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SPECIFICATION SS – 51/9
400KV COUPLING CAPACITORS
FOR POWER LINE CARRIER SYSTEM

I. SCOPE

This hereby Specification covers rating characteristics, technical features and testing for 400 KV coupling capacitors.

II. KEYWORDS

Coupling capacitors, capacitors, capacitor stack, capacitor unit, capacitor element

III. STANDARDS

The coupling capacitors shall conform to IEC 60358-1 and IEC 60358-2 standards.

IV. USE

The coupling capacitors in conjunction with the line traps and line tuners shall provide a low loss signal path for selected power line carrier (PLC) frequencies while attenuating other PLC frequencies and noise. In other words, it will be used to couple high frequency power line carrier signals to the 400 KV transmission lines.

V. 400KV ELECTRIC SYSTEM CHARACTERISTICS

- | | |
|---|---|
| 1. Nominal Voltage (phase to phase) | : 400KV |
| 2. Maximum Operating Voltage (phase to phase) | : 420KV |
| 3. Number of phases | : 3 |
| 4. Nominal frequency | : 50Hz |
| 5. Frequency variation | : ± 0.2 Hz |
| 6. Short circuit Level | : 40KA |
| 7. Lightning Impulse withstand level | : 1550KV |
| 8. Method of grounding | : The 400KV system is effectively earthed |

VI. OPERATING CONDITIONS

- | | |
|----------------------------------|-------------------------------|
| 1. Installation | : Outdoors |
| 2. Limits of ambient temperature | : -25 °C, +45 °C |
| 3. Altitude | : Up to 1000m above sea level |
| 4. Pollution Level | : moderate |
| 5. Other climatic conditions | : snow, ice and fog |

VII. REQUIRED DESIGN FEATURES OF THE COUPLING CAPACITORS

1. Construction

The coupling capacitors shall consist of an assembly of capacitors units connected in series (capacitor stack) housed inside a porcelain or a silicon rubber housing and filled with oil.

2. Capacitor Unit

Each capacitor unit shall be an assembly of capacitor elements.

3. Capacitor elements design features

- a. The capacitor elements shall consist either of
 - Aluminum foil and
 - Polypropylene – paper dielectricor
 - Aluminum foil and
 - All film dielectric
- b. Contact between elements shall be achieved by pressure or soldering.

4. Insulating Housing

The coupling capacitor's insulating housing shall consist of either extra high strength porcelain or a cylindrical tube of fiber-reinforced epoxy of high strength, coated with Silicon Rubber (SiR) as to provide superior seismic performance.

The porcelain housing shall comply with IEC 62155 standard. The silicon rubber housing shall comply with IEC 61462 standard.

5. Oil Requirements

The oil used in the coupling capacitors shall be biodegradable and free of any PCB content. PCBs or PCTs are not allowed.

6. Base of the Coupling Capacitor

The base of the coupling capacitor shall allow the coupling capacitor to be mounted on top of a steel structure and this base shall be equipped with a low voltage terminal.

The base shall also bear on itself an earth terminal.

7. Bellows

The coupling capacitors shall be equipped with metallic (stainless steel) bellows in order to accommodate any oil volume changes due to temperature fluctuations.

8. Head of the Coupling Capacitor

On the top of the head of the coupling capacitor, a line terminal shall be installed in a vertical way.

9. Line Terminal

The line terminal shall be a cylindrical rod of aluminum or copper tin plated of 30mm in diameter and with a minimum length of 80mm.

The line terminal shall be installed vertically on the top of the head of the line terminal.

10. Low Voltage terminal

This terminal, which shall be located at the base of the coupling capacitor, shall be provided through an insulating bushing. This terminal shall be used for the connection to the PLC equipment.

11. Carrier Earthing Switch

The carrier earthing switch will be used for earthing of the low voltage terminal. The earthing switch shall be closed, if no drain coil is connected to the low voltage terminal, in order to prevent the occurrence of high voltage to this terminal.

The position of the earthing switch shall be clearly visible.

12. Earth terminal

This terminal, which shall also be located at the base of the coupling capacitor and shall be used for the connection to the earthing grid of the switching station.

VII. REQUIRED RATED CHARACTERISTICS OF THE COUPLING CAPACITORS

1. Rated capacitance at 50Hz (C_r) : $\geq 4400\text{pF}$ or as mentioned in the

	Inquiry
2. Capacitance tolerance at 50Hz	: - 5% ÷ +10% of C_r
3. Rated frequency (f_r)	: 50Hz
4. Rated Voltage (U_r)	: $400/\sqrt{3}$ KV
5. Highest Voltage for equipment (U_m)	: 420KV
6. Rated voltage factor	1.2 continuously 1.5 for 30s
7. Rated temperature category	: -25°C/B, (-25°C/+45°C)
8. Rated short-duration power-frequency withstand voltage	: 680KV rms
9. Rated switching impulse voltage withstand	: 1175KV peak
10. Rated lightning impulse withstand voltage	: 1550KV peak
11. Capacitor loss factor ($\tan\delta$) at 20°C	: ≤ 0.003
12. Partial discharge level	
at 291KV	: ≤ 5 pC
at 420KV	: ≤ 10 pC
13. Radio Interference Voltage (RIV)	
at 267KV	: $\leq 2500\mu$ V
14. PLC frequency range	: 30kHz to 500kHz
15. Variation of Capacitance at PLC frequency range	: - 20% ÷ +50% of C_r
16. Equivalent series resistance between line and low-voltage terminal at PLC frequency range	: $\leq 40\Omega$
17. Creepage distance of the insulation housing	: 10500mm
18. Short-duration power-frequency withstand voltage of low voltage terminal	: 10KV rms
19. Stray capacitance between low voltage terminal and earth terminal at any frequency in the PLC frequency range	: ≤ 200 pF
20. Stray conductance between low voltage terminal and earth terminal at any frequency in the PLC frequency range	: $\leq 20\mu$ S
21. Low voltage terminal bushing's creepage distance	: 60mm

IX. ADDITIONAL REQUIRED DESIGN FEATURES OF THE COUPLING CAPACITORS

1. The coupling capacitor should be able to carry continuously a high frequency current with rms value of 1A, additionally to the power frequency current.
2. The coupling capacitor can be comprised from more identical capacitor units, connected in series. The capacitance of each unit cannot deviate more than 5% from the capacitance of any other unit.
3. The coupling capacitor should be able to withstand the mechanical stresses resulting from winds of 158km/h which corresponds to wind pressure of 120kg/m² with a coefficient of dynamic pressure of 1.0.
4. There will be provisions for all metal parts of the coupling capacitor which are at earth potential in normal service to be connected to earth.
5. The coupling capacitors must be equipped with lifting lugs or other means for lifting purposes.
6. All metal parts of the coupling capacitor shall be hot-dip galvanized

X. RATING PLATE

The following information shall be given on the rating plate of each coupling capacitor:

1. Manufacturer and type
2. Serial Number and year of manufacture
3. Rated Capacitance, C_r , in pF
4. Rated Voltage, U_r in KV
5. Rated frequency, f_r , in Hz
6. Temperature category
7. Power frequency withstand voltage in KV
8. Switching impulse withstand Voltage in KV
9. Lightning impulse withstand voltage in KV
10. Number of units which constitute the complete capacitor
11. Type and mass of insulating oil

12. Total mass, in kg
13. Reference to IEC standard

XI. TESTS

All testing shall be in accordance with IEC 60358 standards and shall be carried out on the coupling capacitor as a whole (Capacitor Stack).

A. Routine Tests

The following routine tests are required:

1. Tightness test.
The method is left to the choice of the Manufacturer.
2. Capacitance and capacitor loss ($\tan\delta$) measurement at power frequency
The measurement will be performed at 23KV and at 208kV-254KV, before the AC voltage test and PD measurement. The measurement will be performed again at 208kV-254KV, after the AC voltage test and PD measurement.
3. AC Voltage test, dry
 - The test voltage being applied between the line and the earth terminals and the low voltage terminal shall be connected directly, or by a low impedance to earth.
 - Test voltage: 680KVrms for 1 minute
4. Partial discharge (PD) measurement
The measurement can be performed during the AC voltage test, while decreasing the voltage, or after the AC voltage test, using a prestress voltage equal to 80% of the AC voltage withstand level for 60s.
The measurement of PD will be performed at 291KV and at 420KV..
5. AC Voltage test for low voltage terminal
 - The test voltage being applied between the low voltage terminal and the earth terminal
 - The test voltage shall be 10KV rms for one (1) minute

B. Special Tests (on one piece of the order)

Mechanical strength test

The test force F_T shall be equal to

$$F_T = [(450 \times I \times d) + 500] \times 1.5 \text{ N}$$

Where I = Length of coupling capacitor in m

d = the largest shed diameter of the insulating envelope.

In any case the test force F_T shall be at least 1500N.

The test force will be applied horizontally and vertically to the capacitor line terminal.

C. Type tests

Before and after the electrical type tests (par. C.1, C.2 and C.3 below), the electrical routine tests (par. A.2, A.3 and A.4) will be repeated. The type tests are as follows:

1. Radio Interference Voltage (RIV) test
The test voltage will be 267KV.
2. Chopped Lightning Impulse test
The voltage impulses will be applied between line and earth terminals with the low voltage terminal connected directly, or via low impedance, to earth. The applied voltage and the current at the low voltage terminal will be recorded during the test.
Positive polarity impulses will be applied as follows:
 - One reduced level, full wave impulse 1.2/50 μ s (50%-75% of 1550KV), as reference
 - Three full level, full wave impulse 1.2/50 μ s at 1550KVNegative polarity impulses will be applied as follows:
 - One reduced level, full wave impulse 1.2/50 μ s (50%-75% of 1550KV), as reference
 - One full level, full wave impulse 1.2/50 μ s at 1550KV
 - Two chopped wave impulses 1.2/2-8 μ s at 1783KV
 - Two full level, full wave impulses 1.2/50 μ s at 1550KV
3. Switching Impulse test, wet
The voltage impulses will be applied between line and earth terminals with the low voltage terminal connected directly, or via low impedance, to earth. The applied voltage and the current at the low voltage terminal will be recorded during the test.
Positive only polarity impulses will be applied as follows:
 - One reduced level, full wave impulse 250/2500 μ s (50%-75% of 1175KV), as reference
 - Fifteen full level, full wave impulses 250/2500 μ s at 1175KV
4. High frequency capacitance and equivalent series resistance measurements
The measurements shall be performed at -25°C, +20°C and +40°C, over the whole PLC frequency range of 30Hz-500Hz.
5. Stray capacitance and stray conductance measurement of the low voltage terminal

XII. DATA WHICH IS REQUIRED TO BE SUBMITTED BY THE BIDDERS

1. Bidders must provide all information requested in attachment "A" 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. Detail outline drawings of the coupling capacitor
3. Explicit drawing of all the terminals (line, low voltage and earth) of the coupling capacitor.

4. Explicit drawings of the base and head of the coupling capacitor
5. Any technical brochures which describe in detail the offered coupling capacitor.
6. Any type test certificates for the type and special tests specified in this hereby specification. Acceptance or not lies on IPTO's judgment.

XIII. DATA WHICH MUST BE SUBMITTED BY THE SUCCESSFUL BIDDER

After the signing of the contract, the successful bidder shall furnish three (3) sets of drawings for approval, prior to the coupling capacitor construction. These drawings shall include the following:

1. Detail outline drawings of the coupling capacitor.
2. Explicit drawing of all terminals (line, low voltage and earth) of the coupling capacitor.
3. Explicit drawings of the base and head of the coupling capacitor.
4. Name plate markings

XIV. PACKING

The coupling capacitors shall be delivered in entirely closed and robust wooden boxes of at least 20mm thickness. The boxes will be of "pallet type", with strengthened base.

Each wooden box will include one (1) piece (coupling capacitor) and all necessary assembling material of the coupling capacitor (if applicable).

ATTACHMENT "A"
400kV COUPLING CAPACITORS
FOR POWER LINE CARRIER SYSTEM

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

1. Manufacturer :
2. Type :
3. Description of construction :
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4. Description of the capacitor elements design :
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5. How is contact achieved between capacitor elements? :
6. Type of the insulating housing of the coupling capacitors :
.....
7. Color of the insulating housing :
8. Description of the oil of the coupling capacitors :
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9. Where are the low voltage and earth terminals located at? :
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.....
.....
10. Type of bellows :
11. Describe the base of the coupling capacitor and how it is mounted on a steel structure :
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12. Description of the line terminal :
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13. Description of the low voltage terminal :
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14. Description of the earth terminal	:

15. Rated characteristics of the coupling capacitors	
a. Rated capacitance at 50Hz (C_r)	:
b. Capacitance tolerance	:
c. Rated frequency (f_r)	:
d. Rated voltage (U_r)	:
e. Highest voltage for equipment (U_m)	:
f. Rated voltage factor	:

g. Rated temperature category	:
h. Rated short-duration power frequency withstand voltage	:
i. Rated switching impulse withstand voltage	:
j. Rated lightning impulse withstand voltage	:
k. Capacitor loss factor ($\tan\delta$)	:
l. Partial discharge level at 291KV	:
at 420KV	:
m. PLC frequency range	:
n. Variation of Capacitance at PLC frequency range	:
o. Equivalent series resistance at PLC frequency range	:
p. Creepage distance of the insulating housing	:
q. Short-duration power frequency withstand voltage of the low voltage terminal	:
r. Stray capacitance of the low voltage terminal	:
s. Stray conductance of the low voltage terminal	:

- t. Creepage distance of the low voltage terminal's bushing :
16. Does the offered coupling capacitor comply with the requirements of paragraph IX, of hereby specification? :
:
17. Does the offered coupling capacitor include a carrier earthing switch? :
18. Total weight of the coupling capacitor including oil :
19. Total length of the coupling capacitor :
20. Largest shed diameter of the insulating envelope :
21. Diameter of the head of the coupling capacitor :
22. Weight of the insulating oil :
:
23. Mechanical strength of the coupling capacitor (Force at line terminal) :
24. Will the package of the coupling capacitors follow the requirements of par. XIV of this hereby specification? :