according to IEC 60076-1. Also the peak efficiency index (PEI), calculated from measured values, shall not exceed the minimum T2 PEI limit (par.VII.18) with no tolerance, which is 99.770%, according to EN 50629. Otherwise the autotransformer is rejected. The measurement uncertainty is not taken into account, according to IEC 60076-19 and EN 50629.

On each successfully inspected autotransformer, any difference in the losses versus the guaranteed ones (without tolerance), shall be negative or zero. If such difference is positive, meaning the losses ascertained during inspection exceed the guaranteed ones (without tolerance), a penalty shall be imposed on the Seller consisting of the difference CL’ – CL. CL is calculated from the mathematical type stated above and the guaranteed loss values, whereas CL’ is calculated from the same mathematical type as CL and the measured loss values during inspection.

If the difference CL’ – CL is negative, the Seller is not entitled to any additional payment, whereas if this difference is positive, the penalty shall be imposed.