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SPECIFICATION SS – 38/8
LINE TRAPS
FOR POWER LINE CARRIER (PLC)

I. SCOPE

This hereby specification covers the required technical characteristics, constructional features and testing requirements of line traps.

II. KEY WORDS

Line traps, Wave traps, Power line carrier, Tuning device, Main coil.

III. STANDARDS

The line traps shall be in accordance with the latest edition of IEC 60353 Standard.

IV. USE

The line traps are to be used in series in PPCs 400 kV and 150 kV transmission lines and to be inserted in the line between the point of connection of carrier-frequency signals and adjacent power system elements such as bus bars, VTs etc.

V. PPC's 400kV AND 150kV ELECTRICAL SYSTEM CHARACTERISTICS

	<u>150 kV System</u>	<u>400 kV System</u>
1. Nominal Voltage :	150 kV	400 kV
2. Maximum operating voltage :	170 kV	420 kV
3. Frequency :	50 Hz	50 Hz
4. Number of phases :	3	3
5. Basic insulation level (BIL) :	750 kV Crest	1550 kV Crest
6. Short circuit level :	30 kA	40 kA
7. Grounding Method :	Solidly grounded	Solidly grounded

VI. OPERATING CONDITIONS

1. Installation :	Outdoors
2. Ambient Temperature during operation :	-25°C to + 45°C
3. Altitude :	Up to 100 m above sea level

- | | |
|----------------------|-------------------|
| 4. Pollution : | Medium |
| 5. Other Conditions: | Show, Ice and fog |

VII. DESCRIPTION OF THE LINE TRAP FUNCTION - REQUIRED COMPONENTS OF THE LINE TRAP

1. Description of the Function

The main function of the line trap is to present a high impedance at the carrier frequency band while introducing negligible impedance at power frequency. The high impedance limits the attenuation of the carrier signal within the power system, by preventing the carrier signal from being :

- Dissipated in the substation
- Grounded in the event of a fault outside the carrier transmission path
- Dissipated in a tap line or a branch of the main transmission path

2. Required Components

The line trap shall consist of the following basic components :

- Main coil
- Tuning device
- Protective device

VIII. REQUIRED TECHNICAL CHARACTERISTICS OF THE LINE TRAP COMPONENTS AND DESCRIPTION OF THEM

1. Main Coil

- a. The main coil of the line trap is an air-core dry-type reactor inductor which carries the power – frequency current of the transmission line.
- b. The winding of the main coil can be constructed with either one of the two well established winding technologies, that is :
 - Encapsulated design (E-design)
utilizing aluminum wire or cable or
 - Open style design (O-design)
utilizing aluminum flat bar conductor

2. Tuning Device

a. The tuning device consists of a combination of capacitors, inductors and resistors all having relatively low power ratings, connected across the main coil, thus forming a blocking circuit which provides high impedance over a specified PLC – frequency range.

b. Required type of tuning

- Single frequency tuning or
- Wide – band tuning

depending on the required carrier frequency bandwidth

c. The tuning device will have power frequency voltage withstand for 5 sec duration and lightning impulse voltage withstand, as stated in par. XI for the line trap. It will be also designed, in order to withstand the voltage at line trap terminals, which is produced by continuous current equal to the rated, or by overload current of corresponding duration, according to Table I, par. XI.

d. The bipolar withstand voltage (U_{BPD}) of each individual capacitor element of the tuning device, at 10^5 pulses, shall be higher than the residual voltage U_p (at 20 kA discharge current) of the surge arrester divided by the number 'n' of series connected capacitor elements.

e. To meet changing PLC – frequency requirements, the tuning device must be easily accessible for replacement or field adjustment and for changing its components without removing the line trap. It shall be so designed that neither significant alternation in the line trap blocking requirements, nor physical damage shall result from either the temperature rise or the magnetic field of the main coil at continuous rated current, rated short-time or emergency overload current.

3. Protective Device

The protective device shall be a gapless metal-oxide surge arrester connected in parallel with the main coil and the tuning device. It shall protect the main coil and the tuning device by reducing transient overvoltages.

a. Required technical characteristics of the gapless metal-oxide surge arrester :

	<u>For the surge arrester of 150kV line traps *</u>	<u>For the surge arrester of 400kV line traps *</u>
1. Rated Voltage (U_r) for line trap with 0.2mH rated inductance	$2.4kV \leq U_r \leq 3.1kV$	$3.0kV \leq U_r \leq 4.0kV$
1.1 Rated Voltage (U_r) for line trap with 0,5 mH rated inductance	$6.0kV \leq U_r \leq 7.8kV$	$7.6kV \leq U_r \leq 9.9kV$
2. Nominal discharge current :	10 kA	10 kA
3. Impulse withstand current 4/10 :	100 kA	100 kA
4. Residual Voltage at 10KA discharge current and a waveshape of 8/20 μs :	$\leq 22 kV$	$\leq 29 kV$

* The values of rated and residual voltages are valid for line traps with rated inductance values (L_{IN}) 0.2 mH and 0.5 mH.

IX. REQUIRED LINE TRAP ACCESSORIES

1. Bird barrier

The line trap must be equipped with a bird barrier of such design (grid), so that no entrance to the line trap shall admit a sphere having a diameter of 16 mm.

2. Terminals

The line trap shall be equipped with aluminum flat pad terminals of about 100mmX100mm in dimensions and undrilled. The terminals shall be located on

opposite sides of the line trap with one at the top and the other at the bottom of the line trap. The terminals of the line traps should be able to withstand a 1000N static load.

X. INSTALLATION REQUIREMENTS

A. For the 150 kV System

1. The line traps shall be designed as to be capable of being installed with the following two (2) ways :
 - a. Suspended via single point bracket
 - b. Pedestal mounted directly on top of coupling capacitor, which its top base has a diameter of about 30 cm. The pedestal, an invert cone in shape, shall be part of the supply and its base, which shall be used for the mounting to the coupling capacitor, shall be delivered undrilled.
2. The suspension system of the line trap shall be designed for a tensile stress of at least twice the mass of the line trap in kilograms, multiplied by 9.81 to convert to the Newtons, plus 5000 N.

B. For the 400 kV System

The line traps shall be designed as to be capable of being pedestal mounted and on steel structure via three (3) station post insulators. The pedestal shall be part of the supply, but not the post insulators.

XI. REQUIRED RATING CHARACTERISTICS OF THE LINE TRAP

	<u>For the 150 kV System</u>	<u>For the 400 kV System</u>
1. Rated power frequency :	50 Hz	50 Hz
2. Rated main coil inductance at 100kHz frequency (L_{IN}) :	0.2mH or 0.5mH (see inquiry)	0.2mH or 0.5mH (see inquiry)
3. Rated continuous current :	1000 A	2000 A or 3000 A (see inquiry)
4. Rated short-time current :	31.5 kA/1s	40 kA/1s
5. Carrier frequency bandwidth (Δf_R) based on blocking resistance :	As indicated in the inquiry.	As indicated in the inquiry.
6. Self-resonant frequency of main coil:	$\geq 500\text{kHz}$	$\geq 500\text{kHz}$
7. Quality factor Q of main coil at 100kHz frequency:	≥ 30	≥ 30

8.	Power frequency voltage withstand between the terminals of the line trap :	3.1kV for 0.2mH 7.8kV for 0.5mH	4.0kV for 0.2mH 9.9kV for 0.5mH
9.	Lightning impulse voltage withstand between the terminals of the line trap :	1.3x residual voltage of protection device at 10kA	1.3x residual voltage of protection device at 10kA
10.	Minimum blocking resistance :	See Note 2	See Note 2
11.	Emergency overload current :	As indicated in the Table I below	As indicated in the Table I below

Table I

Emergency overload current as a percentage of rated continuous current

Ambient temperature (°C)	Emergency Period		
	15min	30min	60min
+45	138.75	128.75	118,75
+40	140	130	120
+20	145	135	125
0	150	140	130
-20	155	145	135
-25	156.75	146.75	136.75

Note 1 :

The rated main coil inductance (L_{tN}) includes the compensation due to self-capacitance of the coil. The power frequency inductance (L_p) can have up to 10% greater value than the rated inductance at 100kHz frequency (L_{tN}). The rated inductance will have tolerance up to $\pm 10\%$ between stated and measured value.

Note 2 :

The minimum blocking resistance depends on the carrier frequency bandwidth. The formula used for the calculation of the minimum resistive component is as follows:

$$R_b \approx \frac{2 \cdot \pi \cdot k \cdot L_{tN} \cdot (f_{1R} \cdot f_{2R})}{f_{2R} - f_{1R}}$$

Where: L_{tN} = rated inductance of the line trap

f_{1R} =The minimum frequency of the carrier frequency bandwidth

f_{2R} =The maximum frequency of the carrier frequency bandwidth

$k = 0.9$ to 0.7 , with 0.7 applicable for low carrier frequencies (below 150KHz)

XII ADDITIONAL REQUIRED CHARACTERISTICS OF THE LINE TRAP

1. Limits of temperature rise

The temperature rise in any part of the line trap under rated continuous current conditions shall not exceed the values given in table II at altitudes up to 1000m and at temperature range from -25°C to $+45^{\circ}\text{C}$

Table II

Limits of temperature rise

Insulation class and reference temperature ($^{\circ}\text{C}$)	Maximum temperature rise ($^{\circ}\text{C}$)	
	Hot spot measured by direct methods	Average value measured by increase in resistance
105 (A)	70	60
120 (E)	95	80
130 (B)	105	85
155 (F)	130	110
185 (H)	150	135
220 (C)	195	155

2. Radio Influence voltage (RIV)

The radio influence voltage (RIV) observed at a test voltage of 113 kV ($1.15 \cdot (U_m / \sqrt{3})$) for the 150kV system and at test voltage of 280kV ($1.15 \cdot (U_m / \sqrt{3})$) for the 400kV system shall be $\leq 500\mu\text{V}$ for both cases.

Where $U_m = 170\text{kV}$ for the 150kV system and $U_m = 420\text{kV}$ for the 400kV system

XIII. RATING PLATES

The main coil, the tuning device and the protective device shall be provided with rating plates of weatherproof material fitted so that they are readily visible. The inscriptions shall be indelibly marked and include the following data:

1. Rating plate of the main coil

- Manufacturer's name and year of manufacture
- Type
- Serial number
- Rated inductance (mH)
- Power-frequency inductance (mH)
- Rated continuous current (A)
- Rated power frequency (Hz)
- Rated short-time current (kA) and duration (s)
- Total weight (Kg)

2. Rating plate of tuning device

- Manufacturer's name and year of manufacture
- Type

- c) Serial number
- d) Frequency band (s) (kHz)
- e) Blocking impedance (minimum value) (Ω)
- f) Blocking resistance (minimum value) (Ω)
- g) Rated impulse protective level (kV)
- h) Belonging to main coil with rated inductance (mH) and serial number

3. Rating plate of the protective device

- a) Manufacture
- b) Serial Number
- c) Continuous operating voltage (kV)
- d) Rated voltage (kV)
- e) Maximum residual voltage at nominal discharge current (kV)
- f) Nominal discharge current (kA)
- g) Rated short-circuit current (kA)

XIV. TESTS

The tests specified below shall be carried out in accordance with IEC-60353 unless is indicated otherwise

A. Routine Tests

1. Power frequency voltage test on tuning device. The test voltage shall be
 - For the 150kV system, for line trap with 0.2mH rated power frequency inductance: $1.3xU=3.1kV$
 - For the 150kV system, for line trap with 0.5mH rated power frequency inductance: $1.3xU=7.8kV$
 - For the 400kV system, for line trap with 0.2mH rated power frequency inductance: $1.3xU=4.0kV$
 - For the 400kV system, for line trap with 0.5mH rated power frequency inductance: $1.3xU=9.9kV$
 - Duration= 5 sec
2. Measurement of the rated inductance of the main coil at 100kHz frequency (L_{tN})
3. Measurement of the power frequency inductance of the main coil at 50Hz frequency (L_p)
4. Measurement of blocking resistance (R_b) and blocking impedance (Z_b) in the carrier frequency bandwidth, as specified in the inquiry.
5. Measurement of tapping loss (A_t and A_{tR}) in the carrier frequency bandwidth, as specified in the inquiry.
6. Residual voltage test on protective device in accordance with IEC-60099-4

B. Type Tests

1. Temperature Rise test

It (test current) = Rated continuous current (I_N) or if for some reason it is not possible, then $I_t \geq 90\% I_N$

2. Measurement of Radio Influence voltage

- The test voltage for the 150kv line traps shall be 113kV
- The test voltage for the 400kv line traps shall be 280kV

3. Lightning Impulse voltage test

This test shall be carried out as described in IEC 60353

4. Short - time current tests

The test current shall be the rated short-time current of the line trap

- a. The mechanical strength of the line trap shall be proved and
- b. The thermal behavior of the line trap shall be proved

5. Residual voltage test on protective device in accordance with IEC-60099-4 at 8/20 μ s waveform:

- a. 5kA
- b. 10kA
- c. 20kA

If the above residual voltage values do not appear on the test certificate, then their calculation will be provided by the protective device manufacturer.

6. Voltage endurance test of capacitor elements on bipolar pulses

The test will be executed with bipolar (positive and negative) pulse frequency of 50Hz and voltage rise rate on each pulse at least 40kV/ μ s. The test will be executed at least four (4) times, at different voltage level of pulses, with measurement of the corresponding life of the capacitor element in pulse number. From these measurements, the withstand voltage at bipolar pulses (U_{BPD}) of the capacitor element for life of 10^5 pulses will be graphically defined.

XV. DATA TO BE SUBMITTED BY ALL BIDDERS

1. Bidders must provide all information requested in "ATTACHMENT 'A' or B" depending on the system voltage for which the line trap is intended for, of this hereby specification. Failure on the bidder's part to comply with this request will be taken as sufficient reason for rejection of the offer.

2. Technical pamphlets and brochures of the line trap which will help the evaluation process

3. Drawings showing the outline dimensions and dimensional details of

- a. The line trap itself
- b. All of its components
- c. The pedestal

4. Any official test reports for the type tests specified in this hereby specification. Acceptance or not lies on the Judgement of PPC S.A.
5. Any voltage endurance test reports on the capacitor elements of the tuning device

XVI. DATA TO BE SUBMITTED BY THE SUCCESSFUL BIDDER

After the signing of the contract the successful bidder shall submit three (3) sets of the following drawings for approval, prior to the line traps construction.

1. Outline drawing of the line trap and its components and accessories
2. Detail dimensional drawings of the line trap itself, its components, and pedestal
3. A detailed drawing indicating mounting of the line trap on pedestal

XVII. PACKING

The line traps along with their pedestal shall be delivered inside of entirely closed robust wooden boxes of at least 20mm thickness. One line trap will be packed per box. The boxes will be of "pallet type" with strengthened base.

**“ATTACHMENT A”
LINE TRAPS
FOR THE 150KV SYSTEM**

Data to be provided by bidders. Failure to comply will constitute sufficient reason for rejection of the offer.

1. Manufacturer :
2. Type :
3. List all the components of the line trap :
.....
.....
4. Which winding technology is employed for the winding of the main coil :
.....
.....
5. Which type of tuning is employed :
.....
.....
6. Technical Characteristics of the protective device :
 - a. Manufacturer :
 - b. Type for line trap with 0.2mH / 0.5mH rated inductance :/.....
 - c. Rated voltage for line trap with 0.2mH / 0.5mH rated inductance :/.....
 - d. Continuous operating voltage for line trap with 0.2mH / 0.5mH rated inductance :/.....
 - e. Nominal discharge current :/.....
 - f. Impulse withstand current :/.....
 - g. Residual voltage at 5kA discharge current and 8/20 μ s waveform :/.....
 - h. Residual voltage at 10kA discharge current and 8/20 μ s waveform :/.....
 - i. Residual voltage at 20kA discharge current and 8/20 μ s waveform :/.....

- j. Is the surge arrester of the gapless metal oxide type; :
- 7. Indicate the bipolar withstand voltage (U_{BPD}) of each capacitor element of the tuning device :
- 8. Indicate the number of series connected capacitor elements of the tuning device for line trap with 0.2mH / 0.5mH rated inductance :/.....
- 9. Is the line trap equipped with a bird barrier of such design so that no entrance to the line trap shall admit a sphere having a diameter of 16mm? :
- 10. Shape and material of the line trap terminals :
:
- 11. Describe the method of installation of the line trap :
:
:
:
- 12. Tensile suspension stress of the line trap :
- 13. Rating Characteristics of the line trap with 0.2mH / 0.5mH rated inductance
 - a. Power frequency :
 - b. Power frequency inductance :/.....
 - c. Rated inductance (at 100kHz) :/.....
 - d. Continuous Current :/.....
 - e. Short – time current of 1s duration :/.....
 - f. Quality factor Q of main coil at 100kHz frequency :/.....
 - g. Self-resonant frequency of main coil :/.....
 - h. Carrier frequency bandwidth (Δf_R) based on blocking resistance :/.....

- i. Carrier frequency bandwidth (Δf) based on blocking impedance :
- j. Is the emergency overload current according to table I? :
- k. Power frequency voltage withstand between the terminals of the line trap :
- l. Lightning impulse voltage withstand between the terminals of the line trap :
- m. Minimum blocking resistance :
- n. Minimum blocking impedance :
- 14. Are the limits of temperature rise according to table II? :
- 15. Radio Influence Voltage (RIV) :
- 16. Approximate power losses of the line trap with 0.2mH / 0.5mH rated inductance :
- 17. Core cross – section of the main coil for line trap with 0.2mH / 0.5mH rated inductance :
- 18. Total height of the line trap without the pedestal with 0.2mH / 0.5mH rated inductance :
- 19. Total height of the line trap including the pedestal :
- 20. Total diameter of the line trap :
- 21. Total weight of the line trap without the pedestal :
- 22. Total weight of the pedestal :
- 23. Dimensions of the pedestal :
- 24. Are the line traps with their pedestals, going to be delivered packed inside of entirely closed robust wooden boxes of "pallet type" with strengthened base of at least 20mm thickness, one line trap per box? :

**“ATTACHMENT B”
LINE TRAPS
FOR THE 400KV SYSTEM**

Data to be provided by bidders. Failure to comply will constitute sufficient reason for rejection of the offer.

1. Manufacturer :
2. Type :
3. List all the components of the line trap :
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.....
4. Which winding technology is employed for the winding of the main coil :
.....
.....
5. Which type of tuning is employed :
.....
.....
6. Technical Characteristics of the protective device :
 - a. Manufacturer :
 - b. Type for line trap with 0.2mH / 0.5mH rated inductance :/.....
 - c. Rated voltage for line trap with 0.2mH / 0.5mH rated inductance :/.....
 - d. Continuous operating voltage for line trap with 0.2mH / 0.5mH rated inductance :/.....
 - e. Nominal discharge current :/.....
 - f. Impulse withstand current :/.....
 - g. Residual voltage at 5kA discharge current and 8/20 μ s waveform :/.....
 - h. Residual voltage at 10kA discharge current and 8/20 μ s waveform :/.....
 - i. Residual voltage at 20kA discharge current and 8/20 μ s waveform :/.....

- j. Is the surge arrester of the gapless metal oxide type; :
7. Indicate the bipolar withstand voltage (U_{BPD}) of each capacitor element of the tuning device :
8. Indicate the number of series connected capacitor elements of the tuning device for line trap with 0.2mH / 0.5mH rated inductance :/.....
9. Is the line trap equipped with a bird barrier of such design so that no entrance to the line trap shall admit a sphere having a diameter of 16mm? :
10. Shape and material of the line trap terminals :
:
11. Describe the method of installation of the line trap :
:
:
:
12. Tensile suspension stress of the line trap :
13. Rating Characteristics of the line trap with 0.2mH / 0.5mH rated inductance
- a. Power frequency :
- b. Power frequency inductance :/.....
- c. Rated inductance (at 100kHz) :/.....
- d. Continuous Current :/.....
- e. Short – time current of 1s duration :/.....
- f. Quality factor Q of main coil at 100kHz frequency :/.....
- g. Self-resonant frequency of main coil :/.....
- h. Carrier frequency bandwidth (Δf_R) based on blocking resistance :/.....

- i. Carrier frequency bandwidth (Δf) based on blocking impedance :
- j. Is the emergency overload current according to table I? :
- k. Power frequency voltage withstand between the terminals of the line trap :
- l. Lightning impulse voltage withstand between the terminals of the line trap :
- m. Minimum blocking resistance :
- n. Minimum blocking impedance :
- 14. Are the limits of temperature rise according to table II? :
- 15. Radio Influence Voltage (RIV) :
- 16. Approximate power losses of the line trap with 0.2mH / 0.5mH rated inductance :
- 17. Core cross – section of the main coil for line trap with 0.2mH / 0.5mH rated inductance :
- 18. Total height of the line trap without the pedestal with 0.2mH / 0.5mH rated inductance :
- 19. Total height of the line trap including the pedestal :
- 20. Total diameter of the line trap :
- 21. Total weight of the line trap without the pedestal :
- 22. Total weight of the pedestal :
- 23. Dimensions of the pedestal :
- 24. Are the line traps with their pedestals, going to be delivered packed inside of entirely closed robust wooden boxes of "pallet type" with strengthened base of at least 20mm thickness, one line trap per box? :